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Incorporating subsistence into hedonic price and nutrient demand models

Cristanna M. Cook

To the Graduate Council:

I am submitting herewith a dissertation written by Cristanna M. Cook entitled "Incorporating subsistence into hedonic price and nutrient demand models." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

David B. Eastwood, Major Professor

We have read this dissertation and recommend its acceptance:

Jean Skinner, John Brooker, Dan McLemore

Accepted for the Council:

Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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INCORPORATING SUBSISTENCE INTO HEDONIC PRICE AND NUTRIENT DEMAND MODELS

A Dissertation
Presented for the
Doctor of Philosophy
Degree
The University of Tennessee, Knoxville

Cristanna M. Cook

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ABSTRACT

Economic theory concludes that utility from the consumption of goods increases at a decreasing rate. This condition also applies to the characteristics model of consumer choice. However, most applications for food use hedonic price equations and nutrient demand equations that do not account for declining marginal utility. Another problem is that nutrient valuation studies have not considered the level of nutrient adequacy or status. In addition, nutrient consumption models have not accounted for the nutritional status of the consumer when trying to identify the variables that influence nutrient consumption.

Data from the 1977-78 Nationwide Food Consumption Survey were used to test for differing valuations of nutrients by subsistence, or nutrient status level. Nutrient status for each household was defined using the Nutritional Goals of the USDA Thrifty Food Plan.

Results showed that consumers below subsistence differ in the valuations of nutrients from those above. Households below the defined status level had higher marginal implicit prices for vitamin C and minerals than households above the defined subsistence level. This result is consistent with economic theory.

However, the undersubsistence group had lower implicit prices for B vitamins and food energy. In both instances vitamin A had negative implicit prices, which is not consistent with theory but does reflect low vitamin A diets in the United States.

Nutrient consumption analysis showed that in the undersubsistence or nutritionally at-risk households, having a working female household head was significantly and negatively related to nutrient consumption. This result was not found for households that had met their nutritional requirements. Food stamp bonus did not influence the consumption of nutrients for the most nutritionally at risk households but was significantly and positively related to nutrient consumption for marginally at risk households.

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CHAPTER 1

INTRODUCTION

In the Food and Agricultural Act of 1977, the U.S. Congress extended the purview of the government's intervention in food matters to consideration of adequate nutrition and nutrition-related food policy. Not only were policy concerns oriented toward the quantity of food produced and consumed but also toward the nutritional quality of food.

The quality and quantity of food consumed by a person (diet) determines that person's nutritional status, which is a major determinant of the well-being of the individual (National Academy of Sciences, 1986). Diet quality is measured in terms of the quantities of nutritional attributes contained in the foods consumed. A consumer's nutritional well-being depends upon his consumption in relation to his metabolism. Dietary needs vary by age and sex and are reflected in the Recommended Dietary Allowances (RDA for minerals, vitamins, calories, and protein). The first RDA for nutrients was published in the United States in the early 1940's (Harper, 1985).

The levels of nutrients present per unit of food are well defined for a wide range of foods in the United States. Separate nutrient analyses have been established for several

other countries because food systems differ greatly by country (Sanjur, 1982). Since 1936, the United States Department of Agriculture (USDA) has conducted national food consumption studies at about ten year intervals to provide information on the types and amounts of foods eaten by a sample of the U.S. population. The Nationwide Food Consumption Surveys (NFCS) are used to infer nutrient well-being for the society.

With increased media and government focus upon good nutrition, consumers have become more aware in recent years of the importance of the nutritional content of their food consumption (Pao, 1981). Recent work has shown that consumers do consider nutrition in their decision making (Rudell, 1979; Frick, Herrmann, and Warland, 1986). An important economic consideration with respect to food demand is to develop a model that incorporates nutrients in a way that reflects the consumer unit's decision making. Consumers choose foods because they derive utility or satisfaction from them. Satisfaction can be defined in terms of the value of a good to the consumer.

Consumer Value and Nutrient Analysis

How the value of any good or service is determined comprises a large part of the theory of economics and usually is analyzed using the traditional demand and supply

tools. Factors that impart value have been defined through the past 200 years by economists such as Smith, Bentham, Dupuis, Gossen, Ricardo, Jevons, and Hicks, just to name a significant few (Stigler, 1950).

Consumer satisfaction was assumed to be derived directly from the quantities of purchased market goods. The concept of marginal utility was paramount in this demand-side analysis. The famous historical argument between the importance of value in use and value in exchange was a demand side argument that was eventually laid to rest by the marginalists who explained why some goods became "priceless" in terms of the marginal utilities associated with those goods. The change in total utility due to a small change in consumption determined the value of the good from the demand side.

The thesis that a market good generates utility directly was not challenged until more recent times. An alternative thesis is that the physical properties of a good (attributes or characteristics) are the sources of utility. This characteristics model approach leads to a situation in which the consumer's valuation of a good (such as food) can be shown to be a function of the quantities of characteristics the item contains and that person's valuation of those attributes.

Economic models of consumer demand start with a functional representation of consumer satisfaction or utility subject to constraints that are supposed to represent the mental calculus used by the consumer as he identifies needs, searches for alternatives, and makes appraisals of alternative goods that may satisfy his needs. Through the maximization of utility subject to the resource constraint, the economist can derive the consumer's demand for a good. The arguments in the traditional utility function are the quantities of goods consumed, and the arguments in the demand function are prices of goods and income. If the economist expands the analysis beyond the representative consumer, then the arguments of the demand function are extended to include sociodemographic variables which proxy the cultural and ethnic backgrounds that define the consumer's value system, including the assessment of the quality, performance, and perceived need for a good or service.

If characteristics generate utility, then the arguments in the utility function of the consumer should be replaced with them. Maximizing this utility function subject to the budget constraint and consumption technology, which transforms goods into characteristics, leads to the demand for attributes. Included in the demand for attributes are the implicit hedonic prices, or the person's valuations of

the attributes that generate utility. If nutrients generate utility, the hedonic prices used in the demand for nutrient equations are estimated by regressing product price on the various nutrient components in the foods consumed.

A major difficulty of characteristic theory applied to food consumption is that inferences drawn from empirical work suggest that implicit price coefficients have minor impacts on the estimates of the demand for nutritional attributes (Terry, 1985). Other factors besides the nutrient components such as model specification and omitted variables can affect the analysis (Terry, 1985).

An Alternative Functional Representation in Nutrient Demand Analysis

Lancaster (1971), building on the work of Stigler (1945) developed a characteristic model with an application to nutrient demand analysis. Stigler had attempted to find the least cost subsistence diet for the consumer. He did this by finding the set of foods that would provide the 1945 RDA for nutrients at least cost. Lancaster's model also provided a solution for finding the most efficient set of foods. However, the consumer makes his decision based upon the nutrient qualities directly. The emphasis was not on the quantity of foods, but rather on their nutritional composition.

In addition, Lancaster hypothesized that at low income levels, the consumer would likely be interested in obtaining the most nutrients per dollar. As income increases, nutrient values are of less importance. Utility increases at a decreasing rate beyond the level of subsistence. Lancaster's analysis touched on the idea that there is a basic subsistence level, and this level differs by consumer characteristics such as income.

The nutrient demand model may be a better approximation of the real world in explaining consumer purchases if it incorporates a basic nutritional level of subsistence. Consumers purchase minimum amounts of food in order to at least obtain a subsistence level of nutrition. Utility may be derived from nutritional levels in excess of the subsistence level. The concept of a base or subsistence food level refers to the quantity and variety of foods that allow a person to carry out the normal bodily functions, given the daily demands on his energy use. When subsistence is used in a consumer demand model, the implication also is that consumers are cognizant of the need for a base nutrition level.

Klein-Ruben (1947) first incorporated the notion of subsistence in a utility function. In their derivation of a true cost of living index, they assumed a linear expenditure function in expressing the cost of living index in

terms of prices and properties of the specified demand function. The interpretation of the Klein-Ruben utility function and the associated linear expenditure (demand) system was given by Samuelson (1947). The consumer is assumed to buy a necessary or subsistence set of goods. Any income left over after buying the necessary set of goods is spent on all commodities in fixed budget shares. This level of income spent on nonsubsistence goods is called supernumerary income.

Although the original Klein-Ruben utility function and associated linear expenditure (demand) system are expressed in terms of quantities of goods, the arguments of the function could be characteristics rather than quantities of goods. Thus, it is possible to model demand for nutrients incorporating a subsistence level of nutrient use.

Defining Subsistence

Researchers have attempted to place values on the nutrition components without separating out a base level of subsistence (e.g., Adrian and Daniel, 1977; Morgan, 1979; Eastwood, Gray, and Brooker, 1986; Ladd and Suvannunt, 1976; LaFrance, 1986; Hager, 1987; Terry, 1985; Morse, 1988). The literature presents six different methods for defining subsistence:

1) cost minimization based on foods purchased and consumed by the household, without incorporating nutrient adequacy standards,

2) a probability density function based upon individual dietary intake that develops an alternative to the RDA as a standard,

3) the USDA-constructed Thrifty Food Plan that incorporates fixed expenditure levels of foods purchased and consumed by the household and nutrient adequacy standards,

4) attitude scales that measure importance of physiological need in Maslow's need hierarchy and the relationship to food intake,

5) a switching regression methodology used to measure different need levels of individual dietary intakes without incorporating a nutrient adequacy standard, and

6) a 21-meal-at-home equivalent person measure adjusted for nutritional adequacy level with foods purchased and consumed by the household.

Each way of defining subsistence has advantages and disadvantages. These are explained in this study.

Objectives of the Study

The specific objective of this study is to develop a characteristics model of consumer demand that incorporates

the utility derived from nutrients above their respective subsistence levels. This objective will be fulfilled by:

1) considering alternative ways of incorporating subsistence and choosing the most appropriate method,

2) incorporating subsistence into the characteristics model and deriving the behavioral implications,

3) estimating the hedonic prices and the nutrient demand equations with the new characteristic model, and

4) evaluating the results and stating the policy implications from the estimates.

The characteristic model used is an adaptation of that developed by Ladd and Suvannunt (1976) and extended by Terry (1985). After implicit prices are estimated, these prices can be used as arguments in the nutrient demand equations along with sociodemographic variables. However, existing studies often estimate nutrient consumption functions and do not include implicit prices in the model. Based upon the existing literature, the following demographic variables may be used: household income, number of members in the household, race, education, development stage of the family unit, employment status, urbanization, and geographic area.

CHAPTER 2

LITERATURE REVIEW

There are many approaches to understanding the consumer's decision making process. The following literature review describes those approaches appropriate for the model of consumer choice developed in the present research.

The Consumer Decision Process

The process of using a commodity to meet a consumer's needs and desires is a type of problem solving (Burk, 1968). Process implies a sequence of connected behaviors toward an end. These behaviors in the consumer decision process are identification of a need, search for alternatives to meet that need, and appraisal of the defined alternatives (Gartner, Kolmer, and Jones, 1960). A host of factors influences the consumer decision process (Burk, 1968). This is particularly true for food consumption. Studies have shown how differing consumer characteristics affect the consumer information process of including nutrition information in food choice (Jacoby, Chestnut, and Silberman, 1977; Lenahan, Thomas, Taylor, Call, and Padberg, 1973; Klopp and MacDonald, 1981).

There is consensus among the various studies showing the consumer's desire for nutrition information is high. This desire has been represented through willingness to pay measures as well as simple self-report data on the desirability of having nutrition information. The Lenahan et al. (1975) study found that 50.9 percent of the sample would use the information provided on nutrition labels at least occasionally. They also found that direct use of nutrition label information by consumers increases over time. Jacoby (1977) indicated that Federal Trade Commission studies overwhelmingly show that consumers want and would use nutrition information. However, the results of this study indicated lower rates of nutrition information acquisition than were expected from survey results showing high levels of desire for information. This conclusion was also substantiated by Klopp and MacDonald (1981). Both Jacoby et al. (1977) and Klopp and MacDonald (1981) found certain consumer characteristics more often associated with consumers who used nutrition information. Students and younger consumers in general, those with prior nutrition knowledge, the more highly educated, those who did advance meal planning, those who were not loyal to specific brands, and consumers who had time to read and process nutrition information while shopping were more likely to use nutrition information.

Rudell (1979) divided the nutrition information process into three stages: acquisition, processing, and effects. She likens this to the behavior modification paradigm (S-O-R) used by pyschologists to describe an organism's response to a stimulus. The stimulus is nutrition information, and the response is food choice. Where other studies usually have emphasized one stage, she attempts to integrate all three in a model of nutrition information processing. Her approach is summarized in Figures 1, 2, and 3.

Consumer characteristics affect the technique used by the consumer to take in information (i.e., spectator or active participant), amount of information taken in, and type of information thought useful by the consumer (Figure 1). Consumer characteristics, strategy of acquisition, and amount and type of information influence the number, source, and content of thoughts about nutrition (Figure 2). Combining consumer characteristics; amount, type, and strategy of information acquisition; and number of cognitions (thoughts) determines the consumer's evaluation of his food choice and any possible change in product choice (Figure 3).

Rudell (1981) selected her sample purposively since her interest was in understanding what she called the process of decision making and was not particularly interested in generalizing her results. She found that, in her sample,

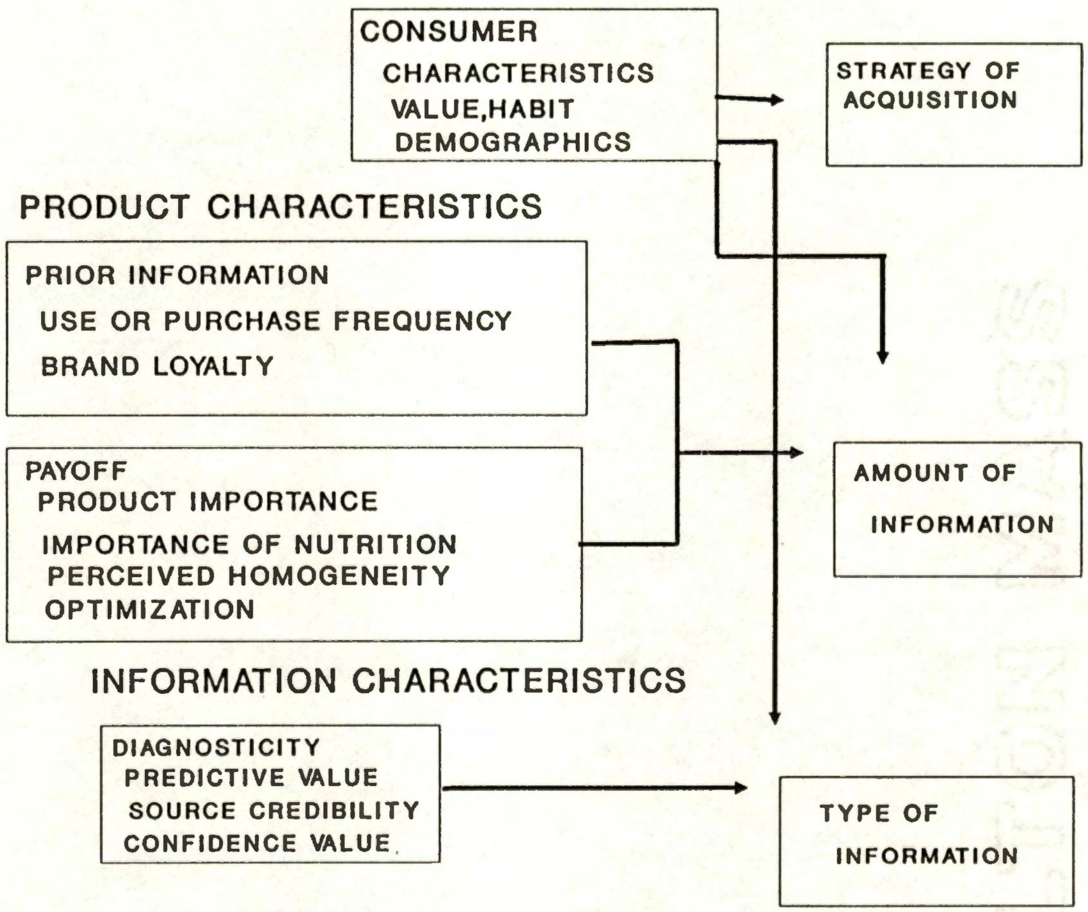


Figure 1. Information Acquisition.

Source: Fredrica Rudell, 1979, Consumer Food Selection and Nutrition Information. Praeger, New York.

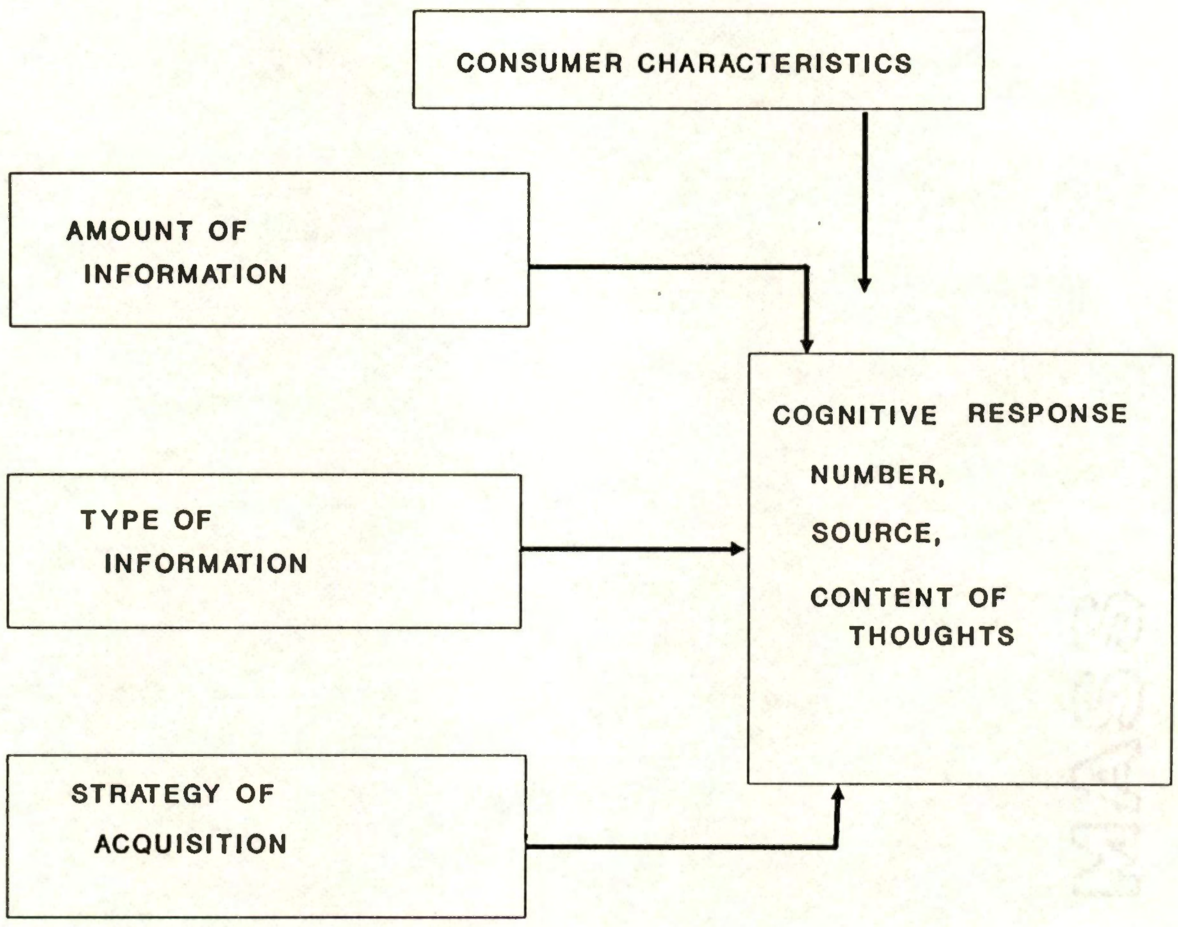


Figure 2. Information Processing

Source: Fredrica Rudell, 1979, Consumer Food Selection and Nutrition Information. Praeger, New York.

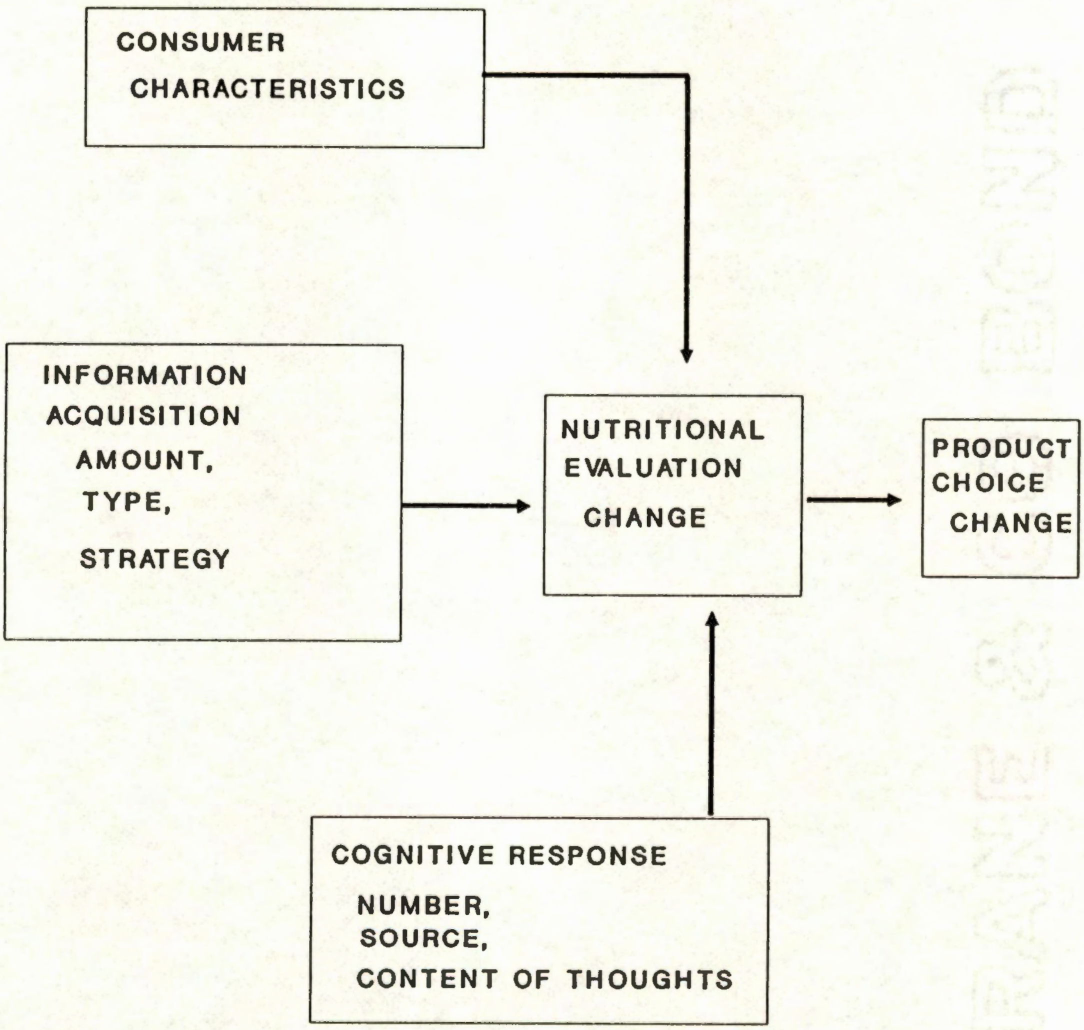


Figure 3. Information Effects on Evaluation and Choice.

Source: Fredrica Rudell, 1979, Consumer Food Selection and Nutrition Information. Praeger, New York.

several variables provided an "efficient set" to explain nutrition information acquisition. In addition to the variables mentioned in other studies, she found income to be a very good predictor of consumers who used nutrition information. Unlike other studies she found measured nutrition knowledge was uncorrelated with the acquisition of information. Evidently, the more confident people are of their nutrition knowledge, the less they rely on nutrition information. Only the importance of nutrition to the consumer had a consistent and significant effect on taking in information on specific product nutrient characteristics. Consumers felt that ingredient lists had the highest average predictive value (belief that the information is associated with nutritional quality) and confidence value (respondent's confidence of own ability to understand the information). In decreasing order of popularity were vitamin content, protein content, Consumer Reports, calories, advertising claims, government information, and comments of friends as important kinds and sources of nutrition information.

Actual and perceived nutrition knowledge, although not related to acquisition of nutrition information, were positively correlated with a person's total number of thoughts or cognitions about nutrition. Exposure to more total information was significantly and positively related to the total number of thoughts generated. Thoughts about

general nutrition concepts, not specific nutritional knowledge, were significantly and positively related to behavior change (willingness to change purchases) as measured using a before-after test.

Respondents were asked to evaluate the taste, value for the money, nutritional value, and family appeal of each alternative product. The greatest change occurred with respect to nutrition value. So Rudell concluded that nutrition information through formed cognitions does affect the consumer's perception of nutritional value of food products. High income and vitamin usage were the major and positive predictors of food choice change.

In general, research in the nutrition information processing literature provides evidence that consumers consider nutrition when making food purchases. These studies have provided a great deal of agreement on the kind of sociodemographic variables that influence nutrition information access, nutrition information processing, and food choice change. They suggest that economic models of the consumer decision process should reflect such decision making.

Consumer Values of Nutrient Characteristics

Terry (1985) and Morgan et al. (1979) have shown that estimation of nutrient demand and/or hedonic equations

explain more of the variations in the dependent variables when dietary components are combined in ways more in keeping with the way consumers perceive nutrients. Morgan (1979) carried out a restricted analysis (F-tests for significance of variables included in her model) that showed the inclusion of dietary variables was a part of the consumer decision making process. Expectancy-value models (Cohen, Fishbein, and Ahlota, 1972), as they have been applied in consumer research, assume consumers view different product dimensions with several attributes attached to each dimension. The place of nutrients in the decision making of consumers is likely to be best modeled using this idea. Consumers do not consider all nutrients, but aggregate them. Consumers do not know how to evaluate every vitamin or mineral contained within a particular food. Information has been widely available on functions of and importance of the macro nutrients, fat, carbohydrate, and protein. There has also been media attention on selected vitamins and minerals such as calcium, vitamin C, and iron. Consumers likely perceive all other nutrients lumped or aggregated under the labels of vitamins and minerals. Although discussions with nutritionists led to specification of the above probable categorizations of nutrients, Terry's full model analysis (1985) showed a high degree of pairwise multicollinearity among nutrients, thereby making it tenuous to evaluate

individual effects. Grouping decreased the pairwise collinearity among the remaining nutrients.

Morgan (1987) mentioned several other reasons to justify an aggregated specification of nutrient demand models. Other investigations (Federal Trade Commission, 1976) have found that individuals evaluate foods in terms of key dietary factors or lump nutrients into aggregates. The level of knowledge necessary to understand the function of each nutrient and evaluate its impact and necessary level would require high information access cost. Thus, consumers are optimizing by lumping nutrients rather than spending the time cost necessary to refine nutrient distinctions and/or reduce the information overload potential.

Irrespective of how nutrients are grouped, to value components of foods such as nutrients, a model must be chosen for analysis. The consumer characteristics models provide such methodological tools.

The Concept of Chararacteristics

The economic analysis of product characteristics is more difficult than the economic analysis of quantities of products because one must be able to measure characteristics and the quantities of goods are easier to measure. According to Lancaster (1971), the key to operationalize the characteristics model lies in the definition of what are the

relevant characteristics to analyze. Consumers' reactions should be based upon their desires for the given characteristics which should be defined objectively. So calorie content of a food or color of an automobile are objective criteria for judgement. Taste and beauty are not objective characteristics. For example, if one wants to assess taste or beauty, one must identify their dimensions in ways that can objectively be measured. The characteristics model is not applicable to aesthetic considerations in the consumer's decision making process; nor is it amenable to concepts such as taste which can not objectively be defined.

The search for characteristics of a good comes from properties of the goods themselves (Lancaster, 1971). Any objective property such as size, shape, color, or performance is a possible characteristic. One must select those that are measurable and relevant. What is relevant to one good may not be relevant to another.

Without some justification to analyze only part of the complete set of all possible varieties of all possible goods, it would not be possible to apply characteristic models. This is the same kind of problem that exists in traditional demand models. Lancaster bases the grouping of goods upon the idea of technical separability. This concept is defined as a situation in which there exists a subset of goods and a subset of characteristics such that no good in

the goods subset possesses any characteristic not in the characteristic subset, and no characteristic in the characteristic subset is possessed by any good not in the goods subset. Thus, a good in the selected subset is technically unrelated to any good not in the subset.

To show technical separability, Lancaster discussed the shape of indifference curves in characteristic space. For such separability to exist, the shape of the indifference curve between two characteristics must be independent of characteristics included in the goods set of which these two characteristics are not a part. He used a Cobb-Douglas function to illustrate the point. If there exits a set of goods which are defined by two characteristics, z_1 and z_2, and a third characteristic z_3 exists and is independent of the utilities derived from consuming z_1 and z_2 we may write:

(1) $\dfrac{\partial u_1/\partial u_2}{\partial z_3}$, for $1, 2 \varepsilon G$, $3 \not\in G$

We can use the Cobb-Douglas utility function to illustrate (1):

(2) $u(z_1, z_2, z_3) = z_1^a z_2^b z_3^c$.

The ratio of $\partial u_1/\partial u_2$ in this case is :

(3) $\dfrac{az_2}{bz_1}$.

And since this ratio is not a function of z_3, then

And since this ratio is not a function of z_3, then

$$(4) \qquad \frac{\partial(u_1/u_2)}{\partial z_3} = 0.$$

Thus, we can appeal to what Lancaster calls technical separability, or what is generally known as weak separability, to look at only a few characteristics.

Appealing also to the principle of weak separability, we can assume that the marginal rate of substitution between two commodities within one expenditure category is independent of the quantities of all commodities not in that subset. So, the ratio of marginal utilities derived for any two food items is independent of quantities of any other nonfood item consumed. This assumption allows food to be considered independently of any other expenditure item in the consumer's allocation process (Johnson, Hassan, and Green; 1984). In addition, appealing to separability allows analysis of nutritional characteristics in the consumer's decision making to be independent of the other attributes like taste and texture, variables that are not easily measured. However, if the excluded variables such as taste are highly correlated with included characteristics, then we have the problems associated with omitted variables. A technically separable grouping assumes at least the presence of relevant characteristics. Defining relevant characteristics is not a simple matter, but with respect to

food, studies have shown that nutrients are relevant characteristics (Terry, 1985; Morgan, 1987; and Rudell, 1987).

Selection Criteria for Relevant Characteristics

One problem with characteristic theory is that the possible number of characteristics for any good can be infinite. To test the theory, one must confine analysis to a workable number of characteristics. This occurs when the number of characteristics is less than the number of goods.

A characteristic is relevant if by ignoring it in the analysis there would be a different set of predictions about the choice of goods by consumers. Common sense can tell us that some characteristics are irrelevant, such as the serial number on durable goods. A characteristic may be irrelevant technically or preferentially. Ease of starting a car may have at one time been a technically relevant criteria for autos. But now, since all cars start well, it is a technically irrelevant variable. With preference irrelevancy if the item is not important to the consumer in his preference structure, then there is no value from including it in the analysis. From market analysis studies, we know that nutrient characteristics are indeed included in the decision making of consumers. Therefore, nutrition attributes are relevant characteristics.

Lancaster's Model

Assuming separability and relevancy, we can postulate Lancaster's characteristic theory as:

(5) maximize $U(X_1, X_2, \ldots X_m)$, s.t.

$$\sum_{i=1}^{n} x_{ij} = X_j \text{ for } (j = 1, \ldots, m), (i = 1, \ldots, n) \text{ and}$$

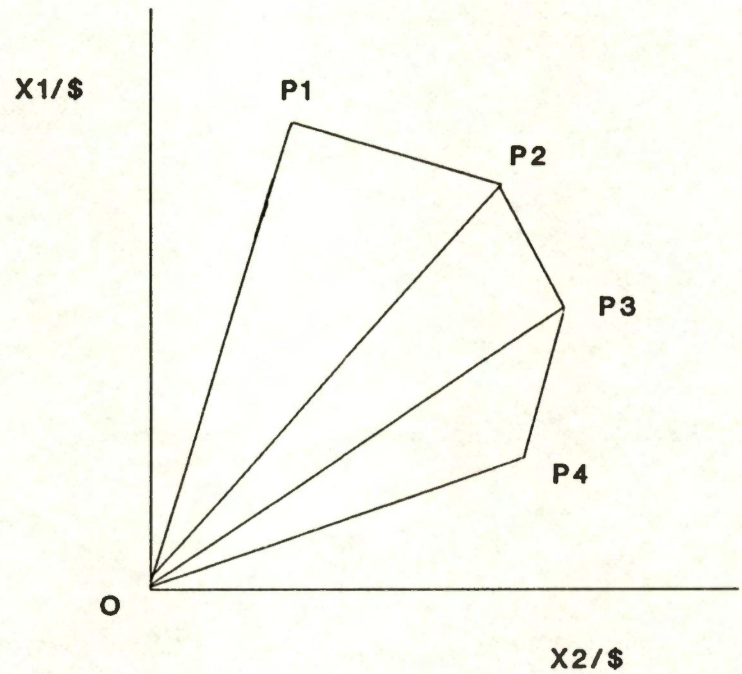
$$\sum_{i=1}^{n} P_i q_i = I, \text{ for}$$

$$X_j \geq 0,\ x_{ij} \geq 0, \text{ and } q_i \geq 0,$$

where

U = consumer utility,
X_j = total amount of the jth characteristic,
I = income,
P_i = price of the ith good,
x_{ij} = quantity of the jth characteristic provided by the ith good,
q_i = quantity of the ith good,
m = the number of attributes, and
n = the number of goods.

Figure 4 presents the essence of Lancaster's approach. Here we have four products, P1, P2, P3, P4, and two characteristics, X1 and X2. Four rays from the origin, labeled OP1, OP2, OP3, and OP4, show the proportions of the two characteristics obtained from various levels of each good. If one can measure the attributes, then one can calculate the amount of attribute per dollar expenditure. These values are plotted along the rays as points P1, P2, P3, and P4 for fixed prices and income (Figure 4). The line connecting



X1=CHARACTERISTIC ONE
X2=CHARACTERISTIC TWO
P1-P4=PRODUCTS

Figure 4. Characteristic Consumption and the Efficiency Frontier.

these points is called the efficiency frontier or P1-P3 and shows purchase possibilities. Consumers will not buy P4 because they can get more of both attributes by buying P1, P2, P3, or some combination of these products. Therefore, P4 does not lie on the efficiency frontier.

This frontier can be constructed without knowing the exact preferences of the consumers. The frontier shifts out in a parallel fashion, given market prices, as income increases. To know what product or product combination the consumer will choose (i.e., a point on the efficiency frontier), we must know the consumer's preferences for characteristics. The consumer buys some combination of X1 and X2 along the income-adjusted efficiency frontier.

The Lancaster model is subject to three specific assumptions for a unique solution (Hendler, 1975). These are nonnegative marginal utility (NNMU), independence of distributed characteristics (IDC), and linear consumption technology (LCT). As Hendler (1975) shows, violation of NNMU leads to a situation that may not yield a unique solution. It would then be impossible to judge a consumer's efficiency of choice without knowing his own preferences (Ladd, 1982). In the absence of NNMU, indifference curves can have positive slopes, and without knowing the exact preference structure, one cannot determine the optimal level of characteristics (Ladd, 1982). Allowing for negative

marginal utility at some point of consumption may be more realistic, especially with food attributes. The concept was discussed by Lancaster, although not explicitly incorporated into the formulation of his model. His concept of closed satiation eliminated the possibility that an attribute may provide negative marginal utility. Hendler (1975) provides an alternative interpretation in which overall marginal utility of a good is positive although one of its characteristics has negative marginal utility.

Both Lucas (1975) and Hendler (1975) have questioned the assumption of independence of distributed characteristics (IDC). When IDC does not hold, the consumer prefers to accquire the attributes from one product rather than another. Violation of this assumption means that a unique level of utility may not exist. Two or more levels of utility, each level relevant for a different distribution of attributes among goods, could exist. A unique tangency on the objective effeciency frontier may no longer exist. One would have to know how the utility function is affected by the distribution of characteristics (Ladd; 1982).

An LCT means that increasing consumption of a product by a certain amount increases the levels of each characteristic obtained from the product by constant amounts. One would have to posit a nonlinear functional relationship, $X_j = f(x_{ij},..., x_{nj}, q_i,..., q_n)$, in place of $X_j = \Sigma x_{ij}q_i$, in

order to account for a nonlinear consumption technology. This, of course, would require detailed knowledge of the technical relationships among attributes and goods. For some purposes such as the study of nutrient characteristics, the assumption of a linear relationship is acceptable. Suppose one unit of food i contains x_{ij} units of a jth characteristic. This incremental effect holds regardless of the amount used. For example, the marginal effect on food energy contained in an ounce of milk is the same for a glass or a gallon. Therefore, the total amount of the characteristic obtainable is a linear combination of the units of the foods times their respective attribute contents (the x_{ij} would be the same for each unit consumed).

Other Theoretical Formulations of the Characteristics Model

The earliest empirical work on product attributes related to food was that of Waugh (1928). He related the prices of vegetables in the Boston wholesale market to characteristics of the vegetables. He found a tendency existed for market prices of vegetables to vary with physical characteristics that the consumer identified with quality. His analysis did not present a theory of characteristics.

About 25 years later, Theil (1951-52) and Houthakker (1951-52) developed theoretical models that incorporated attributes. Both Theil and Houthakker assumed that price of a product is a reflection of its quality. Theil's utility function included the quantities of the various products and a set of vectors of input-output coefficients, one vector for each product. This utility function is maximized subject to a budget constraint. In the budget constraint, price of each good is a function of the vector of input-output coefficients that measure the underlying attributes or qualities of goods. To test his theory, he regressed price paid on family income and family size. He also regressed quantities purchased on the same two variables using a sample of clerical and manual workers in Amsterdam. Calculations of quantity and quality elasticities showed that clerical workers have lower income elasticities of quality and quantity than manual workers. The clerical workers had much higher incomes than the manual workers, and the estimates of the elasticities implied that the families of clerical workers are more satiated than the families of manual workers with respect to both quality and quantity dimensions.

In Houthakker's version (1951-52) each commodity is described by two variables, physical quantity and quality. Price is defined in terms of quality and quantity, and price

is a linear function of the quantity and quality. So one maximizes utility where utility is a function of the quantity and quality variables subject to the expenditure constraint. There was no attempt to test this model. The essential idea of both these models is to find a hypothesized relationship between price and quality.

Ladd and Suvannunt: The Hedonic Price Equation

In the Houthakker-Theil models, commodities with different characteristics are treated as the same good with a variable quality. In the Lancaster model, commodities with different characteristics are treated as separate goods. Quality is chosen implicitly by the choice of goods. In the Houthakker-Theil models, consumers choose qualities explicitly. Only one quality level is chosen, and the consumer cannot simultaneously choose low and high quality goods (Hanemann, 1982). Whenever consumers do purchase high and low quality goods at the same time, such as foods, the Lancaster model is more appropriate than Houthakker-Theil.

The Ladd and Suvannunt approach overcomes some difficulties inherent in earlier characteristics models. This approach can allow for nonlinear consumption technologies and negative marginal utility. The basic model can also be modified to allow for nonindependence of the distribution of characteristics (Ladd and Suvannunt, 1976).

Their model allows for n products and m common characteristics. Each product may also supply some kind of unique characteristic, or one not provided by any other product. As in other models, there are input-output coefficients, x_{ij}'s, which through technical relationships turn quantities of goods into quantities of attributes. Utility then is a function of the attributes, common and unique, that are contained in the goods. Ladd and Suvannunt (1976) present two new themes:

1) the market price of each good equals the sum of the quantities of the characteristics obtained from the marginal unit of the product consumed multiplied by the respective marginal implicit prices of the characteristics, and

2) consumer demand functions for goods are affected by the characteristics of the goods.

Utility can be written as a function of the attributes:

(6) $U = U(X_1, X_2, \ldots. X_m, X_{m+1}, \ldots. X_{m+n})$.

Because $X_1, X_2, \ldots. X_m, X_{m1}, \ldots. X_{m+n}$ are functions of the quantities, q_i's, and x_{ij}'s, or input-output coefficients, the amount of the jth nutrient available to the consumer is a function of the q_is and x_{ij}s or $X_j = f(x_{ij}, \ldots., x_{m+n}, q_1 \ldots., q_n)$. Therefore:

(7) $U = U(q_1, q_2, \ldots. q_n, x_{11}, x_{12}, \ldots. x_{1m}, x_{21}, \ldots. x_{nm}, \ldots. x_{nm+n})$.

The consumer cannot change the x_{ij}'s because these magnitudes are fixed. Each consumer faces the usual budget constraint:

$$(8) \quad \sum_{i=1}^{n} P_i q_i = I.$$

We can form a Lagrangian in order to deduce the consumer's maximizing behavior using either form of the utility function (6) or (7):

$$(9) \quad L = U(q_1, q_2, \ldots q_n, X_{11}, X_{12}, \ldots X_{1m}, X_{21}, \ldots X_{nm}, \ldots X_{nm+n}) - \Theta \sum_{i=1}^{n} (P_i q_i - I).$$

The usual second order conditions must hold, and the first order conditions are:

$$(10) \quad \partial L/\partial q_i = 0 = \sum_{j=1}^{n} (\partial U/\partial X_j)(\partial X_j/\partial q_i) + (\partial U/\partial X_{m+i})(\partial X_{m+i}/\partial q_i) - \Theta P_i, \quad \text{for } i = 1 \ldots n, \text{ and } j = 1 \ldots m, \text{ and}$$

$$\partial L/\partial \Theta = 0 = I - \sum_{i=1}^{n} P_i q_i.$$

We can solve (10) for P_i:

$$(11) \quad P_i = (1/\Theta) \sum_{j=1}^{n} (\partial U/\partial X_j)(\partial X_j/\partial q_i) + (1/\Theta)(\partial U/\partial X_{m+i})(\partial X_{m+i}/\partial q_i).$$

Θ, is the marginal utility of income or $\partial U/\partial I$. Substituting this expression into (11), letting $\partial I/\partial X_j =$

$(\partial U/\partial X_j)(\partial X_j/\partial I)$, and recognizing that one unit of a food provides one unit of its unique characteristic, we have:

$$(12)\ P_i = \sum_{j=1}^{n} (\partial X_j/\partial q_i)(\partial I/\partial X_j) + \partial I/\partial x_{m+i}.$$

Expression (12) is a general representation of the hedonic price function.

Assuming $\partial X_j/\partial q_i = x_{ij}$, $(\partial U/\partial X_j)(\partial I/\partial U) = B_j$ and $\partial I/\partial x_{m+i} = B_{m+i}$, we may write:

$$(13)\quad P_i = B_1x_{i1} + B_2x_{i2} + \ldots + B_mx_{im} + B_{m+i}.$$

Equation (13) assumes that the marginal utilities are constant. This may be an overly restrictive assumption. It also assumes a linear consumption technology. Equation (13) shows the price paid for a product as the sum of the marginal yields of various characteristics provided by the product multiplied by the marginal implicit prices of the product's characteristics. Marginal monetary values will not necessarily sum to the prices of the goods since the estimation process is stochastic (Ladd and Suvannunt, 1976). One can at least test the hypothesis that the product's price is related to its characteristics.

An alternative formulation of this model by Terry (1985) eliminated the unique characteristic. For some applications, the unique factors may not be present. Ladd and Suvannunt assumed the uniqueness was a function of raw material source. Using (13) they estimated the implicit

prices of 16 nutritional attributes. Terry did not include unique characteristics since nutrients can be found in more than one food product and his empirical work pertained to estimation across foods.

It is also possible, if desired, to overcome the necessity for the IDC assumption (Ladd and Zober, 1977). We can define a variable t_{ij} as the total quantity of characteristic j obtained from total consumption of product i. If we divide another variable, X_j or the total amount of the attribute from all products, by the total amount of the attribute gained from product i, we get a measure of the importance of product i's contribution to the total amount of attribute consumed. The X_j/t_{ij} ratios are now variables in the utility function. In this way, we can account for consumer preferences for their attributes coming from particular products rather than others. However, if there is no reason to assume that consumers care how they derive their attributes, then there is no reason to make such an adjustment.

A change in the nature of an attribute can affect the quantities demanded of a good. Even if prices and income remain constant, purchases of the products can vary if the input-output coefficients vary. Varying the input-output relationship changes the demand for nutrients. One can derive the effects of a change in any one x_{ij}, say x_{uv}.

This is easily done by using the formulation of utility containing the x_{ij}'s and finding (Ladd and Suvannunt):

$$(14) \quad \partial q_r/\partial x_{uv} = -(1/\Theta) \sum_{j=1}^{n} (\partial U_i/\partial x_{uv}) S_{ir}$$

where

$U_i = \partial U/\partial q_i$ and S_{ir} is the Slutsky substitution term. So the change in the quantity of q_r consumed depends, in part, upon the effects of the change in marginal utility and the substitution terms. The assumption is usually made that the x_{ij}s do not change during the relevant time period used for empirical work.

Demand for Attributes: An Extension of the Characteristic Model

Alternate formulations of the demand for attributes exist. Anderson, de Londono, and Hoover (1976) instead of using the characteristic model, estimated a complete price elasticity matrix and used these values to determine, with given supply shifts, how the demand for calories and protein would change using a sample from Cali, Columbia. The methodology was that developed by Frisch (1959). This method assumes want independence and is valid only for broad groupings of commodities and not suited to the range of disaggregated goods used in his study (Johnson, Hassan, and Green, 1984; Capps and Havlicheck, 1984).

A theoretically stronger approach is that of Price, West, Scherer and Price (1976) and Adrian and Daniel (1976). These studies related the consumption of various nutrients to selected demographics and income. Essentially, both studies estimated augmented Engel functions and did not estimate implicit prices nor did they use implicit prices in their demand for nutrients.

Pitt (1978) used a tobit model to estimate food demand equations. From estimates of the quantity of nutrients per unit of food item, tobit estimates of price elasticities were derived for nine micro and macro nutrients. He, like Anderson, de Londono and Hoover (1976) was interested in the way in which government intervention through supply changes or consumer subsidies would change nutrient well-being. This analysis is ad hoc in the sense that no theoretical characteristics model was developed. However, it is another way in which one can translate the estimates of demand for goods into concepts similar to nutrient demand equations.

Unlike these other studies, Terry (1985) extended the Ladd and Suvannunt model and estimated implicit prices that were used in his demand for nutrient equations. This study is an important extension of Ladd and Suvannunt. Their attribute model is the basis of Terry's implicit price equation. However, Terry extended their model by including implicit prices in the demand for nutrients model. For the

U.S. population, implicit own-prices were significantly and negatively related to the demand for nutrients except for fat, vitamin A, and thiamin. These were not significantly related to nutrient demands. Like other studies he also included possible relevant sociodemographic variables. The explained variation for all nutrients, except for vitamins A, B12, and C, was greater than 50 percent.

Numerous other studies exist that have applied some variation or application of the characteristics model. However, most of these have been for durable goods (e.g., Fetting, 1963; Triplett, 1963; Dhyrmes, 1967; Fischer, 1967; Griliches, 1971; and Palmquist, 1984). Other studies exist that have either applied the characteristic model to nondurables, specifically food, and/or estimated demand for nutrients sometimes using an ad hoc approach (e.g., Adrian and Daniel, 1976; LaFrance, 1986; Hager, 1987; Chavas and Keplinger, 1983; Davis and Neenan, 1979; Ladd and Zobber, 1977; and Lane, 1978).

Incorporating Subsistence Levels

Consumer demand models should reflect consumer decision making. The psychological literature has provided the foundation for the incorporation of subsistence purchases in models of how consumers choose goods. Maslow's hierarchy of needs organizes human wants into a pyramid, from the base

survival needs to those of self-actualization, conceptually at the peak of the pyramid. Self-actualization needs, or the needs for achievement through creativity, become active only after all other needs such as the physiological, safety, and belonging needs have been at least partially satisfied. A person struggles to provide the base needs before attempting to fulfill higher level needs. Very few are privileged enough to have to concern themselves with fulfillment of self-actualization.

A person's need level influences many decisions in life, including purchase behavior. This is reflected in Price, Price, and West (1980). They found consumers who indicated a high level of survival need, as measured by part of a 30 item scale, were less likely to purchase certain kinds of foods such as fruit salads and fruit juices. Consumers concerned with base survival needs were more likely to serve substantive, basic foods. As the survival need level becomes satisfied, the desire for the purchase of foods and other goods that satisfy higher level needs increases.

As Morgan has said (1987), a consumer's physiological need level is related to his income level. As income increases the basic survival needs tend to become satisfied through market purchases, and income increments tend to be reallocated toward less pressing needs. This reallocation

is consistent with estimated high food/nutrient income elasticities at low-income levels and the tendency for income elasticities to decline at higher income levels (Alderman, 1985). However for the very lowest income levels, Chavas and Keplinger (1983) found income elasticities of nutrient demand to be very low. They hypothesized an Engel function with a consumption threshold portion with very low income elasticities defining a survival level.

Contrary to Chavas and Keplinger, most studies have found the elasticities of food income and food expenditures are declining functions of income. However, these patterns only form a rough guideline for the nutrition component of food policy analysis (Alderman, 1985). This is because nutrient elasticities are far less predictable than those for total food expenditure (Alderman, 1985). For example, in studies of calorie elasticities in the Third World, Sri Lanka was found to have a calorie elasticity of only .18 while the value for India was .44 and .56 for Morocco. So one may not to be able to posit a general nutrient threshold or subsistence level based on income level. The threshold levels may differ by society or social grouping. These conflicting results may also be explained by differences in the quality of data, extent of home production and nonmarket food availability, and/or model and statistical limitations.

Another concept of subsistence was provided by Geary (1951-52), Klein and Rubin (1947), and Samuelson (1952). Geary developed the specific utility function for the demand equation presented by Klein-Rubin, and Samuelson gave the interpretation.

Klein-Ruben used an expenditure system of the form:

$$(15)\ \Sigma_i p_i q_i = \Sigma_i \Sigma_j\ a_{ij}(P_j) + \Sigma_i B_i(I),\ \text{with restrictions},\ \Sigma_i B_i = 1,\ \text{and}\ \Sigma_i \Sigma_j\ a_{ij} = 0.$$

A new demand equation can be constructed, using the symmetry properties of the Slutsky equation, that incorporates subsistence:

$$(16)\ q_i = \beta_i + B_i/P_i(I - \sum_{j=1}^{n} \beta_j P_j)\ \text{for n products.}$$

When (16) is multiplied by P_i, the familiar linear expenditure system results:

$$(17)\ P_i q_i = P_i \beta_i + B_i(I - \sum_{j=1}^{n} \beta_j P_j).$$

The utility function implicit in Klein and Rubin's derivation and developed by Stone is of the form:

$$(18)\ u = \sum_{i=1}^{n} B_i \log(q_i - \beta_i).$$

This means that u is defined only when $q_i > \beta_i$. One can use (18) to derive (16) directly. The formulation of the problem is to :

$$(19)\ \text{Maximixe } u = \sum_{i=1}^{n} B_i(\log(q_i - \beta_i)) \text{ subject to}$$

$$I = \sum_{i=1}^{n} P_i q_i.$$

Forming the Lagrangian function and taking derivatives yields the first order conditions:

$$(20)\ L = B_i \log(q_i - \beta_i) + \Theta(I - \sum_{i=1}^{n} P_i q_i),$$

$$(21)\ \delta L/\delta q_i = B_i/(q_i - \beta_i) - \theta P_i = 0, \text{ and}$$

$$(22)\ \delta L/\delta = I - \sum_{i=1}^{n} P_i q_i.$$

Second order conditions ensure a maximum. Solving (21) and (22) for q_i gives:

$$(23)\ q_i = \beta_i + B_i(I - \sum_{j=1} P_j \beta_j)/P_i.$$

When (23) is multiplied by P_i one gets the linear expenditure system. The demand system of (23) preserves the general demand conditions of homogeneity, symmetry, and adding up.

Samuelson (1947-48) provided the economic explanation of the linear expenditure system. The assumption that $I > \sum_{j=1}^{n} P_j \beta_j$ means that a consumer uses up a certain amount of income in acquiring each β_i at current prices and then distributes the remaining income over the set of available commodities in fixed proportions represented by the B_is.

The notion of habit persistence is similar to the concept of subsistence, and habit persistence has been incorporated in numerous studies (Johnson, Hassan, and Green, 1984) that have used various models such as the linear expenditure system, quadratic demand system, and the almost ideal demand system. Habit persistence is incorporated using lagged quantity or sociodemographic variables and thus usually involves time series data.

In nutrient demand analysis, a subsistence level quantity of foods purchased may be defined in terms of a subsistence level of nutrition rather than quantities of foods, and it is possible to use cross-section data. The concept of subsistence has not been incorporated into the consumer characteristics model. The present research will incorporate a measure of subsistence into the consumer characteristics model of Ladd and Suvannunt.

CHAPTER 3

THEORETICAL FRAMEWORK

Terry's Simplified View of the Consumer Goods Characteristics Model

The commonly employed method to model nutrient demand was developed by Ladd and Suvannunt. This approach is less controversial than the earlier Lancaster model since several questionable assumptions implicit in the Lancaster method can be avoided.

In the consumer goods characteristics model, CGCM, as adapted by Terry, the unique characteristics are not included because nutrients are common to more than one food. The arguments in the utility function are the common characteristics provided to the consumer from use of all products. Utility can be expressed as:

(24) $u(X_1, X_2, \ldots, X_m)$ subject to

$$X_j = X_j(x_{1j}, \ldots, x_{nj}, q_1, \ldots, q_n), \quad j=1,2,\ldots,m,$$

$$I = \sum_{i=1}^{n} P_i q_i, \text{ with } X_j,\ x_{ij},\ q_i >= 0,$$

where

X_j = the total amount of the jth characteristic provided to a consumer by the consumption of all products,

x_{ij} = the amount of the jth characteristic provided by one unit of the ith product,

P_i = the price of the ith product,

q_i = the quantity of ith product consumed, and
I = consumer income.

With this model, unlike that of Lancaster, one does not have to assume a linear consumption technology (LCT), or independence of distributed characteristics (IDC), or nonnegative marginal utility (NNMU).

As noted by Hendler (1975), it is possible that the overall marginal utility of a product may be positive, but some of the characteristics may have declining or even negative marginal utilities at some level of consumption. It is possible to develop a formulation of the CGCM that allows for such disutility. This is the more logical assumption in the analysis of foods.

For nutrient analysis, LCT is an appropriate assumption because there indeed is a linear relationship among quantities of foods and the amounts of nutrients contained in these foods.

As Ladd and Zorber (1977) have indicated, it is possible to overcome even the IDC assumption, if the application necessitates. However, this is not necessary in the present study because there is no advantage to the consumer to acquire nutrients from any particular source.

From the first-order conditions in the modified model as used by Terry (1985), the hedonic price equation derived from (24) is:

$$(25)\quad L = u(.) + \Theta(I - \sum_{i=1}^{n} P_i q_i),$$

where

$u(.)$ is $u(q_1,q_2,\ldots,q_n, x_{11},\ldots,x_{1n}, x_{21},\ldots,x_{2n},\ldots,x_{nm})$, and L is the Lagrangian function,

$$(26)\quad \partial L/\partial\Theta = I - \sum_{i=1}^{n} P_i q_i = 0, \text{ and}$$

$$(27)\quad \partial L/\partial q_i = \partial u(.)/\partial q_i - \Theta P_i = 0.$$

The marginal utility $\partial u(.)/\partial q_i$ can be represented as:

$$(28)\quad \sum_{j=1}^{m} (\partial u/\partial X_j)(\partial X_j/\partial q_i).$$

So, (27) can be rewritten as:

$$(29)\quad \partial L/\partial q_i = \sum_{j=1}^{m} (\partial u/\partial X_j)(\partial X_j/\partial q_i) - \Theta P_i = 0,$$

and one can solve for P_i or:

$$(30)\quad P_i = \sum_{j=1}^{m} (\partial u/\partial X_j)(\partial X_j/\partial q_i)(1/\Theta).$$

Θ represents the marginal utility of money, or $\partial u/\partial I$. The marginal rate of substitution of income for the jth attribute is $(\partial u/\partial X_j)/(\partial u/\partial I)$ or $(\partial u/\partial X_j)(\partial I/\partial u)$. The $\partial I/\partial X_j$ is the implicit price paid for one more unit of the jth attribute or the consumer's marginal willingness to substitute X_j for I. The implicit price equation can be written as:

$$(31)\quad P_i = \sum_{j=1} (\partial X_j/\partial q_i)(\partial I/\partial X_j).$$

An interpretation of (31) is that the price paid for the ith product by the consumer equals the sum of the marginal monetary values of all product characteristics, where the marginal monetary value of each characteristic is the marginal implicit price of that characteristic times the quantity of that characteristic obtained from the marginal unit of the product.

The $(\partial I/\partial X_j)$ term can be written as the parameter B_i and the other term represents the x_{ij}s which are known (Ladd and Suvannunt, 1976; Terry, 1985).

In traditional demand analysis, the demand equation is a function of prices and income. If one is not considering just the representative consumer, then one would add other demand shifters besides income. With the characteristics model, demand for characteristics are also functions of prices and income, as the first order conditions of (26) and (27) show. As one moves from the representative consumer, one can also include other variables that can affect characteristic demand. Since the x_{ij}s are considered constant over the relevant time period, the demand equation for characteristics can be written as:

(32) $X_j = f_j(B_j, I, S)$

where

S = a vector of consumer characteristics.

A New View of the CGCM: Incorporating Subsistence in the CGCM

Previous formulations of characteristics models do not include any measure of subsistence in the utility function. However, the work cited in Chapter 2 clearly points to its presence. An extension of the CGCM that accommodates subsistence is developed below.

The amount of the jth nutrient consumed can be separated into the subsistence level Ω_i and the quantity of the nutrient purchased after meeting minimum subsistence levels, D_j, or $X_j - \Omega_j$. D_j is still a function of the q_is consumed and the consumption technology that determines the amount of the jth attribute within all of the n products consumed. The x_{ij}s are considered exogenous. Also, the Ω_js are assumed to be fixed for a short period of time, because subsistence levels change gradually over the life-cycle. We can rewrite (24) as:

(33) $u = u[(X_1 - \Omega_1), (X_2 - \Omega_2), \ldots., (X_m - \Omega_m)]$

The budget constraint and nutrient level equations are:

(34) $I = \sum_{i=1}^{n} P_i q_i$, and

(35) $X_j = X_j(x_{1j},\ldots.,x_{nj},q_i,\ldots.,q_n)$.

The first order conditions can be expressed interchangeably in terms of D_j or X_j because any change in X_j changes D_j by the same amount in the short run.

(36) $(\partial u/\partial D_j)(\partial D_j/\partial q_i) = \Theta P_i$.

The result can be solved for P_i as in the usual CGCM model:

$$(37)\ \Theta P_i = \sum_{j=i}^{m} (\partial u/\partial D_j)(\partial D_j/\partial q_i),$$

$$(38)\ P_i = \sum_{j=1}^{m} (\partial u/\partial D_j)(\partial D_j/\partial q_i)(1/\Theta),$$

$$(39)\ P_i = \sum_{j=1}^{m} (\partial u/\partial D_j)(\partial D_j/\partial q_i)(\partial I/\partial u)$$

since $\Theta = (\partial I/\partial u)$.

Interpretation depends upon the definition of subsistence, or the way it is introduced into equation (39), and theoretical considerations.

The Assumption of Decreasing Marginal Utility

Morse (1988) has shown that declining marginal utilities of nutrients are necessary to obtain a unique maximum bundle of characteristics. He has discussed several admissible forms of the hedonic price equation that allow declining marginal utility and compared them with the linear form. To have a unique maximum, P_i must be positive as well as increasing at a decreasing rate. This means that the hedonic price equation (39) must be of a form where:

(40) $\partial P_i/\partial(X_j - \Omega_j) > 0$ and,

(41) $\partial^2 P_i/\partial(X_j - \Omega_j)^2 < 0$.

Estimation of (39) for food has traditionally assumed $\partial X_j/\partial q_i = x_{ij}$, or LCT. The term $[\partial u/\partial(X_j - \Omega_j)][\partial I/\partial u]$ must be formulated in such a way to allow (40) and (41) to hold. Using a functional form that assumes constant marginal utilities of nutrients means that $\partial u/\partial(X_j - \Omega_j)$ and $\partial I/\partial u$ change in such a way to keep the relationship between terms constant. This implies that either both derivatives $\partial u/\partial(X_j - \Omega_j)$ and $\partial I/\partial u$ are constants or change in ways to offset each other. If we assume declining marginal utility of attribute X_j, then $\partial u/\partial(X_j - \Omega_j)$ will decrease and must exactly be off-set by $\partial I/\partial u$ to keep constant Ω_js. To have this happen, it is easy to see that $\partial u/\partial I$ or the marginal utility of money must decrease. Assuming perfectly elastic supply curves and constant money income, the real income effect associated with price changes (as considered here) is negligible (Morse, 1988).

The other possibility is that both terms are constants, and this means that the hedonic price equation would not exhibit declining marginal utility. If there is no declining marginal utility then the hedonic price equation is not necessarily associated with a unique solution maximum. Morse (1988) shows that alternative forms of the hedonic price equation provide for more theoretically sound estimation of implicit prices than the linear form. One

specific form reported in the present analysis is consistent with Morse's work as explained below.

(42) $P_i^g = \Sigma\, b_j^g\, x_{ij}$.

Equation (42) can be estimated for those households that are over the defined subsistence level for all nutrients (g=1), for those households that are below the defined subsistence level for all nutrients (g=2), and for those households who are intermediate (households that are under the subsistence level for at least one nutrient, but not all nutrients, (g=3)). Equation (42) also allows P_i for positive x_{ij} to increase at a decreasing rate as long as $b_j^1 < b_j^2$. For example, as x_{ij} increases (then X_j increases ceteris paribus), its incremental impact is associated with a declining marginal implicit price as a household crosses from below to above subsistence. The marginal implicit price equation (43) should be positive. That is, the first-order partials should be positive. Given the above assumptions, the condition is met if:

(43) $b_j^g > 0$ for $j = 1,\ldots,m$, $g = 1, 2, 3$.

The second-order condition, equation (44) is also met with respect to overall behavior if:

(44) $b_j^1 < b_j^2$ for $j = 1,\ldots,m$.

As Figure 5 illustrates, there may be declining marginal utility across subgroups, but within a subgroup,

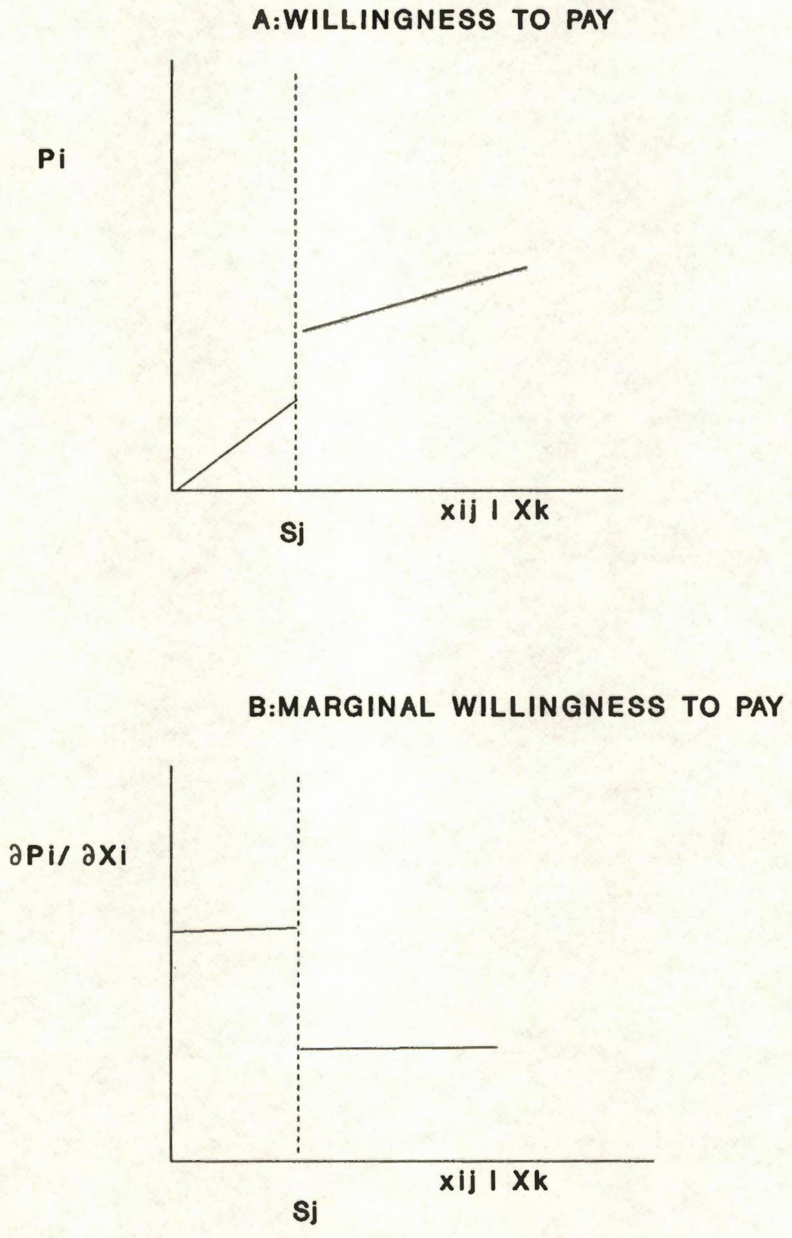


Figure 5. Willingness to Pay and Marginal Willingness to Pay.

marginal valuations may be relatively consistent. The possibility exists that even though second-order conditions are not met by the within-group linear form, linear estimates may provide reasonable approximations for each subgroup and at the same time allow for declining marginal utility across groups.

The double-log form of the hedonic price equation poses a problem. About 25 percent of all the NFCS observations within each household would have to be deleted if the double-log form is used. Many foods eaten by each household do not contain one or more of the nutrients. However, consumers did purchase the other nutrients when they purchased the foods not containing a particular nutrient. An example would be the presence of vitamin B12 only in foods of animal origin. These observations should not be eliminated from the dataset. It is thus necessary to either add a value to the zero observations or use average nutrient values for each household to overcome the problem of taking logs of zero observations if the double-log form is used. These procedures may cause lower R^2s or introduce the problem of errors in variables which may cause biased or inconsistent parameters. The linear form, although not obeying the second order conditions within groups, may be a better empirical approximation.

The Demand for Nutrients

A demand for nutrient equation should have implicit prices as part of its arguments. Such a formulation could be represented as:

$$(45)\ X_j = X_j(B_1,....B_m,\ I,\ S),$$

where

$B_1,....B_m$ = implicit prices,
I = income, and
S = a vector of consumer characteristics.

However, the problem of stocastic regressors makes the inclusion of estimates of implicit prices problematic. Most of the demand for nutrient models use an augmented Engel specification without prices as arguments. The augmented function has other variables in addition to income. No theoretical structure for the form of the nutrient demand equation has been presented. Chavas and Keplinger (1983) show that the consumption of the jth nutrient, X_j, for an individual can be written as:

$$(46)\ X_j = \sum_{i=1}^{n} B_{ij}q_i.$$

Engle functions have the form:

$$(47)\ q_i = q_i(S).$$

One can write:

$$(48)\ X_j = X_j(S).$$

Equation (45) poses no identification problem, even with a nonlinear hedonic price equation if the supply of the products consumed are assumed to be perfectly elastic.

In general, certain demographic variables have empirically been shown to be significantly related to nutrient demand and expenditure functions. As Davis et al. (1982) have indicated, estimates of demand equations have tended to use time-series data, and the nature of these data restricts analysis to prices and income.

Price

Nutrient demand equations with estimated marginal implicit prices were estimated by Terry (1985) and Morgan et al. (1979). They found hedonic prices to be significant variables in their demand/hedonic price equations. However, it should be noted that the implicit prices used pose the serious problem of stocastic regressors.

Income

Income in most studies is significantly related to nutrient intakes. One may hypothesize that as income increases, consumption of most foods (normal goods) would increase. This would lead to an increase in consumption of most nutrients unless some good is an inferior good and high in a particular nutrient that would decrease in the person's

diet as income increases. Pitt (1983) found all expenditure elasticities were positive, but increasing food expenditure resulted in less than proportionate increments in the consumption of all nutrients (protein, fat, carbohydrates, calories, calcium, iron, thiamin, riboflavin, and niacin). Adrian and Daniel (1976) found positive and significant income effects for all nutrients except carbohydrates and fat. Although differing from the results of Pitt, Adrian and Daniel used a U.S. sample, and this fact could account for the negative fat and carbohydrate parameters because Americans are concerned with negatively imaged nutrients.

Some nutrient demand studies also show income at least sometimes positively related to nutrient demand (Davis and Neenan, 1979; Eastwood, Brooker, and Terry, 1985; Scearce and Jensen, 1979; Basiotis, Morgan and Johnson, 1983; Chavas and Kepplinger, 1983; Akin, Gilkey, and Popkin, 1983). But one study (Davis, Moussie, Bailey, and Wagner, 1982) found no relationship between income and intake. This latter study used biochemical nutrient measures rather than dietary intake parameters. An interpretation of this result is that biochemical measures do not capture the process of consumer decision making.

Age, Sex, and Household Size

In consumption analysis, household size, age, and sex can be combined using an index called an adult equivalence scale. This scale gives household size as a function of age and sex and can include nutrient adequacy measured by the RDA. Basiotis et al. (1983) developed such a scale with their low-income sample. In their model, food expenditure is deflated by an aggregate household size measure which gives food cost per adult equivalent. The individual size variables were measured by number of family members in six age-sex groups and were significant.

Eastwood, Brooker, and Terry (1986) included household size and age in their nutrient demand equations and found these variables to be significant in the protein, fat, carbohydrates, minerals, vitamin A, B vitamins, and vitamin C equations. Numerous other studies show age and/or sex and/or size as significant (Adrian and Daniels, 1976; Blanciforti and Green, 1983; Davis and Neenan, 1979; Chavas and Kepplinger, 1983; and Scearce and Jensen, 1979). In Davis, Moussie, Bailey and Wagner (1982), household size and age were not significant, but sex was significant.

Race-Ethnicity

Chavas and Kepplinger found that blacks have significantly different intakes from whites for thiamin and energy

when blacks are in the school lunch program. The nutrient intakes for blacks are also better when blacks were part of the school breakfast program. Scearce and Jensen (1979) found being black was significantly related to lower consumption of calcium, vitamin A, vitamin C, and the B complex vitamins. Race is also a significant variable in Eastwood, Brooker, and Terry (1986), Basiotis et al. (1983), and Adrian and Daniel (1976).

Region and Degree of Urbanization

Regional location reflects differences in climate, kinds of resources available to produce foods, and price variations. Consequently, these factors affect food availability. In addition, urban versus rural location also represents differences in price variations and differing access to home produced food. Eastwood, Brooker, and Terry (1986) found central city households consumed more protein, minerals, and vitamin A, vitamin C, and B complex vitamins than nonmetropolitan households. Regional impacts were limited. Adrian and Daniel (1977) found that farm households consumed more of all nutrients except vitamin A and vitamin C than did urban or rural nonfarm households.

Since these two studies had different data sets and different variable definitions of degree of urbanization, the results are not directly comparable. However both

studies find degree of urbanization significant. In Basiotis et al. (1983) the relationship between nonmetropolitan location and nutrient intake is not significant. Suburban nutrient intakes are significant. There are significant regional differences as well.

Education

Eastwood, Brooker, and Terry (1986) found education to have an inconsistent effect on nutrient demand because there are decreases in some nutrient demands and increases in others that are associated with good health occurring as education increases. Similarly, Scearce and Jensen (1979) found higher education levels of the homemaker were not associated with demand for nutrients. This would be expected because better education does not necessarily mean better nutrition education. Better nutrition education itself has not been highly associated with improved nutrient intakes (Shannon and Chen, 1988). However, Davis et al. (1982) and Davis and Neenan (1979) found nutrition knowledge of the homemaker exerts a significantly positive impact on intake.

Employment Status

The effects of employment status of male/female household heads on nutrient/food consumption is not clear.

Capps and Love (1983) found spouse unemployment and unemployment of both male and female household heads positively related to consumption of fresh vegetables. They hypothesize that unemployment allows greater opportunities to obtain and prepare fresh vegetables. Employment status of the person responsible for meal planning was not identified as significant by Eastwood, Brooker, and Terry (1986). The nutrition literature shows that employment status of the mother does not appear to influence dietary intake of adolescents (Skinner, Ezell, Salvetti, and Penfield, 1985). Goebel and Hennon (1982) did show that wife's employment status was significantly related to meal preparation time. However, this result does not necessarily impact upon nutritional well-being.

Family Life Cycle

As Schafer and Keith (1981) have indicated, families in the same life cycle stage face similar events and circumstances. Thus, differences in family life cycle stages would be reflected in food choice and diets. Several studies have used the family life cycle concept and found the variable significant to understanding food patterns/ nutrient demands (Shafer and Keith, 1981; Blancifiorti, Green, and Lane, 1981; Scearce and Jensen, 1979).

Other Variables

Policy variables have also been included in nutrient demand studies. Policy variables that have been used are participation in food stamp program, FNEP, and WIC and the school lunch and school breakfast programs. In most cases, participation does affect nutrient intakes, although several studies that use a nutrient demand approach do not analyze intakes relative to a standard of well-being such as the RDA.

The stochastic regressor problem makes it difficult to include hedonic prices in a demand for nutrient model. It is possible to include variables that have been shown to affect nutrient implicit prices and/or consumption of nutrients. Eastwood (1988) has shown that marginal implicit prices differ by income level, and numerous studies have indicated that nutrient demands are affected by income level. Consumption of nutrients should be affected by the variables that affect marginal implicit prices. Consequently, whether the household has met its subsistence level or not may influence the nutrient consumption function if marginal implicit prices are affected by this variable.

Although there are no traditional economic reasons to include any specific demographic variable other than income in nutrient demand models, empirical results do show that to reflect reality one should include demographics.

CHAPTER 4

MODEL SPECIFICATION

In order to incorporate subsistence levels of nutrients into a consumer demand model, one must first define subsistence. The literature supplies various concepts of subsistence pertinent to cross-sectional data.

Cost Minimization

Parato and Bagali (1976) were the first to report an attempt to separate what they called the nutrition component from the non-nutrition component using a cost minimizing linear programming framework. A more appropriate definition of their nutrition component would be the subsistence level deemed necessary for normal daily functioning. Their intent was not to estimate nutrient hedonic price or nutrient demand equations but to estimate Engel curves from residual expenditures, or expenditures left over after purchasing subsistence amounts of foods. Therefore, their research gives no indication of the demand for nutrients in their cost minimizing approach. In addition, because of data limitations, their analysis was for one food group only--meat, poultry, and fish. Thus, their results are of limited use because nutrients are obtained from all foods. However,

their approach gives one method of including subsistence level quantities in an analysis of nutrient demand. Using the amount of consumed nutrients as the right hand side of resource constraints and solving the cost minimization problem using the 1965 Household Food Consumption Survey, they then calculated residual expenditure by multiplying average prices by the quantities in surfeit or deficit of the calculated cost minimizing quantities. Residual expenditure was then analyzed using the linear expenditure system to derive Engel curves for 104 region, urbanization, and income classes.

Parato and Bagali's emphasis is on analysis of the nonnutrition component. This nonnutrition component is more appropriately labeled a nonsubsistence component. Parato and Bagali did not incorporate nutritionally or RDA based resource constraints. They simply used purchased quantities of goods to derive their nutrient levels which are the right-hand side of their nutrient resource constraints. They felt that since not all consumers are knowledgeable of the RDAs, the RDAs are inconsequential in consumer decision making process. While this might have been a valid criticism of the use of the RDA's in the past, it is less valid today as consumers do have more information on nutritional matters, and changes in food expenditure patterns do reflect incorporation of this nutrition

information (Pao, 1981; Gifft, Washbon, and Harrison, 1972). This research brings up the issue that the RDA may not be an appropriate tool with which to model nutrient constraints. However, as previously indicated, we do have evidence that consumers consider nutritional information including RDAs when making purchases. The RDAs may not be an appropriate standard for another reason--the RDAs can overestimate the degree of inadequacy (National Academy of Sciences, 1986).

The Probability Approach

The problems with the RDAs as measures of nutrient adequacy are well documented (National Academy of Sciences, 1980). There is also confusion concerning whether the RDAs are established for the individual or group (Beaton, 1985). In fact, RDAs do refer to individual intakes and not group intakes. However, it is not possible to use the requirements to predict any particular person's intake.

Nutrient requirements are determined for a category or type of person specified by age and sex. The allowance levels cover the needs of all individuals of a particular category who are already healthy. Scientists have set this safe level at the average RDA for selected nutrients plus two standard deviations. This means that all but a small percentage of individual nutrient needs will be satisfied.

The energy requirement is set at the average requirement for the specified category (National Academy of Sciences, 1980).

Many kinds of adequacy can be defined (National Academy of Sciences, 1986):

1) prevention of clinical deficiency symptoms,

2) maintenance of specified levels of the nutrients or the metabolites in tissues, and

3) the maintenance of enzyme activity at various levels.

Each of these definitions may be associated with different requirements. Basing requirements upon symptom avoidance is the earliest method used. Now, estimates of requirements are based upon:

1) collections of data on nutrient intakes of healthy individuals,

2) review of the clinical consequences of nutritional deficiency and how these consequences have been corrected through diet change,

3) biochemical measurement of adequacy of molecular function in relation to nutritional intake, and

4) studies of subjects, both human and the lower animals, maintaining diets containing deficient levels of a nutrient.

In nutrition and economic nutrition research, it is common to use the RDA as a fixed cut-off point to estimate

adequacy of nutrient intake. Since the RDAs are established at high levels, this leads to an overestimation of the prevalence of inadequacy. Researchers have arbitrarily selected cut-off points like 66 percent, 75 percent, or even 130 percent of the RDAs. There has not been a theoretical rationale for these cut-offs. The probability approach does match requirements with actual need so that underestimation of well-being is less likely.

Some of the most innovative work in adequacy standards is being done at the Center for Agriculture and Rural Development (CARD) at Iowa State University under the auspices of HNIS (Human Nutrition and Information Service). This work involves finding a more appropriate measure of nutrient requirements based upon the probability approach.

A requirement for a nutrient is the minimum intake that will maintain normal function and health (CARD, 1988). As indicated by the National Academy of Sciences report on RDAs (1980), there are differences of opinion about the specific levels of nutrients needed for health. Thus, estimates of nutrient requirements are now based upon a combination of information sources and require considerable exercise of judgement.

The concept of RDAs may not be appropriate to describe "usual" intake. However, RDAs or some cut-off point measure of the RDAs have been applied to distributions of average

intakes for sampled populations to measure adequacy. Simplicity is the main advantage of the RDA cut-off method. It is more appropriate when relative comparisons of groups over time are to be made (CARD, 1988). It is also more valid to use the RDA cut-off method when the group sampled has similar RDA requirements such as a sample of elderly. In fact, the practice has been used with very heterogeneous samples.

The probability method is supposedly more reflective of true physiological needs. This method tries to find the true requirement distribution. Once the requirement distribution is found, the actual intakes can be compared to it, and the probabilities of the actual intakes being less than the requirement level can be stated. The percentage of the population below the requirement level can be found. The difficulty with the application of this method is that the requirement distributions have only been found for five nutrients for a very restricted segment of the population (Battese, Nusser, and Fuller, 1988). This research also indicates that the requirement distributions follow gamma or Weibull distributions rather than the normal distribution. In addition the method assumes no correlation between intakes and requirements (the variables are independently distributed).

The Thrifty Food Plan

For 50 years the U.S. Department of Agriculture (USDA) has prepared guides for selecting nutritious diets at different levels of cost (Peterkin, Chassey, and Kerr, 1975).

Four food plans have been developed by the USDA: thrifty, low, moderate, and liberal (Peterkin, 1976). Each plan specifies amounts of foods within different food groups that provide nutritious diets at specified fixed cost levels for adults and children by age and sex. The amounts of foods can be summed over all family members to determine the nutritious food plan for a family. Since nutrition information changes and new food products are continuously introduced, the plans are appropriately updated to incorporate the latest nutrient requirements. The four food plans were revised in 1981. All plans are still derived using a quadratic programming formulation that finds the combination of food groups that represent as little change from the consumer's food consumption patterns as needed to meet the required RDA's at a specified cost (Ravindram, 1972). All four plans are derived in the same way but at varying cost levels. The Thrifty Food Plan uses the lowest cost level. This plan is the least costly of the four food plans developed by the Human Nutrition Information Service.

The Thrifty Food Plan is based upon the idea that the food plan that is least disruptive to food practices will be most acceptable. In creating the plan, the average quantities of food consumed within specified food groups calculated from the NFCS survey for households eligible for food stamps were revised only as necessary from the normal patterns of consumption to provide nutritious diets while controlling cost.

A quadratic programming model selected the optimum Thrifty Food Plan for specified sex-age categories. This was done by minimizing the squared deviations of number of food groups in the plan from the number of food groups in ordinary consumption patterns. This allowed as little change as possible from established food patterns that would still meet the nutritional and cost constraints of the model.

Costs incorporated into the plan are determined by looking at average prices paid by the low-income sample for all types of food purchased. The recent update of the Thrifty Food Plan used percentage changes in price indices of detailed food expenditures to account for consumer costs more accurately. The update also included revised RDA levels for some nutrients and added new information of the content of nutrients in food. However, since the data used in the present study are the 1977-78 U.S. sample, prices and

information on requirements closest to that time period will be used.

The nutritional quality of the Thrifty Food Plan is high. The plan has been criticized by some as being overly generous and by others as being inefficient as the basis for the food stamp allotment. As household costs/expenditures increase, the likelihood that household food will provide the RDA increases (Peterkin, Kerr, Hama, 1982). This does not mean that households that spend near the food stamp allotment level necessarily will have poor diets as measured against the RDA standard (Peterkin and Kerr, 1982). Of those low income households with food costs at or near the food stamp allotment level, 12 percent had diets that provided the RDA for all 11 nutrients studied, and 34 percent had diets that furnished at least 80 percent of the RDA for the 11 nutrients (Peterkin, Kerr, Hama, 1982). Thus, for those low income consumers who purchase nutritious foods with the thrifty food plan level of cost, diet quality is high. These families tend to purchase diets higher in milk and dairy products, eggs, dry legumes, nuts, vegetables, fruits, and grain products than households with less nutritious diets. The criteria or standard used to assess the quality of the low income diet in the 1977-78 NFCS was the RDA as established in 1974 (National Academy of Sciences, 1980).

The thrifty food method establishes the number of food groups that minimize the differences between consumer food consumption patterns (quantities of food groups in the actual food consumption patterns) and the quantities of food groups in the food plan. This objective function is subject to a food cost and set of nutritional constraints. A weighting procedure is used to cause deviations to be minimized on the basis of the percentage change rather than change in pounds of food groups. The analysis does not include nutrients from alcoholic beverages. Foods within a food group are similar to each other in nutritive value.

The subsistence level measure that can be used is the nutritive value of food in the Thrifty Food Plan for the 11 sex-age groupings as a percentage of the Recommended Dietary Allowances. These values are derived from the quadratic programming routine which establishes the number of food groups appropriate to the age-sex cell. Once these quantities in pounds of foods per food class are determined, then the nutritive level of these foods is assessed and compared to the RDA. This approach may be superior to the nutritional equivalent approach because it considers the actual prices paid by consumers to determine the fixed costs of the Thrifty Food Plan and yet still allows for nutritious diets for the specified age-sex class.

The 21-Meal-Nutritionally-Equivalent-Person (21-MNEP)

The 21-MNEP is a method commonly used to evaluate whether nutritional needs are met by households using home food supplies (Smallwood and Blaylock, 1981). As Smallwood and Blaylock show, the assumptions of this method do not invalidate its use. A more complicated method (MAHNS) or the Meal-Adjusted Household Nutrition Scale was almost identical in results to that provided by the 21-Meal Nutritionally Equivalent Person measure.

The 21-MNEP measures the number of meals eaten from home food supplies during a 7-day period in terms of an adult male nutritionally equivalent person for three meals a day for 7 days compared in proportion to the RDA for an adult male 23-50 years of age. The 21-MNEP can be calculated for all nutrients under consideration relative to the nutritional needs of an adult male. One adult male eating all 21 meals from home food supplies is equivalent to one 21-MNEP. To calculate the needs of other persons in equivalent nutrition units, one divides their RDA by the allowance for an adult male and adjusts the result by the proportion of meals eaten at home. Table 1, adapted from Smallwood and Blaylock, shows how base or subsistence nutritional needs for a household may be derived for calcium. The first calculation made is to compute the

TABLE 1

Establishment of Equivalent Nutrition Units
for Calcium

(1) Household Members	(2) Meals At Home	(3) Meals Away	Total Meals (4) % Meals At Home * 21	(5) RDA	(6) Equivalent Nutrition Units	(7) Columns (4)*(6)
Male, age 25	14	7	14.00	800	1.00	14.00
Female, age 25	17	2	18.79	800	1.00	18.79
Male, age 9	19	3	18.24	950	1.19	21.59
Female, age 2	21	0	21.00	725	.91	19.11
			Total 71.93			Total 73.49

Source: D. Smallwood and J. Blaylock, 1981, Impact of Household Size and Income on Food Spending Patterns, USDA, ERS Technical Bulletin No. 1650, US Government Printing Office, Washington, D.C.

equivalent nutrition units for each household member. Next, one computes the adjusted at-home meals by multiplying the proportion of meals at home by 21. Then, this adjusted at-home figure is multiplied by the nutrition equivalent units. These values are summed over all members of the household to get the units of calcium intake for the household for a week in adult equivalents.

Thus, for the hypothetical household in Table 1, the weekly total calcium requirement in adjusted meals times the nutrition units is 73.49. This value would then be divided by 21 to give household size in 21-MNEP adjusted for nutrition needs.

To incorporate a subsistence level, the concept of nutritional equivalent, as developed by Smallwood and Blaylock, can be used. To find a summary number for the household that represents a base subsistence level, we can calculate the nutrient requirements for the household in terms of the adult male. For the household we would find the number of equivalent nutrition units that are based on the RDA for the specified nutrient and the household's total intake of the specified nutrient and adjust the consumption intakes by the subsistence amount. For the example in Table 1, the household equivalent nutritional units for calcium would be 4.10 (the sum of column 6).

Essentially, this method incorporates subsistence in nutrient demand analysis by simply using the established RDA's and considers the quantities of foods that accommodate the RDA's as the subsistence base. While this approach is not directly based upon market behavior, it can be used to develop a subsistence measure.

Hama and Chern (1988) used a simultaneous system to estimate Engel functions and nutrient demands. They used household size 21-meal-at-home equivalent persons as an independent variable. This measure was unadjusted for nutritional needs and thus is not a measure of subsistence. It would have been possible to use the 21-MNEP measure adjusted by nutritional needs and thereby build into their model a household subsistence level.

The Switching Regression Method

Akin, Guilkey, and Popkin (1983) used a switching regression model to find basic need levels for 14 nutrients. The procedure involved stratifying their sample into age categories and need regimes defined by the estimated level of the switching variable. Switching regression analysis is used when parameters are hypothesized to vary but one does not know a priori the point at which the switch occurs. Consequently, the level of this variable must be estimated

along with the parameters of the independent variables in the model.

The effects of the explanatory variables on nutrient consumption are different depending on the estimated need level. If nutrient consumption is below the estimated need level, then the parameters of the independent variables take on one set of values. If the nutrient consumption is above the estimated need level, then the parameters of the independent variables take on another set of values. Since income is a major variable that influences use of nutrition information and thus, ultimately, nutrient consumption, the use of income as a percentage of the poverty level is an appropriate indicator or switching variable. The authors felt that the level of nutrient consumption that defined basic need had not been established and so they used a switching regression method defined by Quandt (1971) which uses a maximum likelihood function to estimate the switching level of the indicator variable and the parameters of their model. If all the model's independent variables including the switching variable could have differentiated the sample on some a priori basis, then the problem of testing the null hypothesis of no difference between parameters of differing subsets of the sample could have been made using a standard Chow test (1960). The subsistence levels of nutrients for varying age-sex classes could be defined in this manner.

A Psychological Measure of Subsistence

Washington State University data showed food expenditures to be positively affected by an index of physiological need. This index was constructed using several attitudinal statements that were supposed to measure physiological need as conceptualized in Maslow's hierarchy of need. The index variable was significant at the .01 level for the sample of food stamp recipients. The effect was not significant for the subsample of eligible nonrecipients (Morgan, 1987). These results emphasize the importance of including some measure of subsistence in models of consumer food use. This particular data set does not incorporate nutrient demands.

Comparison of Subsistence Measures

Any one of the six conceptual ways of incorporating subsistence levels into the characteristics model of consumer nutrient demand has potential. However, the data requirements and computational requirements of several methods make them less desireable than simpler methods. In addition, some methods presented in the literature do not incorporate any standard of nutritional adequacy while others only indirectly consider market behavior.

Parato and Bagali's method does not incorporate nutritional standards, although it does consider market behavior by establishing cost minimizing quantities of foods

purchased by the sample households. The cost minimizing quantities of foods could be used to derive subsistence nutrient levels for selected household types, although the computational requirements are large.

The probability approach requires data for age-sex classes that are not yet available. Subsistence levels have been worked out for calcium, energy, iron, protein, and vitamin C for women between 19-50 years of age from the CSFII (Continuing Survey of Food Intakes by Individuals). In addition, this method requires that there be no correlation between intakes and requirements. In fact, there are many sources of correlations between intake levels and requirements (CARD, 1988). Another correlation source is that consumers are concerned with nutritional well-being and do adjust their food intakes and, thus, nutrient intakes to accommodate what they perceive to be better nutritional quality, although admittedly not exactly defined in the consumer's thinking. Since consumers are somewhat aware of the RDAs, their food purchase decisions would be better modeled by a measure of subsistence that reflects the RDAs and not just physiological thresholds.

The switching regression method assumes that parameters of a specified model are not fixed and depend upon an indicator variable. These parameters are estimated for two or more levels of the indicator variable. The assumption is

that food consumption and nutrient consumption behavior differ by level of need defined in the literature as income of each respondent's household as a percentage of the poverty index for that household. No a priori assumptions are made concerning nutrient intake levels of the respondents but only that nutrient levels would differ by need. A problem with this approach is that it defines "high need" individuals in terms of actual consumption behavior without any reference to nutritional adequacy measure.

The 21-meal-nutritionally-equivalent person adjusted for nutrient needs does take into account the nutrition needs of the household. The method is only indirectly tied to food purchase decisions. It is a measure of how well households, relative to one another, are meeting their nutrition needs from household food supplies. The advantage of this method is that it is already calculated in the Nationwide Food Consumption Survey for 1977-1978, the data set used in the present study. This measure includes meals served to guests in the household and adjusts for meals eaten away from home by family members.

The intake levels in the Thrifty Food Plan are determined using a quadratic programming procedure that does consider market prices as well as nutritional adequacy. The number of food groups are determined by minimizing the squared deviations between the food plans and the

household's actual consumption patterns. With the nutrient goals built into the model, it is possible for a household to choose foods that are nutritious as well as fit into low-income budgets. The nutritional requirements are based upon the Recommended Dietary Allowance.

The attitudinal scale measure of physiological need based upon Maslow's need hierarchy could be used to incorporate subsistence. However, this measure does not account for nutrient adequacy.

Considering data requirements, computational efforts, and need for a subsistence measure that can reflect consumers' concerns with nutritional quality and market prices, the Thrifty Food Plan's level of nutritional quality is most expedient to use. The 21-MNEP method is another possible approach, but it is only indirectly based on market purchase (meals consumed at home from home food supplies adjusted for the number of meals eaten away).

Incorporating Subsistence Levels in the Hedonic Price Equation

The 1977-78 NFCS provides data on the levels of protein, fat, carbohydrate, calcium, iron, magnesium, phosphorus, vitamin A, thiamin (vitamin B1), niacin (vitamin B3), riboflavin (vitamin B2), vitamin B6, vitamin B12, ascorbic acid (vitamin C), and food energy. Since this

information is provided on a household basis, it is possible to estimate implicit prices and nutrient demand equations at the household level.

The household is a close approximation of a consuming unit because dependent members of a consuming unit do not have necessary financial resources to make extensive purchase decisions. When nutrient analysis is based upon household data, the measure of nutrient adequacy is a household measure and not an individual measure. The Thrifty Food Plan guidelines are based upon household purchases.

The Thrifty Food Plan sets dietary guidelines for 11 nutrients by age-sex classification (Table 2). These guidelines were used in the present research to establish the subsistence level for each household. The specified aggregation of nutrients were minerals (calcium, iron, and magnesium), B vitamins (niacin, riboflavin, thiamin, B6, and B12), food energy (a composite index of carbohydrate, fat, and protein), vitamin C and vitamin A. This aggregation was chosen to reduce multicollinearity problems and mirror as much as possible previous nutrient aggregation (Terry, 1985).

TABLE 2

Nutritive Value for the 1975 Thrifty Food Plan
on a Daily Basis

Category	Nutritive Component										
	Food Energy (Kcal)	Calcium (mg)	Iron (mg)	Vitamin A (I.U.)	Ascorbic Acid (mg)	Magnesium (mg)	Niacin (mg)	Riboflavin (mg)	Thiamin (mg)	Vitamin B6 (mg)	Vitamin B12 (µg)
Infant	1018	944	7.7	36.29	36.8	184	16.3	1.70	0.82	1.11	3.86
Child 1-2	1265	766	12.6	2936	41.0	190	20.6	1.61	1.10	1.20	3.73
Child 3-5	1680	844	14.5	3229	44.2	220	23.5	1.75	1.23	1.31	3.91
Child 6-8	2205	1053	19.4	3778	52.9	287	30.9	2.15	1.58	1.59	4.61
Child 9-11	2730	1262	24.4	4773	69.3	348	38.0	2.62	1.97	1.94	5.61
Male 12-14	2940	1330	25.6	5250	70.4	371	40.6	2.71	2.04	1.99	5.80
Male 15-19	3150	1340	27.0	5707	79.1	363	42.9	2.77	2.11	1.98	6.07
Male 20-54	2835	920	27.0	5665	77.5	336	42.4	2.24	1.99	1.94	5.42
Male 55+	2520	840	24.4	5751	77.1	302	37.2	2.09	1.84	1.84	5.00
Female 12-19	2310	1260	19.7	5484	75.7	298	33.3	2.41	1.59	1.60	5.36
Female 20-54	2100	840	20.5	5527	75.6	281	33.9	1.97	1.57	1.68	4.94
Female 55+	1907	840	20.1	5631	78.8	272	31.4	1.97	1.59	1.68	4.67
Pregnant	2520	1272	22.9	6558	92.0	378	42.1	2.68	1.84	2.10	6.55
Lactating	2730	1292	23.6	6999	97.1	378	43.2	2.71	1.87	2.10	6.68

Source: Betty Peterkin, 1976, "Thrifty Food Plan," Nutrition Program News, USDA, January-April:1-8..

Functional Form of the Hedonic Price Equation

Where hedonic prices have been estimated for food consumption, a linear function has been used (Morse, 1988). Morse (1988) has clearly shown that one of the implications of this form is inability to assume declining marginal utility in consumption. All the work previous to Morse's study considering functional form, concentrated upon statistical justification and not economic theory. Morse's Box-Cox analysis provided an empirical test of the theoretical restrictions, and results were consistent with declining marginal utility.

Many functional forms that allow P_i to increase at a decreasing rate with changes in X_j exist. Some are double-log, semi-log, and log-reciprocal. The Box-Cox procedure finds values of transformation parameters that maximize an appropriate likelihood function. Specific values of this parameter apply to the linear, double-log, semi-log and log-reciprocal form. If the likelihood maximization values of the parameter are significantly different from the parameters associated with a specific form, then we know that functional form is not appropriate. The likelihood ratio method of Box and Cox (1984) can test the difference between the likelihood parameters and the parameters associated with each functional form. Morse's analysis found the double-log form not significantly

different from the Box-Cox maximum likelihood point estimates. Equation (42) allows declining marginal utility and will be used in the present study. The conformity to theory and ease of estimation make (42) an appropriate hedonic price equation to test the importance of including a subsistence measure in the hedonic price equation. Zero observations limit the application of the double-log form. This consideration led to the linear approximation used. If there are significant differences among the subsistence groups as specified in (44), then declining utility may be substantiated as long as $b_j^1 < b_j^2$.

Data Source

A food consumption analysis of nutrients has to use data sources that provide information on the nutrient content of foods. Several government sources exist: National Survey of Food Intakes by Individuals (HANES), Continuing Survey of Food Intakes by Individuals (CSFII), and the National Food Consumption Survey (NFCS). The NFCS is the only government survey with information on food expenditure and nutrient content.

The government monitors food use on three levels (Peterkin, Rizek, and Tippet, 1988):

1) First level--Food available for consumption by the U.S. civilian population. This disappearance data is

derived from data on production, imports, exports, military use, and beginning and year-end inventories. The quantities of foods on a per capita basis are used to find the nutrient content of food supplies. This information has been collected since 1909.

2) Second level--Food used by households. The quantities of foods households used during a 7-day period and the cost of those foods are surveyed. Quantities of foods reported are converted to pounds, and the nutrient content of foods used by the sample households are determined.

3) Third level--Individual food intakes. These are measures of food intakes from a 1-day dietary recall and a 2-day dietary record.

The NFCS records food use at levels 2 and 3. Nutrition studies that use NFCS use the dietary intake data. Economic studies of intakes/expenditures use food used by households, although Chavas and Kipplinger (1983) used individual food intake.

The 1977-78 NFCS consists of two area probability samples of all states except Alaska and Hawaii. The basic survey obtains information from 6,000 households, involving approximately 15,000 individuals. Another part of the survey is the low-income survey of 3,600 households with approximately 10,000 individuals. The larger sample is an

area probability sample that allows every unit at every stage of the sampling process to be selected with a known probability. Sampling yields data that are statistically representative with known sampling error to the larger U.S. population. Data were collected over all four seasons and from four regions: West, North Central, South, and Northeast.

In recent work with the 1977-78 NFCS (Hager, 1985; Terry, 1985), only the spring quarter of the sample is used. The major reason for this is the desire to limit the variability of food purchases across seasons. A second reason is to have a manageable sample to use since computer limitations make it difficult and sometimes impossible to process all four quarters.

The NFCS provides, though disappearance data, the nutrients contained in foods consumed by the approximately 3,300 households during the spring quarter. The nutrients analyzed are protein, fat, carbohydrates, calcium, iron, magnesium, phosphorus, vitamin A, thiamin, riboflavin, niacin, vitamin B6, vitamin B12, vitamin C, and food energy. The Thrifty Food Plan uses established quidelines for food energy, protein, calcium, iron, magnesium, vitamin A, thiamin, riboflavin, niacin, vitamin B6, vitamin B12, and vitamin C.

The Thrifty Food Plan's dietary goals are equal to or greater than the RDAs for the nutrient groups used in the present analysis. RDAs are based upon empirical and clinical analyses which indicate nutrient levels consumed on a daily basis that would cover the needs for most individuals within the particular age-sex class for which levels are defined. Average food energy levels are used for each age-sex class designation. These averages are based upon activity levels for moderately active individuals within each age-sex category. Underestimation of highly active individual family members with respect to food energy is a possibility. However, misclassification of a household based upon underestimation of food energy intake for highly active household members would increase the probability of accepting the null hypothesis of no difference among subsistence groups. Since an average energy intake--the midpoint of the RDA range--is used to access nutrient status in the nutrition literature, it is accepted practice to use this measure as a basis to which actual consumption patterns can be compared.

Based on previous work (Morgan et al., 1987; Terry, 1985), nutrients are aggregated to reduce multicollinearity, reflect consumer decision making across broader aggregates (Weimer, 1980), and provide comparability with other research. Since consumers recognize vitamin C, this vitamin

is analyzed separately. Vitamin A is measured in terms of international units and not milligrams or micrograms and so is not combined with other nutrients. The B vitamins are combined as one group. All minerals for which the Thrifty Food Plan had established nutrient intakes are combined.

Because of problems with missing, incorrect, or inappropriate data, only 2,163 observations were available for use in the present analysis. Only households that had consumed at least 20 foods were used. About 30 percent of the spring sample had to be eliminated because these households failed to purchase food or purchased too few food items which would affect the estimated marginal implicit prices.

Demographic and policy variables included race, ethnicity, income, size of household, sex, age, education and employment of male and female household heads, participation in WIC, food stamps, school lunch and breakfast programs, and direct distribution of food.

All data used in the present analysis came from the 1977-78 foods used by household level.

CHAPTER 5

RESULTS AND DISCUSSION

Testing the Assumption of Nonvarying Marginal Implicit Prices

Defining Subsistence Groups

Subsistence, as defined, was incorporated into the hedonic price model by dividing the 2,163 observations from the 1977 NFCS into 3 groups that represented different subsistence levels. Each household's actual consumption of the aggregated nutrient groups was compared to the level of nutrient intakes established by the Thrifty Food Plan. If the household met all its requirements, for all household members, it was placed in the "over" subsistence level group. D_i is positive for the five nutrient groups in this case. If, for all household members, the requirements as established by the Thrifty Food Plan, were not met, the household was placed in the "under" subsistence group. D_i is negative for the five nutrient groups. Households that met some but not other of their nutrient requirements were placed in an "intermediate" group. At least one D_i is positive for the respective household and at least one D_i is negative. There were 310 households in the over group, 412

households in the under group, and 1,441 in the intermediate group.

Within each subsistence group, the x_{ij} for each food was used as the unit of observation for the independent variables. The price paid by each household for each food was the expenditure divided by the respective quantity. Estimated coefficients of equation (42) should reflect implicit valuations of nutrients across households within the three groups, and equation (43) can be used to assess marginal implicit prices across households in the groups.

Analysis

Equation (42) for each subsistence subgroup was estimated using ordinary least squares. Then an OLS regression was calculated for the entire sample. No other variables besides the x_{ij}s were included in the hedonic price equation since the theoretical model does not explicitly have them present and it was not clear from existing ad-hoc empirical work what would be the most appropriate way to capture preference differences. Cross-sectional data give notoriously low R^2s. However, since the major purpose of the present analysis was to test the significance of subsistence as a differentiator of hedonic values, the overall R^2s are not of major importance.

Since three groups were involved, it was not possible to use the standard Chow test because this F test allows division of the sample into two subgroups. A more general F test as explained by Intriligator (1978) and adapted by Eastwood (1988) was used. It was constructed to test for differences among coefficients as follows. Let G equal the number of subgroups, and m equal the number of estimated coefficients within a subgroup. Then there are k = Gm estimated coefficients altogether, and there are h = (G - 1)m differences among the sets of estimates for the subgroups. The h differences among the k estimated coefficients can be expressed as a set of linear constraints. Let A denote this constraint matrix. It has dimensions h by k. Let B represent a vector of the k estimated coefficients. H is the matrix of independent variables for the entire sample. The null hypothesis is that there are no significant differences among the subgroups. The computed F value is shown below and has h and n - K degrees of freedom:

(49) $F = (AB')[A(H'H)^{-1}A']^{-1}(AB)/hs^2$.

$(H'H)^{-1}$ is a block diagonal matrix composed of the variance-covariance matrices of each separate subgroup regression. Since the data are cross-sectional and the observations are independent from one another, there would not be mutual correlation or autocorrelation among the error terms for

each observation. So the off-diagonals in the block diagonal matrix are zero.

Intercept and No-Intercept Models

If one assumed a common attribute formulation, there is no reason to include an intercept term in the model. When and intercept is included, it is interpreted as the effect of a unique attribute for the food. However, since the present analysis goes across all foods over each household, there is no unique attribute. Thus, no-intercept models are used in the present analysis.

No-intercept models must redefine R^2 (Eastwood et al, 1989). When a no-intercept model is used, R^2 may be negative or greater than one. The problem arises because the Σe need not be zero. Aigner (1971) points out that the raw moment form of the regression and not the mean-corrected form of calculating R^2 provides the correct R^2. The computer program used in this analysis does recalculate R^2 for the no-intercept model.

Hedonic Coefficients and Implicit Prices

Table 3 presents the coefficients for food energy, vitamin C, vitamin A, minerals, and B-complex vitamins by subsistence group. Table 3 also contains the R^2 adjusted for no-intercept, the s^2 or the mean square error, the

TABLE 3

Implicit Prices for All Groups, Linear Model[a]

Variable[b]	Subsistence Group		
	Under	Over	Middle
Food Energy (in $/kcal.)	.000232* (.00000698)	.000298* (.00000682)	.000294* (.00000368)
Minerals (in $/mg.)	.000236* (.00000755)	.000186* (.00000648)	.000210* (.00000357)
B Vitamins (in $/mg.)	.020907* (.00033210)	.023157* (.00032284)	.024495* (.00017646)
Vitamin C (in $/mg.)	.002357* (.00006841)	.001145* (.00006835)	.001278* (.00003521)
Vitamin A (in $/I.U.)	-.000020* (.00000130)	-.000010* (.00000091)	-.000013* (.00000052)
R^2	.48	.50	.48
S^2	1.34	1.19	1.39
F	3367.95*	3279.38*	12455.12*
N(foods)	17911	16386	67309

*Significant at least at the .05 level.
[a]Standard errors in parenthesis.
[b]Food energy is a composit of carbohydrate, protein, and fat. Food energy is measured in kilocalories (kcal).
Minerals contain magnesium, iron, and calcium. Minerals are measured in milligrams (mgs.).
B vitamins contain niacin, riboflavin, thiamin, B6, and B12. B vitamins are measured in milligrams (mgs.).
Vitamin C is measured in milligrams (mgs.)
Vitamin A is measured in International Units (I.U.).

overall F statistic, and the number of usable observations within each group. All coefficients are statistically significant. The constructed F test showed that the three sets of coefficients (Table 3) are significantly different from one another. The s^2 used was the pooled value of 1.34, since a test of the differences of variances for each individual equation from the pooled variance showed no statistical differences. The F value was 26.15. For (10 and 102,005) degrees of freedom, this F value is significant at the .001 level. The degrees of freedom are based upon the number of parameters in the model that are being compared m(G - 1) and the number of observations in the pooled sample. This leads to the inference that there are significant differences among the hedonic coefficients for the three equations.

The coefficients in Table 3 can be interpreted as marginal implicit prices. All the coefficients are less than one. A small change in quantity of the respective nutrient does not have much impact on price. This is realistic since a unit change in a nutrient has a very small effect on a household's diet.

Studies of implicit prices of nutrients have shown vitamin A with negative coefficients (Adrian and Daniel, 1976; Terry, 1985; Morse, 1988). Using the linear model, the implicit prices of vitamin A in all groups had negative

signs. Several explanations have been offered for negative implicit prices of nutrients, none of them satisfactory. One such explanation argues that the presence of certain vitamins imparts unpleasant taste, or texture characteristics to foods (Ladd and Suvannunt, 1976). Another explanation is that the statistical problem of multicollinearity causes improper signs. There is no direct way to account for the first explanation since taste parameters were not included in the data set. Pairwise multicollinearity checks on the data did not show much evidence of correlation when the linear model was used. Vitamin A, the variable with negative implicit prices, showed low correlation with all other variables over all equations but no more correlation than was shown among the other nutrients.

However, as Belsley (1980) points out, incorrect signs are neither a necessary nor sufficient condition for the existence of collinearity, and more refined techniques are required to assess the possible harmful effects of multicollinearity. His method shows that the appropriate way for diagnosing collinearity is to check for:

1. a high condition index (above 30) associated with,
2. high variance-decomposition proportions for two or more estimated regression coefficients.

The condition index is simply the ratio of the largest eigenvalue or characteristic root of the equation system to

each other eigenvalue or characteristic root. This analysis looks at the proportion of the variance of two or more coefficients associated with a particular characteristic root. If the proportion of variance associated with the condition index is greater than .5 for at least two variables and if the condition index is greater than 30, then multicollinearity that degrades the estimates is present, according to Belsley.

Analysis using the double-log form did show more negative coefficients than when the linear model was used. Negative coefficients are not easily reconciled with the theory of implicit prices. Multicollinearity may explain the negative values in the double-log model (test estimates not reported). For example, in this data set, the double-log form in the over subsistence group showed that the fourth condition index was associated with explaining a large degree of the variance (.57) for vitamin A and for minerals (.58) accompanied by a condition index over 30. However, these variables were significant. Thus, although some degree of degradation of the estimates is possible, this did not affect the significance of the variables. Perhaps this multicollinearity did affect the signs. Similarly the fourth condition index was over 30 and was associated with explaining a high degree of the variance in the vitamin A variable (.69) and the mineral variable (.47)

for the under subsistence group. In this group, the variances in food energy and minerals were associated with one conditioned index with variance decomposition values of (.46) for minerals and (.97) for food energy. A high condition index over 30 was associated with the mineral variable variance decomposition of (.61) and the food energy variable variance decomposition of (.96) in the middle group. But again, these coefficients were significant. It is possible that the vitamin A variable's negative signs in all these groups has resulted from multicollinearity problems.

The negative signs with the double-log form on the vitamin C coefficients cannot be accounted for by multi-collinearity. The negative values for food energy in all groups might also be explained by multicollinearity. However, again these variables are significant.

The problem with the negative double-log implicit price estimates is that they cannot be easily reconciled with the hypothesized functional form. Implicit prices should be positive. The linear model provides more support for positive implicit prices than the double-log form.

Adding a value to the zero observations and using a double-log form also provided negative implicit prices and added no insight beyond that already discussed for the double-log form.

The relative values of the implicit prices across groups are open to interpretation. If one assumes utility to be a function of quantities of nutrients consumed over subsistence levels, then the over subsistence group would have higher positive valuations than the under subsistence group. If one assumes declining marginal utility, then nutrients should matter more to those who are under their subsistence levels. Which of these two behavioral situations prevails is an empirical question. Table 3 and Table 4 show a mixed picture. The only nutrient aggregates more highly valued by the under subsistence group are those of minerals and vitamin C. The negative implicit prices for vitamin A impose a problem of reconciliation with the economic theory although from a nutrition perspective, the negative implicit prices have a clearer interpretation. The American diet is oriented to consumption of foods that provide minerals and B vitamins--meat and meat products. It is not oriented to the consumption of fruits and vegetables that provide vitamin A. Demand studies (Buse, 1989) show that consumers have recently reduced expenditures on fatty and low quality meats and purchase higher quality cuts of meats. This change in expenditure pattern does not mean that consumers necessarily are replacing these foods with foods high in vitamin A. Consumers are simply eating a

TABLE 4

Price Flexibilities for All Groups

Variable	Subsistence Group Under	Over	Middle
Food Energy	.2624	.3293	.3166
Minerals	.1243	.1015	.1126
B Vitamins	.3181	.3490	.3521
Vitamin C	.0872	.0467	.0500
Vitamin A	-.0496	-.0315	-.0374

different cut of meat. The American diet remains oriented to foods that are low in vitamin A.

The linear model provides higher implicit prices for food energy, B vitamins, vitamin C, and vitamin A than the double-log form. It also provides positive implicit prices for all nutrients except vitamin A. Therefore, only the former is discussed further.

The under group had a smaller negative implicit price for vitamin A. This group had a larger positive implicit price for minerals than the over group. Lower implicit prices occurred for the B vitamins in the under group, although the numerical difference was small. In this linear model, the under group had a lower value for food energy. The under group had a higher marginal valuation of vitamin C than the over group. Thus, the valuation was mixed with the under group having higher valuations for vitamin C and minerals, somewhat lower valuation for B vitamins, and lower valuations for vitamin A and food energy. However, with the linear model, most of the valuations were positive which fits better with economic theory.

As Table 3 (p. 92) shows, the computed F values lead to inferences of significant overall relationships. The R^2s also are high for household level cross-section data. These measures of overall fit support the use of CGCM as a way of analyzing consumers' valuations of nutrients.

Primary interest centers on the under-over subgroups, since they are the most distinct. The over group had higher estimated coefficients for food energy and B vitamins. With respect to declining marginal utility, this suggests that the over subgroup households had diets that were lower in food energy and B vitamins (hence higher marginal implicit prices) and higher in minerals and vitamin C (hence lower marginal implicit prices). These findings are only partially supportive of the functional relationship displayed in Figure 5 on page 51. The higher implicit prices for minerals and vitamin C follow the hypothesized relationship as theory would predict. However, the fact that the over subsistence group has higher implicit prices for food energy and B vitamins is not in keeping with the theory. This result is more consistent with the concept of utility as a function of quantities of nutrients consumed over the subsistence level. However, the possibility exists that the households' valuations have been imprecisely captured and a household size interaction term may help account for nutrient valuations.

The lower implicit prices for B vitamins and food energy for the under group suggest higher consumption of products such as meat that contain high quantities of the B complex vitamins. These foods tend to be high in food energy as well. High valuations of minerals and vitamin C

in the under subsistence group indicate a fertile ground for nutrition education efforts. The households could redirect their consumption to increase intakes of foods that contain minerals and vitamin C.

The significant differences found among these subsistence groups shows that the change in household food price associated with a one unit change in the quantity of a nutrient does significantly differ by subsistence group even though vitamin A had negative implicit prices over all groups.

Table 4 gives the percent change in price for a percent change in nutrient use. The advantage of price flexibilities over the coefficients in Table 3 (p. 92) is that the former are pure numbers, because they refer to percentage changes in the valuations due to percentage changes in the respective nutrients. Inspection of Table 4 indicates that B vitamins, followed closely by food energy, have the greatest percentage impact on households' valuations of nutrients. This suggests that promotions of these two types of nutrients would have greater impacts on the prices households are willing to pay for foods.

The Consumption of Nutrients

The Model

Empirical work has shown various demographic variables important to the attribute consumption decision (see Chapter 3, pp. 53-60). The form of the nutrient consumption function is usually linear. Since there is no theoretical or empirical evidence that suggests another form more appropriate, preliminary analysis using the subsistence groups defined the nutrient consumption model as:

$$(49)\quad X_j = B_o + B_1I + B_2BN + B_3C + B_4S + B_5NE + B_6NC$$
$$B_7SO + B_8MA + B_9E2 + B_{10}E3 + B_{11}E4 + B_{12}D2$$
$$+ B_{13}D3 + B_{14}D4 + B_{15}D5 + B_{16}D6 + B_{17}D7 +$$
$$B_{18}WH + B_{19}BL + B_{20}FW + e.$$

The dependent variable, X_j, is weekly aggregate household consumption of a particular nutrient ($j=1,. . .,5$) obtained from all foods. Equation (49) was estimated for the five nutritional attributes over all foods consumed by the households within each subsistence group. The unit of observation was the household. The pooling of the household food observations to estimate equation (42) was due to the fact that household specific marginal implicit prices were not available. However, to the extent that disaggregation into three subgroups is consistent with homogeneous valuations within each subgroup, a partial price accommodation

occurs. To the extent this holds, the problem of omitted variable bias is reduced. The variables for equations (49) are:

X_1 = food energy in kilocalories consumed per household per week,
X_2 = B vitamins in milligrams consumed per household per week,
X_3 = vitamin C in milligrams consumed per household per week,
X_4 = minerals in milligrams consumed per household per week,
X_5 = vitamin A in international units (I.U.) consumed per household per week,
I = net disposable income per household after taxes,
BN = value of food stamps minus dollar value paid,
C = central city residence,
S = suburban residence,
NE = northeast region,
NC = north central region,
SO = south region,
E2 = meal planner with at least some high school education,
E3 = meal planner with at least some college education,
E4 = meal planner with college degree,
MA = meal adjustment or the number of meals consumed out of household supplies divided by 21,
D2 = family life cycle where the female head was present and the average age of the children was under six years,
D3 = family life cycle where the female head was present and the average age of the children was greater than six to less than 12 years,
D4 = family life cycle where the female head was present and the average age of the children was from 12 to less than 19 years,
D5 = family file cycle where the female head was present and the average age of children was 19 years or older.
D6 = family life cycle where no children were present and the female head was over 40 years,
D7 = family file cycle where the female head was absent,
WH = white household,
BL = black household, and
FW = employment status of female homemaker.

All variables except I, BN, MA, and X_1 - X_5 were coded using 1 if the household met the category criteria or 0 if the household did not match the category criteria. To prevent singularity, base categories were excluded. The excluded categories were nonmetropolitan residence, race other than black or white, western region, elementary school education, family life cycle stage where no children were present and the female head was under 40 years of age, and female household head not employed. For all estimated equations, application of the Belsley criteria showed no significant multicollinearity.

Analysis of Food Energy

Table 5 presents the coefficients, standard errors, and significance levels for food energy consumption for all three subsistence groups and the combined sample. The intercept term, income, the third, fourth and seventh life cycle stages were significant variables across all equations. Life stages three and four correspond to families where the female head is present and the average age of the children ranges from age 6 to less than 12 for stage three and age 12 to less than age 19 for stage four. Stage seven includes households where the female head was absent. Life stages with no children present were much lower in food energy demand, as would be expected. Stage five had

TABLE 5

Household Food Energy Consumption by Subsistence Level for Selected Demographic Variables, Parameter Estimates and Standard Errors[a] (in kcal.)

	Subsistence Level			Total Sample
Variable	Under	Middle	Over	All
Intercept	39033.58* (9841.79)	34305.31* (5875.006	70665.14* (20052.81)	37804.81* (5305.91)
I	.49* (.20)	.57* (.09)	1.55* (.29)	.77* (.29)
BN	4.17 (47.95)	85.99* (38.68)	25.12 (133.04)	60.06 (33.33)
C	-3554.51 (3371.15)	1832.34 (1877.85)	3483.32 (5728.06)	711.01 (1774.97)
S	548.80 (3193.50)	-251.02 1865.72)	12965.84* (5729.09)	136.56 (1743.22)
NE	3570.41 (4060.11)	-1599.60 (2222.50)	6027.73 (7026.32)	-1001.17 (2116.12)
NC	1917.21 (4020.75)	-1276.22 (2242.03)	-8406.97 (6682.49)	-2717.24 (2109.93)
SO	-17.88.15 (3999.87)	-2223.61 (2205.51)	-4658.41 (6745.33)	-3393.34 (2080.91)
MA	-551.97 (814.96)	-188.66 (486.28)	1177.69 (1502.46)	254.28 (453.22)
E2	-7941.59 (4684.78)	-619.77 (2359.52)	1655.60 (6473.91)	814.05 (2216.22)
E3	-13864.48* (5505.87)	-5377.46 (2871.57)	-929.65 (8748.85)	-4274.08 (2720.35)
E4	-20221.48* (6022.19)	-12579.61* (3174.82)	-13703.23 (9285.33)	-11110.01* (2989.84)

TABLE 5 (continued)

	Subsistence Level			Total Sample
Variable	Under	Middle	Over	All
D2	31381.94* (5912.37)	27959.32* (3328.28)	10843.23 (15703.73)	20108.66* (2814.24)
D3	39736.62* (6162.61)	43965.89* (2967.45)	101278.25* (14887.78)	38538.21* (2858.34)
D4	33913.84* (6906.14)	44086.94* (2768.21)	57801.09* 10269.34)	43877.83* (2789.27)
D5	4812.70 (8749.25)	-6078.84 (2592.88)	30914.65 (11344.59)	24540.12 (3246.65)
D6	-6163.17 (7035.80)	39366.27 (5607.33)	-2435.16 (8578.85)	-1964.48 (2560.26)
D7	25716.88* (12626.60)	2844.78* (4769.80)	90627.85* (42747.60)	35355.19* (5836.13)
WH	-3713.27 (5877.21)	2844.78 (4769.80)	-31917.98 (17276.62)	-1053.35 (4150.22)
BL	-11403.80 (6738.76)	4978.36 (5189.69)	-26392.66 (18397.16)	1192.71 (4548.69)
FW	-7585.39* (2756.02)	-4284.63* (1637.70)	546.67 (5123.27)	-7283.73* (1513.56)
F-value	13.65*	53.44*	9.23*	49.42*
R^r	.33	.45	.51	.33

*Significant at least at the .05 level.
[a]Standard errors in parenthesis.

households where the female head was present, and the average age of children was 19 years or older. This variable was not significant for the under subsistence group. Stage six had no children present, and the female head was over 40 years. This stage was not significant across all equations.

The bonus value of foodstamps seems to have had a significant positive effect only for the middle group. This suggests that a major target group is not affected by the food stamp bonus program.

Education of the meal planner was a significant variable, especially in the under subsistence group. High school and college education was negatively and significantly related to consumption of food energy. As education level increased, households tended to consume less food energy.

The presence of a working female decreased the tendency to consume food energy, particularly in the under and middle subsistence groups. This variable was not related to food energy consumption for those over the subsistence level. This suggests that the income generated by the working female was not necessarily more often allocated to home food consumption in households with poorer diets than in those households with adequate diets.

Coming from a white or black household was not related to food energy consumption in the under subsistence group, middle group, or the overall sample.

Mineral Consumption

The pattern of variables that were significant in mineral consumption was similar to the pattern of food energy consumption (Table 6). Across all equations, the intercept, income, second, third, fourth and seventh life cycle stages were significant. The second stage involves families where the female head was present and the average age of children was under six years. As with food energy consumption, food stamp income was not significantly related to mineral consumption level except for the middle group. It was related to mineral consumption level in the total sample. Education of the meal planner was significant only in the under subsistence group. Similar to food energy consumption, as education increased, the tendency for households to consume minerals decreased. This is consistent with the food energy result. Lower food energy intake may impede the inclusion of sufficient nutrient intake such as minerals. The only significant location variable in the over group was suburb residence. Living in a suburb was positively associated with mineral as well as food energy consumption.

TABLE 6

Household Mineral Consumption by Subsistence Level
for Selected Demographic Variables,
Parameter Estimates and Standard Errors[a]
(in mgs.)

	Subsistence Level			Total Sample
Variable	Under	Middle	Over	All
Intercept	16715.60* (5789.61)	11514.18* (3377.26)	32700.09* (10463.11)	15058.78* (2917.73)
I	.38* (.12)	.30* (.05)	.84* (.15)	.43* (.05)
BN	47.96 (28.23)	47.44* (22.25)	7.51 (69.50)	48.68* (18.35)
C	-3138.18 (1985.10)	1595.79 (1080.56)	-30.34 (2992.23)	295.95 (977.12)
S	1549.73 (1880.49)	1431.79 (1073.58)	6949.07* (2992.23)	1338.59 (959.64)
NE	2394.12 (2367.62)	-456.22 (1278.88)	1943.34 (3670.68)	-546.53 (1164.92)
NC	84.46 (2367.62)	-665.17 (1290.13)	-5272.76 (3490.80)	-170.47 (1164.92)
SO	-1166.21 (2355.33)	-1149.38 (1269.11)	-2168.81 (3523.63)	-1830.59 (1145.54)
MA	-333.75 (479.89)	115.33 (279.81)	779.44 (784.85)	271.97 (249.50)
E2	-5477.76* (2758.64)	553.61 (1357.73)	118.01 (3381.84)	561.03 (1220.02)
E3	-8184.17* (3242.14)	(276.31) (1652.38)	-2021.28 (4570.23)	-510.36 (1497.54)
E4	-10886.94* (3546.17)	-3289.97 (1826.88)	-7759.87 (4850.48)	-3803.48 (1645.90)

TABLE 6 (continued)

	Subsistence Level			Total Sample
Variable	Under	Middle	Over	All
D2	18696.87*	22136.93*	15909.00*	11769.95*
	(3481.50)	(1915.18)	(8203.32)	(1549.23)
D3	20773.36*	22136.93*	46320.52*	19227.05*
	(3628.86)	(1707.54)	(7777.05)	(1572.41)
D4	19563.70*	24670.70*	32731.82*	24408.76*
	(4066.69)	(1592.90)	(5926.19)	(11787.27)
D5	3322.58	13917.85*	18094.28*	13656.65*
	(4143.03)	(1492.01)	(4481.42)	(1409.42)
D6	-1917.80	-2768.49	2535.52	-369.73
	(4143.03)	(1492.01)	(4481.42)	(1409.42)
D7	19856.42*	21540.93*	60097.18*	20608.96*
	(7435.19)	(3226.61)	(22330.52)	(21608.96)
WH	-1172.82	4806.37	-15059.47	1735.20
	(3460.80)	(2744.67)	(9024.97)	(2284.69)
BL	-9478.73*	863.02	-19105.09	-2527.10
	(3968.80)	(2986.28)	(9610.32)	(2504.04)
FW	-1766.63	-1630.73	-1651.38	-3056.73*
	(1622.89)	(942.38)	(2676.30)	(835.96)
F-value	7.97*	45.39*	12.86*	46.13*
R^2	.30	.41	.50	.32

*Significant at least at the .05 level.
[a]Standard errors in parenthesis.

B Vitamin Consumption

Income again was a significant variable in B vitamin consumption (Table 7). Food stamp participation was not significant in the under subsistence or over subsistence levels but did have significance in the middle and overall groups. Suburb living was significant and positively related to B vitamin consumption in the over equation. Region was almost always not significant. The pattern of consumption associated with the education of the meal planner described previously was present with B vitamin consumption. Increasing education was negatively and significantly related to B vitamin consumption, especially among families that were below the household subsistence level. As with previous nutrient groups, family life cycle, especially stages two, three, four, and seven were significantly related to nutrient consumption across all subsistence levels. Thus, having no children in the household and the female over 40 (stage six) was not related to nutrient consumption. Generally, as the average age of household children increases, B vitamin consumption tended to increase. Again, a very significant finding is that working females decreased the consumption of B vitamins within the under subsistence group. This relation held for the entire sample as well. Black households consumed

TABLE 7

Household B Vitamin Consumption by Subsistence Level for Selected Demographic Variables, Parameter Estimates and Standard Errors[a] (in mgs.)

Variable	Subsistence Level: Under	Middle	Over	Total Sample: All
Intercept	383.81 (108.25)	328.63* (67.47)	1016.62* (225.28)	408.87* (61.21)
I	.007* (.002)	.007* (.001)	.02* (.008)	.01* (.001)
BN	.61 (.52)	1.14* (.44)	1.44 (1.49)	1.02* (.38)
C	-27.16 (37.08)	19.89 (21.56)	30.97 (64.35)	8.01 (20.47)
S	6.63 (35.12)	4.79 (21.42)	132.76* (64.36)	3.22 (20.12)
NE	91.00* (44.65)	-11.12 (25.52)	50.77 (78.94)	-3.96 (24.41)
NC	57.98 (44.22)	12.27 (25.75)	-61.72 (75.07)	-1.51 (24.41)
SO	6.51 (43.99)	-11.78 (25.33)	-26.85 (75.78)	-20.59 (24.00)
MA	-5.87 (8.96)	-.196 (5.58)	9.67 (16.88)	3.35 (5.23)
E2	-70.05 (51.52)	8.00 (27.10)	-10.53 (72.73)	15.65 (25.56)
E3	-138.85* (60.56)	-44.12* (32.98)	-76.67 (98.29)	-45.51* (31.38)
E4	-202.691* (66.27)	-123.27* (36.46)	-235.98* (104.31)	-122.30* (34.45)

TABLE 7 (continued)

	Subsistence Level			Total Sample
Variable	Under	Middle	Over	All
D2	335.99* (65.03)	328.21* (38.22)	12.97 (176.42)	216.67* (32.46)
D3	466.24* (67.78)	536.30* (34.08)	1019.39* (167.25)	449.02* (32.95)
D4	416.55* (75.96)	519.18* (31.79)	564.32* (115.37)	505.99* (32.95)
D5	123.69 (96.23)	299.40* (36.75)	273.55* (127.45)	292.46* (37.45)
D6	-15.40 (77.39)	-36.47 (29.78)	-106.51 (96.38)	6.5 (29.53)
D7	304.31* (138.87)	519.76* (64.39)	1125.38* (480.24)	450.38* (67.32)
WH	-80.98 (64.64)	36.52 (54.78)	-417.06* (194.09)	-27.44 (47.87)
BL	-151.73* (74.12)	50.03 (59.60)	-334.66 (206.67)	2.16 (52.47)
FW	-79.27* (30.31)	-52.50* (18.81)	-8.65 (57.56)	-89.21* (17.52)
F-value	9.61*	54.52*	13.58*	48.82*
R2	.34	.45	.52	.33

*Significance at least at the .05 level.
[a]Standard errors in parenthsis.

significantly less B vitamins if they were in the under subsistence group.

Vitamin C Consumption

Income was a significant variable increasing vitamin C consumption except in the under subsistence group (Table 8). Having the female homemaker working was significantly and negatively related to vitamin C consumption except in the over subsistence group. However, a working female homemaker was negatively related to overall consumption of vitamin C. Food stamp bonus was not significant in the over and under subsistence groups but was significant in the over all sample and the middle group. Education of the homemaker was significantly and negatively related to vitamin C consumption. As education level increases from having a high school education to some college, vitamin C consumption decreased, a pattern appearing among other nutrients as well.

Vitamin A Consumption

Income was significantly related to vitamin A consumption across all equations (Table 9). Food stamp bonus again was not significant in the under and over subsistence levels but was related to consumption in the overall consumption

TABLE 8

Household Vitamin C Consumption by Subsistence Group for Selected Demographic Variables, Parameter Estimates and Standard Errors[a] (in mgs.)

	Subsistence Level			Total Sample
Variable	Under	Middle	Over	All
Intercept	1255.43* (328.87)	1243.17* (348.14)	3536.95* (1209.91)	1437.62* (301.84)
I	.01 (.007)	.04* (.006)	.06* (.02)	.04* (.005)
BN	1.81 (1.60)	7.73* (2.29)	-1.19 (8.03)	4.76* (1.90)
C	-111.80 (112.65)	99.98 (111.28)	-307.23 (345.61)	-18.83 (100.97)
S	53.54 (106.71)	39.67 (110.56)	114.74 (345.67)	-68.30 (99.17)
NE	-7.01 (135.67)	88.41 (131.70)	-146.90 (423.97)	-85.51 (120.03)
NC	39.12 (134.35)	121.27 (132.86)	-583.71 (403.20)	-58.67 (120.38)
S	-177.85 (133.66)	-71.76 (130.69)	-324.06 (406.99)	-174.03 (118.38)
MA	-24.93 (27.23)	18.77 (28.82)	106.19 (90.65)	41.36 (25.78)
E2	-396.97* (156.54)	61.04 (139.82)	-201.46 (390.61)	63.63 (126.07)
E3	-423.25* (183.98)	186.98 (170.16)	106.19 (527.87)	193.04 (154.75)
E4	-220.53 (201.23)	202.24 (188.13)	-613.60 (560.24)	185.43 (160.09)

TABLE 8 (continued)

Variable	Subsistence Level			Total Sample
	Under	Middle	Over	All
D2	1240.70* (197.56)	1753.89* (197.23)	1337.39 (947.50)	769.00* (160.09)
D3	1306.06* (205.93)	2237.90* (175.85)	4770.67* (898.27)	1626.38* (162.49)
D4	1152.38* (230.77)	1827.54* (164.04)	2432.48* (619.61)	1771.29* (158.67)
D5	626.83* (292.36)	1151.08* (189.63)	2295.04* (684.49)	1293.99* (184.69)
D6	-70.88 (235.10)	57.02 (153.65)	648.64 (517.61)	317.99* (145.65)
D7	944.44* (421.92)	1933.06* (332.28)	8142.99* (2579.23)	1776.66* (332.00)
WH	-147.38 (196.39)	-71.54 (282.65)	-1410.71 (1110.01)	-122.31 (258.76)
FW	-199.93* (92.09)	-228.16* (97.05)	-130.56 (309.12)	-367.32* (86.39)
F-value	8.03*	31.84*	5.91*	24.43*
R^2	.30	.33	.34	.20

*Significant at least at the .05 level.
[a]Standard errors in parenthesis.

TABLE 9

Household Vitamin A Consumption by Subsistence Level for Selected Demographic Variables, Parameter Estimates and Standard Errors[a] (in mgs.)

	Subsistence Level			Total Sample
Variable	Under	Middle	Over	All
Intercept	94301.62* (22841.99)	19844.09 (21862.79)	337728.11* (77608.29)	75433.89 (18714.73)
I	.95* (.46)	1.67* (.35)	3.64* (1.11)	2.08* (.32)
BN	126.12 (111.30)	469.13* (143.92)	185.56 (514.88)	310.03* (117.53)
C	-10892.60 (7824.16)	4214.71 (6988.09)	-15433.68 (22172.69)	-2704.06 (6148.59)
SO	3637.64 (7411.85)	5929.70 (6942.95)	38088.81 (22172.69)	3452.28 (6148.59)
NE	2999.26 (9423.19)	15854.67 (8343.32)	-12678.43 (27195.17)	-5203.96 (7463.88)
NC	8762.19 (8343.32)	15854.67 (8343.32)	-30181.41 (25862.53)	5454.60 (7442.04)
S	-3349.63 (9283.39)	3883.74 (8207.42)	-8319.43 (26105.74)	-1270.76 (7339.59)
MA	-3824.41* (1891.46)	731.20 (1809.60)	-8106.33 (5814.79)	-359.36 (1598.59)
E2	-24201.99* (10873.00)	731.20 (8780.55)	-7323.34 (25862.53)	3690.86 (7339.69)
E3	-24565.70* (12778.67)	19597.10 (10686.07)	-40943.35 (33859.75)	10005.38 (9595.07)
E4	-30413.78* (13977.02)	-7537.27 (11814.56)	-37790.75 (35936.07)	-8375.04 (10545.60)

TALBE 9 (continued)

	Subsistence Level			Total Sample
Variable	Under	Middle	Over	All
D2	77537.61*	89742.80*	36701.73	42100.21*
	(13977.02)	(12385.64)	(60776.49)	(9926.25)
D3	78887.73*	17871.11*	169289.31*	82633.18*
	(14302.91)	(11042.85)	(57618.33)	(10074.74)
D4	82524.92*	94849.48*	169289.31*	94567.72*
	(16028.60)	(10301.42)	(39744.33)	(9838.19)
D5	18815.36	65303.26*	63640.21	65165.91*
	(20306.29)	(11908.65)	(43905.77)	(11451.43)
D7	65959.65*	106703.47*	99491.79	86362.39
	(29305.32)	(20866.74)	(165441.53)	(20584.89)
WH	-26648.03*	40032.72*	-134746.89*	6587.01
	(13640.52)	(17750.02)	(66863.90)	(14638.45)
BL	-23343.11	91705.14*	-73519.93	56122.47*
	(15640.10)	(19312.54)	(71200.61)	(16043.91)
FW	-11052.14	-13540.02*	-9894.91	-23428.85*
	(6396.51)	(6094.42)	(19828.07)	(5356.18)
F-value	7.23*	24.48*	4.60*	19.89*
R^2	.28	.27	.27	.17

*Significance at least at the .05 level.
[a]Standard errors in parenthesis.

equation and the middle group equation. Similar to previous nutrient consumption patterns, as education of the meal planner increased, the consumption of vitamin C decreased. The only other variable that was significant in the under subsistence groups and not in the over group was that of the meal adjustment factor. As members of the household ate more meals from home food supplies, the meal adjustment variable would be negatively related to nutrient consumption. If the household increased its number of meals inside the household, then there would be a increase in home nutrient consumption. In the case of vitamin A, the coefficient was negative and significant. For all other nutrients, this variable was not significant in distinguishing between over and under subsistence groups.

The results showed that vitamin A consumption was affected by the degree to which household members choose to consume at home or away from home in the under subsistence group. This showed the lack of desire for foods high in vitamin A when those foods were eaten from home food supplies. This is in keeping with the higher negative implicit price found for vitamin A in the under subsistence group.

Coming from a white or black household was significantly and positively related to vitamin A consumption in the intermediate group. White households in both the over

and under groups were significantly but negatively related to vitamin A consumption. No such pattern appears for black households. In fact, vitamin A consumption was significantly and positively related to vitamin A consumption in the overall sample for black households.

CHAPTER 6

SUMMARY AND CONCLUSIONS

Summary

Basic Approach

The traditional approach to consumer behavior has utility as a function of the physical quantities of goods and services consumed. Empirical and theoretical work by investigators such as Waugh, Lancaster, and Houthakker implied or explicitly identified utility functions with qualities as variables. Utility was a function of total quantities consumed of a product's characteristics as well as the quantities of the goods themselves.

Ladd and Suvannunt provided an approach that could easily be applied to the study of nutrient components of food without the limiting assumptions of earlier models. This approach basically considered the structural relationship among three derivatives--$(\partial U/\partial X_j)(\partial X_j/\partial q_i)(\partial I/\delta U)$. The term, $(\partial U/\partial X_j)(\partial I/\partial U)$, represents the implicit price of the attribute, and the other term is derived by knowing the amount of the attribute in one unit of good i.

Estimates of implicit food prices have generally been based on linear models. However, constant implicit prices

are highly unrealistic. With a positive B_j, the two derivatives that make up B_j must change in a way that keeps B_j constant. It has been shown (Morse, 1988) that a constant B_j is theoretically inconsistent with unique utility maximization. Thus, a functional form of the hedonic price equation should account for a hedonic price function that increases at a decreasing rate. This kind of functional form is more in keeping with rational consumer maximization that allows the value of an attribute to decline as the quantity of the attribute consumed increases. Models that approximate declining marginal utility might be used if empirical considerations make other models impractical. The hedonic price function states that for each product consumed, the price paid by the consumer equals the sum of the implicit prices of the attributes of the product multiplied by the respective quantities of those characteristics obtained from one more unit (the marginal unit) consumed.

Research on nutrient hedonic price equations has often not included other attributes besides nutrients in the model. The principle of weak separability has been used to justify such an exclusion. Thus, there is no theoretical or empirical basis to include preference variables that capture household differences. Consequently, models that use cross-sectional data tend to have relatively low R^2s.

However, to the extent that assuming weak separability is consistent with real world behavior, the parameter estimates are unbiased and efficient.

Up to the present, little research has been carried out that investigates how implicit prices vary by subsistence level. Research has pointed to the fact that a person's psychological need level is related to the kinds of foods consumed. However, measuring the value placed on nutrients by consumers can give a clearer picture of consumption patterns of consumers who are below or above a defined nutrient consumption level. Nutrition education then could be targeted to consumers who place less value on the consumption of vital nutrients.

Nutrient demand equations can also be estimated. These equations differ in the literature in terms of the kinds of variables included. Sometimes, household implicit prices are used along with social and demographic variables. Many models do not include estimated implicit prices and simply estimate a nutrient Cagel-type function rather than a nutrient demand equation. This latter approach removes the problem of stochastic regressors which may make estimates both biased and inefficient under certain assumptions. Previous research has identified variables that affect nutrient consumption. These variables are income, food stamp participation, region, city, suburb, and

nonmetropolitan residence, education, number of meals consumed at home, family life cycle which incorporates age and size of household, employment status of the homemaker and race.

Data from 2,163 households located in the contiguous states were used to estimate implicit prices and nutrient demands. These data came from the spring quarter of the Nationwide Food Consumption Survey, 1977-1978. Data were separated by subsistence group as defined by the nutrient levels in the USDA Thrifty Food Plan. Three subsistence levels were defined--those under, over, and intermediate in nutrient consumption. All households that consumed more than the minimum nutrient levels for food energy, minerals, B vitamins, vitamin C, and vitamin A were defined as the over subsistence group. All households that consumed less than the defined subsistence levels for the nutrients were defined as the under subsistence group. Any household that was under on any one nutrient level was included in the intermediate group.

The Thrifty Food Plan was chosen to define subsistence because the nutrient values of the plan are established by finding the pounds of food per week for each of the 11 age-sex categories using a quadratic programming routine that finds quantities of selected food groups that represent as little change as possible from the quantities of food

groups actually consumed by low-income consumers as was necessary to meet certain specifications. Specifications were set for the nutrient content and cost of the plan and for quantities for each food group. Change was measured in terms of weighted squared deviations from the amount of food groups in the consumption pattern. With total change minimized, the weighting of squared deviations allowed small changes in amounts of several food groups, rather than a large change in one food group to meet the specification. Data from the Survey of Food Consumption in Low-Income Households, conducted as part of the Nationwide Food Consumption Survey, were used as the basis for the food consumption pattern and base food prices in the Thrifty Food Plan development. Food energy was used rather than protein, carbohydrate, and fat levels since food energy levels have been established by the Thrifty Food Plan and dietary goals for carbohydrate had not been included in the Thrifty Food Plan.

The nutrient levels of the Thrifty Food Plan were chosen to represent subsistence since these levels were derived by consideration of dietary goals as well as market prices paid by the consumer and thus are related to market decisions that the consumer has made. For the nutrients considered in this study, the dietary goals established by the Thrifty Food Plan exceeded the recommended dietary

allowances except for certain age categories for B6 and iron. These exceptions were 90 percent of the RDA for iron for a child 1-2 years old and .02 milligrams of vitamin B6 per gram of protein. For a child of 1-2 years, cereal fortified with iron (which is not part of the food plan) was recommended as a source of the remaining 10 percent of the RDA. The RDA for vitamin B6 assumes protein intakes for adults well above the RDA levels and levels actually consumed, so the .02 milligrams of vitamin B6 per gram of protein was used rather than the RDA itself.

The Value of Nutrients

Utility theory based upon the Stone-Geary utility function implies that utility is a function of goods consumed over a base subsistence level. This implies that the marginal utility values associated with consumption over a base subsistence level will differ from those utility values associated with consumption below a base subsistence level. Analysis of hedonic coefficients and implicit prices did show differences among subsistence groups. The double-log hedonic price equation generated results that were considered theoretically incorrect. Most estimated coefficients were negative.

Linear hedonic price equations within subgroups but differing across subgroups allowed for a first approximation

of nutrient valuations that permitted declining marginal utility across the subgroups. A test of significant differences among subgroups' coefficients led to the rejection of the null hypothesis of no significant differences among subgroups. With the exception of vitamin A, marginal implicit price estimates were significant and positive at least the .05 level. These results suggest that the analysis of household food consumption should accommodate subsistence levels. B vitamins and food energy are estimated to have the largest percentage impacts on food prices.

Nutrient Consumption

The variables that affected nutrient consumption were consistent across subsistence groups for all nutrients. Fifteen nutrient consumption equations were estimated. A linear functional form was used since neither the literature nor theory has provided evidence for another functional form. Income was only insignificant for the under subsistence group for vitamin C consumption. For a change in income, the change in nutrient consumption was always less for the under group than the over group over all nutrients. Food stamp participation measured by the value of food stamps above what the consumer paid for the food stamps also was not significant in the over and under subsistence groups

although in the overall sample, this variable was significant for mineral, B vitamins, vitamin C, and vitamin A consumption.

Suburban living was significantly associated with consumption of food energy and minerals for the over subsistence group. Living in the Northeast was significantly associated with the consumption of B vitamins for those in the under subsistence group. No other location variable was found to be significant.

The meal adjustment variable generally was not significant. It was only significantly related to vitamin A consumption in the under group. But the coefficient was negative indicating that as consumers eat more foods at home, they do not prefer foods that include vitamin A.

In general, the education of the meal planner was significant and negatively related to nutrient consumption for food energy, minerals, B vitamins, vitamin C and Vitamin A for the under subsistence group. Education of the meal planner was not significantly related to nutrient consumption in the over subsistence group. Several life cycle stages were consistently significant across all subsistence groups. In general, the family life cycles where the female head was present and the average age of the children was 19 years or older and where no children were present and the female head was over 40 years old were associated with lower

nutrient demands than stages two, three, four or seven. The life cycle stage where the female head was over 40 years old and no children were present, stage six, was usually not significantly related to nutrient consumption in the over or under subsistence groups. Being a black household was significantly and negatively related to mineral consumption in the under subsistence group. Being a white household was significantly and negatively related to B vitamin consumption in the over group. However, race did not relate to nutrient consumption within subsistence groups in a consistent way except that race was generally not significant. However, a female working did differ between the under and over subsistence groups for food energy, B vitamins, minerals, and vitamin C. This variable was significant in the overall sample for all nutrients and for the middle group for vitamin A.

Conclusions and Implications

Hedonic price coefficients were significantly different by subsistence group for both the double-log and linear functional forms, but the linear subgroup results only were presented, given theoretical and empirical considerations.

In the linear model, the implicit price of vitamin A was negative across all three groups, and the under subsistence group had a lower negative valuation. Food energy

valuation for the under group was lower than for the over group as was B vitamin consumption, although only by a small amount for B vitamins. The positive implicit prices using the linear form are theoretically correct. However, even with the linear model, some marginal evaluations were higher for the over subsistence group.

For the general public, it is difficult to know how to restructure one's food energy consumption to ensure adequate nutrient intakes. Food labeling does not provide the necessary educational material to show how to increase nutrient intakes while decreasing over-all food energy. Programs such as Weight Watchers (Williams, 1985) do provide the necessary structure for those individuals who find the motivation to join the program. The general public does not make use of nutritional professionals such as Registered Dieticians who could restructure diets to be lower in food energy content and adequate in other nutrient content.

However, it is clear that consumers value nutrients since all variables had significant implicit price coefficients. Thus, nutrition does matter to consumers in all subsistence groups. Consumers might be amenable to labeling information or in-store marketing devices that point out the nutritional benefits of foods in terms of aggregate nutrient groups or individual nutrients of which consumers have knowledge.

Since research clearly indicates that consumers do not assess individual nutrients, the present labeling by individual nutrient is less meaningful to the consumer who, although concerned with nutrition matters, does not understand the importance of most individual nutrients. This kind of easy access to levels of aggregate nutrients in foods (i.e., minerals, B vitamins, fiber, protein, fat, carbohydrates, or food energy, and other individual nutrients familiar to the general public) would be especially helpful to consumers whose marginal valuations of nutrients are high.

The under subsistence group of households in the present study had their highest valuation per milligram of nutrient for minerals and vitamin C. Household members as purchasers of foods might be influenced by easy access to information documenting the foods high in minerals and vitamin C. Rudell's study showed consumers who had more general thoughts or cognitions about nutrition did change their food purchases to accommodate better nutritional choice. Consumers who valued nutrition (thought nutrition important) were more likely to take in nutrition information. The more consumers processed general nutrition concepts, not specific nutrition knowledge, the more they were willing to make nutritious food choices (i.e., whole wheat bread rather than white bread). So presenting general

nutrition concepts to the consumer or redefining nutrition labels in terms of general nutrition concepts (aggregates of nutrients) would likely be more often incorporated into purchase behavior by those who value the particular nutrient/nutrient group. This would be particularly helpful for households that are low in all nutrient intakes relative to some standard measure such as the RDAs or the nutrient levels in the Thrifty Food Plan.

The existence of working females in the household influenced nutrient consumption for most of the nutrient groups studied. This appears to conflict with studies that show increases in family income increases the adequacy of the diet of family members. However, studies that explicitly relate female working heads to adequacy of diet as measured by the RDAs tend to show few significant differences in nutrient adequacy. Most of these studies have used adolescents as their subjects (Varner and Skinner, 1989). The pattern of nutrient consumption in the current analysis was affected by employment status of the female head. The measure of nutrient adequacy used here differs from other analyses in that a household measure of subsistence was used rather that an individual measure. This measure identified households that were placed in the specific subsistence grouping. In addition, those households placed in the under group were below the defined

subsistence levels for all nutrients. Thus, although a female working may not be related to diet adequacy as measured by individual intakes in relation to the RDA, overall household consumption of nutrients was decreased by female heads working. Working women significantly affected the household consumption of nutrients among those households that were below the defined subsistence level. This points to the importance of expenditure decisions by families whose nutrient consumption level is below the defined household standards. Additional income generated by working women may be used to purchase nonfood items. Although it is possible that additional income may be used to purchase food away from home, these purchases are not accounted for in the present analysis.

Income was related to nutrient consumption for all groups. This result is in keeping with most studies that include income as a variable influencing nutrient intakes. Analysis of calorie consumption in other countries show that at least 90 percent of the variation in the average level of calorie intake per capita among households within selected developing countries can be explained by average income levels (Knudsen and Scandizzo, 1979). So it is not surprising that income also affected nutrient levels used in the present analysis.

That the level of education of the meal planner was inversely related to nutrient household consumption may indicate that general measures of one's education level do not reflect nutrition education, a result which has been substantiated in the literature (Scearce and Jensen, 1979). Increases in education were significantly associated with decreased household consumption in the under subsistence group. A major implication of this finding is that nutrition education efforts could be directed toward households where multiple deficiencies exist if a diagnostic tool could be used to identify those households. A household measure would capture the general nutrient pattern for the entire household. Present methods of analysis use individual nutrient analysis and often do not capture household consumption patterns.

A problematic result was that the bonus food stamp variable was not significant in the under subsistence level but was significant in the over-all nutrient regressions and the intermediate group. Possibly, the level of nutrient well being of the under subsistence group was high enough so that additional or different food purchases made little impact on nutrient consumption. The nutritive values of the Thrifty Food Plan were at least the value of the RDA for all nutrients except vitamin B6 and iron for children 1-2 years of age. Additional study would be necessary to find out

whether using more arbitrary subsistence levels (levels not related to actual consumption patterns) might provide differing results.

Another interpretation may be that the bonus food plan affected the nutrient demands of marginal households but not those households that were most at risk or households that had no risk. This result would suggest that the eligibility criteria may not be directed toward the appropriate groups.

Limitations

Developing a household measure of nutrient consumption by summing consumption levels for every household member over all foods for all nutrients would be more accurate than using overall nutrient values for the entire household. Then one could compare each person's consumption to the established subsistence level. This is more in keeping with what the nutritionist does when checking for nutritional adequacy but would be a complete household measure. However, no current data set provides individual nutrition data on all members of the household on an individual basis.

The grouping of nutrients in this study, although based upon existing empirical research, is rather arbitrary. Using indicator nutrients rather than aggregating nutrients may be as valid or more valid than lumping nutrients in a way that may make sense from a consumer decision making

framework but makes no sense from a nutritional point of view.

Although the double-log form is well founded in theory and empirical analysis, the numerous negative implicit prices imply another functional form would be appropriate. The problem is to select a form that can be estimated using the hedonic price framework. The linear form may provide a practical approximation.

It is possible that using average prices and average nutrient consumption values in the double-log estimation process to avoid zero values has led to a reduction in the power of the model. The overall fit of the model would likely increase if average values were not used. However, one must then account for the problem of zero nutrient observations. It may be the that linear approximation is more realistic.

Since estimates may be sensitive to how subsistence levels are defined, other subsistence levels could be defined and implemented. A switching regression methodology, as an example, would allow placement in subgroups on a maximum likelihood criterion. Comparison could be made among the different methodologies. However, for the switching regression method, no computer program is available that models the defined problem, although appropriate theoretical models exist.

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