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A Demand Systems Analysis of Food Commodities by U.S. Households Segmented by Income

**John L. Park, Rodney B. Holcomb, Kellie Curry Raper,
and Oral Capps, Jr.**

Using the 1987–88 Nationwide Food Consumption Survey, twelve food commodity groups were analyzed according to household poverty status. Parameter estimates were used to obtain subsistence expenditures, own-price elasticities, expenditure elasticities, and income elasticities. Own-price elasticities were similar between the income groups for most commodities. However, income elasticities were consistently higher for the lower-income group. The use of average estimates of price and income elasticities for the population as a whole for the projection of individual commodity demands is not likely to be successful if notable changes are evident in income distribution.

Key words: food demand analysis, Generalized Heckman Procedure, income, poverty status.

At present, greater numbers of households fall into either the “low-income” category or the “high-income” category, resulting in what the media refers to as the “shrinking middle class.” Raunika, Huang, and Purcell point out (p. 43) that “prior to the 1980s, the trend was toward the relative enhancement of lower-income groups via a shift in income to improve their purchasing power... However, this trend was reversed in the 1980s with a shift in the income distribution toward higher-income groups.”

It is possible that lower-income households may respond differently to changes in prices and income than higher-income households. As Pinstrup-Andersen and Caicedo note (p. 414), “the utilization of average estimates of price and income elasticities for the population as a whole for the projection of individual commodity demands is not likely to be very successful

if significant changes occur in income distribution.” Based on the work of Pinstrup-Anderson and Caicedo, we hypothesize that in societies such as the United States, where visible changes have occurred in income distribution, commodity demand projections should be based on individual income strata rather than on average estimates of price and income elasticities. Also, it is reasonable to expect different levels of “subsistence expenditure” for groups segmented by income. This information may be useful to policy analysts, particularly those involved with government food assistance programs; in general these programs have been targeted at low-income groups.

Previous empirical work on groups segmented by income in the extant literature has focused on developing countries and staple foods. Senauer reported that lower-income households are more price and income responsive for the consumption of rice in various developing countries. Timmer found a similar result for the consumption of rice and cassava among lower-income households in Indonesia. In contrast to the United States, households in developing countries can spend 60%–80% of their income on food. Also, 40%–60% of food expenditures can be accounted for by one staple food (Senauer).

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However, there is no reason to believe that previous results for developing countries will hold for developed countries such as the United States. Several studies have examined differences in household behavior for income groups in the United States. Blaylock and Blisard, for example, discovered food spending to be more equally distributed than income, possibly due to subsistence requirements and government efforts to provide an adequate diet. In a study of expenditures on breakfast cereals, Jones, Chern, and Mustiful found lower-income groups to be more responsive to changes in price than higher-income groups. This study, however, was confined to a specific geographic location and commodity group. In addition, data limitations prevented analysis of income responsiveness. In another study, Huang and Raunikaar showed that food away from home was a luxury good for lower-income households and a normal good for higher-income households, but a measurement of price responsiveness was lacking.

In the literature on demand analysis, there exists a myriad of studies which report estimates of own-price and income elasticities for various commodities. However, few studies center attention on the fact that these key parameters may change at different levels of income. Our objective in this paper is to investigate possible differences in own-price elasticities, income elasticities, and subsistence expenditures by level of income. Using the 1987–88 Nationwide Food Consumption Survey (NFCS), we partition the sample into two income classes. Subsequently, using the Linear Expenditure System (LES), we estimate own-price and income elasticities for twelve food commodity groups. The LES was chosen for its incorporation of subsistence consumption; the system also works well for broad commodity groups. Quality-adjusted prices were used in this analysis to provide a fair comparison of two potentially distinct groups (Cox and Wohlgenant). We then compare the corresponding set of demand elasticities between the two groups. Because the results may be beneficial to federal agencies who target principally low-income groups, we provide examples of how to use the elasticity estimates in dealing with food policy issues.

Data

The data set for this analysis is the household portion of the 1987–88 NFCS, targeted at all

private households in the forty-eight contiguous states. The survey was designed to provide a sample of 6,000 households. However, only 4,495 completed acceptable interviews. The data set provided detailed records on the money value, quantity, and type of foods purchased by the household over a one-week period. Our analysis considered only housekeeping households, that is, those households with at least one person having eaten ten or more meals from the household food supply during seven days prior to the interview. Also, some households failed to report income figures, or had nonresponses in other categories. These households were not used for analysis. On net, our sample consists of 4,068 households.

An additional fifty-two households were removed from the sample because they reported annual incomes less than \$1,000, which seemed unreasonable. Finally, only white, black, and Asian/Pacific Islander households were analyzed, providing a total sample of 3,869 households for estimation purposes.

A degree of controversy exists concerning the validity of the 1987–88 NFCS. In particular, the General Accounting Office has criticized these data on the grounds of low response rate and quality control. While it is true that the data may not adequately represent certain groups, the distribution of individuals on the basis of race, urbanization, food stamp participation, and income seems representative of the U.S. population in 1988 (Nayga and Capps).

Twelve aggregate commodity groups were chosen for this analysis: food away from home (FAFH), beef, pork, chicken, fish, cheese, milk, fruits, vegetables, breakfast cereals, bread, and fats and oils. Also, information was collected on various socioeconomic and demographic characteristics of households including income and household size.

Prices were not provided by the NFCS. Therefore, prices were imputed by dividing a group's expenditures by its corresponding quantities. In the case of FAFH, this quantity is an actual number of meals. Thus, the imputed price would represent the price of a meal away from home. Differences in these prices were attributed to quality differences. As Cox and Wohlgenant showed, adjusting prices for quality differences is important. Therefore, prices were subsequently adjusted for quality differences among households by regressing imputed prices on selected sociodemographic characteristics, namely race, region, urbanization, income, and household size, as follows:

$$(1) \quad p_i = b_0 + b_1NE + b_2MW + b_3WEST \\ + b_4CC + b_5SUB + b_6BLACK \\ + b_7ASIAN + b_8INCOME + b_9HSIZE + \varepsilon_i$$

The variables include p_i , the imputed price of the i th commodity group; NE , a binary variable representing a household located in the Northeast; MW , a binary variable representing a household located in the Midwest; $WEST$, a binary variable representing a household located in the West; CC , a binary variable representing a central city household; SUB , a binary variable representing a suburban household; $BLACK$, a binary variable representing a black household; $ASIAN$, a binary variable representing an Asian household; $INCOME$, annual income after taxes; and $HSIZE$, the household size. These variables are common to analyses of expenditure or Engel functions (Blaylock; Capps and Havlicek). One category was omitted from each demographic characteristic to avoid singularity due to the use of binary variables. Thus, reference households correspond to those that reside in the South, live in nonmetropolitan areas, and are white.

Quality-adjusted prices for each commodity were generated by adding $\hat{b}_0$ to the residuals derived from each commodity regression (Cox and Wohlgemant). This procedure is common in the literature to generate quality-adjusted prices. Not all households purchased all commodities during the survey period. When either expenditure or quantity was zero, the quality-adjusted price was equal to $\hat{b}_0$ for that commodity group.¹

The principal goal of this study was to analyze the effects of income level upon household food consumption behavior. To accomplish this goal, the data were partitioned into a low-income group and a high-income group. The basis for this segmentation was the 1987–88 poverty guidelines as developed by the U.S. Department of Health and Human Services (DHHS) (table 1). These poverty guidelines are adapted from poverty thresholds published by the Bureau of Census. They are used by federal

Table 1. 1987–88 Food Program Eligibility Criterion

Household Size (Number of People)	1987–88 Poverty Income Guidelines (\$)	Poverty Status (\$) (130% of Poverty Guidelines)
1	5,360	6,968
2	7,240	9,412
3	9,120	11,856
4	11,000	14,300
5	12,880	16,744
6	14,760	19,188
7	16,640	21,632
8	18,520	24,076
9	20,320	26,416
10	22,120	28,756
11	23,920	31,096
12	25,720	33,436

Source: U.S. Department of Health and Human Services.

agencies to determine whether a person or a family is financially eligible for assistance under a particular governmental program. The fundamental idea of poverty guidelines is to ensure a household can meet its food needs (Senauer, Asp, and Kinsey). The poverty income guidelines have been established for households from one to eight persons. In addition, DHHS calculated poverty-level income for households with more than eight members as the eight-person poverty income plus \$1,800 for each additional person. Several major federal food assistance programs use 130% of the poverty guideline to determine eligibility for benefits.

Partitioning the data in this manner resulted in the creation of a poverty status group that consisted of 782 households with an average annual before-tax income of \$6,850 (table 2), and a nonpoverty status group with 3,087 households with an average annual after-tax income of \$33,244 (table 3). Not only did this partitioning allow for the comparison of parameter estimates between different income levels, but also segmenting the data set in this manner showed that roughly one-fifth of the sample households were eligible for government food aid.

An analysis of the composition of the two groups as exhibited in table 4 revealed some interesting differences. Given this segmentation, 47% of households in the poverty group reside in the South. We also found that 52% of the nonpoverty households were classified as suburban households by the NFCS. Finally, white

¹ As an anonymous reviewer pointed out, Wales and Woodland (p. 449) state that "although intuitively appealing and possibly useful for prediction purposes, this approach does not generally provide consistent estimates of parameters of the model due to sample selectivity and simultaneity problems." Even though we could apply the Heckman technique to overcome the sample selectivity problem to obtain consistent estimates of the parameters in equation (1), it appears impossible to derive consistent estimates of these parameters independently from those of equation (2) to be discussed later. Consequently, we use the traditional procedure to generate quality-adjusted prices.

households accounted for 91% of the nonpoverty group, while black households accounted for 27% of the poverty group. Not surprisingly, mean expenditures on FAFH are notably higher for the nonpoverty group. Furthermore, looking at data densities, we see that 87% of nonpoverty households purchased FAFH, compared to only 60% of poverty households. In general, data densities were higher for the nonpoverty group.

The generation of quality-adjusted prices admits the possibility that some of the prices may be negative. This situation suggests that, after accounting for quality differences, one would have to pay a particular household to consume the good in question. Thirty-one households in

the lower-income group had a negative quality-adjusted price for at least one commodity, corresponding to 4% of this sample. Sixteen households in the higher-income group had a negative quality-adjusted price for at least one commodity, corresponding to less than 1% of this sample. Negative quality-adjusted prices are sensible within the framework of this analysis. But, to determine to what extent the negative prices influence the parameter estimates, the LES was estimated with and without these prices. Because virtually no differences in parameter estimates were evident, the empirical results reported correspond to those derived by including negative quality-adjusted prices.

Table 2. Descriptive Statistics for Poverty Status Households ($n = 782$)

Variable	Mean	Standard Deviation	Data Density ^a	Minimum	Maximum
Expenditures					
FAFH	12.1520	22.1430	0.6010	0	249
Beef	5.3299	6.0227	0.8031	0	62
Pork	3.2852	4.6263	0.6253	0	34
Chicken	2.0780	2.4667	0.6599	0	19
Fish	2.0000	4.7149	0.4604	0	64
Cheese	1.7046	2.2808	0.6304	0	15
Milk	2.9041	3.1145	0.8619	0	29
Fruits	2.0908	2.4993	0.6701	0	19
Vegetables	2.3798	2.6075	0.7519	0	22
Breakfast cereals	1.7826	2.2286	0.6535	0	17
Bread	1.3824	1.3954	0.7685	0	10
Fats and oils	1.3478	1.4541	0.6905	0	9
Quality-Adjusted Prices					
FAFH	3.9574	3.1314	—	-1.7818 ^b	37.5490
Beef	1.5261	0.5361	—	0.4175	4.9332
Pork	1.7028	0.4699	—	0.4016	4.0394
Chicken	1.0321	0.5312	—	0.0380	4.8640
Fish	2.4785	0.7097	—	-0.3469 ^c	9.2928
Cheese	1.7182	0.5361	—	0.3716	5.0175
Milk	0.3581	0.1666	—	0.1109	3.0077
Fruits	0.5831	0.2135	—	0.1121	1.9804
Vegetables	0.7226	0.2217	—	0.1600	2.0649
Breakfast cereals	1.5740	0.5124	—	-0.4031 ^d	4.6309
Bread	0.9245	0.2739	—	0.2683	2.9350
Fats and oils	1.0283	0.3551	—	0.2922	3.1271
Socioeconomic Variables					
Income	6,850	3,570	—	1,052	29,200
Household size	2.5716	1.6286	—	1	12

^a Data Density is defined as ratio of nonzero expenditures to total observations.

^b 29 households had a negative quality-adjusted price.

^c 1 household had a negative quality-adjusted price.

^d 1 household had a negative quality-adjusted price.

Procedure

Because some households chose not to consume some commodity groups, the dependent variable could have a zero value for some observations. These nonpurchases could be due to household inventory or nonpreference. The possibility of the former becomes a reality the shorter the survey period—in this case, one week. Although the relatively broad aggregation of commodities combats this problem to a degree, we still encounter zero expenditures. Numerous studies have addressed the econometric implications of this zero-expenditure

problem. Estimation techniques which fail to take into account the censoring of the dependent variables give rise to biased parameter estimates. This analysis employs a generalization of the Heckman procedure as described by Heien and Wessells and Heien and Durham to account for zero expenditures. They utilize a two-step estimation procedure that is computationally simple and provides consistent and asymptotically efficient parameter estimates.

First, from a probit regression, we determine the probability that a given household would purchase the good in question. From this information we compute the inverse Mills ratio

Table 3. Descriptive Statistics for Nonpoverty Status Households ($n = 3,087$)

Variable	Mean	Standard Deviation	Data Density ^a	Minimum	Maximum
Expenditures					
FAFH	31.187	35.021	0.8685	0	350
Beef	6.6064	7.1407	0.8377	0	92
Pork	3.7127	4.8327	0.6809	0	53
Chicken	2.4833	3.7148	0.6408	0	100
Fish	2.9281	5.8710	0.5319	0	70
Cheese	2.3000	2.4594	0.7732	0	27
Milk	3.3625	3.2625	0.9174	0	38
Fruits	3.2773	3.8134	0.7982	0	57
Vegetables	3.5274	3.4760	0.8452	0	31
Breakfast cereals	2.0842	2.3890	0.7169	0	23
Bread	1.6420	1.4559	0.8367	0	14
Fats and oils	1.6252	1.5914	0.7658	0	19
Quality-Adjusted Prices					
FAFH	6.4277	4.1371	—	-0.3206 ^b	65.6210
Beef	1.7995	0.7432	—	-0.6702 ^c	9.7177
Pork	1.7790	0.6324	—	0.2409	7.6352
Chicken	1.2452	0.6953	—	-0.2250 ^d	7.7679
Fish	2.5834	1.0661	—	-1.1028 ^e	16.5140
Cheese	1.6784	0.6912	—	0.0926	6.7734
Milk	0.3489	0.1344	—	0.1063	2.0127
Fruits	0.5679	0.2564	—	0.0150	4.3128
Vegetables	0.7090	0.2339	—	0.1105	2.5314
Breakfast cereals	1.5912	0.5398	—	0.0364	4.6593
Bread	0.9368	0.3078	—	0.0570	3.2222
Fats and oils	1.0475	0.3932	—	-0.1170 ^f	4.7877
Socioeconomic Variables					
Income	33,244	23,815	—	6,996	330,300
Household size	2.7347	1.3434	—	1	9

^a Data Density is defined as the ratio of nonzero expenditures to total observations.

^b 1 household had a negative quality-adjusted price.

^c 3 households had a negative quality-adjusted price.

^d 5 households had a negative quality-adjusted price.

^e 9 households had a negative quality-adjusted price.

^f 1 household had a negative quality-adjusted price.

Table 4. Percentage of Households in Each Demographic Category

Category	Poverty Status Group	Nonpoverty Status Group
Region		
Northeast	16	22
Midwest	22	27
West	15	19
South	47	32
Urbanization		
Central City	30	21
Suburban	31	52
Non-Metropolitan	39	27
Race		
Black	27	8
Asian	1	1
White	72	91

(MR_{hi}) for the h th household for the i th commodity. All available observations are used for the probit analysis, where the dependent variable equals one if the expenditure is nonzero, and zero otherwise (denoted by Z_{hi}). Saha, Capps, and Byrne mathematically characterized the process. Denoting the normal cumulative density function by Φ , they show that

$$(2) \quad \begin{aligned} \text{pr}[Z_{hi} = 1] &= \Phi(\mathbf{W}_h \boldsymbol{\delta}_i), \\ \text{pr}[Z_{hi} = 0] &= 1 - \Phi(\mathbf{W}_h \boldsymbol{\delta}_i) \\ i &= 1, \dots, n; h = 1, \dots, H \end{aligned}$$

where $\mathbf{W}_h$ is a vector of regressors related to the purchase decision, and $\boldsymbol{\delta}_i$ is the coefficient vector associated with these regressors. The first-stage provides estimates of MR_{hi} as follows:

$$(3) \quad \hat{MR}_{hi} = \begin{cases} \frac{\phi(\mathbf{W}_h \hat{\boldsymbol{\delta}}_i)}{\Phi(\mathbf{W}_h \hat{\boldsymbol{\delta}}_i)} & \text{for } Z_{hi} = 1 \\ \frac{\phi(\mathbf{W}_h \hat{\boldsymbol{\delta}}_i)}{1 - \Phi(\mathbf{W}_h \hat{\boldsymbol{\delta}}_i)} & \text{for } Z_{hi} = 0 \end{cases}$$

where ϕ represents the probability distribution function. In the second stage, the inverse Mills ratio is used as an instrument that incorporates the censoring latent variable in estimation of an LES. All H observations are used for the second-stage estimation.

Given that the commodities considered are broad food group classifications, the LES was used to obtain parameter estimates (Phlips). A separate demand system was estimated for each group. Each equation within the LES was augmented with the inverse Mills ratio to account for any bias resulting from zero values in the dependent variable. The demand functions derived from this specification are written as

$$(4) \quad p_{ih}q_{ih} = p_{ih}\gamma_i + \beta_i(Y_h - \sum_j p_{jh}\gamma_j) + \alpha_i(MR_{hi}) + v_i$$

where $p_{ih}q_{ih}$ is the expenditure on the i th commodity group by the h th household; p_{ih} is the quality-adjusted price of the i th commodity group for the h th household; γ_i is the subsistence quantity of the i th commodity group; $p_{ih}\gamma_i$ is the subsistence expenditure level on the i th commodity group for the h th household; Y_h is the total weekly food expenditures on all commodity groups; $Y_h - \sum_j p_{jh}\gamma_j$ is the supernumerary income, or budget remaining after subsistence expenditures for the h th household; β_i is the marginal share of supernumerary income for the i th commodity group; and MR_{hi} is the Inverse Mills Ratio for the i th commodity group and for the h th household.

The equation for fats and oils was omitted from system estimation to avoid singularity of the variance-covariance matrix of the disturbance terms. Because the LES is derived from a direct utility function, homogeneity and symmetry will hold at every point and need not be imposed (Phlips).

Empirical Results

Parameter estimates were obtained for each group using a nonlinear maximum likelihood estimation routine (tables 5 and 6). The only insignificant estimates (at the 5% level) were selected parameters associated with the inverse Mills ratio (except for the estimate of γ for FAFH in the poverty status group). In each of the respective groups, in accordance with theory, all γ 's were positive, and all β 's were positive and between zero and one. The subsistence consumption (γ) of cheese exceeded the mean consumption of cheese in the poverty status group, the only theoretical violation in both estimations.

The β parameters in the LES correspond to marginal budget shares, the fraction of an additional dollar of supernumerary total expenditure

Table 5. Parameter Estimates for Poverty Status Households

Commodity Groups	Parameter Estimates			
	γ_i	β_i	α_i	R ²
Food away from home	0.4562 (1.67)	0.5534 (36.44)	0.7073 (3.67)	0.7000
Beef	2.1405 (13.00)	0.0990 (16.13)	0.0844 (0.60)	0.3373
Pork	1.0590 (8.19)	0.0649 (13.03)	0.2494 (1.48)	0.2030
Chicken	1.6245 (15.26)	0.0304 (10.89)	-0.5580 (-4.97)	0.2777
Fish	0.3251 (2.92)	0.0378 (6.19)	0.9387 (3.90)	0.1211
Cheese	1.0083 (13.77)	0.0254 (10.24)	-0.8034 (-5.72)	0.3054
Milk	4.0201 (10.59)	0.0500 (13.98)	0.2169 (1.99)	0.1417
Fruits	2.4318 (10.28)	0.0307 (10.60)	-0.3181 (-2.13)	0.1141
Vegetables	2.3187 (13.11)	0.0371 (13.36)	-0.3662 (-3.30)	0.1955
Breakfast cereals	1.0383 (14.39)	0.0274 (11.59)	-0.7247 (-5.75)	0.3091
Bread	1.2077 (16.72)	0.0186 (12.83)	-0.3432 (-4.35)	0.2782
Fats and oils	0.2868 (2.07)	0.0253 (12.28)	—	—

Note: t-ratios are in parentheses.

Table 6. Parameter Estimates for Nonpoverty Status Households

Commodity Groups	Parameter Estimates			
	γ_i	β_i	α_i	R ²
Food away from home	0.6377 (3.42)	0.6863 (96.14)	0.3166 (4.69)	0.7717
Beef	2.2028 (28.38)	0.0634 (25.69)	0.0179 (0.26)	0.2117
Pork	1.2007 (19.54)	0.0350 (20.27)	0.1215 (1.41)	0.1018
Chicken	1.3360 (21.22)	0.0232 (17.16)	-0.1661 (-1.82)	0.1505
Fish	0.4869 (8.53)	0.0335 (15.28)	0.7900 (6.28)	0.1168
Cheese	1.0566 (34.80)	0.0187 (22.87)	-0.5290 (-9.55)	0.2716
Milk	5.2547 (25.85)	0.0322 (25.80)	0.0002 (0.003)	0.1244
Fruits	2.8520 (20.73)	0.0350 (25.29)	-0.0279 (-0.45)	0.1139
Vegetables	2.8155 (24.29)	0.0330 (26.23)	-0.0438 (-0.72)	0.1147
Breakfast cereals	1.1869 (32.24)	0.0152 (18.35)	-0.8018 (-12.52)	0.2656
Bread	1.4718 (41.21)	0.0097 (18.44)	-0.4612 (-11.52)	0.2361
Fats and oils	0.6615 (9.71)	0.0148 (19.23)	—	—

Note: t-ratios are in parentheses.

spent on a particular commodity. The γ parameters correspond to subsistence quantities. Using likelihood ratio tests, the estimates of both the marginal budget shares and the subsistence quantities differ significantly between the below-poverty and above-poverty income groups.

A full report of own-price and cross-price elasticities is available upon request. Uncompensated own-price elasticities are presented in tables 7 and 8. All estimated own-price elasticities are less than zero. A comparison of the own-price elasticities shows small differences

for chicken, cheese, fruits, vegetables, and fats and oils. Expenditure elasticities also are presented in tables 7 and 8. Our results for price elasticities for breakfast cereals are not in accord with those of Jones, Chern, and Mustiful. The estimated expenditure elasticities range between zero and one, with the exception of the elasticity for FAFH. The expenditure elasticity for FAFH is greater than one for both groups.

Income elasticities, not expenditure elasticities, are at the heart of policy decisions. However, income elasticities are not directly ob-

Table 7. Elasticities for Poverty Status Households

Commodity Groups	Elasticities		
	Own-Price ^a	Total Food Expenditure ^b	Income
Food away from home	-0.9336	1.7432	1.1223
Beef	-0.4478	0.7112	0.4578
Pork	-0.4867	0.7563	0.4869
Chicken	-0.2177	0.5596	0.3603
Fish	-0.6124	0.7237	0.4659
Cheese	-0.0094	0.5696	0.3667
Milk	-0.5291	0.6597	0.4247
Fruits	-0.3426	0.5615	0.3615
Vegetables	-0.3220	0.5963	0.3839
Breakfast cereals	-0.1084	0.5890	0.3792
Bread	-0.2074	0.5161	0.3323
Fats and oils	-0.7867	0.7197	0.4633

Note: All respective elasticities are calculated using the sample means of the data. Mean quantities were obtained by dividing mean expenditure by mean quality-adjusted price.

^a Uncompensated own-price elasticities calculated as $[\gamma(1 - \beta)/q] - 1$.

^b Total food expenditure elasticities calculated as $(\beta * Y)/(p * q)$.

Table 8. Elasticities for Nonpoverty Status Households

Commodity Groups	Elasticities		
	Own-Price ^a	Total Food Expenditure ^b	Income
Food away from home	-0.9588	1.4246	0.6092
Beef	-0.4380	0.6213	0.2657
Pork	-0.4448	0.6102	0.2609
Chicken	-0.3456	0.6041	0.2583
Fish	-0.5848	0.7407	0.3167
Cheese	-0.2434	0.5255	0.2247
Milk	-0.4723	0.6197	0.2650
Fruits	-0.5231	0.6911	0.2955
Vegetables	-0.4528	0.6064	0.2593
Breakfast cereals	-0.1077	0.4729	0.2022
Bread	-0.1685	0.3832	0.1639
Fats and oils	-0.5800	0.5883	0.2515

Note: All respective elasticities are calculated using the sample means of the data. Mean quantities were obtained by dividing mean expenditure by mean quality-adjusted price.

^a Uncompensated own-price elasticities calculated as $[\gamma(1 - \beta)/q] - 1$.

^b Total food expenditure elasticities calculated as $(\beta * Y)/(p * q)$.

tained from the LES. They are retrieved through the use of an auxiliary linear regression of total expenditure on income (Hymans and Shapiro; Manser; Capps, Tedford, and Havlicek). The income elasticity for total expenditure calculated from this auxiliary regression can then be used to calculate an income elasticity as follows:

$$(5) \quad e_{I,i} = e_{Y,i} e_{Y,I}$$

where $e_{I,i}$ = income elasticity for consumption for the i th commodity; $e_{Y,i}$ = expenditure elasticity for consumption for the i th commodity; and $e_{Y,I}$ = income elasticity for total expenditure on all commodities.

The aforementioned auxiliary regression was obtained for each income group. From these regressions income elasticities for total expenditure were calculated at the means of the data. For the lower-income group this value was 0.6438, and for the higher-income group this value was 0.4276. As expected, these values are less than one with the result that the calculated income elasticities are less than their corresponding expenditure elasticities.

Income elasticities (tables 7 and 8) are consistently higher for the poverty status group. Values range from zero to one, with the exception of the income elasticity of FAFH, which is greater than one for the poverty status group. FAFH for the poverty status group is a luxury good, but FAFH is a normal good for the nonpoverty status group. This result is in accord with previous work by Huang and Raunikaar. Overall, the poverty status group was more responsive to changes in income than the nonpoverty group.

A useful feature of the LES is the estimation of subsistence quantities. Using these estimates and mean imputed prices, weekly and annual subsistence expenditures for the commodities were obtained (table 9). Total weekly subsistence expenditures are \$24.30 and \$18.68 for the nonpoverty group and the poverty group, respectively. The bulk of the difference is due to higher expenditures on FAFH by nonpoverty households. Commodity group subsistence expenditures, in general, are higher for nonpoverty households than for poverty households. An exception is subsistence expenditure on chicken, which is higher for households in the poverty group. Annual subsistence expenditures for the commodity groups totalled \$971.36 for poverty status households, accounting for approximately 14% of their annual before-tax income. The percentage was

Table 9. Subsistence Expenditures by Commodity Group

Commodity Groups	Mean Weekly Subsistence Expenditures (\$)	
	Poverty Status Households	Nonpoverty Status Households
Food away from home	1.81	4.10
Beef	3.27	3.96
Pork	1.80	2.14
Chicken	1.68	1.66
Fish	0.81	1.26
Cheese	1.73	1.77
Milk	1.44	1.83
Fruits	1.42	1.62
Vegetables	1.68	2.00
Breakfast cereals	1.63	1.89
Bread	1.12	1.38
Fats and oils	0.29	0.69
Weekly total	18.68	24.30
Annual total	971.36	1,263.60

substantially less for nonpoverty households with expenditures of \$1,263.60, representing only 4% of annual before-tax income.

Policy Implications

The previously discussed results may be used in making food policy decisions. To illustrate, Pinstrup-Andersen, de Londoño, and Hoover estimated a matrix of demand elasticities of twenty-two food commodities in Cali, Colombia, for five income strata. On the basis of their estimates, changes in nutritional levels (measured in calories and protein) of different population income strata could be examined from shifts in individual food commodity supplies. Similarly, we could use the methodology described by Pinstrup-Andersen, de Londoño, and Hoover to estimate changes in levels of key nutrients such as iron, calcium, and calories, particularly for the poverty-status group.

Alternatively, for any commodity, q_i , given estimates of own-price, cross-price, and income elasticities, we may write

$$(6) \quad \% \Delta q_i = \sum_{j=1}^n \epsilon_{ij} \% \Delta p_j + \eta_i \% \Delta y$$

($i, j = 1, 2, \dots, n$)

where ε_{ij} represents the various price elasticity estimates, and η_i represents the estimate of the income elasticity for commodity i . Thus, given percentage changes in the prices of the various commodities as well as the percentage change in income, we may calculate the percentage change in quantity demanded for any commodity i . If we let $\% \Delta q_i = k$ and rewrite $\% \Delta q_i$ as $[q_i^F - q_i^0]/q_i^0 = k/100$, where q_i^F (q_i^0) is the new (initial) equilibrium level of quantity demanded after (before) the change in prices and income, then we can ascertain the impact of changes in prices and income on levels of nutrient elements. If we let μ_i represent the nutrient content per unit of commodity i , then this impact is given as

$$(7) \quad \mu_i(q_i^F - q_i^0) = \frac{\mu_i q_i^0 k}{100}.$$

Estimates of μ_i for selected commodities are available from the USDA via the nutrient data bank (Life Sciences Research Office). With this framework, one is then in the position of ascertaining the relative nutritional impacts of alternative food, agricultural, and/or macroeconomic policies for low-income groups.

Finally, one could use these empirical results to estimate the minimum percentage change in income of the poverty status group to effectively eliminate particular nutritional deficiencies, conditional on various levels of percentage changes in prices. In the simplest case, if it is assumed that $\% \Delta p_j = 0$ for all j , then $\% \Delta q_i = \eta_i \cdot \% \Delta y$. Further, if $\mu_i(q_i^F - q_i^0) = \tau_i$ represents the recommended nutrient level (which may be similar to a RDA), then using equation (7) we have

$$(8) \quad \eta_i \% \Delta y = \frac{\tau_i}{\mu_i q_i^0}.$$

Therefore, $\% \Delta y = \tau_i / [\mu_i \cdot q_i^0 \cdot \eta_i]$. Hence, these empirical estimates could be used to design policies with the goal of improving human nutrition.

Concluding Remarks

Twelve food commodity groups were analyzed according to household poverty status. A Heckman two-step procedure for a system of equations was employed to account for bias introduced from nonexpenditure on given com-

modities by a household. The second step of the estimation involved the use of the Linear Expenditure System. Parameter estimates were used to obtain subsistence expenditures, own-price elasticities, expenditure elasticities, and income elasticities.

The results indicate that if the emphasis of policy analysis is centered on poverty status households then analysts should employ demand parameter estimates using observations indigenous to this income group, and not average estimates for the population as a whole. This analysis could be enhanced through a further partitioning of income groups, the use of adult equivalency scales in lieu of household size, or the use of particular sociodemographic variates.

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