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A Recognition of Health and Nutrition Factors in Food Demand Analysis

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A theoretical framework in which to formally consider health and nutrition factors in demand analyses is developed. The framework is employed to empirically identify and assess the impacts of information pertaining to cholesterol on the demands for beef, pork, poultry, and fish. Issues in considering health and nutrition factors in food demand analysis are documented.

Key words: health and nutrition factors, demand analysis, Rotterdam model.

Nutrition and health issues appear to be major concerns for consumers. In a recent Food Marketing Institute survey, 93% of the respondents indicated concerns about the nutritional content of foods. Almost two-thirds of those surveyed in a U.S. Department of Agriculture (USDA) study reported they had adjusted household diets in the previous three years for health or nutrition reasons (Jones and Weimer). Concerns are on the rise for particular nutrients, notably fat and cholesterol (Borra). As well, organizations representing producer groups appear to be very conscious of health and nutrition concerns in the promotion of products. The deliberate or inadvertent omission of such nontraditional, noneconomic variables may have deleterious consequences in the estimation of structural demand relationships. To quote Manderscheid:

> In both experimental and nonexperimental studies uncontrolled variables may, if they are important, affect the relationships being studied. A study of the relationship between skim and whole milk prices at retail might be upset by a "cholesterol scare" if such a scare received widespread public attention and if the experimental design or statistical procedure did not remove its effect. (p. 134)

Bringing together diverse viewpoints of agricultural economists specializing in demand analysis and those interested in human nutrition is no easy task. The intent of this article is to formally consider the role of health and nutrition factors in food demand analysis. Specific objectives are: (*a*) To conduct a literature review of selected studies that deal with health and nutrition issues. (*b*) To develop a theoretical framework in which to formally consider health and nutrition factors in demand analyses. Much consideration is given to the growing interest with regard to the issue of structural change in demand analysis. (*c*) To employ the theoretical framework to empirically identify and assess the impacts of information pertaining to cholesterol on the demands for beef, pork, poultry, and fish. Annual data dealing with U.S. per capita consumption levels and corresponding nominal prices over the period 1966 to 1988 are used in this exercise. (*d*) To document key issues in considering health and nutrition factors in food demand analysis.

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Literature Review

Agricultural economists possess some prior experience in analyses of health and nutrition issues. Borrowing in part from Huffman, it is possible to classify such analyses into various categories: (*a*) assessment of dietary quality, (*b*) determination of demand for specific nutrients, (*c*) construction of hedonic price or consumer goods characteristics models for nutrients, and (*d*) assessment of attitudes and information about health and nutrition on the demand for food products.

Assessment of Dietary Quality

Assessments of dietary quality are important from the standpoint of personal health and public nutritional policy. Objectives of government programs such as the Food Stamp Program (FSP); National School Lunch Program (NSLP); Women, Infants, and Children Program (WIC); and National School Breakfast Program (NSBP) include the attainment of nutritionally adequate diets, particularly for the segment of the population whose incomes fall below the poverty level.

Typically, definitions of nutritionally adequate diets rest on: (*a*) nutrient-to-calorie density ratios (Blanciforti, Green, and Lane; Windham et al.; Johnson, Burt, and Morgan); (*b*) Recommended Dietary Allowances (RDAs) (Huffman; Peterkin, Kerr, and Hama); and (*c*) Nutrient Achievement or Adequacy Ratios (NARs) (Lane; Davis and Neenan). Nutrient density is the unit measurement of each nutrient per 1,000 kilocalories. RDAs, although arguably the best standards for assessment of nutrient adequacy, are not available for all nutrients. Peterkin, Kerr, and Hama suggest that if 80% of the RDAs for 11 nutrients (protein, calcium, iron, magnesium, phosphorus, vitamin A, thiamin, riboflavin, vitamin B6, vitamin B12, and vitamin C) is met, the diet either for individuals or households is deemed nutritionally adequate. In fact, there are roughly 45 essential nutrients, but RDAs have not been established for many of these. Huffman defines nutritional adequacy in terms of meeting 100% of the RDAs for 13 nutrients, the 11 previously mentioned as well as food energy and niacin. NARs express the amount of a nutrient consumed as a percentage of the amount recommended as established by the RDAs. Lane calculates NARs for nine nutrients: food energy, protein, calcium, iron, vitamin A, vitamin C, thiamin, riboflavin, and niacin for households in rural California. Davis and Neenan calculate NARs for protein, calcium, iron, vitamin A, and vitamin C for households located in central Florida.

Johnson, Burt, and Morgan employ the 1977–78 USDA Nationwide Food Consumption Survey (1977–78 NFCS) to focus on the influence of participation in the FSP on dietary quality. They provide evidence to indicate that participation in the FSP positively affects dietary quality. Huffman, using the spring portion of the 1977–78 NFCS together with probit and logit analysis, finds that participation in the WIC program is positively associated with the attainment of nutritionally adequate diets. Lane finds that participation in the FSP and the Food Distribution Program are key factors of dietary quality. Davis and Neenan provide evidence to indicate that participation in the FSP and the Expanded Food and Nutrition Education Program are important determinants of nutritional status.

As well, it is of interest to identify economic and demographic factors which may affect dietary quality so as to determine target groups for food policy programs. Huffman for instance identifies and assesses economic and demographic factors associated with attaining nutritionally adequate diets. Key factors include race and food expenditures per adult equivalent as well as age, sex, and education of the household head. Blanciforti, Green, and Lane, using the dietary component of the second year of the 1972–73 Consumer Expenditure Survey conducted by the Bureau of Labor Statistics (BLS), examine the demand for relatively more versus relatively less nutritious food, as defined by nutrient-to-calorie density ratios, for seven stages of the life cycle. They recommend the use of nutrition education as a policy tool to improve the nutritional quality of diets.

Demand for Specific Nutrients

It is necessary to determine the effects of various economic and sociodemographic variables on demands for nutrients as well as on the incidence of nutrition risk. Knowledge of factors which influence nutrition demands is useful in the design and implementation of programs to promote improvements in nutri-

Table 1. Selected Studies Pertaining to the Demand for Specific Nutrients

Researcher(s)	Data Set[a]	Nutrients Considered[b]	Food Assistance Programs Considered[c]	Socio-Demographic Factors Considered
Price et al.	Washington State Children	10: Th, Rb, Ni, FE, Pr, Ca, Ph, Iron, VA, VC	FSP, NSBP, NSLP	Household Size, Region, Urbanization, Ethnicity
Akin, Guilkey, Popkin	1977–78 NFCS (Basic Sample) School-Age Children	5: FE, VB_6, Iron, VA, VC	NSLP	Urbanization, Income, Household Size, Race, Ethnicity
Chavas, Keplinger	1977–78 NFCS (Spring Portion)	12: FE, Pr, Ca, Th, Iron, Rb, VB_6, VB_{12}, VC, Ph, VA, Ni	FSP, NSLP, NSBP, WIC, Group Meals for the Elderly	Income, Ethnicity, Education, Household Size, Race
Scearce, Jensen	1972–73 BLS, CES	9: FE, Pr, Ca, Iron, VA, VB_1, VB_2, Ni, VC	FSP	Education, Urbanization, Income, Lifecycle Stage, Race, Household Size
Devaney, Fraker	1980–81 Cross-Sectional Survey of Students, 1980–81 Household Survey of Parents	7: FE, Chol, VB_6, VA, Iron, Ca, Mg	NSBP	Race, Ethnicity, Education, Employment Status, Region, Household Size, Urbanization
Basiotis et al.	1977–78 NFCS (Low Income)	8: Iron, Pr, Ca, FE, Rb, Th, VC, VA	FSP	Household Size and Composition, Urbanization, Race, Income, Region

[a] NFCS = U.S. Department of Agriculture Nationwide Food Consumption Survey. BLS, CES = Bureau of Labor Statistics, Consumer Expenditure Survey.
[b] FE = Food Energy, Pr = Protein, VA = Vitamin A, VB_1 = Vitamin B_1, Th = Thiamin, Ca = Calcium, VC = Vitamin C, VB_2 = Vitamin B_2, Rb = Riboflavin, Ph = Phosphorus, VB_6 = Vitamin B_6, Chol = Cholesterol, Ni = Niacin, Iron = Iron, VB_{12} = Vitamin B_{12}, Mg = Magnesium.
[c] FSP = Food Stamp Program, NSBP = National School Breakfast Program, NSLP = National School Lunch Program, WIC = Women, Infants, and Children Program.

tion as well as to make current programs more effective and efficient.

A typical model of demand for specific nutrients resembles the Engel function. The formulation is as follows:

(1)
$$N_{ki} = \alpha_k + \beta_k Y_i + \delta_{k1} Z_{1i} + \delta_{k2} Z_{2i} + \dots + \delta_{kg} Z_{gi} + \phi_{k1} X_{1i} + \phi_{k2} X_{2i} + \dots + \phi_{kh} X_{hi} + \epsilon_{ki},$$

where N_{ki} corresponds to the intake of nutrient k by individual i or household i; Y_i corresponds to the income level of the ith economic agent (individual or household); $Z_{1i}, \dots, Z_{gi}$ constitute a set of binary variables that denote participation in various government food assistance programs by the ith economic agent; and $X_{1i}, \dots, X_{hi}$ refer to a set of sociodemographic factors.

Considerable literature exists on links between nutrition and income. The effectiveness of income transfers to alleviate nutritional deficiencies varies across countries. Timmer and Alderman, using household budget data from Indonesia, examine the determinants of demand for calories in order to develop food policy recommendations. They suggest that with stable prices, income redistribution may improve the nutritional status of the population. Similarly, Pinstrup-Anderson and Caicedo, using household survey data from Cali, Colombia, find that income redistribution may increase the demand for calories and protein at low income levels. On the other hand, Adrian and Daniel, using data from the 1965–66 USDA Household Food Consumption Survey, provide evidence to indicate that nutrient consumption in the United States, where a far higher proportion of the population has higher incomes, is not typically responsive to income.

Selected studies pertaining to the demand for specific nutrients are exhibited in table 1. Demand models for nutrients are typically used to predict the nutrient intakes of individuals, given anthropomorphic, economic, and sociodemographic characteristics. In order to investigate the nutritional achievement of individuals, NARs may then be calculated. In this way, the construction of demand models for nutrients leads to assessment of dietary quality. In addition, the construction of the models permits analyses not only of the impacts of various government programs but also of sociodemographic factors on levels of nutrient intakes.

Cross-sectional data sets are used in the various selected studies. Except for the study by Price et al., the respective data sets pertain to national samples, typically from the 1977–78 NFCS. Common nutrients considered are food energy, iron, vitamin A, vitamin C, and calcium. Government programs frequently considered are the FSP, NSLP, and NSBP. In most instances, evidence exists to indicate that participation in government food assistance programs leads to increases in the levels of nutrient intakes, *ceteris paribus*. Finally, sociodemographic factors most commonly employed in the models are income, household size, ethnicity, and urbanization. In many instances, the effects of the respective sociodemographic factors on nutrient levels are statistically significant, *ceteris paribus*. However, the influence of the sociodemographic variates varies (both direction and magnitude) across samples and model specifications.

Hedonic Price Models

Hedonic price and/or characteristics models are very attractive in analyses pertaining to nutrition issues. The principal product from such models is the assessment of marginal monetary values of nutrients.

The hedonic function is typically similar to the following:

$$(2) \qquad P_i = \alpha_i + \sum_j \gamma_{ij}\eta_{ij} + V_i,$$

where γ_{ij} is the marginal implicit price of the jth nutrient and/or dietary component, η_{ij} is the amount of nutrient and/or dietary attribute j associated with a unit of product i, and P_i is the price of product i (Eastwood, Brooker, and Terry; Morgan; Morgan, Metzen, and Johnson; Huffman). For each product consumed, the price paid by the consumer equals the sum of marginal monetary values of the characteristics of the product. The marginal monetary value of each characteristic equals the quantity of the characteristic obtained from the marginal unit of the product consumed multiplied by the marginal implicit price of the characteristic.

On the basis of the model, it is possible to determine how much the consumer is willing to pay say, for example, the removal of one gram of fat or how much to pay for the inclusion of one gram of protein. Morgan, Metzen, and Johnson use this model to determine a set of hedonic prices for the nutritional characteristics of breakfast cereals. Eastwood, Brooker, and Terry; Ladd and Suvannunt; Huffman; and Capps employ the hedonic price function to determine a set of marginal monetary values for 7, 8, 13, and 14 nutrients, respectively.

Hedonic prices for nutrient elements from the studies of Eastwood, Brooker, and Terry; Huffman; and Capps are exhibited in table 2. The selection of these studies rests on the fact that the 1977–78 NFCS is the common data base. Huffman; and Eastwood, Brooker, and Terry use the spring portion of the survey, while Capps uses all seasons from the survey. Little similarity exists, except for perhaps protein and iron, among the estimates of various nutrient characteristics. To illustrate, according to Huffman (Capps), the consumer is willing to pay 1.954¢ (.968¢) for the removal of one gram of fat; yet according to Eastwood, Brooker, and Terry, the consumer is willing to pay .248¢ for the inclusion of one gram of fat. For protein, according to the results of these three studies, the consumer is willing to pay roughly .44–.65¢ for the inclusion of one gram, and for iron, the consumer is willing to pay .29¢ for the removal of one milligram.

The consideration of nutritional elements in demand analyses is not a straightforward issue. Usually, the representative consumer does not possess much information in regard to the nutritional content of foods. Moreover, nutritional factors are not necessarily independent of one another; for example, fat and calories are highly correlated. Also, although it may be desirable to increase iron but simultaneously decrease cholesterol in the diet, particular foods (notably red meat) are excellent sources of both iron and cholesterol.

Nevertheless, the key assumption is that consumers care about the nutritional characteristics of food. To quote LaFrance,

> even if consumers do not compute or calculate at the margin the values of obtaining an additional microgram of vitamin B_6, for example, they are undoubtedly aware of health and nutritional needs in general. Even if con-

Table 2. Hedonic Prices in Cents per Unit for Nutrient Elements of All Food from Selected Studies Using the 1977-78 NFCS

Nutrient	Eastwood, Brooker, and Terry	Huffman	Capps
Food Energy (¢/cal)		0.052*	0.132*
Protein (¢/gm)	0.440*	0.439*	0.648*
Carbohydrates (¢/gm)	0.021*		−0.547*
Fats (¢/gm)	0.248*	−1.954*	−0.968*
Calcium (¢/mg)		−0.003	0.026*
Phosphorus (¢/mg)		−0.068	−0.027*
Iron (¢/mg)		−0.285	−0.290*
Magnesium (¢/mg)		0.035*	0.102*
Thiamin (¢/mg)		−103.150*	−25.259*
Niacin (¢/mg)		13.842*	2.933*
Riboflavin (¢/mg)		−0.303	−9.913*
Vitamin A (¢/IU)	−0.002*	−0.003	0.003*
Vitamin B_6 (¢/mg)		−36.219*	−13.044*
Vitamin B_{12} (¢/mg)		8.230*	0.324*
Vitamin B (¢/mg)	2.335*		
Vitamin C (¢/mg)	0.165*	0.365*	0.175*
Minerals (¢/mg)	0.012*		

Note: Asterisk indicates statistical significance at the .01 level; NFCS = U.S. Department of Agriculture Nationwide Food Consumption Survey; cal = calorie; gm = gram; mg = milligram; IU = International Unit.

sumers are not fully aware of the actual levels of various nutrients in each food item, it remains a biological fact that certain vitamins, minerals, protein, carbohydrates, and fatty acids are essential to the continued survival and health of the human body. (p. 3)

Attitudes and Information About Health and Nutrition

Use of attitudinal variables and information about health and nutrition in demand analysis is fragmentary.

National consumer attitudinal research appears to support the opinion that consumers prefer leaner beef (Yankelovich, Skelly, and White). Several studies have been conducted recently to examine consumer attitudes and preferences toward beef. Branson et al. examine the effects of different degrees of leanness on consumer demand. Skaggs et al. and Menkhaus et al. analyze the potential of marketing branded, low fat, fresh beef. The results of these studies indicate that: (*a*) consumer health concerns are evident in regard to the ingestion of animal fats, (*b*) consumers are willing to compromise on taste for a product that is perceived to be more healthy, and (*c*) health related factors influence the decision to purchase leaner meats. A study prepared by Decision Center, Inc., for the American Meat Institute focuses on the awareness and usage of the lean brand of beef offered by Giant Foods, Inc., a chain located in the Baltimore-Washington area. This particular brand is popular with female customers who are employed and under 40, who have children, and who are concerned about health and nutrition.

Capps, Moen, and Branson focus attention on consumer willingness to try lean meat products from a retail food chain in Houston. Via probit analysis, using survey data elicited by telephone, they provide empirical evidence that fat-conscious consumers (consumers with a predisposition toward buying low-fat foods), are more likely to try lean meat products than nonfat-conscious consumers, *ceteris paribus*.

The role of nutrition and health information has been a focus in several studies of consumer food choices. For example, Stokes and Haddock find that exposure to nutrition information and instruction on its use increases purchases of "nutritious" food. Schutz, Judge, and Gentry discuss the importance of nutrition, brand, and sensory attributes to purchases of several foods.

Putler as well as Brown and Schrader investigate the effect of cholesterol information on egg consumption. Putler models the effects of cholesterol information in a demand relationship for eggs via a nonlinear time specification corresponding to a diffusion process. The reason for this diffusion process rests on the premise that health information is unlikely to be received by all consumers instantaneously. Instead, this information diffuses through the population over time. On the basis of this diffusion model, Putler augments the traditional set of Marshallian demand equations via a nonlinear trend variable of the form,

$$\frac{\exp[(B + \alpha)T] - 1}{\exp[(B + \alpha)T] + B/\alpha}. \tag{3}$$

The variable T is $\{(t - t^*) + (t + t^*)\}/2$, where t is the current period and t^* is the time at which cholesterol information begins to affect consumption. Using quarterly time-series data from 1960 to 1985, the hypothesis that health information has no effect on shell egg consumption is rejected. On the basis of the diffusion model, the beginning of the health information effect on shell egg consumption is the second quarter of 1969, and the full impact of the health information is achieved by the fourth quarter of 1980.

Brown and Schrader construct a cholesterol information index to estimate the effect of cholesterol information on egg consumption. This index is based on a running total of the number of articles available to the medical profession. Each article supporting the linkage between cholesterol and heart disease adds one unit to the running total (lagged two quarters) and each article refuting the linkage subtracts one unit. Brown and Schrader, using quarterly time-series data from 1955 I to 1987 II, augment the typical Marshallian demand relationship for eggs via the inclusion of the cholesterol information index. Adjustments are also made for seasonality as well as the percentage of women in the labor force. Results from this study indicate that, *ceteris paribus,* information on the links between cholesterol and heart disease decrease per capita shell egg consumption.

Chang and Kinnucan expand the Brown and Schrader index to include those articles available not only in the United States but also in Canada. Using a variation of the AIDS model to capture demand interrelationships for butter, margarine, shortening oils, and salad oils in Canada, they conclude that over the period 1973 II to 1986 III cholesterol information negatively impacted butter consumption but positively impacted salad oil consumption, *ceteris paribus.*

In sum, current knowledge pertaining to nutrition and health determinants of food demand centers on the assessment of dietary quality, the estimation of nutrient demand relationships, the estimation of hedonic price models, and the use of attitudinal variables and information about nutrition and health in demand relationships.

Theoretical Framework

The purpose of this section is to describe a theoretical framework to measure the impact of health and nutrition information on the demand for food products. To motivate this theoretical development, consider the issue of structural changes in domestic demand. To quote Purcell

> changes in prices of competing meats such as pork and poultry cannot explain the dramatic drop in inflation-adjusted beef prices since 1979 . . . it is difficult to accept that there has been no structural change in beef demand or that any shifts in beef demand can be explained by changes in prices of other products. (pp. 18–19)

A plethora of studies by agricultural economists exists with regard to structural change in the demand for meat products (see for example, Chalfant and Alston; Haidacher et al.; Nyankori and Miller; Braschler; Chavas; Martin and Porter; Choi and Sosin; Moschini and Meilke; Dahlgran; Eales and Unnevehr; Goodwin). The various studies typically employ econometric procedures such as switching regression models; time-varying parameter models; Farley-Hinich and Harvey-Collier tests; Chow tests; CUSUM and CUSUMQ tests, which rely on recursive estimates and recursive residuals; and nonparametric approaches (compliance or noncompliance to weak and strong axioms of revealed preference) to ascertain the existence or nonexistence of structural change. Although the evidence is far from unanimous, structural change appears to exist in the demand for meat products. The nonconsensus of empirical results is attributable to alternative approaches in model development as well as to differences in data and econometric and inferential procedures. Further, information about saturated fats and cholesterol in the diet appears to be the major explanation for structural change, albeit other reasons include unprecedented economic shocks in the 1970s, increases in participation in the labor force by women, and changes in income distribution, age distribution, and racial composition.

Assessing structural change in demand relationships is indeed very difficult. Evidence of structural change is a direct consequence of changes in the underlying utility function, a construct not directly observable. Since the utility function is not observable, structural change is usually analyzed through the use of Marshallian demand functions. Analyses of structural change subsequently rest on departures from constancy of parameters of the corresponding demand functions. However, demand parameters may vary not only because of structural change but also due to model misspecification. The bottom-line implication from this discussion is the following—it is necessary to formally investigate the sources of structural change. Consequently, the ideal approach is the identification and use of variables that may explain shifts in the utility function. To illustrate, Unnevehr employs a measure of change in income distribution in demand model specifications for meat products.

In this light, the theoretical framework in this article, to formally consider health and nutrition information, is similar to the work of Basmann in conjunction with consumer demand with variable preferences. The utility function can be expressed as

$$U_t = U(q_t; \theta(r_t)), \tag{4}$$

where $\theta(r_t)$ reflects consumer preferences for the commodity vector, q_t. The vector, r_t represents exogenous state variables, similar to those in the Houthakker-Taylor state adjustment model. The state variables correspond to stock of knowledge, psychological stock of habits, or physical stock of goods. With this framework, by assumption, the formulation of consumer preferences rests in part on information about the characteristics of q_t.

In the case of health and nutrition, the vector r_t may consist of scientific information pertaining to cholesterol, sodium, dietary fiber, or saturated fats. The key assumption is that changes in scientific information about health and nutrition factors (r) in time t lead to changes in the commodity vector, q_t, which in turn gives rise to changes in the parameters of the utility function. The parameters of utility functions are dependent on particular variables to account for changes in tastes and preferences. Subsequently, maximization of $U_t = U(q_t; \theta(r_t))$ with respect to q_t, given r_t, under classical conditions, yields Marshallian demand functions of the form

$$q_t = q_t(y, p; \theta(r_t)). \tag{5}$$

Consumer demand relationships depend not only on prices and income but also state variables. This framework is not inconsistent with the concept of the information-augmented quantity vector of market goods put forward by Choi and Sosin. Importantly, this framework may also apply to the assessment of information in regard to either food safety (Smith, van Ravenswaay, and Thompson; Swartz and Strand) or advertising (Chang). In particular, in consideration of issues of food safety, the perception of the quality, $\theta(r_t)$, of a good by the consumer, by assumption, affects the utility function. This perception of product quality depends on information, r, available to consumers. Demand may decline (rise) in direct fashion with the extent of "negative" ("positive") media coverage, because such coverage leads to adjustments in consumer perceptions of product quality. Chavas suggests that the issue of cholesterol and fat in meat demand be considered as a problem of product quality. In accord with household production theory, the exogenous release of information regarding saturated fat intake and heart disease may alter beliefs by consumers about the ability of red meats to provide the fundamental good "good health."

While theoretically attractive, typically data limitations prevent the implementation of this approach. For example, although health and nutrition concerns are prime candidates as sources of structural change, generally data are lacking to permit tests of such hypotheses. Because of data limitations, previous empirical studies capture the impacts of health and nutrition information on demand relationships via the use of trend variables (Putler; Brown; Hamilton; Schuker; and Shulstad and Stoevener). However, according to Kmenta (p. 568), "The term 'trend' is always a camouflage for factors that change over time, and it would certainly be preferable if these factors could be identified and measured."

Further, according to Basmann,

> In econometric demand analysis, the introduction of time as an independent trend variable to "explain" the effects of changes in taste is at best an expedient it would be better to avoid, if possible, since trend parameters are not capable of causal or legal interpretation. (p. 48)

As well, to quote Chalfant and Alston,

> Whether a parametric or nonparametric approach is used, there is often a lack of data about the nature of

the structural change, and the alternative hypothesis is usually no more specific than that the null hypothesis is incorrect. It would be preferable to incorporate directly the determinants and the nature of the hypothesized structural change in a more specific alternative hypothesis. For example, proxies for increased health consciousness could be included. However, problems arise because of the number of possible influences, the lack of adequate data, and the uncertainty about the manner in which they might affect demands. (p. 397)

Nevertheless, Stigler and Becker appeal to economists to augment their models to account for changes in demand relationships. Perhaps the best example of this approach, at least with regard to health and nutrition information, is the work of Brown and Schrader.

Empirical Application

Brown and Schrader suggest the use of the cholesterol information index variable in demand equations for red meat and poultry. In particular, to account for demand interrelationships among meat products, the next section rests on a systems analysis, the use of a Rotterdam model, to investigate simultaneously the impacts of prices, total expenditure, and cholesterol information on the consumption of beef, pork, poultry, and fish.

The representation of the traditional Rotterdam model, the starting point for this analysis, is as follows:

$$(6)\quad w_{it}^*Dq_{it} = \alpha_i + b_i\left[D_{yt} - \sum_k w_{kt}^*Dp_{kt}\right] + \sum_j c_{ij}Dp_{jt} + \epsilon_{ij}, \qquad i, j, k = 1, \ldots, n,$$

where

$$(7)\quad Dq_{it} = \ln[q_{it}/q_{it-1}],\quad Dp_{jt} = \ln[p_{jt}/p_{jt-1}],\quad Dy_t = \ln[y_t/y_{t-1}],$$

and

$$w_{it}^* = \tfrac{1}{2}(w_{it} + w_{it-1}).$$

The Rotterdam model is a directly specified demand system. Chang and Kinnucan employ a variation of the AIDS model in consideration of the impact of cholesterol information on the consumption of fats and oils in Canada.

The term w_{it}^* corresponds to a two-period moving average of the average budget share of the ith good in period t and Dq_{it}, Dp_{jt}, and Dy_t correspond to the natural logarithm of the ratio of q_{it} to q_{it-1}, p_{jt} to p_{jt-1}, and y_t to y_{t-1}, respectively. In short, D represents the log difference operator. The parameter b_i corresponds to the marginal budget share of the ith good and the parameter c_{ij} corresponds to the compensated cross-price elasticity of good i with respect to the price of good j weighted by the budget share for the ith commodity.

To insure symmetry and homogeneity, classical restrictions from utility maximization, as well as adding up, it is necessary to employ the following constraints:

(8) Symmetry

$$c_{ij} = c_{ji},$$

Homogeneity

$$\sum_j c_{ij} = 0 \ \forall_i, \text{ and}$$

$$\left.\begin{array}{l}\sum_i b_i = 1\\ \sum_i c_{ij} = 0\end{array}\right\}\text{Adding up}$$

Formally to consider health and nutrition information (specifically in this instance cholesterol information), it is necessary to modify the Rotterdam model as follows:

$$(9)\quad w_{it}^*Dq_{it} = \gamma_i\ln(CHOL_{t-l}) + b_i\left[Dy_t - \sum_k w_{kt}^*Dp_{kt}\right] + \sum_j c_{ij}Dp_{jt} + \epsilon_{it}.$$

$CHOL_{t-l}$ corresponds to the cholesterol index developed by Brown and Schrader. The symmetry and homogeneity conditions are the same as in the traditional specification, but it is necessary to add a constraint to the adding-up conditions, namely $\sum_i \gamma_i = 0$. The intercept term α_i in equation (6) corresponds to a time trend. In equation (9), the time trend is replaced by the natural logarithm of the cholesterol index.

Annual data over the period from 1966 to 1988 from the USDA series *Food Consumption, Prices, and Expenditures* constitute the source of economic information in this exercise. The per capita consumption figures (q_{it}) are on an edible-weight basis; the price series, from *Livestock and Poultry Situation and Outlook* and unpublished data from the U.S. Department of Commerce, correspond to nominal retail prices ($/pound) for the respective

Table 3. Structural Parameter Estimates and Associated *t*-Statistics of the Rotterdam Model

Dependent Variable	Cholesterol Information Index	Meat Expenditure	Prices: Beef	Prices: Pork	Prices: Poultry	Prices: Fish	R^2	DW
Beef	−.000219	.3675*	−.1458*	.0966*	.0415*	.0077	.488	1.935
	(−0.52)	(3.39)	(−3.74)	(2.87)	(2.28)	(0.38)		
Pork	−.000884*	.5327*		−.1271*	.0130	.0175	.726	1.743
	(−2.05)	(4.83)		(−3.38)	(0.78)	(1.00)		
Poultry	.000892*	.0527			−.0504*	−.0042	.362	1.230
	(5.02)	(0.68)			(−2.31)	(−0.23)		
Fish	.00021*	.0471				−.0224*	.298[b]	1.872[b]
	(1.75)[a]	(1.50)[a]				(−1.36)[a]		

Note: Asterisk indicates statistical significance at the .10 level. The omitted equation is Fish.
[a] Based on variance-covariance matrix of parameter estimates.
[b] Based on parameter estimates of the fish equation.

products. The data pertinent to this analysis are available from the authors upon request. Data on cholesterol information are available from Brown and Schrader. This information is available on a quarterly basis, but to be consistent with annual price and quantity data, the cholesterol variable is put on an annual basis.

To estimate the parameters of this demand system, this study employs the iterative Zellner estimation (IZEF) procedure. The IZEF procedure assures the large-sample properties of consistency and asymptotic normality of the estimated coefficients so that conventional tests of significance are applicable. The level of significance chosen is .10.

The equations are assumed to have additive disturbance terms. Because of the adding-up constraint, only three of the equations are independent. Under this condition, the usual estimation procedure, followed in this study, has been to drop one of the equations, estimate the remaining system, and calculate the parameters in the omitted equation using the classical restrictions (Barten). The IZEF procedure produces parameter estimates invariant to the choice of the deleted equations as long as the disturbance terms possess the classical properties. The omitted equation in this study corresponds to fish consumption.

The structural parameter estimates and associated *t*-statistics of the modified Rotterdam model are exhibited in table 3. The goodness-of-fit statistics range from .298 to .726. No evidence of serial correlation is evident in any of the equations.

In the beef and pork equations, the coefficients associated with the cholesterol information index variable are negative. Yet only in the pork equation is this coefficient statistically different from zero. In the remaining equations, the corresponding coefficients associated with the cholesterol index are not only positive for poultry and fish, *ceteris paribus,* but also they are statistically different from zero. Consequently, there exists sample evidence to indicate that cholesterol information, with a half-year lag, is a statistically significant determinant in the consumption of pork, poultry, and fish.

Key determinants of meat consumption are unequivocally own prices. Cross-price effects are important for beef and pork as well as for beef and poultry. Total meat expenditure is a statistically significant factor in the demand relationships for beef, pork, and fish but not in the demand relationships for poultry.

Compensated own-price and cross-price elasticities as well as expenditure elasticities from the Rotterdam model are exhibited in table 4. All compensated own-price elasticities are negative, in agreement with theory. The compensated cross-price elasticities are positive, indicating that the various meat products are substitutes except for the cross-price elasticities of poultry with respect to fish and vice versa.

The beauty of the empirical application lies in the ability to test directly the hypothesis that health and nutrition information affects consumption patterns of meat products. Indeed, it is important to consider alternative demand

Table 4. Compensated Own-Price Elasticities, Cross-Price Elasticities, and Expenditure Elasticities from the Rotterdam Model

	Beef	Pork	Poultry	Fish	Total Meat Expenditure Elasticity
Beef	−.3573	.2367	.1017	.0188	.9003
Pork	.3426	−.4510	.0462	.0621	1.8891
Poultry	.1784	.0560	−.2165	−.0179	.2267
Fish	.1001	.2275	−.0542	−.2733	.6094

systems to ascertain the sensitivity of the results to functional form. However, the results from this exercise suggest that at least the issue of the importance of health and nutrition information on the demand for food products is open to further study.

Issues

Data Needs

First, to employ the theoretical framework previously discussed, it is necessary to obtain data on health and nutrition information available to consumers and/or attitudes of consumers toward health and nutrition. In general, at present, such information is lacking. Although a cholesterol information index is currently available over time, additional information indices are needed pertaining to other nutrients, for example, dietary fiber, sodium, saturated fat, monounsaturated fat, and polyunsaturated fat. With such indices, it may be possible to identify and assess more generally the role of health and nutrition information on the demand for specific food products.

It is meritorious to consider attitudinal variables in demand analyses in addition to the traditional economic factors. This information is best garnered from individual consumers, not from aggregate time-series data. Along this line, Menkhaus, St. Clair, and Hallingbye provide empirical evidence to suggest that attitudes toward health-related factors including high fat content, high cholesterol, and high calories are key factors in the decision by consumers who purchase less roasts, steaks, and ground beef than previously.

To paraphrase Buse, those agencies and organizations designing and implementing expenditure surveys (e.g., USDA, BLS) must be encouraged to expand the scope of those surveys since to agricultural economists, they are perhaps the primary sources of data to conduct demand analyses. In fact, there exists movement in this direction. Beginning in 1989, the Continuing Surveys of Food Intake by Individuals (CSFII) includes a follow-up telephone survey to ask respondents about their diet and health knowledge. This situation represents the first time that a nationwide sample will be used to study the relationship between individuals' actual dietary intakes and their attitudes and knowledge about dietary behavior.

In the attempt to assess structural change in the demand for food, primarily meat products, empirical studies rely on the use of aggregated time-series data. Such data, however, are not typically amenable to revealing shifts in tastes and preferences due to health concerns. With aggregate time-series data, the characteristics of the definitional unit of consumption may not be the same over time. Of course, this problem may occur in cross-sectional studies as well, depending on the level of aggregation for the commodity. To illustrate, according to Baumer (p. 2), "A pound of pork consumed in 1986 is counted as the same as a pound of pork consumed in 1966. Today's hog is 50 percent leaner than the hog 25 years ago." As well, nutrient elements such as cholesterol, fat, salt, and food energy vary widely within and among aggregate product categories. At a minimum, improvements in disaggregated time-series information pertaining to the consumption of various products (e.g., sirloin, hamburger, roasts; ham, pork chops, bacon; specific types of finfish and shellfish; turkey; chicken) is needed.

Research Challenges

Research is needed to identify and assess non-economic variables (e.g., attitudinal variables) that may be important in explaining variations in the consumption of food products. In this light, it may be beneficial to agricultural economists to work jointly with psychologists, sociologists, nutritionists, and home economists in the consideration of such noneconomic variables.

Consumers receive information about nutrition and health from several sources: (*a*) doctors, nurses, other health professionals; nutritionists, dietitians, or home economists (people source); (*b*) radio, television, newspapers, magazines, books, government health organization publications, food company publications (media source); and (*c*) food packages or labels (package source). Research to assess the impacts of the source of nutrition and health information on food consumption, *ceteris paribus,* merits attention. This factor constitutes in essence a measure of the role of influencers on food consumption behavior. With the exception of the work by Ippolito and Mathios, studies to assess the impacts of sources of nutrition information on food expenditure or consumption patterns are lacking.

In conjunction with the issue of the role of influencers on food consumption behavior, new labeling proposals are under consideration by the federal government (Bacon). Few policy changes have been initiated since 1975 when nutritional labeling was originally implemented. Agricultural economists can play a pivotal role in addressing this issue. For instance, it is possible to update the work of Lenahan et al.: (*a*) to discover the labeling formation most acceptable to the consumer for presenting nutrition information; (*b*) to discover the outlet most used by the consumer for receiving nutrition information; (*c*) to identify the rate of perception, understanding, and use of nutrition information on labels; and (*d*) to determine the nature and importance of nonuse benefits (Padberg) of nutrition information as perceived by consumers.

The forthcoming 1987–88 NFCS contains information on 28 nutritional elements. Hence, with this survey, it will be possible to update studies in the assessment of dietary quality, the determination of demand for specific nutrients, and the construction of hedonic prices for nutrients. Of course, such efforts will require the use of interdisciplinary teams composed of nutritionists and agricultural economists. Furthermore, unlike previous USDA Nationwide Food Consumption Surveys, the 1987–88 NFCS contains information on saturated fat, monounsaturated fat, polyunsaturated fat, cholesterol, dietary fiber, vitamin A, carotenes, vitamin E, folacin, zinc, copper, sodium, and potassium. Therefore, the 1987–88 NFCS constitutes not only a rich source of nutrition information but also for particular nutrients a new set of information.

Additionally, with the 1987–88 NFCS, it is possible to determine whether or not individuals or households meet any of the seven dietary guidelines set forth by the USDA and the Department of Health and Human Services (DHHS) [(*a*) eat a variety of foods; (*b*) maintain desirable weight; (*c*) avoid too much fat, saturated fat, and cholesterol; (*d*) eat foods with adequate starch and fiber; (*e*) avoid too much sugar; (*f*) avoid too much sodium; and (*g*) if you drink alcoholic beverages, do so in moderation]. Attainment of a single guideline or multiple guidelines may also constitute alternative measures of diet quality. Consequently, it is possible to identify food use patterns conditional on the attainment or nonattainment of dietary guidelines, all other factors invariant. As well, issues in regard to the demographics of nutrition may be worthy of attention. For example, which population groups achieve nutritional or dietary guidelines? Also, are consumers who purchase convenience or formulated foods more or less likely to achieve the dietary guidelines? With the myriad of formulated foods in the marketplace, this latter question is unequivocally of interest. In fact, a paucity of economic and nutritional information exists pertaining to formulated foods. In the spirit of the works by Havlicek et al.; Capps, Tedford, and Havlicek; and Capps and Pearson, attempts to add to this sparse store of knowledge are worthy of consideration.

Research in this area will assist food production and marketing specialists, agricultural and consumer economists, food program administrators, food and nutrition educators, health professionals, and nutrition and economic researchers to better understand the nature of and reasons for household food selections. Ultimately, improvements can be made in the design and focus of education and assistance programs that have food, nutrition, and food money management components.

Joint efforts of agricultural economists with nutritionists and public health officials are of importance to the National Nutrition Monitoring System (NNMS). The NNMS covers federal nutrition monitoring activities, both in the USDA and the DHHS. Of interest to agricultural economists, the national monitoring of dietary status requires information on the nutrient content of food as well as food consumption. The sources for such information are the decennial food consumption surveys (1977–78 and 1987–88 NFCS) as well as the CSFII initiated in 1985. The CSFII provides information about dietary behavior between the decennial surveys. Opportunities exist for agricultural economists to use food and nutrient consumption information available from the NNMS to conduct analyses of food consumption and to target and develop food assistance and nutrition education programs.

Methodological Considerations

The incorporation of health and nutrition information into demand systems merits consideration. By using the method of translation (Pollak and Wales), parameters of either the cost or the demand functions may, by assumption, depend upon previous levels of health and nutrition information. This procedure is very similar to the work of Green in incorporating advertising effects into demand systems.

Also, scientific information about health and nutrition may be characterized by either geometric or polynomial distributed lag relationships. Polynomial distributed lag relationships may be incorporated in demand system models or single-equation models to formally determine the level of the effect of the information on the demand for the goods, when the information first begins to influence demand, the length of time before the information reaches the full effect on demand, and the time path of the effect of the information.

Finally, price and income elasticities may vary due to the available scientific information in conjunction with cholesterol. Via the use of single-equation models with random coefficients, it may be possible to determine if such information leads to changes in price and income elasticities.

Concluding Remarks

This article promotes the consideration of health and nutrition factors in analyses of food demand. Given the widespread attention on health and nutrition issues from the news media, food product labels, and from medical personnel, it is important for agricultural economists to identify and assess the effects of attitudes and information on the demand for food products. As well, agricultural economists, in a multidisciplinary fashion, play a role in the assessment of dietary quality, the determination of demand for specific nutrients, and the construction of hedonic price functions for nutrients. Research outcomes in these areas will lead to the development of appropriate food production distribution policies as well as to the development of more appropriate marketing practices (e.g., enforcement of food grades and standards as well as updating of food labeling requirements).

Effectiveness of public policies directed toward consumers, farmers, and various intermediaries in the food and fiber sector will increase with improvements in the understanding of the structural elements of food consumption and nutrient intakes. Estimates of food demand parameters are necessary in order to assess the impacts of alternative food, nutrition, and agricultural policies. The capability to adequately ascertain historical, current, and future patterns of food consumption is of extreme importance to both public and private actors in the food system.

Health and nutrition issues are not about to fade away. Almost every new product makes some sort of health or nutritional claim. Recent changes in domestic food use have given rise to questions by those involved in food production, processing, and marketing. For example, are concerns about nutrition and health behind the decline in dairy consumption and beef consumption and behind the rise of poultry and seafood consumption?

Designing foods to make them attractive to consumers is essentially a technological development. To be fully successful, this development must be guided by information that indicates how the resulting products will fare in the marketplace. Consequently, it is important to understand the role of economic and noneconomic demand factors. To not consider health and nutrition factors directly in demand analysis, or at least to account for them in some fashion, is not only myopic but also, in the words of Purcell, a failure by the discipline.

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