RESEARCH PAPER 1998-5

INCORPORATING NUTRIENTS IN FOOD DEMAND ANALYSIS

by

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Abstract

This study explored the roles of nutrients in the demand for food through utility theory. The findings support the argument that nutrients play important roles in the demand for food. The 1987-88 Nationwide Food Consumption Survey data were used. The impacts of six nutrients (carbohydrates, fats, vitamins, minerals, digestible fibers, and proteins) on the demand for five food groups (dairy, meats, vegetables and fruits, grain products, and other foods) were studied using the Rotterdam demand system.

Key words: Rotterdam demand system, food, nutrients

Incorporating Nutrients in Food Demand Analysis

A number of studies have incorporated nutritional factors into food demand analyses. For example, Brown and Schrader, and Capps and Schmitz used a cholesterol information index as an explanatory variable in their demand equations; Adrian and Daniel, Devaney and Fraker, and Basiotis et al. considered nutrient intake levels as functions of income and sociodemographic variables; and Gould et al., Pitt, and Sahn added nutrient variables directly to their demand models. The modeling approaches of these studies have been ad hoc in that they have not provided a framework about how nutrients can be incorporated in demand analysis using utility theory.

Huang explored how prices and income influenced the demand for nutrients using Lancaster's consumer technology approach. In this study, price and income elasticities for individual purchased foods were used to derive price and income elasticities for nutrients using disappearance data complied by the U.S. Department of Agriculture. A similar approach was taken in a recent study by Huang and Lin in applying the almost ideal demand system to the 1987-88 Nationwide Food Consumption Survey (NFCS) data. In this study, the income elasticity of average price was used to adjust for food quality.

Public health and commodity group campaigns in the United States try to change consumers' diet patterns toward balance and healthy ones. For example, the Dietary Guidelines for Americans advise consumers to choose a diet low in fat (USDA and DHHS, 1995); the California Department of Health Services' five-a-day for better health campaign advises consumers to consume five to nine servings of colorful fruit and vegetables a day; the U.S. Department of Agriculture's Food Guide Pyramid advises consumers how to make the best food choices; and the American Dairy Association's 3-a-day campaign provides guidelines for strong bones. By conveying the nutritional importance of different food items, these campaigns help determine consumers' knowledge about nutrient contents in different food items and may play an important role in the food items purchased and consumed. The information from these campaigns and other sources has likely made nutrient contents important factors in consumers' choices of food items.

The approach used in the current study differs from that taken in the Huang and the Huang and Lin studies. Instead of assuming that prices and income directly influence the demand for nutrients, we assume that the knowledge of nutritional contents in different food groups has impacts on consumers' choices of food they purchased and consumed. For example, if a consumer is looking for low-fat meat product, a package of ground beef labeled 90% fat-free would be more attractive than a package labeled 70% fat-free and the differences in fat contents would influence the quantity and the choice of meat product this consumer purchases. Based on the utility theory, we derive below an extended Rotterdam demand system, which is then used to explain how nutrients affect the demand for food. The objectives of this study are (1) to investigate whether nutrient contents affect the demand for food and (2) if they do, in what fashion.

Model Specifications

In this study, we assume that households' food demand is influenced by three groups of variables: prices and income; the nutritional quality of the food consumed; and household characteristics, such as demographics and household composition. In the following discussion, we will present a way to incorporate the nutritional quality variables in the demand analysis. Household characteristics variables can be incorporated into the demand model using the same method.

Fisher and Shell's simple repackaging model assumes quality change occurs in one good only, say good 1. Higher quality gives higher utility and they introduced the quality parameter θ directly into the utility function, u, as

$$u = u(q_1, q_2, \ldots, q_n, \theta)$$

where θ is a measure of the specifications of good 1 and q_i is the quantity of good *i* consumed.

Using the scaling method Fisher and Shell obtain the following cost and demand functions, respectively,

Cost Function: $x = c(u, p_1, p_2, \ldots, p_n, \theta) = c(u, p_1/\theta, p_2, \ldots, p_n)$

Demand Function $q_1 = (1/\theta)g_1(m, p_1/\theta, p_2, \ldots, p_n)$ and

$q_i = g_1(m, p_1/\theta, p_2, \ldots, p_n)$ for $i \neq 1$;

where x and p_i represent income and the price for good i, respectively.

The above specification is similar to the model of equivalence scales proposed by Barten (1964), i.e.,Utility Function: $u = u(q_1/\theta_1, q_2/\theta_2, \ldots, q_n/\theta_n)$ and

Cost Function: $x = c(u, p_1\theta_1, p_2\theta_2, \ldots, p_n\theta_n)$,

where θ_is are functions of household composition.

In the present s study, nutrient contents are assumed to reflect food quality and the scaling relationship between quantity and quality variables used Barten's model is relaxed. Under these assumptions, the consumer choice problem, maximization of utility subject to the consumer's budget constraint, can be written as

(1) maximize $u = u(q_1, \ldots, q_n, a_{11}, \ldots, a_{1\kappa}, \ldots, a_{n1}, \ldots, a_{n\kappa})$

subject to $\Sigma\, p_i\, q_i = x$

where u is utility; q_i, p_i, and a_{ik} are quantity, price, and the kth nutrient level for food i, respectively; and x is total expenditure or income. Problem (1) is the usual consumer choice problem with the addition of nutrients, which are allowed to affect utility and, in turn, the bundle of goods chosen. That is, this specification assumes that the consumer's utility generated from food is not only a function of the quantities consumed but also a function of levels of nutrients embodied in the food items he/she consumed. For example, a factor influencing the consumption of meat may be the product's protein level. In describing the models here, $a_i = (a_{i1}, . ., a_{i\kappa})$, is treated as a vector of measures of different nutrients in food i. To simplify the notation, it is assumed that the number of nutrients in each food group is the same. In reality, however, due to the richness of different nutrients in each food group, the number of nutrients for each food group in (1) need not to be identical.

The demand equations satisfying (1) have the general form

(2) $$q_i = q_i\,(p_1, . . ., p_n, a_{11}, . . , a_{1\kappa}, . . , a_{n1}, . . , a_{n\kappa}, x)$$

indicating demand for a particular food item by a utility-maximizing consumer depends on the prices for all food items, the nutritional levels in different food items, and total food expenditure.[1]

A basic property of demand systems with factors such as nutrients is that any demand increase(s) for a product(s) as a result of a change in the factor must be offset by demand decreases for other products as total consumer expenditures are constant. In the present case, this property can be written as the differentiation of the budget constraint with respect to a_{jk}, nutrient k in food j, i.e.,

(3) $$\Sigma_i \, p_i \, (\partial q_i/\partial a_{jk}) = 0, \text{ or}$$

$$\Sigma_i \, w_i \, (\partial \log q_i/\partial \log a_{jk}) = 0,$$

where $w_i = p_i q_i/x$, the budget share for food item *i*; and $\partial \log q_i/\partial \log a_{jk}$ is the elasticity of demand for good *i* with respect to nutrient *k* in food item *j*. The elasticity version of (3) shows that the weighted sum of nutrient elasticities (with respect to nutrient for a specific product) is zero where the weights are the product budget shares.

The effect of a nutrient can also be related to the substitution effects generated by price changes (Tintner; Ichimura; Barten, 1977; Phlips), i.e.,

(4) $$\partial q_i/\partial a_{jk} = -(1/\lambda) \, \Sigma_h \, s_{ih} \, \upsilon_{hjk},$$

where $\lambda = \partial u/\partial x$, the marginal utility of income;

$$s_{ih} = (\partial q_i/\partial p_h) + q_h \, (\partial q_i/\partial x),$$

the Slutsky substitution effect or demand price slope with utility held constant; and

$$\upsilon_{hjk} = \partial(\partial u/\partial q_h)/\partial a_{jk} \, ,$$

the effect of the nutrient on marginal utility.

In terms of elastcities, relationship (4) can be written as

(5) $$(p_i q_i/x)(\partial q_i/\partial a_{jk})(a_{jk}/q_i) = - \, \Sigma_h \, (p_i p_h/x) s_{ih} \, [\partial(\partial u/\partial q_h)/\partial a_{jk}](a_{jk}/(\lambda p_h)), \text{ or}$$

$$\beta_{ijk} = w_i(\partial \log q_j/\partial \log a_{jk}) = - \, \Sigma_h \, \pi_{ih} \, \gamma_{hjk},$$

where

$$\pi_{ih} = (p_i p_h/x) s_{ih},$$

the Slutsky coefficient of the Rotterdam model, and

$$\gamma_{hjk} = \partial[\log \, (\partial u/\partial q_h)]/\partial \log a_{jk}.$$

The term γ_{hjk} represents the elasticity of marginal utility of food *h* with respect to nutrient *k* in food *j*.

Under the block-independence assumption of the food group, the unrestricted levels version of the Rotterdam model for the food group associated with (2) can be written as (Barten, 1989; Theil, 1980)

$$w_i \log q_i = \alpha_i + \theta_i \log Q + \Sigma_j \pi_{ij} \log p_j + \Sigma_l \Sigma_k \beta_{ilk} \log a_{lk} \tag{6}$$

$$= \alpha_i + \theta_i \log Q + \Sigma_j \pi_{ij} (\log p_j - \Sigma_l \Sigma_k \gamma_{jlk} \log a_{lk}),$$

where $\theta_i = w_i (\partial \log q_i/\partial \log x) = p_i(\partial q_i/\partial x)$, the marginal propensity to consume; and $\log Q = \Sigma_j w_j \log q_j$, the Divisia volume index.

The regular demand restrictions are

$\sum_i \pi_{ij} = 0$, $\sum_i \theta_i = 0$, and $\sum_i \alpha_i = 0$	adding-up,
$\sum_j \pi_{ij} = 0$	homogeneity, and
$\pi_{ij} = \pi_{ji}$	symmetry.

As an approximation, the θ_is, π_{ij}s, and β_{ijk}s (or γ_{ijk}s) are treated as constants to be estimated. The interpretation of β_{ijk} is straightforward. If β_{ijk} is greater than zero, then there is a positive relationship between the demand for q_i and nutrient *k* from food group *j*. On the other hand, if β_{ijk} is negative, then there is a negative relationship between the demand for food item *i* and nutrient *k* from food group *j*. If β_{ijk} is zero, then there is no relationship between the demand for food item *i* and nutrient *k* from food group *j*. The term β_{ijk}/w_i is the nutrient elasticity of nutrient *k* from food group *j* for the demand for food group *i*. Household demographic variables can be incorporated into the demand model using the same approach. However, most household demographic variables are either dummy variables or have zero values; therefore, we modified the intercept term, α_i, as

$\alpha_i = \alpha_i' + \sum_j \phi_{ij} m_{ij}^k$;

where m_{ij} is the jth demographic characteristics for household *k*. The adding-up restriction requires $\sum_i \alpha_i' = 0$ and $\sum_i \phi_{ij} = 0$.

Note that there is no unique solution for the γ_{jlk}s in (6) (Brown and Lee 2002). Following Theil (1980) and Duffy (1987, 1989, 1990), we assume $\beta_{ijk} = - \pi_{ij} \gamma_{jjk}$ and let $\gamma_{jk} = \gamma_{jjk}$. This restriction can be rationalized by assuming either the amount of a nutrient in food group *j* does not affect the marginal utility of other food groups or has a generic effect on other food groups (Brown and Lee 1997). For this assumption, the levels version of the Rotterdam model can be written as

(7) $$w_i \log q_i = \alpha_i + \theta_i \log Q + \Sigma_j \pi_{ij} (\log p_j - \Sigma_k \gamma_{jk} \log a_{jk}).$$

The total number of γ_{jk}s needs to be estimated equals is $(n \times \kappa)$.

Note that γ_{jk} is positive if the nutrient increases utility. In addition, the last term on the right-hand-side of model (7) can be written as $\log p_j^* = \log p_j - \Sigma_k \gamma_{jk} \log a_{jk}$ that can also be considered as a modified (by nutrients found in food *j*) or the perceived price for food item *j*. The impact of a change in a_{jk} on p_j^* can be expressed as $\partial \log p_j^* / \partial \log a_{jk} = - \gamma_{jk}$. If γ_{jk} is positive, then an increase in nutrient *k* in food group *j* decreases the price perceived by the consumer for food item *j*. In other words, for a given market price, a nutrient may decrease the "perceived" price and increase the demand for the food item. An alternative possibility would be for nutrients to have a quantity-diminishing change. In this case, γ_{jk} is negative, and an increase in the nutrient increases the "perceived" price and decreases the demand for the food item.

When all β_{ijk}s or γ_{jk}s are zeros, model (7) degenerates to the basic Rotterdam model, an indication that nutrients have no impact on consumer's utility. That is, the basic Rotterdam model is nested in model (7), and a likelihood ratio statistic can be constructed to test whether nutrients have impacts on utility (Amemiya).

Data and Results

Foods are classified into five groups by the U.S. Department of Agriculture in its Food Guide Pyramid: dairy products, meats and other protein foods, fruits, vegetables, and grains. The dairy group provides protein, vitamins, and minerals; meats provide protein, B vitamins, iron and zinc; vegetables provide vitamins A and C, folate, minerals, and fiber; fruit and fruit juices provide vitamins A and C, potassium, although low in fat and sodium; while the grain group provides complex carbohydrates, vitamins, minerals, and fiber. The U.S. Department of Agriculture recommends that a daily balanced diet should include 2-3 servings of dairy products; 2-3 servings of meats and other protein products; 3-5 servings of vegetables; 2-4 servings of fruits, 6-11 servings of grain products, with sparing use of fats, oils, and sweets (U.S. Department of Agriculture 1996).

The 1987-88 NFCS data were used in this study. The NFCS data included conversion factors to adjust quantities of different forms of foods to a common basis for grouping into meaningful totals. The nutrient database used consists of nutritive values for food energy, 28 nutrients and other dietary components. The reported nutrient values for the amount of food used by households during the 7-day survey period are measured in terms of edible portion of food brought into the household adjusted by retention factors for vitamin and mineral losses during cooking. This survey has the potential for sampling bias given the low response rate (35 percent) (FASEB, 1991; USDA/ARS, 1994; GAO, 1991). However, the bias is believed to be no greater than that of other, comparable household-level data sets (Murphy et al., 1992).

For the empirical analysis, food items were grouped into five categories: dairy; meats (beef, pork, lamb, poultry, fish, and other protein foods); vegetables and fruits; grain products; and other (fats and oils, sugar and sweets, and miscellaneous). Six nutrients were included in this study: carbohydrates (grams), fats (grams), vitamins, minerals (calcium, phosphorus, magnesium, iron, zinc, copper, sodium, and potassium; measured in milligrams), digestible fibers (grams), and proteins (grams). As discussed above, the dairy and meat groups are rich in proteins, fats, and minerals; vegetables, fruits, and cereals are rich in carbohydrates, digestible fibers, vitamins and minerals; and the other food group is rich in fats, carbohydrates, and minerals; therefore, these nutrients are included in the analysis. As different measurements were used to quantify the contents of vitamins, two variables were created for vitamins. The first group of vitamins includes vitamin C, thiamin, riboflavin, niacin, and vitamin B-6. These vitamins are measured in milligrams (we denote this group as vitamin I). The second group of vitamins includes folate and vitamin B-12, which are measured in micrograms (we denote this group as vitamin II).[2]

There are 4,495 households that completed the food use questionnaires used in the 1987-88 NFCS. Due to missing values in the five food groups and nutrients used in this study, only 4,100 households were used in the analysis. Household demographic variables used in this study include: per capital away-from-home food expenditure, education level (whether the household head attended college or not), race (white, black, and other), whether the household is a single-head family, whether the household was located in a central city, whether the household's income is below the poverty level (annual income as percentage of poverty is smaller than 130), household composition (the number of persons in the selected six age groups), and household size squared (to account for economies of scale in household consumption).

The dependent variables, q_is, are converted from total amounts consumed by the household to average quantities per meal equivalent, or the quantities consumed by the household divided by the total number of meals eaten by household members. Nutrient contents, a_{jk}, are defined as the average nutrients per unit of food consumed; or the total amount of nutrient divided by the quantity of the food consumed. Four Rotterdam models with and without demographic, household composition, and nutrient variables were estimated with all symmetry, homogeneity, and adding up restrictions imposed. The likelihood ratio test statistics are presented in Table 1 (Amemiya, p. 141-6). Based on these test statistics, the Rotterdam model with the selected demographic, household composition, and nutrient variables was chosen for the following discussion. Results are presented in Tables 2 through 5.

Table 2 shows the parameter estimates for model (7). Note that these are conditional demand parameter estimates, as model (7) specifies a food demand subsystem (see Theil, 1980; Chapter 9): the food demand sub-system parameter estimates are conditioned on how the total budget is allocated to broad commodity groups, including the food group. As shown in Table 2, all income and price parameter estimates are at least two times greater than their respective standard errors. All parameter estimates for the income variable (log Q) are positive, all own-price parameter estimates are negative and all cross-price parameter estimates are positive indicating substitution relationships. Of the 19 nutrient demand parameters (γ_{ik}), only four were not statistically different from zero.

Elasticity estimates at sample means for the impacts of income, prices and nutrients are presented in Table 3. Income elasticity estimates indicate that if food expenditure was increased by one percent, the expenditures for the cereals group would increase by more than one percent (luxuries in the food group); the expenditures for the diary, meats, and vegetable and fruit groups would increase by less than one percent (necessities in the food group); the other food group would increase by about one percent. All (compensated) own-price demand elasticity estimates are negative and all cross-price demand elasticity estimates are positive, following the signs of the underlying price parameter estimates in Table 2. All demands are price inelastic except that for cereals. The cross-price elasticities are, as expected, small in comparison to own-price demand elasticity estimates.[3]

Two types of nutrient demand elasticity estimates are presented in Table 3: own-nutrient demand elasticities and cross-nutrient demand elasticities. The own-nutrient demand elasticity shows the percentage change in the demand for a food group due to a one percent change in the particular nutrients found in the food item. The cross-nutrient demand elasticity shows the percentage change in the demand for a food item due to a one percent change in nutrients found in other food groups. Of the 95 nutrient elasticity estimates, 75 of them are statistically different from zero.

The results presented in Table 3 show that own-nutrients had either positive or negative impacts on the demand for the five food groups examined in this study. Of the total 19 own-nutrient elasticity estimates, seven were positive and 12 were negative. A positive (negative) elasticity estimate indicates that the nutrient increases (decreases) the demand for food in the group in question. Four of the own-nutrient elasticities were insignificant at $\alpha = 0.05$ level suggesting the impacts of the nutrients in question had relatively neutral impacts.

The own-nutrient elasticity estimates show that all three dairy nutrients had positive impacts on the demand for dairy products. The positive impacts of protein and minerals on the demand for dairy products are not surprising, as the fact that dairy products provide protein and calcium is widely known. The inclusion of cheese products in the dairy group may contribute to the positive impact of fat content on the demand for dairy products. For example, fluid white milk may have a fat content up to 4 percent while muenster cheese may have more than 30 percent of fat by weight (USDA/ARS undated).

Results show that mineral contents in meats increased the demand for meats while fat content decreased the demand for this group. Past research found that high levels of fat in the diet are linked to increased blood cholesterol levels and a greater risk for heart disease. Public health campaigns in the United States, e.g., the Dietary Guidelines for Americans (U.S. Department of Agriculture and U.S. Department of Health and Human Services, 1996) and the American Heart Association Guideline, advise consumers to choose a diet low in fat. The finding that fat content decreases the demand for meats may be an indication that as early as in the late 1980s, U.S. consumers had already become aware of the detrimental impacts of fat content in meats on their health and thus avoided the consumption of meat products with high fat content.

Results for the own-nutrient impacts show that carbohydrate and mineral contents had negative impacts on the demand for vegetables and fruits. Carbohydrates, dietary fiber, and vitamin I (vitamin C, thiamin, riboflavin, niacin and vitamin B-6) contents had negative impacts and mineral contents and vitamin II (vitamin B-12 and folate) contents had positive impacts on the demand for cereals. The negative impacts of vitamin I and dietary fiber on the demand for these foods were unexpected.

Results also show that carbohydrate and fat contents decreased the demand for the other food group while mineral contents increased it. The food items included in this group are either high in fats and oils or high in sugar, and the results appear to reflect consumer preferences for these nutrients in the food group.

Of the 76 cross-nutrient elasticity estimates, 60 are statistically different from zero; and of these 60 significant estimates, 28 of them are negative. Generally, food items can be consumed individually or used in combinations to produce different dishes; therefore, cross-nutrient elasticities across food groups could be positive or negative, depending on how each food item was utilized and the interpretation of these cross-nutrient elasticities is problematic.

The coefficient estimates indicate that central city dwellers consumed less meats, more cereals and other foods than non-central city dwellers; white households and those households that had higher away-from-home food expenditure consumed more meats; households that had only a male or a female head consumed more other foods; households with income below 130 percent of the poverty level consumed more dairy products; and households with college-educated heads consumed more meats and less cereals.

The coefficient estimates for the household composition variables were used to derive the marginal impact of adding a particular member to the household on the consumption of these five food groups. Results are shown in Table 5. These estimated marginal impacts indicate that the addition of a household member younger than 7 years old would decrease household consumption of dairy products while the addition of a household member between 7 and 18 years old would increase household dairy consumption. The addition of a household member between 19 and 45 years old would increase household dairy product consumption and decrease household consumption of meats and vegetable/fruit products. The addition of a household member older than 45 years would decrease household consumption of meat products and increase the average consumption of cereals.

Concluding Remarks

This study explored the roles of nutrients in the demand for food through the utility theory. Findings support the argument that nutrients play an important role in the demand for food. The results show that the demand system approach used in this study is promising. The signs of all income and price parameter estimates are consistent with expectation, i.e., positive and less than unity income elasticities; negative own-price elasticities, small and positive cross-price elasticities.

The findings on the impacts of nutrients on the demand for food groups are encouraging with respect to health implications. For example, protein and mineral contents in dairy products had positive impacts on the consumption of these products, and fat content in meats had a negative impact on the consumption of meats. The calcium content in dairy products and the fat in red meat and their effects on health are probably familiar to most consumers. The health benefits of other nutrients, such as vitamins, fiber, and minerals may not be as well known as those for calcium and fats, as seemingly reflected by the other-nutrients results.[4] Perhaps, with more health campaigns and education, consumers may learn the functions of these nutrients and make more informed food consumption choices.

Table 1. Test statistics for the basic and extended Rotterdam models

Model	Degrees of Freedom	Log Likelihoods	$-2[L(\theta^*) - L(\theta)]$[a]
Basic Rotterdam Model		22,136.0	
Demographic Variables Only	5	22,202.1	132.2
Demographic and Household Composition Variables	11	22,281.0	290.0
Demographic, Household Composition and Nutrient Variables	30	22,443.6	615.2

[a]Likelihood ration test statistics (Amemiya, pp. 141-46).

Table 2. Demand parameter estimates[a]

	Intercept	LogQ	Prices				
			Dairy	Meats	Veg&Fruit	Cereals	Other
	α_i	θ_i			π_{ij}		
Dairy	-0.4290*	0.1081*	-0.1138*	0.0432*	0.0211*	0.0290*	0.0206*
	(0.0402)	(0.0015)	(0.0019)	(0.0018)	(0.0015)	(0.0014)	(0.0013)
Meats	-0.0428	0.3198*		-0.2639*	0.0542*	0.1061*	0.0605*
	(0.0605)	(0.0032)		(0.0038)	(0.0023)	(0.0028)	(0.0024)
Veg&Fruit	0.3730*	0.1939*			-0.1472*	0.0407*	0.0313*
	(0.0333)	(0.0020)			(0.0027)	(0.0018)	(0.0017)
Cereals	0.1881*	0.2120*				-0.2183*	0.0426*
	(0.0774)	(0.0033)				(0.0040)	(0.0021)
Other	-0.0893*	0.1662*					-0.1550*
	(0.0277)	(0.0031)					(0.0032)
				Nutrient Demand Parameter (γ_{jk})			
Protein			0.1202*	-0.0214			
			(0.0451)	(0.0343)			
Fats			0.0346*	-0.0588*			-0.0498*
			(0.0110)	(0.0152)			(0.0088)
Minerals			0.3670*	0.1821*	-0.1746*	-0.1057*	-0.0248*
			(0.0460)	(0.0185)	(0.0282)	(0.0543)	(0.0063)
Carbo					-0.0081	-0.1378*	0.1946*
					(0.0186)	(0.0173)	(0.0140)
Vitamin I					-0.0265	0.1013*	
					(0.0204)	(0.0164)	
Vitamin II					-0.0151	-0.0496*	
					(0.0209)	(0.0190)	
Fibers					-0.0761*	0.1090*	
					(0.0251)	(0.0257)	

[a]Numbers in parentheses are standard errors of parameter estimates.
*Statistically different from zero at $\alpha = 0.05$ level.

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Table 3. Demand elasticity estimates[a]

	Demand for				
	Dairy	Meats	Veg&Fruit	Cereals	Other
	Income and Compensated Price Elasticities				
Income	0.8689*	0.9467*	0.9122*	1.2858*	1.0365*
Price – Dairy	-0.9146*	0.1277*	0.0991*	0.1757*	0.1284*
Price – Meats	0.3469*	-0.7813*	0.2549*	0.6436*	0.3774*
Price – Veg & Fruit	0.1693*	0.1604*	-0.6924*	0.2467*	0.1950*
Price – Cereals	0.2329*	0.3140*	0.1913*	-1.3244*	0.2655*
Price – Other	0.1655*	0.1791*	0.1471*	0.2583*	-0.9664*
	Nutrient Elasticities (β_{ij}/w_i)				
Dairy					
Protein	0.1099*	-0.0154*	-0.0119*	-0.0211*	-0.0154*
Fats	0.0317*	-0.0044*	-0.0034*	-0.0061*	-0.0044*
Minerals	0.3356*	-0.0469*	-0.0364*	-0.0645*	-0.0471*
Meats					
Protein	0.0074	-0.0167	0.0055	0.0138	0.0081
Fats	0.0204*	-0.0459*	0.0150*	0.0378*	0.0222*
Minerals	-0.0632*	0.1423*	-0.0464*	-0.1172*	-0.0687*
Veg & Fruit					
Carbohydrates	0.0296*	0.0280*	-0.1209*	0.0431*	0.0340*
Vitamin I	0.0014	0.0013	-0.0056	0.0020	0.0016
Vitamin II	0.0045	0.0042	-0.0183	0.0065	0.0052
Fiber	0.0026	0.0024	-0.0104	0.0037	0.0029
Minerals	0.0129*	0.0122*	-0.0527*	0.0188*	0.0148*
Cereals					
Carbohydrates	0.0246*	0.0332*	0.0202*	-0.1400*	0.0281*
Vitamin I	0.0321*	0.0433*	0.0264*	-0.1825*	0.0366*
Vitamin II	-0.0236*	-0.0318*	-0.0194*	0.1342*	-0.0269*
Fiber	0.0115*	0.0156*	0.0095*	-0.0657*	0.0132*
Minerals	-0.0254*	-0.0342*	-0.0209*	0.1444*	-0.0289*
Other					
Carbohydrates	0.0082*	0.0089*	0.0073*	0.0129*	-0.0481*
Fats	0.0041*	0.0044*	0.0036*	0.0064*	-0.0240*
Minerals	-0.0322*	-0.0349*	-0.0286*	-0.0503*	0.1880*

[a]Income and price elasticities are estimated at sample means.

*Statistically different from zero at $\alpha = .005$ level.

Table 4. Demographic parameter estimates[a]

	Dairy	Meats	Veg&Fruit	Cereals	Other
Central City	-0.0017	-0.0075*	-0.0080	0.0083*	0.0089*
	(0.0016)	(0.0034)	(0.0021)	(0.0036)	(0.0032)
FAH	-0.0001	0.0003*	-0.0002	0.0001	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0002)	(0.0001)
White	0.0045	0.0164*	0.0098	-0.0020	-0.0288
	(0.0037)	(0.0078)	(0.0050)	(0.0083)	(0.0074)
Black	0.0034	-0.0051	-0.0004	0.0113	-0.0092
	(0.0041)	(0.0086)	(0.0055)	(0.0091)	(0.0082)
Single	-0.0004	-0.0006	-0.0005	-0.0057	0.0072*
	(0.0020)	(0.0041)	(0.0026)	(0.0044)	(0.0039)
Poor	0.0037*	-0.0027	-0.0018	-0.0017	0.0025
	(0.0018)	(0.0037)	(0.0024)	(0.0039)	(0.0035)
College	0.0000	0.0076*	-0.0009	-0.0070*	0.0004
	(0.0014)	(0.0030)	(0.0019)	(0.0032)	(0.0029)
≤6 Years	-0.0055*	-0.0070	-0.0048	0.0100*	0.0073*
	(0.0021)	(0.0045)	(0.0028)	(0.0047)	(0.0042)
7-12 Years	0.0047*	-0.0021	-0.0030	0.0016	-0.0011
	(0.0023)	(0.0047)	(0.0030)	(0.0050)	(0.0045)
13-18 Years	0.0027	-0.0038	-0.0032	0.0029	0.0015
	(0.0022)	(0.0045)	(0.0029)	(0.0047)	(0.0043)
19-45 Years	0.0026	-0.0091*	-0.0087*	0.0087*	0.0065
	(0.0020)	(0.0042)	(0.0027)	(0.0044)	(0.0040)
46-65 Years	0.0024	-0.0121*	-0.0034	0.0140*	-0.0008
	(0.0022)	(0.0046)	(0.0029)	(0.0048)	(0.0044)
65+ Years	-0.0022	-0.0139*	-0.0043	0.0168*	0.0035
	(0.0025)	(0.0052)	(0.0033)	(0.0055)	(0.0049)
$(\text{HH Size})^2$	-0.0001	0.0007	0.0005	-0.0010*	-0.0001
	(0.0002)	(0.0005)	(0.0003)	(0.0005)	(0.0005)

[a]The numbers in parenthesis are standard errors of the estimates.
*Statistically different from zero at $\alpha = 0.05$ level.

Table 5. Estimated marginal impact of household member on food demand[a]

Age Group	Dairy	Meats	Veg&Fruit	Cereals	Other
<=6	-0.0003*	-0.0003	-0.0002	0.0001	0.0002
7-12	0.0002*	0.0002	0.0000	-0.0001	-0.0001
13-18	0.0001*	0.0000	0.0000	0.0000	0.0000
19-45	0.0001*	-0.0005*	-0.0007*	0.0001	0.0002
46-65	0.0001	-0.0008*	0.0000	0.0002*	-0.0001
65+	-0.0001	-0.0010*	-0.0001	0.0002*	0.0001

[a]The marginal impact of adding a particular member to the household can be derived as

$$\partial q_i/\partial h_j = q_i w_i(\phi_{ij} + 2\,\phi_{ik} HHZ^2)$$

where h_j is a household member of age group *j*, HHZ is the household size, ϕ_{ij} is the coefficient estimate for h_j, and ϕ_{ik} is the coefficient estimate for HHZ^2.

*Statistically different from zero at $\alpha = 0.05$ level.

Footnote

[1]In general, there is a constant relationship between the quantity of a food consumed and its nutrient levels. Therefore, the nutrient variables are proportional to the quantity of the food item of interest. If one can estimate the demand for each individual food item, the nutrient variables are proportional to changes with respect to the quantity consumed and they are highly correlated and may cause serious multicollinearity problem in estimating the demand equations. In the 1987-88 NFCS data, there are 3,970 food items in the household coding system, when these close to 4,000 food items are grouped into several food categories, such as the approach used in the Huang and Lin study and this study, it becomes evident that nutrient levels in each food group are different from household to household, thus, multicollinearity is not likely to be a problem in the estimation. All simple correlation coefficients for the nutrient variables used in the estimation are smaller than 0.15 except those between vitamin I and vitamin II for the cereal (0.77) vegetable/fruit (0.58) groups, protein and minerals for the diary group (0.51), and fibers and minerals for the cereal group (0.43).

[2]Vitamin A (international units), carotenes (retinol equivalent), and vitamin E (alpha-tocopherol equivalents) were not included in the analysis. These nutrients could not be straight forwardly included in either the vitamin I or the vitamin II group as the units in which they are measured differ from those in the vitamin I and vitamin II groups. Inclusion of these three variables makes estimation more difficult and results for these nutrients were not obtained in this study.

[3]Because different groups of food, treatment of zero consumption, and estimation method are used in this study, the demand elasticity estimates in Table 3 cannot be directly compared with those reported in the Huang and Lin study (the SAS procedure SYSLIN used in the Huang and Lin study does not provide iterative SUR estimates). We estimated the AIDS parameters using the data compiled for this study and the iterative SUR. We found that the demand elasticity estimates are similar in these two models.

The income elasticity estimates obtained from the AIDS model are 1.035, 0.981, 0.994, 0.969, and 1.053; and the own-price elasticity estimates are –0.766, -0.631, -0.700, -0.459, and 0.016; for the dairy, meats, vegetable and fruit, cereals, and other groups, respectively.

[4]A search of LexisNexis medical and health news database for the years 1985 through 1988 results in the following number of headlines and lead paragraphs: 52 for fat; 29 for fiber; one for vitamin C, thiamin, riboflavin, sodium, and potassium; and zero for vitamin-B6 and niacin.

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