DEPARTMENT OF AGRICULTURAL ECONOMICS

Determinants of Affordability of Healthy Food in the Rural Counties: case of the Brazos Valley Area

The relationship between neighborhood characteristics and the affordability of fresh fruits and vegetables

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Introduction

Obesity related illness is a leading cause of mortality and morbidity in the United States and the burden of these diseases is not uniformly distributed across the population. It is well-documented that individuals from lower socio-economic background as well as certain racial/ethnic groups have higher obesity prevalence (Zhang and Wang, (2004); Wang and Beydoun, 2007). Understanding why particular groups of individuals face a greater risk of becoming obese has become one of the most pressing questions in public health.

A leading hypothesis that attempts to explain these health-related disparities is that different groups face different degrees of availability and affordability of healthy food options. The basis for this argument is that individuals with similar traits sort themselves into distinct geographic locations producing relatively homogenous local markets[1]. Store owners then respond to the characteristics of the local market in such a way that maximizes expected profit. These decisions may include the amount of total shelf space; the proportion of shelf space dedicated to particular items; the variety of items offered for sale; and the price of items. For example, so-called "food deserts[2]" may arise if either the demand for healthy food items is sufficiently low or the opportunity cost of supplying health food items is sufficiently high.

In this paper, we focus on the influence of neighborhood and store characteristics on pricing decisions of store-owners and the resulting affordability of healthy food items, specifically fresh fruit and vegetables (F&V). Although this question has been investigated previously, this paper makes an

[1] For example sprawling, areas occupied by mobile homes, poor neighborhoods with cheap rents are more likely attractive to poor individuals.
[2] Poor communities, where residents cannot buy affordable healthy Food (Cummins and Macintyre, 2002)

important contribution to the literature because of the unique dataset used in the analysis and improvements in the empirical methodology.

Our data come from a comprehensive that describes the food environment of a contiguous but diverse set of counties in Texas. Thus, unlike previous work that has relied on random sampling of stores or address only a subset of neighborhood characteristics at a time, we are able to investigate the effects of urbanicity, wealth, income, race, age, education and transportation on the affordability of F&V using the universe of food stores in a region. Additionally, previous studies typically calculate a fixed-basket price index that ignores substitution behavior on the part of consumers. Instead, we calculate an economic price index based on a cost-minimizing consumer who attempts to meet a nutrition constraint. Finally, previous work has ignored the economic theory that underlies missing prices. In this paper, we attempt to estimate the shadow price of missing items through a straight-forward imputation strategy[3] (methodology detailed in the following pages and Dunn et al. (2009)).

It is hoped that the results of this paper will be useful to policy-makers attempting to design policies aimed at decreasing health disparities through making fresh fruits and vegetables more affordable to groups at the greatest risk of obesity and obesity related illness.

It is important to define affordability. Affordability is used by the United States Department of Agriculture (USDA) and other studies (Margaret et al., 2001; Jetter et al., 2006; Block and Kouba, 2006; Burns et al., 2004; Furey et al., 2002 to name a few) to describe the cost of a well-defined basket of food necessary to maintain a certain level of nutrition compared to the same basket in each store surveyed or visited. Others used relative price to measure how costly/costless a particular food items is across stores (Hendrickson et al., 2006).

[3] For more information regarding imputing, go to Barzi Federica and Mark Woodward. "Imputations of Missing Values in Practice: Results from Imputations of Serum Cholesterol in 28 Cohort Studies." *American Journal of Epidemiology*. 160 (1): 34-45.

The paper is structured as follows. The next section reviews the literature on correlates of availability and affordability of F&V as well as methodological issues. Data collection methods are then discussed, followed by presentation of model and results, and then discussion of key findings and areas of future research.

Literature Review

There are numerous studies that examine the correlates of availability and affordability of F&V. One subset of this literature considers variation in availability across store types. In general, supermarkets sell a greater variety of F&V compared to other types of stores like grocery stores (Jetter and Diana, 2006), convenience stores (Block and Kouba, 2006, Andreyeva et al., 2008), and discount stores (Block and Kouba, 2006).

The relationship between neighborhood characteristics and the presence of different types of stores is much more complicated. For instance, supermarkets are less likely to be found in rural areas than in urban areas (Mooney, 2000 and Powell et al., 2004). But within urban areas, neighborhoods that are poorer or have a higher proportion of minority residents are also less likely to have a supermarket present (Morland et al., 2002; Morland and Susan, 2007; Jetter and Diana, 2006; Hosler et al., 2008). However, Block and Kouba (2006) found no statistically significant relationship between the characteristics of neighborhoods in the Chicago area and the presence of different store types.

In addition to allocating the greatest amount of shelf space to F&V and offering the widest variety of items, many authors have found that supermarkets are also the lowest-cost provider of F&V among the different types of food stores (Donkin et al., 2000; Block and Kouba, 2006; and Liese et al., 2007). There is much less agreement, however, about the relationship between neighborhood characteristics and affordability. On the one hand, supermarkets are the cheapest source of F&V and are less likely to be in either poor densely populated urban areas or poor sparsely rural areas (Morland and

Susan (2007)). This would tend to make F&V more expensive in these types of neighborhoods. On the other hand, a number of papers have reported that supermarkets located in economically disadvantaged areas sell produce at a lower price than supermarkets located in wealthier neighborhoods (Ball et al., 2009; Latham and Tina, 2007; Cassady et al., 2007). This would tend to make F&V less expensive for those living in poor neighborhoods. However, these findings are not universal: a number of other researchers have shown that there is no difference in food prices regardless of the types of store and neighborhood characteristics (Andreyeva et al., 2008; Cummins and Macintyre, 2002; Zenk et al., 2006).

Looking at the relationship between availability, affordability and consumption of F&V, earlier studies also found conflicting results. Zenk et al. (2009) found a positive relationship between neighborhood stores, ethnicity and F&V consumption, indicating that the shorter the distance to the stores the greater the benefits. In contrast to previous findings, Pearson et al. (2005) found that there is no statistically significant relationship between store types, neighborhood deprivation, prices of F&V and F&V intakes.

There are important methodological concerns in each of the papers that study the affordability of F&V. First, the cost of F&V typically relies on a fixed market basket like the one defined by the Thrifty Food Plan (TFP) (Andreyeva et al., 2008; Cassady et al., 2007; Pearson et al., 2005; Lee et al., 2002). This neglects the fact that consumers can switch between types of food items when their relative prices change. For example, in areas where apples are relatively expensive, we could expect households to switch toward consuming more oranges or bananas. Therefore, a fixed-basket will overstate the cost facing a household and the degree of bias will increase in the degree of substitutability between items.

A second problem is how these studies treat the prices of missing items, since not all stores will sell all varieties found in the defined basket. Some papers, treat missing prices as zero (Hendrickson et

al., 2006), which is equivalent to saying that they are free. Other papers replace missing prices with the average price of the item across stores that do stock the item (Block and Kouba, 2006; Latham and Tina, 2007; Lee et al, 2002). Neither of these approaches is based on the valid application of economically rational behavior. Instead, one should think about the lowest selling price at which a store would be willing to stock an item, the reservation price. Stores that do not offer the item for sale do so because the reservation price is above what most customers are willing to pay. Thus, missing prices are an indication that the price of the item is higher than what the average store is asking.

In contrast, our study will construct price indices of fresh fruit and fresh vegetables that allow for reasonable substitution behavior and replaces missing prices with estimates of the reservation price. The method leading to the computation of the store-level price indices is detailed in the following section.

Methods-data collection

Area surveyed for the study: Brazos Valley region

The Brazos Valley region of Texas includes seven counties (Brazos, Burleson, Grimes, Leon, Madison, Robertson and Washington) located between the Austin, Dallas and Houston metropolitan areas with a total population of nearly 300,000. For several reasons, the area is ideally suited to study the socio-economic and demographic influences of price. First, 48.6% of the population resides in the Bryan-College Station (BCS) metropolitan area with the remaining 51.4% living in a predominantly rural environment. Second, minority groups are well-represented with 17.8% of the populations claiming Hispanic heritage and 16.5% reporting African-American race. Third, the region suffers from a relatively high poverty rate of 16.8%, greater than both the national and state-wide averages of 12.6% and 16.2%, respectively. Fourth, the main campus of Texas A&M University is located in BCS. Large research universities typically employ well-educated individuals and attract other businesses that require

a well-educated workforce. Finally, there is a great deal of variation within the region. The top panel of Table 1 presents selected socio-economic information for the counties in the Brazos Valley from the US Census Bureau. Median household income ranges from just over $34,000 in Madison County to nearly $45,000 in Washington County. Robertson County has the largest proportion of Blacks at 22.9%, while neighboring Leon County is only 10.1% Black. Leon County also has the lowest percentage of Hispanic residents. In contrast, Hispanics account for 20.8% of the population in Brazos County, the largest county in the region. As expected, it also has the most educated population with 37% holding at least a Bachelor's Degree. Thus, the Brazos Valley region allows us to study the effects of urbanicity, education levels, income levels and demographic make-up on affordability within a compact, contiguous area.

Data collection

The prices of fresh fruit and vegetable items come from the Brazos Valley Food Environment Project (BVFEP). The region was canvassed by driving all Interstates, US Highways, Texas State Highways, Texas Farm-to-Market Roads and other major thoroughfares to locate all stores that could sell food items. Trained investigators classified stores into several categories (e.g. supermarket, convenience store, fast-food restaurant, etc) according to product selection. The investigators used Geographic Information System (GIS) software to geocode store locations. The survey covered 2 stores classified as supercenters, 22 supermarkets, 14 grocery stores and 256 convenience stores[4]. Due to the fact that the food selection in supercenters and supermarkets does not significantly differ and there are

[4] The different types of stores are defined, according to Sharkey et al. (2009), as following: supercenters are very large stores that primarily engage in retailing a general line of groceries in combination with general lines of new merchandise, such as apparel, furniture, and appliances; supermarkets and grocery stores primarily engage in retailing a general line of food, supermarkets are larger in size (>20,000 ft2), number of employees, and sales volume, chain store identification and number of parking spaces; convenience stores (with gasoline and gasoline stations) or food marts primarily engage in retailing a limited line of goods that generally includes milk, bread, soda, and snacks.

only two supercenters in the sample, both types of stores are combined into the category of supermarkets. The bottom panel of Table 1 presents the number of store types by county. Every county had at least one supermarket, but neither Madison nor Washington County had a grocery store. In every county, convenience stores represent at least 77 percent of the total stores surveyed.

After mapping store locations, investigators then entered the establishment with an extensive list of food items in order to catalogue which items were sold and at what price (Bustillos et al., 2009). Ten types of fruits (apples, avocado, bananas, berries, grapes, mango, melons, oranges, peaches and pears) and eleven types of vegetables (broccoli and cauliflower, carrots, corn, green beans, leafy greens, lettuce, okra, onions, potatoes, squash and tomatoes) were included in this catalogue. For some goods, multiple varieties were available. For example, a store might sell Red Delicious, Macintosh and Granny Smith apples. The number of varieties was noted, but only the price of the cheapest variety was recorded. In-store prices were posted in several forms: per item, per ounces, per pound. All prices were later transformed or recalculated into a uniform unit: price per pound. To do so when prices were posted per item, surveyors weighed the items using a sensor scale. The price of food items that were not sold were recorded as missing. Similarly, prices were recorded as missing when a price was not displayed. Contrary to earlier methods (Latham and Tina, 2007; Cummins and Sally, 2002), the survey process did not involve interaction with store employees and managers so that all the recordings were based on direct observation.

Availability and cost of fresh fruits and vegetables

Table 2 summarizes the availability and cost of individual produce types. The most widely available fruit is bananas since they are the most likely fruit to be found in convenience stores. It is likely that these stores offer bananas because one does not need to cut or wash before consumption. Among fruits that require some degree of preparation, apples and oranges are the most common. The

most widely available vegetables are lettuce, onion, potatoes and tomatoes. The most expensive fruits are berries and avocado, while the cheapest are bananas. For vegetables, the most expensive type, tomatoes, is nearly three times more expensive than the cheapest type, potatoes. Tomatoes also have the greatest variability in price.

Price imputation and price index

The results in Table 2 highlight two methodological issues that arise when studying the affordability of F&V. First, a price index must be calculated to reduce the dimensionality of the problem and permit broad patterns to emerge. Second, variation in the number of types of F&V sold requires some stand on missing price information. A key innovation in our study is the use of an economic price index based on a cost-minimizing consumer with Cobb-Douglas preferences attempting to meet an ex post nutrition constraint developed by Dunn et al. (2009). In contrast, previous studies have often used z-scores built from a fixed-basket of goods (Zenk et al., 2006; Donkin et al., 2000; and Furey et al., 2002). The decision to use a fixed-basket as the basis for the price index is not benign, as it eliminates the possibility of substitution between items as relative prices change. High variability in the price of goods that account for a small proportion of consumption but a large proportion of expenditure is particularly problematic in such instances (e.g. strawberries).

The price of consuming a quantity of the aggregate good that is sufficient to attain minimum utility and nutrition levels is defined by:

$$P(p,n) = n\left[\sum_i \left(\frac{p_i}{\alpha_i}\right)\right] \qquad (1)$$

where i indexes the item; p_i denotes the price of good *i*; α_i equals the percentage of all expenditure that goes toward *i* ($\Sigma\alpha_i = 1$); and *n* is the desired number of servings. Since *n* enters as a multiplicative factor, it is set equal to unity for convenience.

The index defined by Equation 1 has several desirable properties. First, it captures the intuitive behavioral response of substituting away from goods that increase in relative price. Second, it incorporates the nutritional aspects of fruit and vegetable consumption through the serving requirements[5]. Finally, its calculation depends only on knowledge of prices and expenditure shares. The BVFEP provides the requisite price information while the expenditure share information can readily be taken from other sources. Here, data from FreshLook Marketing for the Dallas metro area are used to calculate the relevant expenditure shares[6].

Unlike previous work that either set missing prices to zero (Hendrickson et al., 2006) or replaced missing prices with the average price in stores that sold the item (Lee et al., 2002; Block and Kouba, 2006), we impute missing prices in a store from the prices of goods that are sold in the store. The full imputation procedure can be found in Dunn et al. (2009), but a highly stylized and simplified example is instructive for comparison to earlier work. So as an example, if the price of apples tends to be proportional to the price of oranges by a factor *z* in stores where both are sold, then a reasonable imputation for the price of apples in a store that only sells oranges is $z^*p_{oranges}$.

With the set of observed and imputed prices, price indices can be calculated. In this study, for stores that sell at least 4 types of fruit, the prices of all types are used in the index calculation. This index is termed the *high variety fruit price index* (hFPI). For stores that sell only three types of fruit, only the prices of apples, oranges and bananas are used in the calculation of a *basic fruit price index* (bFPI). An

[5] Even when *n* is set to unity, the price index differs from the usual economic index defined by the expenditure function without a nutrition constraint.
[6] We thank Timothy Richards for providing this information and the interested reader can find the expenditure shares in Dunn et al. (2009).

index is not calculated for stores that sell less than 3 items because: 1) these are convenience stores that typically sell only small amounts of apples or bananas; 2) they are likely not prime sources of fruit purchases for most households; and 3) price imputation cannot reasonably be undertaken. Similarly, a *high variety vegetable price index* (hVPI) is calculated using all vegetable types in stores that sell at least six types of vegetables and a *basic vegetable price index* (bVPI) is calculated using the prices of carrots, lettuce, onions, potatoes and tomatoes in stores that sell at least 3 types of vegetables.

Although the need to calculate both high variety and basic indices is driven partly by the imputation process, it is also useful from a policy perspective. For instance, berries are a particularly expensive fruit item that some would consider a luxury. If the goal is to assess the costs of attaining a minimal level of nutrition, focusing on the cost of doing so through the purchase of the most commonly consumed fruit items seems sensible.

Store location characteristics

The neighborhood characteristics of store locations are described by a parsimonious set of variables collected from the US Census Bureau at either the county or Census Block Group (CBG)-level, based on previous findings in the literature connecting affordability to economic prosperity, education levels and demographic composition (Jetter and Cassady, 2006). Median housing value, median income and the percent of households with income below 200% of the poverty line are used to control for asset wealth and the distribution of income. Each is taken at the CBG-level. Education is accounted for by considering the percent of the population in the county with at least a high school diploma. Demographic controls at the CBG-level include the percent Hispanic, percent Black and the percent of the population above age 65. In addition, we include the percentage of households in the CBG who do not have an automobile. These individuals may be less able to comparison shop and store-owners may account for this in their pricing strategies.

Table 3 summarizes the price indices across stores as well as the neighborhood characteristics of store locations. The basic fruit index is cheaper than the high variety index since the latter includes high cost items like berries and avocados. In contrast, the basic vegetable price index is more expensive than its high variety counterpart because in the former a greater weight is applied to tomatoes (which are the most expensive vegetable type).

Although the bVPI can be calculated for 50 stores, since more than one store can be located in a CBG, there are 22 different CBG's that have at least one store with a calculable bVPI. The median value of housing in the set of CBG's used in the subsequent analysis is $66,855. Just over 60% of the population self-reports Caucasian race while 16.5% are Black and 17.8% are Hispanic. About 12% of the population is at least 65 years old and 76% graduated from high school. The rate of poverty below 200% is estimated at 42%. The majority of the population has own transportation—only 9% do not have own an automobile.

Results

As a preliminary analysis of the relationship between affordability and neighborhood characteristics, Table 4 presents averages of the four price indices by median income and education level of residents in the county and the race/ethnic composition of residents in the CBG. The high variety fruit and both vegetable price indices are higher in counties with a median income above $38,500. This relationship disappears when looking at the basic fruit price index. This suggests that high income areas may pay a premium for variety, but the cost of acquiring more common items does not respond to income. Since economists would consider variety a luxury good, the result is sensible.

The cost of fruits and vegetables responds quite strongly to the education level of residents. The high variety and basic fruit price indices are decreasing in the percent of the population with at least a

high school diploma. Interestingly, the relationship is reversed for the high variety and basic vegetable indices. This highlights the importance of considering these sets of goods separately.

The results for the effect of ethnic/racial composition are rather mixed with weak evidence that areas with higher minority concentrations face higher prices. For example, there is no difference by the percentage Black or percentage Hispanic in the high variety fruit or basic vegetable price indices. But, the high variety vegetable price index tends to increase as the proportion of the CBG population that is Black or Hispanic increases. The basic fruit price index is also increasing in the proportion of the CBG that is Black, but does not display a strong relationship with the proportion that is Hispanic.

With respect to the level of poverty, those living in areas of high poverty rate may face more expensive fruits and vegetables. In general, stores charge more for both (high and basic) varieties of fruits and high variety vegetables in the areas where poverty level is above 22%. The prices are cheaper for basic vegetable price index.

Based on this evidence, three interesting results worth further exploration stand out: 1) differences in the cost of fruits and vegetables between wealthy and poor areas may be driven by differences in the demand for variety; 2) education has opposite effects on the price of fruit versus vegetables; 3) affordability is weakly decreasing in the proportion of residents that are minorities. Of course, income, education and ethnicity are generally highly correlated. To assess the independent effect of each, as well as the role of other neighborhood characteristics of interest, we estimate the following using multivariate regression or OLS:

$$P_i = \beta_0 + \beta_1 * \text{Log of median Income} + \beta_2 * \text{Log of housing value} + \beta_3 * \text{percentage poverty level} + \beta_4 * \text{Percentage High School graduate} + \beta_5 * \text{Lack of transportation} + \beta_6 * \text{Percentage aged 65 years or more} + \beta_7 * \text{Percentage Blacks} + \beta_8 * \text{Percentage Hispanics} + \beta_9 * \text{Supermarket} + \beta_{10} * \text{Convenience} + \beta_{11} * \text{Burleson-Madison} + \beta_{12} * \text{Grimes-Washington} + \beta_{13} * \text{Leon-Robertson} + \varepsilon \quad (3)$$

where P_i represents each type of price index (i.e. hFPI, hVPI, bFPI, bVPI) and $\boldsymbol{\beta_i}$ represents coefficients associated with each of the explanatory variables. *Percentage poverty level* is the percentage of persons with income below 200% federal poverty line[7]. *Supermarket* and *Convenience* are indicator variables for store type and *Burleson-Madison, Grimes-Washington* and *Leon-Robertson* are indicator variables that take on the value of unity when the store is located in one of the counties[8]. To address spatial error correlation, all standard errors are clustered at the county level (Moulton, 1990).

The results of the regression equation (3) for each of the price indices are presented in Table 5. The first thing to notice is the relatively high values for R-squared, especially for high variety fruits and basic vegetables price indices, given the size and cross-sectional nature of the dataset. The set of explanatory variables explains at least 43% of the variations for each of the four price indices.

The relationship between economic well-being and the affordability of F&V is rather complex. Areas with higher median housing values are strongly associated with high price indices and the relationship is statistically significant in three of four regressions. Interestingly, the coefficient on median income is negative in three of four regressions. However, neither these coefficients nor the coefficients on percent of individuals with income less than 200% of the poverty line are statistically significant in any of the four regressions. Reconciling these seemingly contradictory results is taken up in the next section.

The availability of transportation[9] does not seem to affect price indices as the coefficient is small in each regression and statistically significant only for the bFPI. In contrast, the level of education for the residents in the Brazos Valley counties is important and significant for the price indices of fruits, both high variety and basic. Areas with a higher proportion of high school graduates tend to pay less.

[7] The federal poverty line for a family of four in 2009 was $22,050.
[8] County dummies help control for unobserved variation across counties as well as differences in when price data was collected.
[9] In this study, the only measure of availability of transportation is car ownership

The demographic composition of neighborhoods has an effect on prices, but generally only through the age of residents. An increase in the percentage of residents who are 65 years old or older will result in a decrease in the prices of both varieties in stores who sell fruits. The effects are positive for the types of vegetables but are not statistically significant. There does not appear to be any relationship between racial composition and the price indices except for stores selling basic variety of vegetables. The coefficient estimates are generally positive for both percent Black and percent Hispanic, but all are exceptionally small.

The costs of F&V also depend upon the type of store. The coefficient on the convenience store indicator variable is positive in each regression and statistically significant for both the hFPI (10% level of significance) and bVPI (0.1% level of significance). Although the supermarket indicator has a negative coefficient on the bFPI, all the coefficients are statistically insignificant.

Discussion and conclusion

Unlike previous work that has relied on random sampling of stores or address only a subset of neighborhood characteristics at a time, we were able to investigate, using a comprehensive dataset, the effects of various factors on the affordability of F&V using the universe of food stores in a region. In addition, previous studies typically calculated a fixed-based price index that ignores substitution behavior on the part of consumers. In this study, we calculated an economic price index based on a cost minimizing consumer who attempts to meet a nutrition constraint. In contrast to previous work that ignored the economic theory that underlies missing prices, we estimated the shadow price of missing items with a simple imputation strategy.

Our results generated important conclusions and interesting questions for further research. First, although supermarkets sell the greatest variety of F&V, they are typically no less expensive than grocery stores once controls for other neighborhood characteristics are included in the analysis. Of course,

deprived areas may be more or less likely to have a supermarket nearby and thus the location decisions of potential store owners are worth further investigation.

Second, convenience stores are not a source of significant variety in F&V. They also tend to sell these products at a higher cost. From a methodological standpoint and facing limited resources, further research might be encouraged to focus on the effects of supermarkets and groceries on fruit and vegetable consumption, at least for non-urbanized areas.

Third, although areas with a higher percentage of minority residents tend to pay more for fruits and vegetables, the association is extremely weak yielding coefficient estimates that are neither statistically nor economically meaningful. In the Brazos Valley, any difference in affordability between racial/ethnic groups is driven by differences in socio-economic status rather than by race in and of itself.

In fact, our results suggest that economically disadvantaged areas may pay less for F&V. Taking housing value as an approximate measure of wealth, stores in wealthier neighborhoods charge a higher price and the relationship is stronger for the high variety indices. This is consistent with the notion that variety in F&V consumption can be considered a luxury good. An alternative hypothesis is that areas with high housing values also have higher rents on commercial property. These costs would then be transferred on to consumers.

The results for other economic characteristics, however, do not help separate these two explanations. The former explanation is supported by the negative coefficients reported on the percent of residents living under 200% of the poverty line, although these are not statistically significant. However, the coefficients on median income also tend to be negative and significant. Although not reported here, when median income in the CBG is replaced by median income in the county, the coefficient is positive and significant. Since rental prices are highly localized, but shoppers may come from adjacent

neighborhoods, these results should encourage future researchers to explicitly consider the problem from a spatial framework.

Elderly individuals can generally be expected to shop at store located near their residencies due to the limitations in their mobility caused by difficulty in driving, lack of public transportation and health problems. This lack of mobility can be advantageous for retailers in the immediate neighborhoods who would then charge a higher price for their items. But this is not seen in the data. Two explanations are possible. First, because this is population on a fixed income, they may be highly price sensitive. Hence, higher prices for F&V can lead to steep declines in consumption. Thus, retailers in areas with more elderly residents must price F&V lower. Alternatively, elderly residents are typically retired, and it is well-known that retirees spend less money on groceries while spending more time shopping compared to non-retirees (Aguiar and Hurst, 2005). Because the marginal value of their time is lower, information acquisition is cheaper. This would actually increase price competition among stores.

The importance of information acquisition is further supported by the large negative effect of education on prices. It is believed that better-educated individuals collect and process information more efficiently. This could then increase price competition in neighborhoods with higher proportions of educated residents.

This research is not without limitations. First, even though the survey covered many variables in census block groups that are small geographical areas, the survey did not cover level of education. Education was obtained from the county level. The use of the variables measured in CBGs together with those measured in county level may introduce or lead to (potential) measurement problems.

In addition, during the survey, the data were collected without consideration or distinction of the brands of the food items recorded. In particular, consumers may treat organic F&V as distinct products that should be analyzed separately. For example, if during the survey, the sole type of fruit or vegetable

displayed was organic, the recorded price was not the cheapest, but certainly the highest. This recorded price may be the cause of some highest price indices. More broadly, this speaks to the quality of items being sold, an unaddressed issue in the literature. Maintaining perishable items while they are on the shelf is costly and this cost will be passed on. Therefore, only stores that expect such an investment to be profitable will do so.

In general, the physical properties of stores have been ignored in the literature. For instance, an important store characteristic that was not recorded, but may influence the willingness of consumers to pay for perishable items is the cleanliness of the store. Cleanliness is costly to the store-owner, but may induce a premium from the consumer. Other characteristics worth exploring include ease of parking, number of check-outs, ease of access from the street, etc.

Finally, as with previous work in this literature, the price competition between stores is ignored. It is known that when stores compete in prices, consumers end up paying less than when the stores do not compete. Again, addressing this concern in a spatial framework would be a valuable contribution.

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Table 1. By county demographic repartition and store per type

Store type	Brazos	Burleson	Grimes	Leon	Madison	Robertson	Washington
Population	170,954	16,598	25,603	16,462	13,379	15,819	32,034
Median income ($)	33,186.74	31,174.54	33,327.9	29,443.27	28,963.93	29,983.7	35,852.43
Education (%): Bachelor or higher	37	13.2	10.3	12.1	11.5	12.7	19.0
Percentage Black	10.7	14.3	18.2	10.1	21.8	22.9	17.8
Percentage Hispanic	20.8	16.5	18.2	10.9	18.9	16.8	11.6
Supermarket	11	2	2	1	2	3	2
Grocery	3	3	2	4	0	2	0
Convenience	114	19	25	25	12	18	32

Source: US Census Bureau and BVFEP.

Table 2. Average store prices per pound of food items (F&V)

		Price	
Produce type	Observations	Mean	Standard Deviation
Fruits			
Apples	46	1.21	0.33
Avocado	36	2.25	0.97
Bananas	65	0.87	0.44
Berries	25	2.80	0.59
Grape	31	1.71	0.48
Oranges	40	1.01	0.38
Peaches	25	1.63	0.33
Pears	27	1.27	0.58
Vegetables			
Carrots	45	0.97	0.38
Corn	27	0.84	0.34
Cruciferous	31	0.93	0.32
Green Beans	21	1.57	0.52
Greens	29	0.98	0.27
Lettuce	53	0.78	0.27
Onion	59	1.05	0.41
Potato	55	0.65	0.36
Squash	32	1.23	0.38
Tomatoes	60	2.25	1.43

Table 3. Conditional descriptive statistics of explanatory variables

Variables	Observations	Mean	Standard Deviation	Minimum	Maximum
High Fruit Price Index	34	1.01	0.14	0.71	1.29
High Vegetable Price Index	32	0.85	0.19	0.53	1.29
Basic Fruit Price Index	37	0.74	0.19	0.45	1.42
Basic Vegetable Price Index	50	0.90	0.25	0.46	1.44
Median Income ($)	22	33,250.09	10,921.56	14,609	55,052
Housing value ($)	22	66,854.55	29,331.92	23,600	138,900
Poverty rate below 200%	22	42.022	15.96	10.84	73.98
Education: Percentage High School graduate	22	73.76	5.65	67.30	81.30
Percentage Household without transportation	22	8.17	5.45	0	20.19
Percentage of residents 65 years and older	22	13.07	4.07	7.7	20
Percentage Blacks	22	17.76	12.59	0.19	44.23
Percentage Hispanics	22	14.22	11.92	3.84	52.59
Supermarket Stores	22	0.36	0.49	0	1
Convenience Stores	22	0.45	0.50	0	1

Table 4: Socio-economic indicators

Variables		hFPI	hVPI	bFPI	bVPI
Income ($)	> 38,500	1.08	0.93	0.70	1.06
	≤ 38,500	0.99	0.84	0.73	0.88
Education (%)	> 15	0.95	0.92	0.68	1.02
	≤ 15	1.03	0.83	0.75	0.85
Black (%)	> 15	1.01	0.89	0.79	0.91
	≤ 15	1.00	0.82	0.69	0.92
Hispanic (%)	> 15	1.01	0.87	0.73	0.90
	≤ 15	1.00	0.82	0.72	0.92
Poverty rate	>22	1.01	0.85	0.73	0.89
	≤22	0.98	0.75	0.63	1.15
Supermarket		0.99	0.88	0.67	0.86
Grocery		1.02	0.76	0.82	0.72
Convenience		1.16	0.82	1.00	1.13

Table 5. Determinant of price of fruits and vegetables

Variables	High variety fruits price index (n=33)	High variety vegetables price index (n=31)	Basic variety Fruits price index (n=36)	Basic variety vegetables price index (n=49)
Economic level				
Log of median	0.148	-0.108	-0.134	-0.042
Income	(0.150)	(0.243)	(0.144)	(0.193)
Log of housing	0.332**	0.448*	-0.045	0.348**
value	(0.122)	(0.229)	(0.133)	(0.131)
Poverty rate	0.002	-0.005	-0.005	-0.005
below 200%	(0.005)	(0.008)	(0.004)	(0.005)
Education level (%)				
High School Graduate	-0.052**	-0.0001	-0.045**	0.015
	(0.015)	(0.027)	(0.014)	(0.030)
Household without	0.003	0.009	-0.006	0.003
transportation (%)	(0.007)	(0.009)	(0.008)	(0.008)
Demographic (%)				
Residents 65 years	-0.056**	0.021	-0.050**	0.035
and older	(0.021)	(0.035)	(0.019)	(0.041)
Blacks	0.004**	0.005	0.0004	0.006*
	(0.002)	(0.004)	(0.003)	(0.003)
Hispanics	0.002	0.006	0.001	0.007*
	(0.003)	(0.006)	(0.004)	(0.003)
Store-types sets				
Supermarket Stores	0.006	0.065	-0.168*	0.074
	(0.070)	(0.100)	(0.095)	(0.072)
Convenience Stores	0.260*	0.117	0.169	0.425***
	(0.150)	(0.140)	(0.198)	(0.093)
Intercept	0.074	-3.432	7.000	-4.280
	(2.054)	(3.170)	(3.118)	(2.800)
F-test	2.950	.	5.65	5.29
P-value	0.007	.	0.000	0.000
R-squared	0.561	0.431	0.479	0.620

Statistical significance: * 10 percent level, ** 5 percent level, *** less than 1 percent level; standard deviations in parenthesis.