Household versus Community Effects:

Who Really Pays More for Food?

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Abstract: One strand of literature shows a household's cost of food to vary with the household's own income and demographic characteristics. For example, low-income households may tend to purchase less costly bundles of food. However, a separate strand of literature also shows food prices to vary spatially with the characteristics of communities, such as real estate prices. In this study, a model is developed that unites these two strands. Simulations further illustrate the effect that a community's characteristics can have on a household's food budget, if the household lives in each of ten cities in the United States.

1. Introduction

In a traditional Engel analyses, estimated with cross-sectional data, a researcher may include only income and demographic characteristics among the variables thought to explain a household's expenditures on a broad composite commodity, such as vegetables, meats, or dairy products. A single market price is not directly incorporated into these models, since each household purchases a composite commodity that is an aggregate of diverse elementary goods. Each of these elementary goods has its own market price. Nonetheless, if the data permit, other measures of a household's cost of food may be included. Unit values are one commonly used measure. Defined as the ratio of expenditures on the composite commodity to physical quantities, a higher unit value signals a more expensive mix of underlying elementary goods. Researchers have modeled unit values primarily as a function of a household's characteristics and, perhaps, the household's region of residence to control for price variation. Low-income households, for example, have been shown to economize by purchasing lower-cost bundles. They may buy, say, more potatoes or frozen mixed vegetables as opposed to fresh asparagus or fresh mushrooms.   Unit values and expenditures on a composite commodity may be estimated together as a system of equations. Procedures have been proposed by Cox and Wohlgenant (1986); Deaton (1988, 1997); and Dong, Shonkwiler, and Capps (1998), among others.

A separate strand of literature, using store-level data, has demonstrated how the economic and demographic characteristics of a community, such as the income of residents, real estate values, population density, and urbanity, influence prices faced by households. Studies, including Frankel and Gould (2001) and Stewart and Davis (2005), among others, show that, even within a narrowly-defined geographic area, such as a city, food prices vary. These findings

suggest that a household's food budget may depend on the characteristics of its community as well as its own income and demographic characteristics. For example, a low-income household may pay a higher price per serving of frozen mixed vegetables than households elsewhere pay. Retailers in the household's community may charge more for a 16 ounce package or, perhaps, they do not also offer a 32 ounce package, which retailers elsewhere tend to sell for less money per serving. However, from these studies, it cannot be explicitly determined how community characteristics affect households' budgets. As noted, the data are not household-level.

To unite these two strands of literature, a model of household food expenditures is proposed that identifies both household and community effects. In this model, unit values depend on a household's income and other characteristics as well as on the characteristics of the household's community of residence. Theory suggests that real estate values and other characteristics of a community may influence the prices that a household faces for elementary food products and also the mix of products offered by retailers in a community. While the study makes no attempt to disentangle these two aspects of the community effects, simulations are conducted to illustrate the net effect of community characteristics on a household's budget for each of ten cities in the United States. The model is estimated with a unique set of cross-sectional data provided by ACNeilsen with information on households, what they paid for food, and the characteristics of their community. The application is to vegetables.

2. Household Effects in Demand Analysis

Working with cross-sectional data on households, researchers often estimate the relationship between household characteristics and food expenditures. Engel analyses are particularly common when the data contain only a household's expenditures on a composite commodity,

income, and other demographic characteristics. Recent applications to vegetable expenditures

include Blisard, Variyam, and Cromartie (2003) as well as Stewart, Blisard, and Jolliffe (2003).

A single market price is not directly incorporated into Engel models, since each

household purchases a composite commodity that is an aggregate of diverse elementary goods.

However, if the researcher's data include quantities purchased, perhaps, other measures of a

household's cost of food may be included. One approach relies on unit values. These values are

often referred to as a measure of the "quality" of goods bought by a household. In fact, unit

values are simply a weighted average price. Deaton (1997) notes that, "A kilo of steak costs a

great deal more than does a kilo of stewing beef…, and even for relatively homogeneous

commodities such as rice, there are many different grades and types. Unit values are computed

by dividing expenditures by physical quantities, and high-quality items, or mixtures that have a

relatively large share of high-quality items, will have higher unit prices" (p. 288).

Houthakker (1952) and Theil (1952) long ago recognized that fitting a demand model

with unit values would require accounting for so-called quality effects. Conventional methods

were later developed by Cramer (1973) and Goldman and Grossman (1978), among others. Cox

and Wohlgenant (1986) first applied these methods to a study of the demand for a composite

food commodity. As shown in the following equation for the unit value paid by household i in

region m at time t, V_{imt}, the approach of Cox and Wohlgenant (1986) decomposes unit values

into exogenous prices faced and the effect of household characteristics on the costliness of the

mixture of foods purchased:

$$V_{imt} = P_{imt} + \beta X_{it} \tag{1}$$

where P_{imt} is the "quality-adjusted" price faced by i, X_{it} is a k-dimensional vector containing

selected characteristics of i, and β is a k-dimensional column vector of unknown parameters.

The elements of X_{it} determine the mix of foods chosen by i, and should include household income, size, race, and ethnicity, among others.

To apply the method of Cox and Wohlgenant (1986), a researcher calculates the mean unit value paid by all households living in the same region of the country and completing the survey during the same season as i, $\overline{V}_{\bullet mt}$. The difference between V_{imt} and $\overline{V}_{\bullet mt}$ is then regressed on X_{it}. The error term in this regression, ε_{imt}, is argued to capture idiosyncratic, supply-related factors, such the market power of retailers in different communities. Prices faced by households equal the sum of regional/seasonal effects and this error term, i.e., $P_{imt} = \overline{V}_{\bullet mt} + \varepsilon_{imt}$.

The above procedure separates P_{imt} from household-induced quality effects after which Cox and Wohlgenant (1986) estimate a demand model for vegetables similar to the following:

$$Q_{imt} = \gamma_0 + \gamma X_{it} + \gamma_{K+1} P_{imt} \tag{2}$$

where quantity demanded, Q_{imt}, is pounds of vegetables and γ and $\gamma_{K+1}$are a k-dimensional column vector of unknown parameters and a single unknown parameter, respectively.

Cox and Wohlgenant (1986) find that household effects explain only a small proportion of the total variation in unit values,[1] as estimated by fitting their data to equation (1), although their model of demand, as represented by fitting their data to (2), better explains variation in quantities demanded than does a more parsimonious model not explicitly including price effects.

However, P_{imt} may not be exogenous in equation (2). More recent studies tend to test for price endogeneity and, for example, Dhar, Chavas, and Gould (2003) contend that it may be a general problem in applied demand analysis. Using unit values to model the demand for beef steaks and roasts, Dong, Shonkwiler, and Capps (1998) find empirical evidence that the method

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[1] R^2 in regressions of V_{imt} - $\overline{V}_{\bullet mt}$ on X_i for fresh, canned, and frozen vegetables is 0.0532, 0.0348, and 0.0384, respectively.

of Cox and Wohlgenant (1986) can lead to biased parameter estimates. Dong and Kaiser (2005) find the same in a model of the demand for cheese.

An alternative approach has been developed by Deaton (1988; 1997). His method does not appear to suffer from simultaneous equations bias, but it does require a researcher to assume that all households face the same prices, if they live in a common, broadly-defined geographic area, such as a region of a country. Under this assumption, the parameters of a pair of unit value and demand equations are estimated in two steps with data from a survey administered in the Ivory Coast. First, using information on how unit values and quantities demanded vary within villages, income and demographic effects are identified. Second, price effects are identified using the remaining variation in quantities demanded along with differences in average unit values between villages.

When working with cross-sectional data from a developed country, the method of Deaton (1988; 1997) may not enable researchers to identify price effects. Using data from the United States, Nelson (1990) relies on differences in mean unit values between regions of the country for the identification of these effects. She fits demand models for eleven food categories, including cereals, beef, pork, poultry, and processed vegetables, among others. The estimated price effect is statistically significant in only one of these eleven equations. "The large standard errors probably arise from a relative lack of spatial price variation (on which the estimation of price elasticities relies, in Deaton's method) in U.S. markets, owing to the existence of a well-developed transportation network" (Nelson 1990, p. 155).

Nelson (1990; 1991) also argues against measuring quantity demanded in physical units, as in both Deaton (1988) and in Cox and Wohlgenant (1986). Invoking the Hicksian Composite Commodity Theorem (HCCT), she demonstrates expenditures to be the appropriate measure of

quantity demanded for a composite commodity. More recent work has appealed to the much less

restrictive Generalized Composite Commodity Theorem of Lewbel (1996), which does not

require strictly proportional movements in the prices of elementary goods, as does the HCCT

(e.g., Asche, Bremnes, and Wessells 1999).

In lieu of (1) and (2), unit value and expenditure equations for a composite commodity,

which are consistent with Nelson (1990; 1991), and which can be simultaneously estimated are:

$$Ln(V_{imt}) = P^*_{imt} + \beta X_{it} \tag{3}$$

$$M_{imt} = \theta X_i + \theta_{K+1} Ln(V_{imt}) \tag{4}$$

where P^*_{imt} are exogenous prices faced by household i, $Ln(V_{imt})$ is the natural logarithm of unit

value paid, M_{imt} is household expenditures, and θ and θ_{K+1} are a k-dimensional vector of

unknown parameters and a single unknown parameter, respectively.[2] Other researchers have

developed variations of this basic model, including Dong, Shonkwiler, and Capps (1998), who

correct for selectivity bias, as is necessary when data contain many zero observations.[3]

Unfortunately, like Deaton (1988; 1997), when not using the method of Cox and

Wohlgenant (1986), households are assumed to face the same prices in, say, the same region of

the country. In fact, unit values are explained with only household characteristics by Dong and

Kaiser (2005) as well as by Dong, Shonkwiler, and Capps (1998). As such, all households in

their nationwide samples are implicitly assumed to face the same prices. To identify the system

of equations, using such an approach, ad hoc instruments may also have to be chosen. Dong and

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[2] To emphasize that the measure of prices faced by households in this study, P^*_{imt}, is not the same as P_{imt} in the model of Cox and Wohlgenant (1986), different notation is used.

[3] This study focuses on modeling expenditures on a single commodity. However, methods have also been developed for incorporating unit values in a demand systems framework. For example, Crawford, Laisney, and Preston (2003), present a method that builds on the approach of Deaton (1988, 1997) with an empirical application to Czech data.

Kaiser (2005), for example, drop a proxy for educational status from an equation "only for identification purposes" (p. 694).

However, an appropriate expression for P^*_{imt} has been developed in a separate body of literature. That literature is examined next. Unlike past analyses, data obtained for this study do not require the assumption that households face the same prices; rather, given a theoretical model, these prices can be allowed to vary by community.

3. Community Characteristics and Prices Faced by Households

A theoretical framework for understanding how community characteristics impact food prices has been developed by Hotelling (1929); Capozza and Van Order (1978; 1980); Salop (1979); Salop and Stiglitz (1977); Rath and Zhao (2001); and Puu (2002), among others. More recent empirical studies include MacDonald and Nelson (1991); Frankel and Gould (2001); and Stewart and Davis (2005), among others.[4] In these latter studies, prices are found to vary even between different communities in the same city.

Models of spatial competition assume consumers to be dispersed over a market area that can be represented by a line, circle, or other geometric form. Salop (1979) proposes a circular market. He also assumes the presence of an outside, homogeneous good. In that model, the homogeneous good is supplied by a competitive industry. There are also spatially dispersed firms, who share a common fixed cost, incur a constant marginal cost of production, and sell a second product. The supply of this second good is monopolistically competitive.

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[4] A wealth of empirical research exists on the subject, much of it dating back to the 1960s and 1970s, when researchers became interested in whether low-income households face higher retail prices than other households do. A review of empirical literature is provided by Kaufman et al. (1997).

In the model of Salop (1979), a consumer's costs for purchasing the second good include the retail price as well as his or her costs for "transportation." Transportation costs include a consumer's expenses for traveling to a store. They also include any loss in utility associated with consuming a more readily available good than the consumer's most preferred good. For example, a consumer may prefer chocolate ice cream, but, if vanilla is more available, eat vanilla instead. It is assumed that, only if the total cost of obtaining the second good is below the consumer's reservation cost, will the consumer purchase this good.[5] The consumer will buy only the homogeneous good otherwise. Significant transportation costs can therefore prevent retailers of the second good from concentrating all of their supply in one location. Customers may incur a prohibitively large cost for transportation to this concentrated site.

The variety of goods available in a market may increase with the number of firms. Salop (1979) shows that firms differentiate themselves about the preferences of consumers. For example, in a market with few retailers, only basic items in small package sizes may be available. However, as more firms enter the market, each may try to differentiate itself from the others. A greater variety of foods in a broader range of package sizes may then become available. For example, stores might offer more niche products and invest more heavily in larger, brighter produce aisles, depending on the preferences of consumers in that market.

Prices for the second good may also decrease with the number of firms. Despite efforts to differentiate themselves, Salop (1979) shows that, as the number of firms in a market increases, each firm may still be "closer" to one of its rivals. In other words, consumers may

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[5] In the model of Salop (1979), demand is inelastic, but he claims that his model can be extended to the case of elastic demand. Puu (2002) examines inelastic demand in a linear market, as does Rath and Zhao (2001).

have more and better substitutes for the goods offered by any single firm. In general, the price charged by a firm will move closer to its marginal cost.[6]

The number of firms in a market is determined in advance of prices. In the model of Salop (1979), just enough firms enter a market so that, once prices are later determined, economic profits will be zero.[7] For instance, given a distribution of firms who are poised to make zero economic profits, a decrease in fixed costs or an increase in demand would allow for positive economic profits. New firms will then enter the market, and, in turn, each firm's market share will decrease. Expected profits then fall with market shares. This process will continue until all firms can once again expect to earn only a zero economic profit.

Empirical studies find proxies for demand conditions in a community, a retailer's fixed costs, transportation costs, and marginal costs to explain differences in prices faced by households, although the magnitude of these community effects can also appear individually small. For example, Stewart and Davis (2005) find an increase of $100,000 in the median value of homes to be associated with a $0.01 increase in the cost of a meal at a fast food restaurant. They argue real-estate prices to proxy for a retailer's costs for doing business in a community. Higher costs imply that a community should be served by fewer firms, and therefore be subject to less price and non-price competition. By contrast, in a study of supermarket prices, Frankel and Gould (2001) find retailers to charge less money in communities with a greater proportion households having an income level between one and two times the poverty line. Given a distribution of income in a community, if one percent of these low-middle income households

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[6] A necessary assumption about firm behavior is that each firm chooses a best price, given the perception that all other firms hold their prices constant. For the implications of a wider range of assumptions about firm behavior, see Capozza and Van Order (1978).

[7] Firms in the model of Salop may relocate when new firms enter a market. However, Capozza and Van Order (1980) show that, if existing firms are immobile, the equilibrium condition must be restated. Firms will enter a market if and only if they can expect to make positive economic profits. In other words, entry is sequentially rational.

fall into poverty, the price of food is expected to rise by 0.85%. Likewise, if that same one

percent of households increases their income to above twice the poverty line, food prices are

expected to rise by 0.52%. The reason, Frankel and Gould (2001) argue, is search costs.[8]

Higher and even middle-income households may have a greater opportunity cost of time and

devote less time to searching for the lowest prices, while households living in poverty may be

less likely to have a car.

4. Economic model

A system of equations can now be developed in which unit values depend not only on a

household's own demographic characteristics, but also on the characteristics of its community.

To begin, let the supply of retail food stores in market m at time t be denoted as N_{mt} and all other

factors that influence a consumer's transportation costs be T_{mt}. There is free entry and N_{mt} is

determined such that economic profits are zero. Fixed costs associated with operating a retail

food store in market m are C_{mt}. The aggregate demand of consumers in this same market is D_{mt}.

By Salop (1979), N_{mt} is decreasing in C_{mt} but increasing in D_{mt} and T_{mt}. That is,

$$N_{mt} = N(\overset{-}{C}_{mt}, \overset{+}{D}_{mt}, \overset{+}{T}_{mt}). \qquad (5)$$

Continuing to follow Salop (1979), let prices in market m at time t depend upon the

marginal costs of firms in that market (MC_{mt}) as well as N_{mt} and T_{mt}. Prices faced in market m at

time t are then

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[8] Not in the model of Salop (1979), search costs are considered by Salop and Stiglitz (1977).

$$P_{imt}^{*} = P(\overset{+}{MC}_{mt}, \overset{+}{T}_{mt}, \overset{-}{N}_{mt}). \tag{6}$$

Finally, Salop (1979) shows that (5) can be substituted into (6) to obtain a reduced form equation for prices faced by households in community m at time t:

$$P_{imt}^{*} = P(\overset{+}{MC}_{mt}, \overset{+/-}{T}_{mt}, \overset{+}{C}_{mt}, \overset{-}{D}_{mt}) \tag{7}$$

where N_{mt} is no longer a separate explanatory variable. Households in different communities are hypothesized to face different prices because of spatial variation in a retailer's fixed costs (C_{mt}), marginal costs (MC_{mt}), transportation costs (T_{mt}), and demand conditions (D_{mt}).

In this model, price variation may stem from both differences in the prices of elementary goods and differences in the types of elementary goods available. As already noted a few times, for example, a household in a particular community may pay a higher price per serving of frozen mixed vegetables than households elsewhere pay. Retailers in the household's community may charge more for a standard 16 ounce package or, perhaps, they do not also offer a 32 ounce "economy" package, which retailers elsewhere tend to sell for less money per serving.

Equation (7) shows that prices may depend on community characteristics. Other researchers cited earlier in this study estimate similar equations. Still, (7) does not show how differences in prices across different types of communities affect food expenditures. For this, a linear relationship is assumed between variables in (7) and that equation is further substituted into equations (3) and (4) above. This substitution yields the following pair of equations:

$$Ln(V_{imt}) = \alpha_0 + \alpha_1 \overset{+}{MC}_{mt} + \alpha_2 \overset{+/-}{T}_{mt} + \alpha_3 \overset{+}{C}_{mt} + \alpha_4 \overset{-}{D}_{mt} + \beta X_{it} \tag{8}$$

$$M_{imt} = \theta X_{it} + \theta_{K+1} Ln(V_{imt}) \tag{9}$$

where α_0–α_4 are unknown parameters, which can be simultaneously estimated with θ and θ_{K+1}

5. Data and Empirical model

Members of a panel provide ACNeilsen with information on their household's purchases of food for at-home consumption using scanners installed in their homes. Thus, these data are known as "Homescan." The sample available for this study contains 7,575 households who participated in the ACNeilsen panel for all 12 months of 2003. Thirty-two households did not purchase any vegetables during that year, and are dropped from the analytical sample.[9]

Along with product identifiers, expenditures, and quantities purchased, the data include a household identifier matching transactions with demographic data, such as the household's income. Unique to this set of data are variables further identifying the census tract where households live and the zip code of the stores at which they shop. This information was combined with data on community characteristics from U.S. Census Bureau and the U.S. Department of Agriculture (USDA).

However, it is important to note that members of the Homescan panel own a computer with internet access. While this may not be an obstacle for the "typical" American household, it may be an obstacle for some low-income households. To partly correct for the problem, ACNeilsen provides a sampling weight for matching the income and demographic characteristics of its panel with the characteristics of the population of the United States. That weight corrects for the under representation of low-income households, in general. However, it still cannot be determined whether the panel well represents all types of low-income households. In particular, due to unique circumstances that extend beyond a household's observable income and demographic characteristics, some types of low-income households may be less likely to have a computer than other types of low-income households. These same types may also be highly

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[9] Given that these 32 households account for only a small proportion of the total sample, no attempt is made to correct for zero-censoring.

unlikely to have a car or, perhaps, even a refrigerator. If so, low-income households with limited

mobility and storage capacity may face even higher prices for food than our study suggests.

Expenditures and Prices Paid

As noted above, the data contain a record of each household's purchases of foods for at-home

consumption. However, it is not possible to perfectly identify all purchases.[10] For this study,

purchases of 26 types of vegetable are identified: artichokes, asparagus, avocados, bell peppers,

broccoli, brussel sprouts, cabbage, carrots, cauliflower, celery, corn, cucumbers, eggplant, green

beans, lettuce, mushrooms, onions, peas, potatoes, radishes, spinach, squash, sweet potatoes,

tomatoes, turnips, and zucchini. These vegetables are included in their fresh, frozen, and canned

forms, and account for 93% of all vegetable spending captured by Homescan,[11] on average. To

be sure, spending on vegetables is not defined to include vegetables in a prepared meal, such as

vegetables in a soup, nor highly processed foods that little resemble a vegetable in its fresh form,

such as tatter tots, tomato juice, or ketchup.

Each household's total vegetable expenditures, M_{im}, and unit value, V_{im}, were

calculated.[12] Expenditures are measured as dollars per person.[13] As shown in table 1, in 2003,

households spent $83.06 per capita on vegetables at a unit value of $0.21 per serving, on

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[10] Among vegetables sold without a bar code, ACNeilsen provides a detailed product description for only major items, such as an onion or a tomato. However, when documenting transactions involving a type of vegetable that accounts for a smaller share of a typical store's sales, ACNeilsen provides only the non-specific product description, "other fresh vegetable." Since this descriptor is provided for more than one type of vegetable, such as kale and garlic, we cannot identify the type of vegetable that was sold. We likewise cannot calculate the number of servings bought and, as discussed below, that information is necessary in order to calculate unit values.

[11] For sales of "other fresh vegetables," as explained in footnote 10, the type of vegetable cannot be identified, but expenditures on the vegetable are known.

[12] The t subscript is hereafter suppressed as the analysis considers the purchases of households over the same time period, 2003.

[13] We account for promotional discounts, and subtract the value of any coupons redeemed.

average. To calculate unit values, expenditures were divided by the physical quantity purchased, also converted to a per capita basis.[14]

Household income and demographics

Following past analyses cited earlier in this study, household characteristics, X_i include the per capita annual income of a respondent's household (INCOME), the square of this income (SQINCOME), a binary indicator of whether the household includes an adult who is not employed outside the home for wages on a full-time basis (HOMEMAKER), a binary indicator of whether one or more heads of household have completed college (COLLEGE), and three binary indicators for race and ethnicity (ASIAN, HISPANIC, and BLACK).

The data do not fully identify the ages and gender of all household members. Typically, such information is included in a demand model. Household members of different ages and gender may not contribute equally to food expenditures. To account for this possibility as best as possible, X_i further includes the age of the head(s) of household (AGE) as well as a binary indicator of whether the household contains one or more children (CHILD).

Income is expected to have a positive effect on both unit values and expenditures. Cox and Wohlgenant (1986) show higher income households to purchase a greater quantity and more expensive mix of fresh vegetables, although they spend less money on canned vegetables, controlling for quality-adjusted prices. Blisard, Variyam, and Cromartie (2003) find a positive association between income and vegetable spending. For the expected effects of other

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[14] Physical quantities are based on the *Food Buying Guide for Child Nutrition Programs, 2000*, published by the U.S. Department of Agriculture Food and Nutrition Service (USDA-FNS 2001). For example, according to the Guide, a pound of broccoli florets makes 7.2 cups of vegetable. Cups were then converted into servings, as defined by the Food Guide Pyramid (FGP) at the time the data were collected. By the FGP, a serving requires one cup of raw, leafy vegetables; ½ cup of fresh, canned, or frozen vegetables; or ¼ cup of dried vegetables.

demographic characteristics, the interested reader is directed to Cox and Wohlgenant (1986); Blisard, Variyman, and Cromartie (2003); and Stewart, Blisard, and Jolliffe (2003).

Community Characteristics

To account for aggregate demand, D_m, a gravity-measure of population per square mile, scaled to tens of thousands of people, POP, is included. This variable proxies for the number of potential consumers living around a household. It includes households living as far as fifty miles away from the center of the zip code in which the household resides, but assigns a lower weight to farther away locations (USDA Economic Research Service 2005).

Measures of the income level of a community's residents are further included among the proxies for aggregate demand, D_m. In particular, following Frankel and Gould (2001), these variables are the percentage of all household's living in poverty, POVERTY, as well as the percentage of all households with an income more than twice their poverty line, WEALTHY. These proportions are obtained from the *2000 Census of the Population* and reflect average conditions across the household's three-digit zip code (U.S. Census Bureau 2005).[15]

A measure of real-estate values, HOUSE, accounts for a retailer's fixed costs for doing business in a community, C_m. Specifically, following Stewart and Davis (2005), as reported in the *2000 Census of the Population*, the median value of housing in a household's three-digit zip code, measured in hundreds of thousands of dollars, is identified.

A measure of urbanity is included to proxy for T_m. Residents of more urban areas are hypothesized to have different costs for transportation than people living in more rural locations. Rural areas tend to be geographically larger than urban ones. All else constant, residents of rural

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[15] A three-digit zip code is simply the first three digits of a five-digit zip code. For example, the five-digit zip codes 20901, 20910, and 20902 all belong to the three-digit zip code 209.

areas may travel farther distances than their urban counterparts. However, residents of more

urban areas may be less likely to own a car and, if they do drive, have more difficulty parking or

face more congested roads. URBAN is the percentage of the population in the household's

three-digit zip code living in an urban community, as defined by *2000 Census of the Population*.

Finally, SOUTH, EAST, and WEST control for variation in MC_m. These variables each

equal one for households living in that region, and zero otherwise. For example, it is likely that

wholesale prices for vegetables in the West tend to be different than wholesale prices in the East

or the Mid-West, the control market.

The Model

Appending a stochastic error term and substituting the relevant variables into (8) and (9) yields

the following triangular system that serves as the basis for the econometric analysis:

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\begin{aligned}
Ln(V_{im}) = \ &\alpha_0 + \beta_1 INCOME + \beta_2 SQINCOME + \beta_3 HSS + \beta_4 SQHSS + \beta_5 CHILD + \\
&\beta_6 HOMEMAKER + \beta_7 AGE + \beta_8 COLLEGE + \beta_9 BLACK + \beta_{10} ASIAN + \qquad (10)\\
&\beta_{11} HISPANIC + \alpha_1 HOUSE + \alpha_2 POP + \alpha_3 URBAN + \alpha_4 POVERTY + \\
&\alpha_5 WEALTHY + \alpha_6 EAST + \alpha_7 WEST + \alpha_8 SOUTH + \upsilon_{im}
\end{aligned}
$$

$$
\begin{aligned}
M_{im} = \ &\theta_0 + \theta_1 INCOME + \theta_2 SQINCOME + \theta_3 HSS + \theta_4 SQHSS + \theta_5 CHILD + \\
&\theta_6 HOMEMAKER + \theta_7 AGE + \theta_8 COLLEGE + \theta_9 BLACK + \theta_{10} ASIAN + \qquad (11)\\
&\theta_{11} HISPANIC + \theta_{12} EAST + \theta_{13} WEST + \theta_{14} SOUTH + \theta_{15} Ln(V_{im}) + \eta_{im}
\end{aligned}
$$

where υ_{im} and η_{im} are the aforementioned stochastic error terms.

However, before data are fit to (10) and (11), it must be considered whether $Ln(V_{im})$

could be endogenous in (11). Hausman (1978) demonstrates that, if the error terms in (10) and

(11) are not independent, then performing ordinary least squares (OLS) on each equation will

yield inconsistent estimates of the parameters in (11). Could there be a non-zero covariance

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between υ_{im} and η_{im}? In the spirit of Dhar, Chavas, and Gould (2003), it is noted that these error terms account for the net effect of omitted factors. The components of η_{im} may include any impact on M_{im} of merchandising and discounting strategies, such as temporary price promotions. In order to obtain a food product at an advertised lower unit price, a household might buy a greater quantity of the product and likewise spend more money in total on that particular product. To the extent that such promotional strategies increase (decrease) a household's annual vegetable expenditures, it is reasonable to expect a negative (positive) correlation between $Ln(V_{im})$ and the error term in (11). If so, it is necessary to identify an instrument (or set of instruments) correlated with P_{im}^* but independent of the error term in (11). Hausman (1978) shows two-stage least squares (2SLS) will then provide consistent estimates of the parameters in a triangular system, such as (10) and (11), and a test for simultaneity bias can be further based on a comparison of the 2SLS estimates with those obtained through OLS.

An obvious choice for a set of identifying instruments is HOUSE, POP, URBAN, WEALTHY, POVERTY, EAST, WEST, and SOUTH. On the one hand, in the model of Salop (1979), each is determined in advance of prices at a first stage and then influences prices faced by households in a second stage. Thus, a theoretical motive exists for using these variables. On the other hand, it could be argued that one or more of these instruments is correlated with an omitted variable in (11). For example, URBAN might proxy for the proportion of "urban-type" stores in a community. Compared to stores in rural locations, urban-type stores could be more or less likely to engage in particular types of merchandising. It might therefore be speculated that URBAN is correlated with the type of merchandising, price promotions, and discounting strategies to which a household is exposed.

Another approach is to use an instrument which, like the instruments above, is correlated with P_{im}^*, but which is less likely to have a direct effect on M_{im} (vegetable expenditures). One possibility is the average price for a dozen large, regular, white eggs paid by all Homescan households shopping at supermarkets and grocery stores in household i's three-digit zip code of residence, EGGS.[16] This instrument should be uncorrelated with merchandising practices in the produce departments at stores at which household i shops that can cause errors in expenditures on vegetables, M_{im}. That is, EGGS should have no impact on M_{im} other than through its correlation with P_{im}^* as a general indicator of the price of food in i's community.

Davidson and MacKinnon (1993) propose a version of Hausman's (1978) test that can be applied using either set of instruments. Equation (10) is first fit by OLS. The residuals from this regression are then included among the explanatory variables in (11). Equation (11) is next estimated, also by OLS, and the exogeneity of $Ln(V_{im})$ is tested by the statistical significance of the coefficient on the residuals from the first regression. Davidson and MacKinnon (1993) show that the estimated coefficients on other variables in (11) are the 2SLS coefficients.

To incorporate the aforementioned sampling weight, estimation was conducted by weighted least squares, weighted 2SLS using the approach of Davidson and MacKinnon (1993), and by weighted three-stage least squares (3SLS) with and without iteration.

6. Results

Weighted least squares and weighted 2SLS estimates are reported in table 2. Similar estimates of the parameters in (10) and (11) were obtained using weighted 2SLS and weighted 3SLS (with and without iteration). These latter estimates are available upon request.

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[16] This product was chosen for its ubiquity. That is, it had been purchased by a large number of households. The value of any coupons redeemed by households are not subtracted from prices.

Results support the use of an instrumental variable technique over weighted least squares. Shown in the second set of columns in table 2 are the weighted 2SLS estimates using the identifying instruments HOUSE, POP, URBAN, WEALTHY, POVERTY, EAST, WEST, and SOUTH. The residual associated with (10) is a statistically significant predictor of vegetable expenditures at the 1% level in (11). It is concluded that a non-zero correlation exists between the error terms, υ_{im} and η_{im}. In fact, as shown in the first set of columns, the weighted least squares estimate of the coefficient on $Ln(V_{im})$, $\hat{\theta}_{15} = 28.08$, is statistically significantly smaller than the weighted 2SLS estimate, $\hat{\theta}_{15} = 79.72$. To be sure, this weighted 2SLS estimate differs from the estimate of the same coefficient, when EGGS is used as the identifying instrument, $\hat{\theta}_{15} = 64.59$, as shown in third set of columns. However, a 95-percent confidence interval about this latter estimate of θ_{15} contains 79.72. Results based on instrumental variables appear robust to the choice of identifying instrument(s). The reason may be that F-statistics for the joint significance of only the identifying instrument(s) are large for both specifications, as shown at the bottoms of the second and third sets of columns of table 2. Instrumental variable techniques are most prone to bias when using only weak instruments (e.g., Bound, Jaeger, and Baker 1995).

As to model fit, if HOUSE, POP, URBAN, WEALTHY, POVERTY, EAST, WEST, and SOUTH are used as identifying instruments, R^2 in the equation for $Ln(V_{im})$ is 0.192 and that in the equation for M_{im} is 0.201. A discussion of the results based on this specification follows.

Expenditures are increasing in unit values. If the demand for an elementary good were being modeled, one would conclude only that demand is inelastic. Price increases reduce the quantity demanded by a less than a proportional amount. Expenditures are therefore increasing in price. However, as the demand for a composite commodity is being modeled, the appropriate

interpretation is more complex. A change in unit values may signify changes in both elementary prices and in the mix of elementary goods making up the composite commodity.

Marginal effects are shown in table 3. For income and household demographics, X_i, these effects can be decomposed into their direct impact on expenditures as well as their indirect (quality) impact through the unit value equation. For example, the estimated direct effect on per person vegetable expenditures of a $1000 increase in a household's per capita annual income is

$\dfrac{\partial M_{im}}{\partial INCOME} = \hat{\theta}_1 + 2\hat{\theta}_2 INCOME = \ (0.909 - 2(0.009)(22.078)) = \ \$0.52$, assuming the

household's per capita income to have been at the weighted mean of $22,078. In words, the household spends $0.52 more per person, which is consistent with the composite commodity being a normal good. However, this same household is also expected to buy a more expensive mixture of the composite commodity. The estimated quality effect on expenditures is

$\left(\dfrac{\partial M_{im}}{\partial Ln(V_{im})}\right)\left(\dfrac{\partial Ln(V_{im})}{\partial INCOME}\right) = \hat{\theta}_{15}\left(\hat{\beta}_1 + 2\hat{\beta}_2 INCOME\right) = 79.717(0.0085 - 2(0.00005)(22.078)) =$

$0.51. Of course, the total marginal effect of a variable in X_i is the sum of these direct and quality effects. Thus, an increase of $1,000 in per capita income is associated with spending $1.03 more per person per year on vegetables due to the direct expenditure and indirect quality effects of $0.52 and $0.51, respectively.

By contrast, the determinants of P_{im}^{*} affect expenditures only indirectly through the unit value equation. Households in different types of communities face different prices and, in turn, have different expenditures. For example, if the median value of homes in a community increases by $100,000, all else constant, it is expected that households living in the community

will spend $\left(\dfrac{\partial M_{im}}{\partial Ln(V_{im})}\right)\left(\dfrac{\partial Ln(V_{im})}{\partial HOUSE}\right) = \hat{\theta}_{15}\hat{\alpha}_1 = \ (79.717)(0.0287) = \$2.29$ more per person per

year on vegetables. This may reflect higher prices for the same elementary foods and, perhaps, differences in the variety of foods available too. HOUSE proxies for a retailer's fixed costs for doing business in a community. Salop (1979) predicts that, where such costs are higher, fewer firms can make a normal economic profit. The fewer the number of firms, the less is price and non-price competition among retailers.

The percentage of all households living in poverty also affects expenditures through the unit value variable. For example, given a unit increase in the percentage of all households living in poverty in household i's community, it is expected that i will spend about $1.02 more on vegetables per person per year. Similarly, household i is expected to spend an extra $0.83 for every unit increase in the percentage of all households enjoying an income above twice the poverty line. Both income groups are argued to have higher costs for searching for lower prices, and that leads to higher values of P_{im}^*. As argued by Frankel and Gould (2001), the lowest prices are found where more low-middle income consumers live.

The coefficients on HOUSE, POVERTY, and WEALTHY are individually small in magnitude, as are similarly defined variables in other cited studies, but simulations reveal how their combined effect could feel economically substantial. Shown in table 4 are a household's expected per person annual vegetable expenditures if that household lives in a selected zip code in each of 10 cities across the United States. It can be seen that expenditures range from a low of $72.66 in Waterville, Maine to a high of $96.57 in Manhattan, New York. To simulate these annual expenditures, the model was evaluated with all household demographics held at their weighted sample means. Community characteristics for a randomly selected zip code in each of

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the ten cities were then substituted into the model.[17] The ten cities themselves were chosen by the authors for illustrative purposes. These differences may represent a lot of money for low-income households, especially keeping in mind that these differences are per household member and prices for other foods may also be higher in communities where vegetables tend to be costly. Notably, the Food Stamp Program provides participating households with enough resources to purchase a healthy, nutritious, and palatable diet, but assumes national average prices.

7. Conclusions and Implications

Two strands of literature, distinct yet related, have been united. Bringing together these two strands, it has been demonstrated how a household's cost of food and food expenditures depend not only on the household's characteristics, but also on those of its community. A limitation of some recent studies modeling the demand for a composite commodity has also been overcome. Expenditure and unit value equations are simultaneously estimated, using theoretically-motivated instruments, compared with ad hoc exclusion restrictions made for the purposes of identification.

This study also expands on research into spatial price variation. Past research has not examined the impact of community characteristics on food expenditures. In this study, for example, it is found find that households living in communities with high real estate prices and a large degree of income inequality will tend to face higher prices and spend relatively more money per year on vegetables. While these coefficients are individually small, their combined implications for households may not be. These findings may therefore be most relevant for policymakers concerned with the welfare of low-income households, as food assistance programs assume low-income households to face national average prices.

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[17] For each city, the sampling frame of zip codes included only those in which a member of the ACNeilsen panel resided.

Community effects identified in this study may reflect both differences in elementary prices faced by consumers and differences in the mix of products offered by retailers across communities. In an often used example in this study, it is noted that a household may face higher prices for frozen mixed vegetables because it must pay more money for a standard 16 ounce package than households elsewhere must pay for the same package, on average, or because retailers in its community do not also stock a 32 ounce economy package sell. Future research might therefore seek to disentangle these two components of community effects. Perhaps, one approach would be to use an index measure of quality (e.g., Davis, 1987), a more refined measure of the quality of a composite commodity than unit values, and see how that index varies with community characteristics.

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Table 1. Variable Names, Definitions, and Descriptive Statistics for Sample [a]

Variable Name	Variable Description	Sample Mean	Standard Error
Dependent			
M	Expenditures on 26 major vegetables ($/person)	83.063	1.354
V	Unit value paid for vegetables ($/serving)	0.211	0.002
Independent -- Household Characteristics Potentially Affecting Quality Chosen			
INCOME	Household income ($1,000/person)	22.078	0.343
CHILD	Household with one or more children (0/1)	0.309	0.010
HOMEMAKER	Adult not working full-time outside home (0/1)	0.630	0.009
HSS	Number of people living in the household	2.523	0.031
AGE	Age of head(s) of household	5.117	0.028
COLLEGE	Household with a college-educated adult (0/1)	0.339	0.009
BLACK	Black household (0/1)	0.110	0.006
ASIAN	Asian household (0/1)	0.019	0.002
HISPANIC	Hispanic household (0/1)	0.086	0.006
Independent -- Community Characteristics Potentially Affecting Prices Faced			
HOUSE	Median cost of housing ($100,000)	1.317	0.014
POP	Gravity-weighted population density (10,000 people)	2.045	0.054
URBAN	Percentage of households living in an urban environment	77.415	0.458
POVERTY	Percentage of households living in poverty	12.231	0.104
WEALTHY	Percentage of households with income twice the poverty line	70.393	0.183
WEST	Community in the West (0/1)	0.204	0.008
SOUTH	Community in the South (0/1)	0.358	0.009
EAST	Community in the East (0/1)	0.191	0.007
EGGS	Average price for a dozen large, regular, white eggs	1.217	0.005

[a] Sample means and standard errors have been calculated using a sampling weight provided by ACNeilsen

Table 2. Parameter Estimates and Auxiliary Statistics

| | Weighted Least Squares | | | | Identiyfing Instruments include HOUSE--EAST | | | | Identiyfing Instruments include EGGS | | | |
| | Unit Value | | Expenditures | | Unit Value | | Expenditures | | Unit Value | | Expenditures | |
	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error	Estimate	Std. Error
CONSTANT	-2.596**	0.199	63.15**	12.598	-2.596**	0.199	142.052**	17.259	-1.859**	0.071	117.557**	20.939
INCOME	0.008**	0.0008	1.469**	0.143	0.008**	0.0008	0.909**	0.166	0.01**	0.0008	1.041**	0.186
SQINCOME	-0.00004**	0.00001	-0.012**	0.002	-0.00004**	0.00001	-0.009**	0.002	-0.00006***	0.00001	-0.01**	0.002
CHILD	0.054**	0.015	-2.823	2.662	0.054**	0.015	-5.478*	2.684	0.059**	0.015	-4.644	2.723
HOMEMAKER	-0.039**	0.01	11.741**	1.883	-0.039**	0.01	13.542**	1.897	-0.037**	0.01	12.942**	1.926
HSS	-0.042**	0.012	-20.361**	2.115	-0.042**	0.012	-18.856**	2.121	-0.036**	0.012	-20.128**	2.148
SQHSS	0.002**	0.002	1.733**	0.273	0.002**	0.002	1.698**	0.272	0.001**	0.002	1.789**	0.273
AGE	-0.082**	0.026	21.41**	4.637	-0.082**	0.026	25.688**	4.668	-0.064*	0.026	26.0**	4.709
SQAGE	0.006*	0.002	-1.276**	0.446	0.006*	0.002	-1.574**	0.447	0.004	0.002	-1.649**	0.449
COLLEGE	0.079**	0.01	3.272	1.783	0.079**	0.01	-1.277	1.904	0.087**	0.01	0.686	2.022
BLACK	-0.054**	0.015	-9.005**	2.507	-0.054**	0.015	-6.99**	2.518	-0.05**	0.014	-7.851**	2.541
ASIAN	0.036	0.031	-7.968	5.644	0.036	0.031	-12.519*	5.669	0.009	0.032	-11.419*	5.708
HISPANIC	-0.053**	0.016	-5.672*	2.847	-0.053**	0.016	-4.347	2.845	-0.068**	0.016	-4.952	2.856
HOUSE	0.029**	0.007			0.029**	0.007						
POP	-0.008**	0.002			-0.008**	0.002						
URBAN	0.002**	0.0003			0.002**	0.0003						
POVERTY	0.013**	0.004			0.013**	0.004						
WEALTHY	0.01**	0.002			0.01**	0.002						
WEST	0.102**	0.016			0.102**	0.016						
SOUTH	0.089**	0.012			0.089**	0.012						
EAST	0.163**	0.014			0.163**	0.014						
EGGS									0.268**	0.016		
Ln(V$_{im}$)			28.084**	2.028			79.717**	8.005			64.59**	11.048
Residuals[a]							-55.153**	8.273			-37.874**	11.242
Model R^2	0.192		0.197		0.192		0.201		0.169		0.2	
F-Statistic[b]					64.10				265.35			

[a] Residuals from the unit value equation.   Statistical significance indicates Ln(V$_{im}$) cannot be treated as exogenous in equation for M$_{im}$.
[b] F-Statistics are for the joint significance of only identifying instruments.
** Indicates significance at the 1% level; * Indicates significance at the 5% level.

Table 3. Marginal Effects [a,b]

	Direct Effect [c]	Indirect Effect [d]	Total Marginal Effect [e]
Household characteristics			
INCOME	0.52	0.51	1.03
CHILD	-5.48	4.27	-1.20
HOMEMAKER	13.54	-3.14	10.40
HSS [f]	-10.29	-2.64	-12.93
AGE	9.59	-1.94	7.65
COLLEGE	-1.28	6.29	5.02
BLACK	-6.99	-4.31	-11.30
ASIAN	-12.52	2.84	-9.68
HISPANIC	-4.35	-4.26	-8.61
Community characteristics			
HOUSE		2.29	2.29
POP		-0.63	-0.63
URBAN		0.15	0.15
POVERTY		1.02	1.02
WEALTHY		0.83	0.83
WEST		8.12	8.12
SOUTH		7.12	7.12
EAST		12.96	12.96

Notes:

[a] Evaluated at weighted sample means.

[b] Based on 2SLS estimates using HOUSE, POP, URBAN, WEALTHY, POVERTY, EAST, WEST, and SOUTH as identifying instruments.

[c] Calculated as $\dfrac{\partial M_{im}}{\partial X_i}$ where $\dfrac{\partial Ln(V_{im})}{\partial X_i} = 0$.

[d] Calculated for household characteristics as $\left(\dfrac{\partial M_{im}}{\partial Ln(V_{im})}\right)\left(\dfrac{\partial Ln(V_{im})}{\partial X_i}\right)$. Similarly, for community characteristics, calculated as $\left(\dfrac{\partial M_{im}}{\partial Ln(V_{im})}\right)$ times the derivative of $Ln(V_{im})$ with respect to characteristic.

[e] Estimated as the sum of the indirect and direct effects.

[f] Assumes per capita income to remain constant.

Table 4. Simulated Community Effects, Selected Cities [a]

Characteristics of a selected zip code in:	Simulated Per Capita, Annual Vegetable Expenditures by Households
Charlottesville, VA	$82.92
Cheyenne, WY	$85.60
Iron Mountain, MI	$78.28
Laurel, MD	$91.59
Manhattan, NY	$96.57
Phoenix, AZ	$83.37
San Francisco, CA	$94.04
Vail, CO	$87.28
Washington, DC	$89.42
Waterville, ME	$72.66

[a] Model was evaluated with household income and all other household demographics at their weighted sample means. Community characteristics for a randomly selected zip code in each of the ten cities were then substituted into the model.