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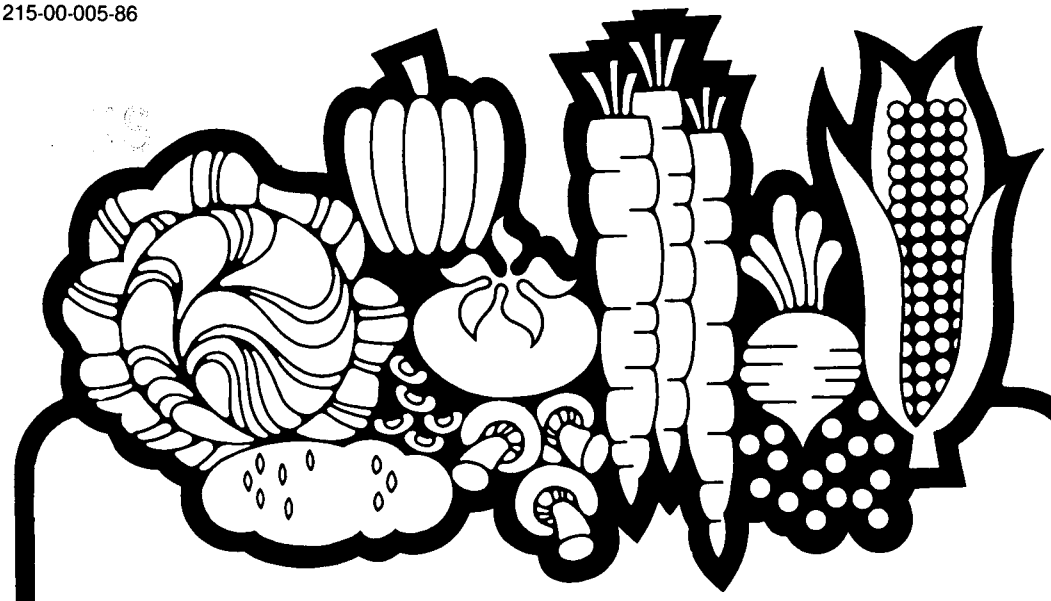

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by

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Demand theory has traditionally been based on the fundamental precept that a product or service generates utility. Utility theory has been used by researchers to analyze consumer choices among goods and services--given consumers' preferences, perceived prices, and budget constraints. In contrast to this classical model, the characteristics, or hedonic approach assumes a set of characteristics, or attributes, produces utility. Variations in these variables lead to differences in prices of products that consumers are willing to pay [Ladd and Suvannunt; Lancaster; and Waugh]. In the case of food products, the price that an individual is willing to pay for a particular food item is a function of the marginal implicit prices that a consumer is willing to pay for each of the nutrients [Terry, Brooker, and Eastwood, 1985].

Objective

This paper presents some results from an ongoing analysis of characteristics models regarding the estimation of implicit prices for food nutrients. The predicted prices of several selected food products based on the estimated implicit demands for these food

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products' attributes are compared to the actual market prices. The effects of region, income, race, urbanization, and education on the predicted food prices are also examined.

Hedonic Model

Basically, the solution of the characteristics model leads to a set of equations that can be estimated by the regression of product prices on relevant characteristics.[1] These are called hedonic price equations. The partial derivatives of these multiple regression equations with respect to each coefficient represent the marginal implicit prices of the respective characteristics. That is, each coefficient is an estimate of the implicit, hedonic, price that a consumer is willing to pay for one additional unit of the respective attribute. In this study the attributes were the average nutritional contents of various foods, adjusted for losses during preparation. Other attributes may also be associated with the utility maximizing choice, such as taste and texture, but it is assumed that these factors are separable from nutritional considerations, and can be analyzed independently.

The relationship between the price paid per unit (the market price) and the nutritional attributes per unit of various food products consumed is assumed to be linear.[2] The dependent variable

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[1]For a detailed explanation of the econometric models used in this analysis, see Terry, Brooker, and Eastwood (1985).

[2]To maintain simplicity 1) interaction terms for the explanatory variables were not included; 2) because of an assumption of no unique attributes, the linear function was estimated without an intercept; and 3) marginal implicit prices of

(Footnote Continued)

is the price per pound paid by surveyed households for each product consumed during a one-week period in the spring of 1977.[3] The quantities of seven nutritional attributes obtained from a pound of each food product are the independent variables.

Results from additional analyses are reported in this paper. Other regressions are computed for subsets of the total sample. That is, hedonic price equations for specified subgroups are estimated. Selection of these groups is based upon an examination of the existing literature and theoretical considerations. Comparisons of results across subgroups require the consequent interpretations to be within the ceteris paribus context and that specification problems are minimal. The variables are region of the United States (4 categories), urbanization (3 categories), income (3 categories), education (2 categories), and race (3 categories). For each criteria the entire 2,227 households were analyzed.

Estimated Implicit Prices of Nutrients

Region of United States

The estimated implicit prices of the seven nutrients for the entire sample of households are in the United States column of Table 1. In addition, the table also shows the estimates for the

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(Footnote Continued)
nutritional attributes were assumed to be constant over the range of quantities consumed in this study.

[3]The 1977-78 Nationwide Food Consumption Survey is the data source. Of the 3,300 households in the spring of977 survey, 2,227 households were included in this study [U.S. Department of Agriculture, 1982].

Table 1. Estimated implicit prices of food nutrients in the United States and four regions, spring season, 1977

Nutrient[a]	Unit	United States	Region			
			Northeast	North Central	South	West
		- - - - - - - - - - dollars per unit - - - - - - - - - -				
Protein	grams	.00432 (40.09)[b]	.00584 (26.75)	.00361 (17.07)	.00329 (17.19)	.00491 (19.26)
Fat	grams	.00249 (69.88)	.00255 (34.06)	.00253 (35.73)	.00240 (39.84)	.00249 (29.49)
Carbohydrates	grams	.00020 (8.57)	.00051 (10.44)	.00016 (3.45)	-.00012 (-2.84)	.00040 (7.15)
Minerals	milligrams	.00012 (59.01)	.00014 (30.23)	.00013 (30.30)	.00012 (34.22)	.00010 (22.02)
Vitamin A	international units	-.00001 (-32.77)	-.00001 (-13.00)	-.00002 (-18.74)	-.00002 (-22.89)	-.00000[c] (-9.93)
Vitamin B	milligrams	.02355 (158.54)	.02163 (71.60)	.02385 (81.63)	.02599 (100.77)	.02167 (60.27)
Vitamin C	milligrams	.00163 (57.43)	.00122 (18.77)	.00158 (30.22)	.00202 (41.13)	.00151 (23.00)
R^2 [d]		.49	.51	.48	.51	.46
F value		14,232	3,629	3,708	4,645	2,385
n.[e]		2,227	493	600	731	403

[a] Data included 14 nutrients; however, due to high degrees of correlation among some of them, the nutrients were grouped into the seven more aggregate categories.

[b] T values in parentheses.

[c] Actual number is -.000009 .

[d] R^2-like values computed using deviations about the means of the respective dependent variable.

[e] Number of households.

four regions. All of the estimated coefficients are highly significant, and the R^2s are reasonably high considering the use of cross-section data.

Each estimated coefficient is a measure of the average household's valuation of the respective nutrient. Positive coefficients indicate the marginal values the average household is willing to pay for additional units of the nutrients. For example, the average household in the Northeast region of the United States is willing to pay $.006 for an additional gram of protein, while in the South the average household is willing to pay $.003.

Vitamin A has a negative coefficient in all regions, which suggests that the average household is willing to pay for its removal. Vitamin A is probably correlated with an omitted variable that has a negative value. One such possibility could be taste, because vitamin A is found predominantly in fresh leafy green vegetables that are frequently described as bitter. The average household in the South has a negative estimated coefficient for carbohydrates, -$.0001 per gram. Some regional variation does seem to occur in the valuations of protein and carbohydrates, but the valuations of the nutrients are fairly consistent. The Northeast has the highest implicit protein price and the South the lowest. Similarly, carbohydrates have the highest coefficient in the Northeast and lowest in the South.

Urbanization

The extent of urbanization has been found to be an important determinant of food demand [e.g., Smallwood and Blaylock, 1984]. Food expenditure patterns may be associated with differences in

life styles related to the degree of urbanization. Rural families are expected to demand larger quantities of energy related nutrients, and perhaps, less of other nutrients. These factors should be reflected in the estimated implicit prices.

To account for these effects the total sample was separated into three categories--central city, suburban, and rural--and separate regressions computed.[4] Rural households, on average, were found to have lower implicit values for protein than central city households (Table 2). The average suburban household has an implicit price coefficient for carbohydrates that is more than twice as high as the rural household counterpart and five times greater than the average central city household. Coefficients for the other nutrients are quite similar among the three urbanization categories. These results suggest that valuations of nutrients do not vary appreciably by urbanization.

Income

The level of household income affects the quantities of various attributes consumed, i.e., income affects the ability to purchase food, and consequently, nutrients through changing the relative position of the efficiency frontier [Brooker and Hinson, 1980].

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[4]The three urbanization categories are defined as follows: central city--population of 50,000 or more for main or core city within the standard metropolitan statistical area (SMSA); suburban--generally within the boundaries of the SMSA, but not within legal limits of the central city SMSA; rural--all U.S. areas not within an SMSA [U.S. Department of Agriculture, 1982, p. 290].

Table 2. Estimated implicit prices of food nutrients in the United States for three urbanization categories, spring season, 1977

Nutrient	Unit	Urbanization		
		Central City	Suburban	Rural
Protein	grams	.00505 (25.00)[a]	.00443 (23.77)	.00344 (19.63)
Fat	grams	.00250 (38.35)	.00245 (39.34)	.00250 (43.05)
Carbohydrates	grams	.00007 (1.64)	.00036 (8.94)	.00015 (3.76)
Minerals	milligrams	.00013 (30.62)	.00015 (38.66)	.00010 (32.90)
Vitamin A	international units	-.00001 (-17.66)	-.00001 (-17.97)	-.00002 (-20.97)
Vitamin B	milligrams	.02414 (85.14)	.02162 (85.21)	.02500 (104.21)
Vitamin C	milligrams	.00148 (27.10)	.00136 (27.81)	.00198 (44.05)
R^2 [b]		.49	.47	.50
F value		4159	4873	5266

[a] T values in parentheses.

[b] R^2-like values computed using deviations about the means of the respective dependent variable.

Implicit prices for nutrients are estimated for households in three income categories -- less than $10,000, $10,000-$24,999, and $25,000 and greater. Inspection of Table 3 reveals the following. The estimated valuations of protein, fat, carbohydrates, and minerals increase with income. Vitamins B and C show declines. These results may reflect the role of food as a necessity. As incomes rise concern about balanced diets may decline, allowing higher income consumers to purchase foods having different mixes of nutrients.

Education

Education of the homemaker may reflect differences in ability, desires, and resourcefulness of the person primarily responsible for food consumption [Adrian and Daniel, 1976; and Searce and Jenson 1979]. The education level could also be associated with an awareness of possible detrimental features of some nutrients. Consequently, declining valuations of fat and carbohydrates are expected, while in the remaining instances the coefficients are expected to be increasing.

The sample was divided into two groups, those with less than a college degree versus those with a college degree. Hedonic price equations were estimated for each subgroup (Table 4). The most pronounced difference occurs with the coefficients for carbohydrates; college graduates as a group had an estimated implicit price that was much higher. These results suggest that level of education, at least between the two groups examined here, does not have much of a role to play in consumers' valuations of nutrients.

Table 3. Estimated implicit prices of food nutrients in the United States for three income categories, spring season, 1977

Nutrient	Unit	Income: Less than $10,000	Income: $10,000-$24,999	Income: $25,000 and greater
Protein	grams	.00371 (23.39)[a]	.00470 (29.83)	.00419 (9.95)
Fat	grams	.00246 (47.02)	.00248 (48.02)	.00255 (18.23)
Carbohydrates	grams	.00005 (1.40)	.00030 (8.76)	.00043 (4.71)
Minerals	milligrams	.00010 (37.03)	.00014 (42.12)	.00019 (19.63)
Vitamin A	international units	-.00001 (-23.80)	-.00001 (-22.14)	-.00001 (-5.51)
Vitamin B	milligrams	.02609 (119.71)	.02153 (99.50)	.02124 (36.91)
Vitamin C	milligrams	.00163 (38.50)	.00176 (43.88)	.00062 (5.20)
R^2 [b]		.50	.48	.47
F value		6487	6805	1037

[a] T values in parentheses.

[b] R^2-like values computed using deviations about the means of the respective dependent variable.

Table 4. Estimated implicit prices of food nutrients in the United States for two education categories, spring season, 1977

Nutrient	Unit	Education: Less than college graduate	Education: College graduate
Protein	grams	.00407 (34.97)[a]	.00576 (20.06)
Fat	grams	.00249 (65.11)	.00247 (25.16)
Carbohydrates	grams	.00016 (6.16)	.00048 (7.37)
Minerals	milligrams	.00012 (54.50)	.00012 (21.18)
Vitamin A	international units	-.00001 (-32.34)	-.00000[b] (-7.35)
Vitamin B	milligrams	.02385 (149.21)	.02198 (54.27)
Vitamin C	milligrams	.00169 (55.17)	.00133 (17.03)
R^2 [c]		.49	.48
F value		12,166	2,044

[a] T values in parentheses.

[b] Actual number is -.000009.

[c] R^2-like values computed using deviations about the means of the respective dependent variable.

Race

Different races possess ethnic backgrounds that can influence utility and, consequently, implicit prices of nutrients. Other studies incorporating race include Burk, 1961, and Rauniker, Purcell, and Elrod, 1966.

Households are grouped into white, black, or other race categories. Other races had an average implicit price of protein that was higher than the other two groups. The black households yielded a negative implicit value for one additional unit of carbohydrates (Table 5). Evidently, because of current levels of consumption of foods high in carbohydrates, black households on the average would pay $.049 to have one hectogram of carbohydrates removed from the foods consumed. Black households also yielded a higher positive value for a marginal unit of vitamin C than either white or other households. These results suggest that different races do place somewhat different values on protein, carbohydrates, and vitamin C.

Estimated Food Prices

Food prices can be predicted using the estimated implicit prices of the nutrients, given the pooled sample equations and the nutritional contents of a food. Since the estimated equations reflect various subgroups, predicted values can be generated on this basis, so the effects of region, income, education, urbanization, and race are also evaluated in comparisons of predicted prices with actual market prices. Ten food products have been selected for illustration of this analysis -- beef steaks, veal cutlets, ham, chicken, turkey, milk, potatoes, cabbage, peppers,

Table 5. Estimated implicit prices of food nutrients in the United States for three race categories, spring season, 1977

Nutrient	Unit	Race		
		White	Black	Other
		- - - - dollars per unit - - - -		
Protein	grams	.00424 (36.59)[a]	.00455 (13.23)	.00640 (11.03)
Fat	grams	.00249 (64.60)	.00240 (22.75)	.00252 (12.85)
Carbohydrates	grams	.00029 (11.14)	-.00049 (-6.59)	.00000 (0.02)
Minerals	milligrams	.00013 (55.64)	.00010 (16.82)	.00008 (7.62)
Vitamin A	international units	-.00001 (-29.35)	-.00001 (-14.37)	-.00001 (-5.88)
Vitamin B	milligrams	.02350 (147.95)	.02483 (49.91)	.02189 (27.23)
Vitamin C	milligrams	.00153 (49.80)	.00249 (28.59)	.00183 (12.93)
R^2 [b]		.49	.48	.53
F value		12,476	1,323	423

[a] T values in parentheses.

[b] R^2-like values computed using deviations about the means of the respective dependent variable.

and eggs. Each predicted food product price is generated for the appropriate group of pooled households by summing the set of the respective food's nutrients multiplied by the nutrients' implicit prices. The quantities of the seven nutrients found in the selected food products are presented in Table 6.

Region of United States

The predicted food prices for all surveyed households combined and for the households separated into four regional groups are presented in Table 7. When the predicted price is greater than (less than) the actual price, an interpretation is that the average household's valuations of the nutrients contained in the food are greater than (less than) the actual market's valuation in 1977. For instance, the predicted price (United States) of beef steak is $.83 per pound versus an actual market price of $1.89 per pound. On the other hand, the predicted price of milk is $2.24 per gallon versus a market price of $1.67. Hence, beef steak is overvalued by the market and milk is undervalued, at least with respect to the predicted "nutrient value" price.

Some of the discrepancies between the predicted prices and the actual market prices may be partially due to seasonal variation in prices of vegetables and cyclical variations in prices of animal products. Another source of discrepancy may be model misspecification. First, one or more important explanatory variables may be omitted from the model. Perhaps foremost in this area would be consumer tastes and preferences that represent habits, cultural factors, and traditions. A second misspecification problem could

Table 6. Quantities of nutrients contained in the selected food products

Food product	Nutrients						
	Protein	Fat	Carbohydrates	Minerals	Vitamin A	Vitamin B	Vitamin C
	grams	grams	grams	milligrams	International units	milligrams	milligrams
Steak, sirloin, U.S. Choice (lb.)	71.2	15.6	0	782.4	240.0	16.6	0
Veal cutlets, U.S. Choice (lb.)	90.3	27.2	0	1078.6	0	22.0	0
Ham, whole, smoked (lb.)	63.6	88.4	0	843.5	0	15.7	0
Frying chicken (lb.)	57.4	15.1	0	780.3	1688.0	16.2	0
Turkey (lb.)	66.6	48.7	0	764.0	15.0	14.6	0
Milk, fresh (gal.)	14.9	15.1	21.1	1026.8	571.8	1.5	4.0
Potatoes, fresh (lb.)	7.7	0.4	62.8	348.0	0	5.9	47.0
Cabbage, fresh (lb.)	5.3	0.8	22.0	372.6	518.0	2.1	162.0
Peppers, green, fresh (lb.)	4.5	0.6	17.8	184.7	1529.0	3.3	410.0
Eggs, Grade A, large (doz.)	48.3	44.7	4.8	999.5	2076.0	2.3	0

Source: 1977-78 Nationwide Food Consumption Survey [USDA, 1982].

Table 7. Market value of selected food products based on estimated implicit nutrient prices and the actual prices in four major cities and the United States, spring season, 1977

Food product	United States	Northeast (New York)	North Central (Chicago)	South (Atlanta)	West (Los Angeles)
	Price in cents per pound				
Steaks, sirloin, U.S. Choice:					
Estimated[a]	83	93	80	79	83
Actual[b]	189	198	155	201	231
Veal Cutlets, U.S. Choice:					
Estimated	111	123	106	107	110
Actual	313	342	276	368	259
Ham, whole, smoked:					
Estimated	96	106	93	93	95
Actual	125	133	107	106	130
Frying chicken:					
Estimated	74	82	71	71	73
Actual	61	67	62	54	63
Turkey:					
Estimated	84	94	81	81	85
Actual	72	76	69	73	74
Milk, fresh:(gal.)					
Estimated	224	258	224	215	215
Actual	167	172	165	201	133
Potatoes, fresh:					
Estimated	30	31	30	30	30
Actual	17	19	26	24	11
Cabbage, fresh:					
Estimated	36	33	37	43	36
Actual	29	32	30	24	21
Peppers, green, fresh:					
Estimated	77	62	74	92	72
Actual	76	63	72	105	81
Eggs, Grade A, large:(doz.)					
Estimated	70	84	63	62	72
Actual	75	81	68	73	74

[a] See Table 1 for implicit values of seven nutrient categories.

[b] Average retail price for May, 1977 [U.S. Department of Labor].

be that the explicit functional form may not be correct. Other potential forms include: semilog, double log, polynomial, etc.

The predicted prices of several food items are highest in the Northeast region, even though the actual market prices of these products are higher in other regions. Predicted prices were fairly consistent across regions except for veal cutlet, cabbage, and peppers. The combined value of the nutrients in a veal cutlet seem to be most preferred by households in the Northeast. Southern households yielded the highest predicted prices for green peppers and cabbage.

Urbanization

The predicted price of milk for rural households, $1.98, is substantially lower than the predicted price of an otherwise comparable household in the suburban and central city locations, $2.58 and $2.50, respectively (Table 8). Even so, the predicted price in the rural region is still higher than the actual market price. Central city predicted prices are higher than the predicted prices in the suburban category for cabbage. Cabbage was unique in that the predicted price for rural households was higher than for suburban or central city households.

Income

As expected, predicted values of the food products generally tended to increase as income increased (Table 9). For most products the increase is small. However, for milk and eggs the increase is substantial. For cabbage, the predicted price for the higher income group of households is substantially less than the predicted price for the lower income group.

Table 8. Market value of selected food products based on estimated implicit nutrient prices for three urbanization categories and the actual prices, spring season, 1977[a]

Food product	Unit	Actual U.S. price[b]	Urbanization		
			Central city	Suburban	Rural
		Price in cents			
Steak, sirloin, U.S. Choice	lb.	189	90	84	78
Veal cutlets, U.S. Choice	lb.	313	120	111	104
Ham, whole, smoked	lb.	125	103	97	91
Frying chicken	lb.	61	80	74	70
Turkey	lb.	72	91	84	80
Milk, fresh	gal.	167	250	258	198
Potatoes, fresh	lb.	17	30	29	31
Cabbage, fresh	lb.	29	36	35	42
Peppers, green, fresh	lb.	76	71	67	90
Eggs, Grade A, large	doz.	75	81	75	60

[a] See Table 2 for implicit values of seven nutrient categories.

[b] United States average retail price for May, 1977 [Bureau of Labor Statistics].

Table 9. Market values of selected food products based on estimated implicit nutrient prices for three income categories and the actual market prices, spring season, 1977[a]

Food product	Unit	Actual U.S. price[b]	Income: Less than $10,000	Income: $10,000-$24,999	Income: $25,000 and greater
		Price in cents			
Steak, sirloin, U.S. Choice	lb.	189	81	84	84
Veal cutlets, U.S. Choice	lb.	313	109	111	112
Ham, whole, smoked	lb.	125	95	98	99
Frying chicken	lb.	61	73	75	75
Turkey	lb.	72	83	85	86
Milk, fresh	gal.	167	207	250	284
Potatoes, fresh	lb.	17	29	32	29
Cabbage, fresh	lb.	29	36	41	23
Peppers, green, fresh	lb.	76	78	83	39
Eggs, Grade A, large	doz.	75	64	76	80

[a] See Table 3 for implicit values of seven nutrient categories.

[b] United States average retail price for May, 1977 [Bureau of Labor Statistics].

Education

The predicted prices of food products increase with education for five of the six products in Table 10. The predicted price for cabbage declined as education increased.

Race

Both meat products have lower predicted prices for the white category than either the black or other categories (Table 11). The "other" category's prices are higher than the predicted prices for the black category. The black households, on the average, yielded higher predicted prices than the white and other categories for potatoes and cabbage. Milk is the only product for which the white household category yielded a higher predicted price than the black and other categories.

Concluding Remarks

This research report is based upon characteristics theory. Models developed in this context lead to equations in which unit market prices are functions of the quantities of attributes a unit of the respective good possesses. Estimated coefficients measure the implicit prices of the attributes. The first set of analyses described differences among these implicit prices for selected subgroups of the population. Statistical results show that differences exist to some extent among region, incomes, and races. Urbanization and educational level subgroups produced more homogenous results.

Estimated implicit prices were used in conjunction with the nutrient levels per unit of selected products to obtain predicted prices. These were compared to the actual prices. Conceptually

Table 10. Market value of selected food products based on estimated implicit nutrient prices for two education categories and the actual market prices, spring, 1977[a]

Food product	Unit	Actual U.S. price[b]	Education: Less than college graduate	Education: College graduate
		Price in cents		
Steak, sirloin, U.S. Choice	lb.	189	82	90
Veal cutlets, U.S. Choice	lb.	313	109	120
Ham, whole, smoked	lb.	125	95	104
Frying chicken	lb.	61	73	80
Turkey	lb.	72	83	91
Milk, fresh	gal.	167	224	250
Potatoes, fresh	lb.	17	30	30
Cabbage, fresh	lb.	29	37	34
Peppers, green, fresh	lb.	76	79	66
Eggs, Grade A, large	doz.	75	69	81

[a] See Table 4 for implicit values of seven nutrient categories.

[b] United States average retail price for May, 1977 [Bureau of Labor Statistics].

Table 11. Market value of selected food products based on estimated implicit nutrient prices for three race categories and the actual market prices, spring season, 1977[a]

Food product	Unit	Actual U.S. price[b]	Race		
			White	Black	Other
		- - - - - - - -	Price in cents	- - - - - - -	
Steak, sirloin, U.S. Choice	lb.	189	83	85	91
Veal cutlets, U.S. Choice	lb.	313	111	114	121
Ham, whole, smoked	lb.	125	97	97	101
Frying chicken	lb.	61	74	75	79
Turkey	lb.	72	84	86	91
Milk, fresh	gal.	167	241	207	207
Potatoes, fresh	lb.	17	21	31	30
Cabbage, green, fresh	lb.	29	37	49	40
Peppers, green, fresh	lb.	76	74	111	84
Eggs, Grade A, large	doz.	75	70	68	76

[a] See Table 5 for implicit values of seven nutrient categories.

[b] United States average retail price for May, 1977 [Bureau of Labor Statistics].

these estimates were transformations of implicit prices weighted by nutrition levels into the predicted prices of market goods. The computations when compared to actual prices generated interesting patterns. The Northeast had most of the highest predicted prices, suburban areas generally had the lowest predicted prices, a mixed pattern occurred with income, the higher education group generally obtained higher predicted prices, and a mixed result occurred for race.

Additional work in this area should be of assistance to governmental policy makers and private food organizations in planning and implementing programs to enhance the nutritional level of consumer diets. As our knowledge of consumer nutritional demand and responses to price changes increases, more efficient markets and better policies should evolve. For products that have predicted prices higher than actual market prices, generic advertising might be designed to capitalize on consumers "nutritional valuation" of these products. Poultry, cabbage, and potatoes are in this group. Other fruits and vegetables, not reported in this paper due to space limitations, did not have predicted prices above the actual market prices. For a product like eggs, where the predicted price fluctuated around the actual market price depending on urbanization, income, education, and race, insight may be obtained to improve "targeting" of promotional and educational material.

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