PLEASURE AND NUTRIENT CONSIDERATIONS IN THE HOUSEHOLD DEMAND FOR FOOD

by

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TABLE OF CONTENTS

Page

APPROVAL ii

STATEMENT OF PERMISSION TO USE iii

ACKNOWLEDGEMENTS iv

TABLE OF CONTENTS v

LIST OF TABLES vii

LIST OF FIGURES viii

ABSTRACT ix

CHAPTER:

1. INTRODUCTION 1

   General Approach and Objectives of the Study 3
   Outline of the Study 5

2. THE THEORETICAL MODEL 6

   The Full Theoretical Model 10
   The Study Sub-Models 14
      Model One 15
      Model Two 16

3. ECONOMETRIC FORMULATION 18

   The Data Set 18
   Model One 19
   Model Two 24

4. EMPIRICAL RESULTS AND INTERPRETATION 27

   Results of Model One 28
      Own-Price Effects 40
      Cross-Price Effects 42
      Income Effect 43
      Average Age Effect 43

TABLE OF CONTENTS--Continued

Page

Results of Model Two 44
Own-Price Effects 52
Cross-Price Effects 53
Income Effect 53
Average Age Effect 54
Concluding Remarks 54

5. CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH . . . 55

Model One Results 57
Model Two Results 58
Suggestions for Further Research 59

REFERENCES 60

APPENDIX 63

LIST OF TABLES

Table		Page
1.	Definitions of variables for model one	29
2.	Nonlinear seemingly unrelated regression summary of residual errors for model one	30
3.	Nonlinear seemingly unrelated regression parameter estimates for model one	31
4.	Definitions of variables for model two	46
5.	Nonlinear seemingly unrelated regression summary of residual errors for model two	47
6.	Nonlinear seemingly unrelated regression parameter estimates for model two	48
7.	U.S. per capita consumption of food in pounds, 1953-1981	74
8.	Data sources for U.S. per capita consumption by food group category	76
9.	Real weighted U.S. retail price indices of foods for urban wage earners and clerical workers, 1953-1981	80
10.	U.S. per capita total nutrients available for consumption, 1952-1981	82
11.	Estimated shadow prices for nutrients, 1953-1981	83
12.	Per capita disposable income and food expenditures and aggregate retail price indices	84

LIST OF FIGURES

Figure		Page
1.	Indifference curves, budget lines and the Engel curve	9
2.	Geometric demonstration of the derivation of demand for good X from indifference map and rotation of budget constraint	9

ABSTRACT

When considering consumer demand for food, there are two important components: pleasure and nutrient content. It has been recognized that households consume food for the pleasure obtained through taste, odor, and appearance of the food. With increasing awareness about proper nutrition and good health, a second element in consumer demand is added. This study was designed to answer the question: *In what ways do pleasure and nutrient content affect consumer food demand?*

Since the components associated with pleasure and nutrient content of food are somewhat indistinguishable from utility, the assumption that they are linearly related to utility allows household production theory to be used. From household production theory, demand functions for food items and nutrient content can be deduced. Model variables include individual food quantities, prices associated with the food items, nutrients available, shadow prices associated with the nutrients, average age of the population, and expenditures on non-food items.

Ideally, a full model which incorporates both pleasure and nutrient content should be compared to more simplified sub-models. The two sub-models developed in this study provide empirical evidence supporting the idea that both pleasure and nutrient content of food are important in household consumption. Since estimation of a full model was beyond the scope of this study, only the results of the two sub-models were obtained.

The overall results of both models were strong in some areas and weak in others. Of the four demand properties discussed, the "pleasure" sub-model did a reasonable job in terms of logical and significant cross-price, income, and average age effects. The strong points of the "nutrient" sub-model were represented in the own-price and income effects.

The research presents evidence that effective food policy must take into account both nutrient and pleasure considerations in household food choice decisions. The results of this study represent an important first step in developing a comprehensive framework and reliable estimates of the household demand for food.

CHAPTER 1

INTRODUCTION

Consumer demand for food has been an intriguing subject for many people and for many reasons. It has long been known that people choose among foods based on smell, taste, appearance, color, and economics. But in recent years, there seems to be an added dimension in the consumer demand for food -- concern about nutrition. With increasing awareness about the impact of nutrition on better health and longer life expectancy, it is believed that the consumption of food also increasingly depends upon the nutrients present in the food diet (Lane, 1984).

There are many other reasons why nutrition is an important topic when dealing with consumer demand for food. The main objective of past agricultural policy has been to ensure a prosperous and stable farm sector. Recently, however, there appears to be a belief that food policy, which is directly related to agricultural policy, will become more nutritionally oriented. Increased awareness of nutrition/health linkages suggests that nutritional objectives, information, and knowledge will influence future food production and distribution policies (Leathers, 1979). The U.S. Department of Agriculture has already changed the grading system on beef carcass to include a grade with less marbling for households concerned about their fat intake. There is also tighter restriction on the pesticides and herbicides which can be used on domestic fruit and vegetables. For example, even with the increased awareness about nutrition and health, some groups of people are still malnourished. In addition to outright poverty, malnourishment can result from insufficient nutrients being contained in the foods eaten or from eating too much of the wrong foods. It is thought that with government intervention, the malnourished people in both cases can be helped.

Another reason that nutritional behavior of consuming households is of interest relates to numerous current government policies and programs which directly or indirectly affect the nutrient intake of the U.S. population. Some of the programs that directly affect nutrient intake are the food stamp program, the school lunch program, the Women, Infants and Children program, and the Aid to Families with Dependent Children program; the government determines the specific foods which can be purchased or used in each of these program. Indirect government policies affect nutrient intake by influencing final consumer choices. For example, agricultural policies designed to promote a stable farm sector through price supports and supply controls for specific agricultural commodities cannot help but affect the final choices available to consumers.

It has been a common notion among economists since the work of Stigler (1945) that purely nutritional requirements have little effect on actual food expenditures in the United States (Smith, 1959). Most economic approaches which have attempted to examine the effect of nutrition on demand and on food expenditures have utilized a linear-programming, minimum-cost diet framework (Stigler, 1945; Smith, 1959; and Foytik, 1981).

There are several reasons why this approach is not sufficient for analyzing the nutritional aspects of food consumption. First, linear programming imposes an undesirable structure on the household's decision process because it does not allow for differences in tastes and usually results in a bland, monotonous diet unless specific constraints are incorporated to account for variety, palatability, and complementarities in the food preparation process. Second, the linear programming approach is untenable because it tends to minimize the importance of the food preparation and consumption aspects of the diet problem. Third, linear programming is not aimed at answering the important question: *Do nutrients matter in household food consumption choices?* The question which linear programming answers is: *If we assume that the household seeks to obtain the recommended daily allowances of the major known nutrients, what is the set of foods that will achieve this at the least cost?* This concept suggests that people consume only for nutritional value and not because they achieve pleasure from foods. But we know there are tradeoffs between pleasure received and nutritional value received from different foods. Therefore, nutritional choices should be analyzed within a positive economic framework, requiring econometric methods as the primary tool for researching the nutritional aspects of food consumption.

General Approach and Objectives of the Study

The general approach adopted in this thesis is to formulate and present a model of household home-food-consumption choices which incorporates the influences of market prices, income, and other household characteristics, as well as the nutrient content of food demand. The specific objectives of this study are: (1) to obtain a flexible approximation of the household's preference function yielding choice functions possessing closed form expressions which facilitate estimation and hypothesis testing, and (2) to learn in what way taste and nutrient content affect the demand for food and, more fundamentally, to determine whether or not nutrient content is a significant determinant of consumer food demand. The different tastes and nutritional intake of food as it relates to the average age of the population will also be studied. The parameters of the model are estimated using aggregated data constructed from government sources for the years 1953-1981.

The theory underlying the model draws from the household production function framework of Becker (1965) and Muth (1966), and the product characteristics approach of Lancaster (1966). Becker and Muth present the idea that households are both consumers and producers of goods. In the case of foods, consumers buy food from outside sources to create a finished meal by combining time, appliances, and food items. The idea presented by Lancaster involves examining the characteristics or properties of goods as they affect consumers' preferences instead of the good itself. In the case of food items, this suggests that the characteristics of food such as odor, appearance, texture, and nutrient content are the reasons that food is consumed. This presents a very challenging problem when one tries to measure the effect of taste upon consumer demand, because often quantitative or even qualitative data are not available.

Outline of the Study

This study is organized as follows. Chapter 2 describes the theoretical model and the assumptions required for the empirical application. The econometric formulation of the model and the data are the topics of Chapter 3. Chapter 4 presents the econometric results and their interpretation. Finally, in Chapter 5, conclusions of the study and suggestions for further research are offered and discussed.

CHAPTER 2

THE THEORETICAL MODEL

This chapter develops the theoretical model of household food demand based on household production theory. This framework will enable the testing of the proposition that taste and, more importantly, nutrient content, significantly influence household food consumption decisions.

It is presumed that people consume food for two basic reasons, pleasure and nutrient content. The pleasure obtained from the consumption of food is derived from the taste, odor, appearance, texture, and other qualities of foods which are not directly measurable. Further, the structure of these characteristics is unknown among households and therefore is considered to be nonlinear. The consumer is not necessarily guaranteed twice as much pleasure from twice the amount of food. In addition, the pleasure associated with food consumption is not necessarily additive; that is, a consumer might experience more pleasure if his/her dessert is accompanied by coffee than from the simple "summation of pleasure" from consuming each item separately.

Nutrient content of food is equally important due to consumers' concern about their health and well-being. Medical research is providing increasing evidence relating good health and a longer life expectancy to proper diet. It is reasonable to approximate nutrients from food in a linear fashion. That is, "[t]wice as much meat yields twice as much protein or twice as much fat; hence the technology must be homogeneous of degree one. Further, the amount of protein contained in an egg is not dependent on the amount of meat consumed, so the technology is additive" (Lucas, 1975, p. 167). Both of these statements support a linear treatment of nutrient demand.

In attempting to explain consumers' decisions, economists assume that individuals are rational; that is, people will not do things which will obstruct or detract from maximizing their satisfaction. To maximize satisfaction, individuals make choices based on their preferences. The preferences individuals reveal are important components in the theory of consumer behavior.

In consumer theory, an individual's preferences are represented by a utility function of the form $u(X_i)$, i=1,2,...n, where X_i refers to the quantity of the i^{th} good chosen. Product quantities (goods) are measured in ordinal rather than cardinal terms. Indifference curves or iso-utility contours are a convenient two-dimensional construct for considering the consumer's utility maximization problem. This concept can be explained by assuming a two good world, X and Y, so that u=u(X,Y). If the utility surface for the two good case is horizontally sliced, the resulting two-dimensional surface represents various combinations of the two goods, X and Y, for which the individual is indifferent. That is, along an indifference curve, an individual's utility from consuming the goods is constant. Since the utility function is assumed to be continuous, there are an infinite number of indifference curves for any particular function, i.e., a unique indifference curve for each utility level. Most indifference curves are downward sloping and convex, demonstrating that an individual's willingness to substitute one good for another diminishes as increasing amounts of a good must be given up -- diminishing marginal rate of substitution, as depicted in Figure 1.

Consumers are assumed to allocate limited resources (i.e., time and income) among available goods and services to obtain the highest utility or satisfaction possible. The solution to this constrained optimization problem requires the consumer to choose good X so that the ratio of the marginal utility to price of that good is equal to the ratio of the marginal utility to price of the other good, Y, i.e., the locus of points where the slopes of indifference curves are equal to the slopes of budget constraint (iso-outlay) curves, as in Figure 1. In an n good world, the consumer chooses that bundle of goods where the ratios of the marginal utility for each good to its price is equal across all goods.

Many different results can be derived from knowing the equilibrium points of choices between goods, as in Figure 1. The locus of points shown in Figure 1 is called an Engle Curve, i.e., the optimal choice of X and Y derived when money income is allowed to vary while the prices of the goods are held constant. Points along this curve will indicate the different equilibrium quantities of the goods that will be purchased when nominal income changes. Another useful technique involves deriving the demands for the different goods. This is accomplished by holding income constant and allowing the price of only one of the goods to change (see Figure 2, panels a and b).

The standard mathematical approach for obtaining demand functions for the goods begins with a Lagrangian utility function which presents the consumer's utility function subject to his/her income constraint,

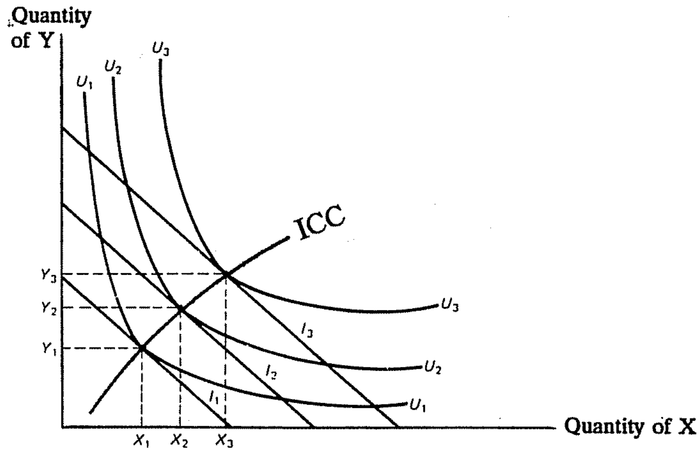

Figure 1. Indifference curves, budget lines and the Income Consumption curve (Nicholson, 1985, p. 122).

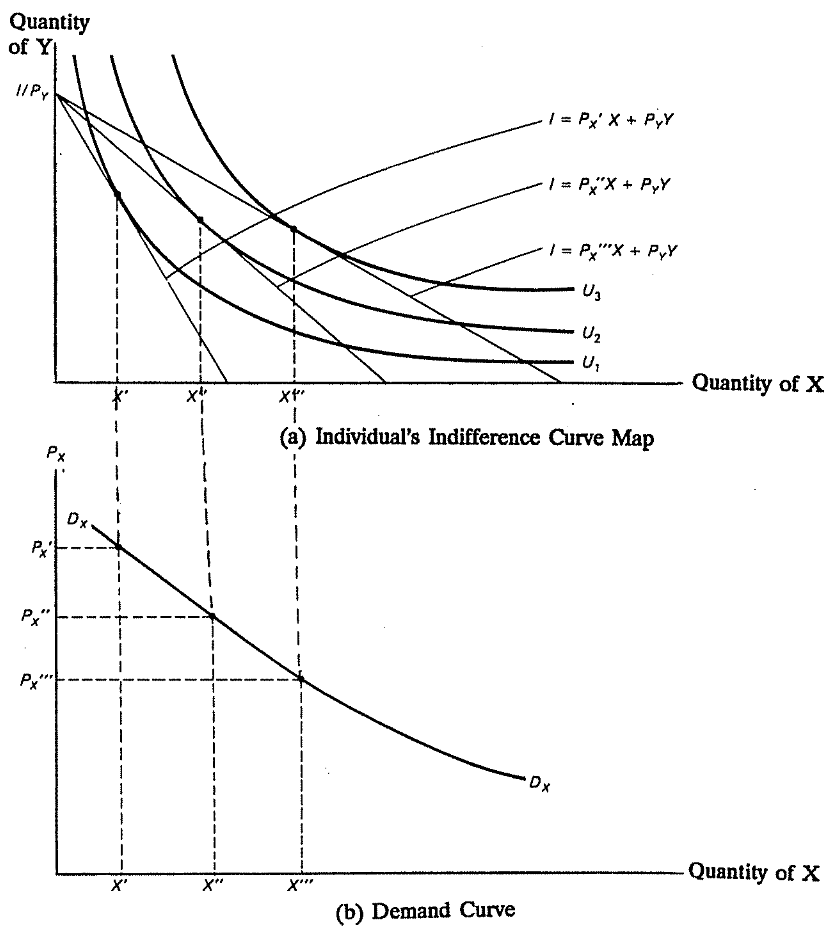

Figure 2. Geometric demonstration of the derivation of demand for good X from indifference map and rotation of budget constraint (Nicholson, 1985, p. 132).

$$Lu = u(X,Y) + \lambda(M-P_xX-P_yY). \qquad [2.1]$$

where P_x and P_y represent the prices associated with goods X and Y, M is total income available, and λ is the marginal utility of money income. Simultaneously solving the first order conditions for maximization of the Lagrangian function ($\delta Lu/\delta X = 0$, $\delta Lu/\delta Y = 0$, $\delta Lu/\delta\lambda = 0$) gives the reduced form Marshallian demand functions,

$$X^* = X^*(P_x,P_y,M) \qquad [2.2]$$

$$Y^* = Y^*(P_y,P_x,M)$$

assuming second order conditions are satisfied.

The Full Theoretical Model

The utility theory discussed above forms the basis of the model structure used in this study. However, the basic utility maximization model is expanded to include considerations of household production and product characteristics. Let us assume the household utility function includes but two basic goods, food and non-food items. The structure of the utility maximization problem is the same as equation [2.1] but is expanded so that the food variable, X, is decomposed into two parts, X_o and Z_o, which represent taste and nutrients. That is,

$$Lu(X_o,Z_o,Y) = u(X_o,Z_o,Y) + \lambda(M-P'X-Y) + \pi(Z-NX) \qquad [2.3]$$

where

X_o = (1x1) scalar function representing taste
Z_o = (1x1) scalar function representing nutrient intake
Y = (1x1) scalar expenditures on non-food items
M = (1x1) scalar of money income
P = (nx1) vector of prices for food items
X = (nx1) vector of food quantities
Z = (mx1) vector of nutrients
N = (mxn) matrix of nutrient content per unit of food
λ = (1x1) scalar of marginal utility of money income
π = (1x1) scalar of marginal utility of nutrient intake

Consumers are assumed to choose as if they maximize their preferences for food based on the utility they receive from the taste and nutrient content of the foods consumed. The household production function assumes that consumers are both producers and consumers of goods (Becker, 1965; Muth, 1966). Consumers purchase the necessary items to prepare an edible meal, including not only the food items such as meat and spices, but also the household appliances used to prepare the food (stove, refrigerator, etc.), and time (labor). It will also be assumed, following Lancaster (1966), that characteristics of food items are what yield the utility of food, not the food *per se*. The difficulty for the analyst is that time, food, appliances, and the characteristics food are not directly measurable.

A quadratic functional form is hypothesized for the X_o and Z_o functions for three main reasons. First, a quadratic approximation allows for a flexible functional form in the demand parameters associated with the food quantities, X, and the nutrients, Z. That is, a flexible functional form requires fewer restrictions on the parameters specific to X and Z. Secondly, a quadratic functional form gives a closed form expression for the resulting demand functions for X and Z. Even though this represents an incomplete demand system, it can still be estimated (LaFrance and Hannemann, 1987). Although the function does not specify the form or nature of the household's preferences over non-food items, it does contain all of the information required to specify the demands for food items, X, and for welfare analysis with respect to changes in the prices and/or quantities of X (e.g., nutrient content). Finally, this functional form permits the inclusion of a normal/infinite income effect by adding only one further parameter (LaFrance and Hannemann, 1987).

Because X_o is unobserved and is indistinguishable from utility, it is reasonable to assume that taste and utility are linearly related. Therefore, let X_o represent a scalar measure of household tastes. This function represents the time allocated to purchasing, preparation and storage of food, and durables (kitchen utensils, refrigerator, stove, or microwave oven) used to prepare the meal. The function also includes a representation of household characteristics (average age, average number of consumers in the household, ethnic heritage, etc.). The quadratic function for X characteristics is approximated by

$$X_o = \tfrac{1}{2}(X-\alpha)'\, B(X-\alpha), \qquad [2.4]$$

where $\alpha = AV_{(1)}$, A is a parameter, $V_{(1)}$ is a (k_1x1) vector of household characteristics influencing taste, and B is assumed to be a symmetric, negative definite (nxn) matrix. Again, with nutrients, some of the characteristics are unmeasurable but linearly related to utility. Therefore, a quadratic function, Z_o, will represent a scalar measure of the household's nutrient intake and other unobservable variables, such as food preparation, which affect the nutrient content of food. Specifically, Z_o is approximated by

$$Z_o = \tfrac{1}{2}(Z-\gamma)'\, D(Z-\gamma), \qquad [2.5]$$

where $\gamma = SV_{(2)}$, S is a parameter, $V_{(2)}$ is a (k_2x1) vector of household characteristics influencing nutrients, and D is assumed to be a symmetric, negative definite (mxm) matrix. The relationship between nutrient intake, Z, nutrient content per unit of food, N, and the quantities of food is represented by

$$Z = NX. \qquad [2.6]$$

The relationship in equation [2.6] implies that the availability of nutrients to the household is independent of the set of durables (such as microwave versus gas-burning oven, etc.) that the household has at its disposal to store and prepare food, and of the quantity of time allocated to the preparation of the meal. This assumption eliminates the possibility of analyzing differences in nutrient intake levels due to different nutrient consumption technologies. The matrix N is constant across households and the total availability of nutrients in the household depends only on the set of food items purchased in the market (LaFrance, 1983, p. 43). The relationship in equation [2.6] represents a constraint on nutrients available.

A second constraint set for this model consists of P, the market prices for food items, Y, the household's expenditures on non-food items, and M, total household income. The relationship is approximated by

$$P'X + Y \leq M. \qquad [2.7]$$

With both the household's taste and nutrient preferences being approximated as a quadratic function, and the constraint functions defined, the Lagrangian utility function is approximated by

$$Lu(X_o,Z_o,Y) = \tfrac{1}{2}(X-\alpha)'\ B(X-\alpha) + \tfrac{1}{2}(Z-\gamma)'\ D(Z-\gamma) + Y + \tfrac{1}{2}\theta Y^2 + \lambda(M-P'X-Y) + \pi(Z-NX) \qquad [2.8]$$

where θ, the nonlinear parameter associated with income, is ≤ 0. It is also assumed at the optimum, the budget constraint of equation [2.7] is binding with equality. The first order conditions for an interior optimum with X, Z, Y, λ, and $\pi > 0$ are

$$\delta Lu/\delta X = B(x-\alpha) - \lambda P - N'\pi = 0$$

$$\delta Lu/\delta Y = 1 + \Theta Y - \lambda = 0$$

$$\delta Lu/\delta Z = D(Z-\gamma) + \pi = 0 \qquad [2.9]$$

$$\delta Lu/\delta \lambda = M - P'X - Y = 0$$

$$\delta Lu/\delta \pi = Z - NX = 0.$$

Simultaneously solving equation [2.9] results in the reduced form demand equations for food items, non-food items, and the nutrient content. With the assumption that an interior solution is reached, the reduced form demand functions are

$$\bar{X} = (B+N'DN)^{-1}[B\alpha+N'D\gamma] + \left[\frac{1+\Theta M-\Theta P(B-N^{-1}DN)^{-1}[B\alpha+N'D\gamma]}{1+\Theta P'(B+N'DN)^{-1}}\right](B+N'DN)^{-1}P$$

$$\bar{Y} = M - P'\bar{X} \qquad [2.10]$$

$$\bar{Z} = N\bar{X}$$

<u>The Study Sub-Models</u>

The focal point of this study will not deal with the full theoretical model; however, an understanding of the full theoretical model provides useful perspective when considering the two sub-models that underlie the empirical work of this study. Equation [2.8] represents a Lagrangian utility function where households consider both taste and nutrient content in their decisions on food consumption. The two sub-models will deal with the individual quadratic functions. Model one hypothesizes that households consume food just for the pleasure obtained. The hypothesis for model two is based on households' consumption of food items for nutritional purposes.

Model One

When dealing with the quadratic function where just taste is considered the only constraint to the function is equation [2.7]. The household's Lagrangian utility function is approximated by

$$Lu(X_o,Y) = \tfrac{1}{2}(X-\alpha)'\ B(X-\alpha) + Y + \tfrac{1}{2}\Theta Y^2 + \lambda(M-P'X-Y) \qquad [2.11]$$

where the variables and parameters are the same as described earlier. First order conditions for an interior optimum with X, Y, and $\lambda > 0$ are

$$\begin{aligned} \delta Lu/\delta X &= (X-\alpha)B - \lambda P = 0 \\ \delta Lu/\delta Y &= (1+\Theta Y) - \lambda = 0 \\ \delta Lu/\delta \lambda &= M - P'X - Y = 0 \end{aligned} \qquad [2.12]$$

Simultaneously solving the first order conditions yields the following demand equations for food and non-food items:

$$\begin{aligned} \bar{X} &= \alpha + \left[\frac{1 + \Theta(M-P'\alpha)}{1 + \Theta P'B^{-1}P}\right] B^{-1}P \\ \bar{Y} &= \left[\frac{M - P\alpha - P'B^{-1}P}{1 + \Theta P'B^{-1}P}\right] \end{aligned} \qquad [2.13]$$

In principle, the parameters in equation [2.13] could be estimated by an iterative nonlinear estimation procedure by adding on an (nxl) vector of stochastic error terms to the reduced-form demand system. This is the procedure advocated by Pollak and Wachter (1975) when there are unobservable outputs in the household production process.

Model Two

Model two hypothesizes that households consume food for the nutrient content only. The Lagrangian utility function is approximated by

$$Lu(Z_o,Y) = \tfrac{1}{2}(Z-\gamma)'\ D(Z-\gamma) + Y + \tfrac{1}{2}\Theta Y^2 + \lambda(M-P'X-Y)+\pi(Z-NX). \quad [2.14]$$

Again, the variables and parameters are as described earlier. First order condition for an interior optimum with X, Z, Y, λ, and $\pi > 0$ are

$$\begin{aligned} \delta Lu/\delta X &= -\lambda P - N'\pi = 0 \\ \delta Lu/\delta Y &= 1 + \Theta Y - \lambda = 0 \\ \delta Lu/\delta Z &= D(Z-\gamma) + \pi = 0 \\ \delta Lu/\delta\lambda &= M - P'X - Y = 0 \\ \delta Lu/\delta\pi &= Z - NX = 0 \end{aligned} \quad [2.15]$$

Using the definition $\rho = -(1+\Theta Y)\pi$, where ρ is the shadow price associated with nutrients, it follows that $P = N'\rho$ from the first two first order conditions in equation [2.15]. Simultaneously solving equation [2.15] with $P = N'\rho$ results in the reduced-form demand equations for nutrients and non-food items,

$$\begin{aligned} \bar{Z} &= \gamma + \left[\frac{1+\Theta(M-\rho'\gamma)}{1+\Theta\rho'D^{-1}\rho}\right] D^{-1}\rho \\ \bar{Y} &= \left[\frac{M-\rho\gamma-\gamma'D^{-1}\rho}{1+\Theta\rho'D^{-1}\rho}\right] \end{aligned} \quad [2.16]$$

Because there is no price data associated with nutrients, it is necessary to generate estimates of the implicit nutrient prices. It is logical to use ρ as an estimate of shadow prices for nutrients. This can be explained by working through a particular primal dual setup. Consider the primal problem,

$$\min P'X \quad \text{subject to } NX = Z. \quad [2.17]$$

The Lagrangian function is

$$Lu = P'X + \rho'(Z-NX) \quad [2.18]$$

with the resulting first order conditions:

$$\delta Lu/\delta X = P' - \rho N = 0$$

$$\delta Lu/\delta \rho = Z - NX = 0 \qquad [2.19]$$

for $X > 0$.

The dual problem associated with the primal setup in equation [2.17] is

$$\max \rho' Z \quad \text{subject to } N'\rho = P \qquad [2.20]$$

which suggests the Lagrangian function,

$$Lu = \rho' Z + X' \, (P - N'\rho). \qquad [2.21]$$

The first order conditions for maximization of equation [2.21] are the same as equation [2.19], as equation [2.20] is the dual problem of equation [2.17]; i.e.,

$$\delta Lu/\delta \rho = Z - NX = 0 \qquad [2.22]$$

$$\delta Lu/\delta X = P' - \rho N = 0$$

If the first equation in [2.22] is multiplied by ρ, the result is $\rho' Z = \rho' NX$. Since $P' = \rho N$ from the second first order condition (in 2.23), it follows then that $\rho' Z = P' X$. Finally, we know from equation [2.15] that $P'X+Y = M$; therefore, $\rho' Z+Y = M$.

In the following chapter, econometric versions of the two sub-models are presented. Data sets available for estimation are considered. Model limitations due in part to data shortcomings are also discussed.

CHAPTER 3

ECONOMETRIC FORMULATION

This chapter presents a brief explanation of the data used and estimation methods for the models discussed in the previous chapter. As with any model, seldom is all the desired information available for straightforward estimation. Thus, econometric models must be constructed that are consistent with the data available for estimation. For this reason, some differences exist between the theoretical models presented and the empirical models that were estimated.

The Data Set

For this study, the main data set consisted of U.S. per capita consumption of 25 food quantities, U.S. weighted retail price indices of food items for urban wage earners and clerical workers (1967=100), U.S. per capita consumption of 16 nutrients in foods available for consumption, estimated shadow prices for nutrient intake values, average age of the U.S. population, and U.S. expenditures on non-food items. A complete description of how the data were constructed from the available data sets is presented in the appendix.

The objective of this study was to determine if both taste and nutrient content matter to households in the consumption of food. To test this proposition, two separate models were estimated. Model one presumes that consumer utility is derived from the pleasure associated with food consumption. Model two, on the other hand, presumes that consumer utility is derived from the nutrient content in foods.

Model One

For model one, the households' choice function is presumed to depend only on the pleasure received from the consumption of food items. The data set for this model consists of the following: 25 U.S. per capita food quantities measured in pounds, 25 U.S. deflated CPI's for the individual food quantities, the average age of the U.S. population, and deflated non-food expenditures for the years 1953-1981.

The household's Lagrangian utility function when only pleasure is considered is represented by

$$Lu = \tfrac{1}{2}(X-\alpha-AS)'\ B(X-\alpha-AS) + Y + \tfrac{1}{2}\theta Y^2 + \lambda(M-P'X-Y) \qquad [3.1]$$

where

X =	(25x1)	vector of food quantities
Y =	(25x1)	vector of deflated non-food expenditures
S =	(1x1)	vector of average age
P =	(25x1)	vector of deflated consumer price indices
M =	(25x1)	vector of disposable income
α =	(1x1)	intercept which represents other household characteristics besides average age
A =	(1x1)	parameter associated with average age
B =	(25x25)	symmetric matrix of parameters for food prices
θ =	(1x1)	parameter which makes the demand equation nonlinear
λ =	(1x1)	Lagrangian multiplier which represents the marginal utility of money income

First order conditions for maximization of [3.1] are

$$\delta Lu/\delta X = B(X-\alpha-AS) - \lambda P = 0$$

$$\delta Lu/\delta Y = 1 + \Theta Y - \lambda = 0 \qquad [3.2]$$

$$\delta Lu/\delta \lambda = M - P'X - Y = 0$$

assuming an optimal interior solution with X, Y, and $\lambda > 0$. Mean reduced-form demands for the food and non-food items, obtained by simultaneously solving the first order conditions of [3.2], are

$$\bar{X} = \alpha + AS + \left[\frac{1+\Theta(M-P'\alpha-P'AS)}{1+\Theta P'B^{-1}P}\right] B^{-1}P \qquad [3.3]$$

$$\bar{Y} = \left[\frac{M-P'\alpha-P'AS-P'B^{-1}P}{1+\Theta P'B^{-1}P}\right] \qquad [3.4]$$

If we add a residual vector to X, say ϵ_x, and a residual vector ϵ_y to Y, then we have the reduced-form demand equations as function of P, M, and S. That is,

$$X = \alpha + AS + \left[\frac{1+\Theta(M-P'\alpha-P'AS)}{1+\Theta P'B^{-1}P}\right] B^{-1}P + \epsilon_x \qquad [3.5]$$

$$Y = \left[\frac{M-P'\alpha-P'AS-P'B^{-1}P}{1+\Theta P'B^{-1}P}\right] + \epsilon_y \qquad [3.6]$$

Note that the budget identity in [3.2], P'X+Y=M, takes the following form:

$$P'X+Y=P'\alpha+P'AS+\left[\frac{1+\Theta(M-P'\alpha-P'AS)}{1+\Theta P'B^{-1}P}\right] P'B^{-1}P+P'\epsilon_x+\left[\frac{M-P'\alpha+P'AS-P'B^{-1}P}{1+\Theta P'B^{-1}P}\right]+\epsilon_y$$

$$= \frac{(1+\Theta P'B^{-1}P)(P'\alpha-P'AS)+(1+\Theta P'B^{-1}P)(M-P'\alpha-P'AS)}{(1+\Theta P'B^{-1}P)} + P'\epsilon_x+\epsilon_y$$

$$= M+P'\epsilon_x+\epsilon_y = M, \text{ implies that } \epsilon_y = -P\epsilon_x. \qquad [3.7]$$

Since all of the parameters in the model are identified from the demands for X, and since the residual for Y is an exact linear combination of the residuals for X, we need only to estimate the n equations for X. Note, however, the severe nonlinearity of X in the reduced-form equation [3.5], making direct estimation virtually impossible. In order to arrive at parameter estimates, equation [3.5] can be solved for X, given Y, therefore producing the reduced-form equation

$$X = \alpha + AS + (1+\Theta Y)\, B^{-1}P + \tilde{\epsilon}_x \qquad [3.8]$$

where $\tilde{\epsilon}_x$ is a conditional residual vector. Since $Y=\bar{Y}+\epsilon_y=\bar{Y}-P'\epsilon_x$, then the reduced form demands for X can be written as

$$X = \alpha + AS + (1+\Theta\bar{Y})\, B^{-1}P + \epsilon_x \qquad [3.9]$$

where $\tilde{\epsilon}_x$ and ϵ_x are related by $\tilde{\epsilon}_x=\epsilon_x-(\Theta P'\epsilon_x)B^{-1}P=(I-\Theta B^{-1}PP')\epsilon_x$. This equation would be easy to estimate because there is only one value for Y, i.e., meaning that income is held constant over time. However, the estimation of equation [3.8] is more realistic because changes in income affect food consumption.

With equation [3.8] there are several assumptions needed to ensure the desired properties for estimation. First, it is assumed that the residuals in [3.8] are distributed independently with mean zero and variance, $\sigma^2:\epsilon_x\sim N(0,\sigma^2)$. However, further assumptions need to be made. The reduced-form demand [3.8] reduces the nonlinearity to just one parameter, Θ. A second property regarding the residual term of [3.8] deals with the $Cov(Y,\tilde{\epsilon}_x)=0$. We know that

$$\begin{aligned} Cov(Y,\tilde{\epsilon}_x) &= E[-P'\epsilon_x\epsilon'_x(I-\Theta PP'B^{-1})] \\ &= -P'\Sigma_{xx}(I-\Theta PP'B^{-1}) \end{aligned} \qquad [3.10]$$

Equation [3.10] will be zero if $P'\Sigma_{xx}=0$ or if $P'\Sigma_{xx}=\Theta P\Sigma_{xx}PP'B^{-1}$. If [3.10] above is post multiplied by P, then $P'\Sigma_{xx}P(1-\Theta P'B^{-1}P)=0$, i.e., $P'\Sigma_{xx}P=0$ or $1=\Theta P'B^{-1}P$. Neither of these propositions will be true for Σ_{xx} positive definite and B^{-1} negative definite. Therefore, the assumption made is that the $Cov(Y,\tilde{\epsilon}_x)=0$ if and only if Σ_{xx} is singular and $\Sigma_{xx}P=0$.

Since the model is nonlinear in the parameter θ, realistic starting values are needed for estimation. Since $\theta=\lambda-1/Y$ from [3.2], θ must lie between the interval of -1/(maximum of Y) and zero. The Y values are scaled down (divided by 100) for ease of interpretation. For the data set used, θ ranges between 0 and -3.35. A negative θ is logical if a consumer increases his/her expenditures on non-food items; holding all other things constant, demand for X must decrease because income is reduced.

Because appropriate starting values are critical for nonlinear regression, two other regressions were run to obtain reliable starting values for model one. The first regression assumes that the value for $\theta=0.0$; therefore, [3.8] becomes linear, i.e.,

$$X_t = \alpha + AS_t + B^{-1}P_t + \epsilon_t \qquad [3.11]$$

where $\epsilon_t \sim N(0,\sigma^2)$ and $t=1,\ldots,29$. Parameter estimates for [3.11] were obtained using ordinary least squares (SHAZAM) for the 25 individual food groups. Each food quantity was regressed on the average age and the 25 food price indices. Estimated coefficients were obtained for the intercept, average age, and 25 prices. A symmetric (25x25) B matrix for the model was created by taking the simple average of the corresponding off-diagonal elements.

The second set of regression results consisted of 11 sets of 25 equations with different values specified for θ. The coefficients obtained from the ordinary least squares regressions (intercept, average age, and the constructed B matrix) were used as the starting values for each set of equations. The equations in each set were made symmetric by imposing that $B_{ij}=B_{ji}$ in each equation. The standard forms of the equations are

$$X_{1t} = \alpha_1 + A_1S_t + (1+\Theta Y_t)*(B_{11}*P_{1t}+B_{12}*P_{2t}+\ldots+B_{1\,25}*P_{25t})$$
$$X_{2t} = \alpha_2 + A_2S_t + (1+\Theta Y_t)*(B_{12}*P_{1t}+B_{22}*P_{2t}+\ldots+B_{2\,25}*P_{25t}) \qquad [3.12]$$
$$\bullet \qquad \bullet$$
$$X_{25t} = \alpha_{25} + A_{25}S_t + (1+\Theta Y_t)*(B_{1\,25}*P_{1t}+B_{2\,25}*P_{2t}+\ldots+B_{25\,25}*P_{25t})$$

where t=1,...,29.

The known interval for Θ was then divided into subintervals. This was done in order to find the shape of the likelihood function so that an appropriate value for Θ could be chosen as a starting value for the final regression run on model one.

Equation set [3.12] was estimated using a nonlinear regression SAS package. Because the likelihood function is not an output of SAS, minimization of the weighted sum of squares was used to determine the appropriate value for Θ.

The parameters in the final estimation of model one where Θ was not fixed consisted of the intercept, average age, Θ, and the constructed-symmetric B matrix. The starting value for Θ and parameter values used in the final regression were from the equation set estimated in the second step, specifically the case where the weighted sum of squares was minimized. The regression results for model one are discussed in Chapter 4.

Model Two

Model two was based on the assumption that households consume food for the nutrient content present. The data for the second model consisted of yearly intake of 16 nutrients available to U.S. consumers, estimated shadow prices for the nutrients, average age of the U.S. population, and U.S. expenditures on non-food items for the years 1953-1981. The model does not include calories as one of the nutrient categories. Calories are an important component of household diets, but are a linear combination of protein, fat, and carbohydrates. Therefore, to avoid the problem of a singular matrix, the calorie nutrient was omitted from the estimation.

As discussed in Chapter 2, prices for nutrients are not directly obtainable, but can be estimated given the relationship between food prices and the nutrient content of food. It was shown in Chapter 2 that this relationship is represented by $P_t=N'\rho_t$, where P_t is the deflated consumer price index, N_t is the nutrient content for one unit of food, and ρ_t is the shadow price associated with the nutrients. Therefore, the ordinary least squares estimator $(N_tN'_t)^{-1}N_tP_t$ can be used to construct the prices for nutrients.

Given ρ_t and the yearly nutrient intake available, the household's Lagrangian utility function including nutrient content can be derived in the following manner:

$$Lu = \frac{1}{2}(Z-\gamma-CS)'D(Z-\gamma-CS)+Y+\frac{1}{2}\theta Y^2+\lambda(M-P'X-Y)+\pi(Z-NX) \qquad [3.13]$$

where the new variables beyond those defined for model one are

$Z = (16x1)$	vector representing yearly nutrient intake available
$N = (25x16)$	matrix of nutrients contained in one unit of food
$\gamma = (1x1)$	intercept which represents other household characteristics besides average age
$C = (1x1)$	parameter associated with average age
$D = (16x16)$	symmetric matrix of parameters for nutrient prices
$\pi = (1x1)$	Lagrangian multiplier which represents the marginal utility of nutrient intake

First order conditions for the maximization of [3.13], assuming an optimal interior solution, with X, Y, Z, λ, and $\pi > 0$, are

$$\begin{aligned} \delta Lu/\delta X &= \lambda P - N'\pi = 0 \\ \delta Lu/\delta Y &= 1 + \theta Y - \lambda = 0 \\ \delta Lu/\delta Z &= D(Z-\gamma-CS) + \pi = 0 \\ \delta Lu/\delta \lambda &= M - P'X + Y = 0 \\ \delta Lu/\delta \pi &= Z - N'X = 0. \end{aligned} \qquad [3.14]$$

As with model one, there are problems with nonlinearity in the parameters of the reduced-form demand equations. Therefore, solving for Z, given a value for Y, a simpler reduced-form demand for nutrients with $\rho_t=-(1+\theta Y_t)\pi_t$ is given by

$$Z_t = \gamma + CS_t + (1+\theta Y_t)\ D^{-1}\rho_t \qquad [3.15]$$

The same procedure as used in model one was used in model two to obtain starting values for the final estimation. Again, the value for θ ranges between 0 and -3.35 to satisfy the first order condition in [3.14]. The first step was to assume that θ=0.0, which makes equation [3.15] linear, i.e.,

$$Z_t = \gamma + CS_t + D^{-1}\rho_t + \Upsilon_t \qquad [3.16]$$

where $\Upsilon_t \sim N(0,\rho\sigma^2)$. An ordinary least squares regression was run on the 16 equations using SHAZAM. The ordinary least squares estimated (16x16) D matrix of coefficients was again made symmetric by taking the simple average of the off-diagonal elements.

The same nonlinear regression package of SAS was used to estimate the 11 sets of 16 equations to determine the shape of the likelihood function as in model one. Again, the minimization of the weighted sum of squares was used to determine θ and initial parameter values because SAS does not directly report the likelihood function.

As with model one, the equations used in the final estimation of model two were constructed to be symmetric by imposing that $D_{ij}=D_{ji}$. That is,

$$\begin{aligned} Z_{1t} &= \gamma_1 + C_1S_t + (1+\theta Y_t)*(D_{11}*\rho_{1t}+D_{12}*\rho_{2t}+\ldots+D_{1\,16}*\rho_{16t}) \\ Z_{2t} &= \gamma_2 + C_2S_t + (1+\theta Y_t)*(D_{12}*\rho_{1t}+D_{22}*\rho_{2t}+\ldots+D_{2\,16}*\rho_{16t}) \qquad [3.17] \\ &\bullet \qquad\qquad \bullet \\ Z_{16t} &= \gamma_{16} + C_{16}S_t + (1+\theta Y_t)*(D_{1\,16}*\rho_{1t}+D_{2\,16}*\rho_{2t}+\ldots+D_{16\,16}*\rho_{16t}) \end{aligned}$$

The regression results for the model two specification are discussed in Chapter 4.

Ideally, in order to make a full comparison of whether both pleasure and nutrient content of food are instrumental in the demand for food, a third, more comprehensive, model as was discussed in Chapter 2 would be estimated. However, such an investigation was deemed to be beyond the scope of this initial research.

CHAPTER 4

EMPIRICAL RESULTS AND INTERPRETATION

This chapter presents the results obtained from the nonlinear estimation of the two models presented in Chapter 2. An overview of model results will be given with specific examples, difficulties encountered, and interpretation. The nonlinear system of equations for both models was run on the statistical package SAS. The estimator used was seemingly unrelated regression equations (SURE), which is generally more efficient than ordinary least squares (OLS) (Johnston, 1984, p. 338).

It should be noted that the summary statistics for each equation, while presented in Tables 2 and 5, are of dubious value. The manner in which the statistical package calculates the sum of square error, mean square error, and R-square values is not reliable when dealing with simultaneous equation systems. As shown by the results for margarine and dry beans, field peas, and nuts, it is possible to obtain a negative R-square (Judge et al., 1980, pp. 251-257), even though normally this would not occur.

Four categories of results are discussed: (1) own-price effects, (2) cross-price effects, (3) income effects, and (4) the effect of average age on consumption (disappearance). For both models, the level of significance for testing the hypothesis that an estimate is significantly different from zero is 5 percent (asymptotic t-ratio > 2.00).

Results of Model One

The overall performance of model one was quite good. Recall that model one hypothesized that households consume food principally for the associated pleasure (taste, etc.) rather than nutrient content. Using starting values obtained from prior estimations described in Chapter 3, the model converged in two iterations.

Model one assumed a quadratic utility function which represents the pleasures associated with food consumption. The demand equation derived by simultaneously solving the first order conditions of the Lagrangian utility function is

$$X_t = \alpha + AS_t + (1+\theta Y_t)\ B'P_t \qquad [4.1]$$

where t=1,29. Variables and parameters in equation [4.1] are as described in Chapter 3 and Table 1 of this chapter.

The demand equations actually estimated were constructed in such a fashion as to make sure the B_{ij} and B_{ji} elements were the same (symmetry of cross-price effects):

$$X_{1t} = \alpha_1 + A_1S_t + (1+\theta Y_t)*(B_{11}*P_{1t}+B_{12}*P_{2t}+\ldots+B_{1\,25}*P_{25t})$$
$$X_{2t} = \alpha_2 + A_2S_t + (1+\theta Y_t)*(B_{12}*P_{1t}+B_{22}*P_{2t}+\ldots+B_{2\,25}*P_{25t}) \qquad [4.2]$$
$$\bullet \qquad\qquad \bullet$$
$$X_{25t} = \alpha_{25} + A_{25}S_t + (1+\theta Y_t)*(B_{1\,25}*P_{1t}+B_{2\,25}*P_{2t}+\ldots+B_{25\,25}*P_{25t})$$

Before the results are presented, it should be stressed that the quantities of food used in the estimation are not quantities of food consumed. The quantity data are, in effect, "disappearance data"; that is, we did not have actual consumption data for food purchased.

Disappearance data will overstate food consumed since it includes spoilage and waste as well.

Table 1 presents the variables used in the estimation of the equations for model one. The summary statistics for the 25 nonlinear equations of food quantities are presented in Table 2, while Table 3 reports the parameter estimates for the nonlinear seemingly unrelated regression equations.

Table 1. Definitions of variables for model one.

Variable	Definition
α_i	Intercept (i=1,...,25; j=1,...,25)
A_i	Average age parameter for the i^{th} food
B_{ij}	Parameter on prices (i=j, own price; i≠j, cross price)
X1	Beef and veal
X2	Pork
X3	Other meat
X4	Fish
X5	Poultry
X6	Butter
X7	Margarine
X8	Other fats
X9	Eggs
X10	Cheese
X11	Flour, cereal, pasta
X12	Frozen dairy
X13	Other dairy
X14	Other sugar
X15	Fresh citrus fruit
X16	Fresh noncitrus fruit and melons
X17	Fresh dark green and deep yellow vegetables
X18	Fresh other vegetables
X19	Potatoes and sweet potatoes
X20	Processed fruit
X21	Processed vegetables
X22	Dry beans, field peas, and nuts
X23	Fresh milk and cream
X24	Coffee, tea, and cocoa
X25	Soft drinks

Table 2. Nonlinear seemingly unrelated regression summary of residual errors for model one.

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square
X1	15.04	13.96	99.495	7.127	2.670	0.949
X2	15.04	13.96	63.604	4.556	2.135	0.870
X3	15.04	13.96	48.476	3.472	1.863	0.140
X4	15.04	13.96	17.289	1.238	1.113	0.388
X5	15.04	13.96	130.043	9.315	3.052	0.957
X6	15.04	13.96	44.521	3.189	1.786	0.414
X7	15.04	13.96	56.715	4.063	2.016	-0.514
X8	15.04	13.96	51.101	3.661	1.913	0.916
X9	15.04	13.96	49.175	3.523	1.877	0.909
X10	15.04	13.96	22.297	1.597	1.264	0.941
X11	15.04	13.96	40.223	2.881	1.697	0.924
X12	15.04	13.96	54.039	3.871	1.968	0.452
X13	15.04	13.96	30.753	2.203	1.484	0.963
X14	15.04	13.96	86.200	6.175	2.485	0.477
X15	15.04	13.96	71.962	5.155	2.270	0.903
X16	15.04	13.96	33.733	2.416	1.555	0.964
X17	15.04	13.96	9.436	0.676	0.822	0.555
X18	15.04	13.96	17.656	1.265	1.125	0.836
X19	15.04	13.96	54.328	3.892	1.973	0.881
X20	15.04	13.96	27.307	1.956	1.399	0.916
X21	15.04	13.96	40.681	2.914	1.707	0.960
X22	15.04	13.96	14.978	1.073	1.036	-0.377
X23	15.04	13.96	125.100	8.961	2.994	0.993
X24	15.04	13.96	8.880	0.636	0.798	0.884
X25	15.04	13.96	362.354	25.957	5.095	0.998

Table 3. Nonlinear seemingly unrelated regression parameter estimates for model one.

Parameter	Estimate	Approximate Std. Error	T-Ratio
α1	196.571	58.125	3.38
A1	-3.167	1.550	-2.04
B11	-258.080	20.629	-12.51
B12	103.758	12.480	8.31
B13	-27.133	16.951	-1.60
B14	28.122	15.653	1.80
B15	8.197	10.166	0.81
B16	-18.934	19.755	-0.96
B17	-1.861	14.543	-0.13
B18	-17.926	15.735	-1.14
B19	21.711	9.624	2.26
B110	-1.067	18.560	-0.06
B111	-35.112	28.566	-1.23
B112	-120.880	12.908	-9.36
B113	108.686	15.177	7.16
B114	-72.572	17.381	-4.18
B115	-3.884	13.919	-0.28
B116	61.489	18.667	3.29
B117	-38.605	13.362	-2.89
B118	57.683	13.010	4.43
B119	-7.609	13.053	-0.58
B120	30.804	12.998	2.37
B121	-24.478	22.259	-1.10
B122	28.508	7.958	3.58
B123	-93.812	28.251	-3.32
B124	5.005	6.774	0.74
B125	196.800	35.669	5.52
α2	43.163	52.137	0.83
A2	0.894	1.375	0.65
B22	-212.980	17.109	-12.45
B23	-51.088	11.188	-4.57
B24	31.912	11.877	2.69
B25	72.100	9.541	7.56
B26	9.671	15.474	0.63
B27	-40.464	12.210	-3.31
B28	82.495	11.305	7.30
B29	-39.397	8.191	-4.81
B210	43.663	12.322	3.54
B211	-62.750	18.747	-3.35
B212	-89.945	9.419	-9.55
B213	-17.407	11.160	-1.56
B214	-11.530	13.618	-0.85
B215	-7.868	13.046	-0.60

Table 3--continued.

Parameter	Estimate	Approximate Std. Error	T-Ratio
B216	-17.767	13.597	-1.31
B217	-25.633	10.150	-2.53
B218	-16.993	11.907	-1.43
B219	-4.385	13.188	-0.33
B220	45.821	11.108	4.12
B221	14.618	13.984	1.05
B222	-0.171	7.953	-0.02
B223	214.507	23.011	9.32
B224	-1.510	6.114	-0.25
B225	-81.894	29.853	-2.74
$\alpha 3$	174.683	43.982	3.97
A3	-4.236	1.168	-3.63
B33	105.331	23.807	4.42
B34	-47.531	15.653	-3.04
B35	-44.353	7.917	-5.60
B36	-66.397	23.195	-2.86
B37	33.082	13.945	2.37
B38	-65.165	17.643	-3.69
B39	45.749	7.745	5.91
B310	-21.656	25.771	-0.84
B311	108.849	26.768	4.07
B312	238.937	17.659	13.53
B313	3.500	17.599	0.20
B314	-63.955	15.702	-4.07
B315	-1.358	10.048	-0.14
B316	79.436	16.858	4.71
B317	44.099	11.003	4.01
B318	-18.015	12.372	-1.46
B319	6.539	9.947	0.66
B320	-99.582	10.262	-9.70
B321	21.029	21.960	0.96
B322	14.383	6.107	2.36
B323	-359.600	30.509	-11.79
B324	-0.371	4.902	-0.08
B325	45.894	31.448	1.46
$\alpha 4$	234.864	49.496	4.75
A4	-5.621	1.283	-4.38
B44	67.408	27.176	2.48
B45	-0.820	10.160	-0.08
B46	134.374	23.800	5.65
B47	-20.575	17.305	-1.19
B48	1.046	17.251	0.06
B49	4.707	9.616	0.49

Table 3--continued.

Parameter	Estimate	Approximate Std. Error	T-Ratio
B410	-16.637	19.677	-0.85
B411	-60.408	38.028	-1.59
B412	-114.680	15.550	-7.37
B413	-86.342	18.882	-4.57
B414	141.586	16.221	8.73
B415	-8.842	13.106	-0.67
B416	-111.460	25.314	-4.40
B417	54.977	18.089	3.04
B418	-81.000	17.106	-4.74
B419	-15.846	12.091	-1.31
B420	-6.085	15.414	-0.39
B421	-1.178	27.535	-0.04
B422	1.670	7.322	0.23
B423	80.427	33.611	2.39
B424	9.111	6.131	1.49
B425	-218.440	37.767	-5.78
$\alpha 5$	40.960	51.009	0.80
A5	2.169	1.384	1.57
B55	-107.320	10.746	-9.99
B56	52.054	12.796	4.07
B57	-26.180	10.199	-2.57
B58	-57.668	9.229	-6.25
B59	-3.021	7.306	-0.41
B510	-23.120	9.146	-2.53
B511	110.959	17.175	6.46
B512	-52.842	7.468	-7.08
B513	-70.908	9.692	-7.32
B514	41.080	11.047	3.72
B515	14.856	10.550	1.41
B516	-28.547	12.902	-2.21
B517	6.945	9.871	0.70
B518	-59.893	9.173	-6.53
B519	-8.578	9.992	-0.86
B520	-24.202	9.325	-2.60
B521	60.551	12.949	4.68
B522	-3.085	6.228	-0.50
B523	172.541	18.444	9.35
B524	3.137	4.966	0.63
B525	-366.010	24.927	-14.68
$\alpha 6$	-340.560	66.206	-5.14
A6	8.591	1.732	4.96
B66	290.255	39.339	7.38
B67	34.044	21.984	1.55

Table 3--continued.

Parameter	Estimate	Approximate Std. Error	T-Ratio
B68	-2.582	23.536	-0.11
B69	56.483	12.439	4.54
B610	-300.560	28.418	-10.58
B611	237.430	40.811	5.82
B612	-197.570	21.830	-9.05
B613	-41.695	25.519	-1.63
B614	-150.800	20.535	-7.34
B615	66.179	17.193	3.85
B616	10.989	29.348	0.37
B617	-3.542	21.996	-0.16
B618	-17.143	18.811	-0.91
B619	40.098	15.507	2.59
B620	-45.035	18.717	-2.41
B621	-170.180	33.194	-5.13
B622	21.995	10.358	2.12
B623	-58.555	47.606	-1.23
B624	8.750	7.569	1.16
B625	476.196	47.600	10.00
α7	160.889	54.955	2.93
A7	-3.804	1.450	-2.62
B77	2.605	21.210	0.12
B78	39.061	16.810	2.32
B79	54.929	9.263	5.93
B710	-94.850	18.321	-5.18
B711	100.475	29.662	3.39
B712	40.502	13.448	3.01
B713	124.518	16.124	7.72
B714	-69.288	15.415	-4.49
B715	-10.448	13.087	-0.80
B716	45.583	20.434	2.23
B717	37.032	14.982	2.47
B718	14.311	13.743	1.04
B719	9.474	12.954	0.73
B720	-36.430	13.988	-2.60
B721	-90.964	22.578	-4.03
B722	17.550	7.932	2.21
B723	-342.650	30.463	-11.25
B724	-2.408	6.180	-0.39
B725	25.255	36.874	0.68
α8	205.321	48.658	4.22
A8	-2.275	1.297	-1.75
B88	-222.640	24.803	-8.98
B89	-37.424	9.463	-3.95

Table 3--continued.

Parameter	Estimate	Approximate Std. Error	T-Ratio
B810	96.434	21.392	4.51
B811	-54.030	34.838	-1.55
B812	82.573	16.469	5.01
B813	-372.210	19.480	-19.11
B814	185.276	15.608	11.87
B815	-15.445	11.493	-1.34
B816	-149.280	21.050	-7.09
B817	53.866	15.945	3.38
B818	-101.160	13.918	-7.27
B819	-38.085	10.550	-3.61
B820	-40.351	13.446	-3.00
B821	83.199	25.286	3.29
B822	-4.068	6.760	-0.60
B823	529.623	34.505	15.35
B824	10.742	5.658	1.90
B825	-478.010	33.399	-14.31
α9	-20.236	40.326	-0.50
A9	0.804	1.079	0.75
B99	38.219	8.888	4.30
B910	-39.429	8.834	-4.46
B911	20.007	16.499	1.21
B912	52.279	6.829	7.66
B913	-4.955	8.789	-0.56
B914	-77.019	9.998	-7.70
B915	14.423	9.904	1.46
B916	44.720	12.283	3.64
B917	2.355	10.244	0.23
B918	43.417	8.368	5.19
B919	14.499	8.864	1.64
B920	-5.899	8.820	-0.67
B921	-81.490	13.275	-6.14
B922	23.292	5.491	4.24
B923	-165.650	17.250	-9.60
B924	13.496	4.379	3.08
B925	171.807	23.417	7.34
α10	286.185	48.229	5.93
A10	-6.716	1.255	-5.35
B1010	229.439	35.465	6.47
B1011	-379.470	34.188	-11.10
B1012	244.338	20.573	11.88
B1013	60.588	21.928	2.76
B1014	122.890	20.012	6.14
B1015	-7.947	11.638	-0.68

Table 3--continued.

Parameter	Estimate	Approximate Std. Error	T-Ratio
B1016	-27.395	21.726	-1.26
B1017	-58.217	14.067	-4.14
B1018	-30.221	15.478	-1.95
B1019	-19.907	11.350	-1.75
B1020	-15.290	13.223	-1.16
B1021	78.818	27.552	2.86
B1022	-19.345	7.363	-2.63
B1023	124.172	37.435	3.32
B1024	-4.883	5.591	-0.87
B1025	-231.850	42.357	-5.47
α11	-617.830	84.129	-7.34
A11	20.740	2.166	9.58
B1111	441.814	83.850	5.27
B1112	-235.140	26.158	-8.99
B1113	309.807	33.012	9.38
B1114	-413.220	28.462	-14.52
B1115	36.850	21.618	1.70
B1116	78.350	47.530	1.65
B1117	-52.648	31.841	-1.65
B1118	-14.348	26.798	-0.54
B1119	50.798	20.542	2.47
B1120	68.465	27.820	2.46
B1121	35.199	48.166	0.73
B1122	22.879	12.202	1.88
B1123	-358.580	57.507	-6.24
B1124	-4.039	10.007	-0.40
B1125	579.352	68.190	8.50
α12	337.102	41.821	8.06
A12	-9.271	1.129	-8.21
B1212	389.204	20.397	19.08
B1213	212.774	17.042	12.49
B1214	-45.790	14.925	-3.07
B1215	28.929	9.845	2.94
B1216	153.604	17.603	8.73
B1217	10.258	12.014	0.85
B1218	130.827	11.977	10.92
B1219	42.052	8.523	4.93
B1220	-54.292	11.121	-4.88
B1221	-361.680	20.440	-17.69
B1222	13.342	5.283	2.53
B1223	-646.330	32.705	-19.76
B1224	-15.657	4.308	-3.63
B1225	209.462	29.397	7.13

Table 3--continued.

Parameter	Estimate	Approximate Std. Error	T-Ratio
α13	74.148	47.153	1.57
A13	-1.706	1.239	-1.38
B1313	-211.530	24.756	-8.54
B1314	40.370	16.061	2.51
B1315	-17.692	11.694	-1.51
B1316	37.579	24.065	1.56
B1317	100.227	16.608	6.03
B1318	-34.007	14.365	-2.37
B1319	-10.270	10.748	-0.96
B1320	-100.780	13.848	-7.28
B1321	202.239	26.454	7.64
B1322	3.930	6.951	0.57
B1323	-21.463	35.936	-0.60
B1324	28.351	5.376	5.27
B1325	-279.490	35.004	-7.98
α14	-6.442	59.931	-0.11
A14	3.382	1.594	2.12
B1414	4.068	23.611	0.17
B1415	6.632	15.278	0.43
B1416	21.085	19.324	1.09
B1417	-96.810	13.608	-7.11
B1418	22.648	13.638	1.66
B1419	30.755	13.852	2.22
B1420	111.714	13.395	8.34
B1421	62.962	22.099	2.85
B1422	-43.064	8.834	-4.87
B1423	517.274	30.175	17.14
B1424	-35.057	6.743	-5.20
B1425	-229.340	41.175	-5.57
α15	-85.300	62.160	-1.37
A15	2.520	1.648	1.53
B1515	-74.148	20.569	-3.60
B1516	61.666	16.019	3.85
B1517	27.898	12.054	2.31
B1518	-14.800	11.939	-1.24
B1519	11.378	14.344	0.79
B1520	-30.384	13.667	-2.22
B1521	-2.709	16.526	-0.16
B1522	12.696	8.336	1.52
B1523	-44.640	23.797	-1.88
B1524	4.198	6.790	0.62
B1525	131.251	36.623	3.58

Table 3--continued.

Parameter	Estimate	Approximate Std. Error	T-Ratio
α16	-242.250	61.797	-3.92
A16	8.752	1.588	5.51
B1616	-72.752	43.003	-1.69
B1617	90.606	24.194	3.74
B1618	-24.151	20.978	-1.15
B1619	25.639	14.567	1.76
B1620	-64.639	19.974	-3.23
B1621	79.040	34.334	2.30
B1622	-7.275	9.105	-0.80
B1623	-135.640	41.044	-3.30
B1624	22.560	7.273	3.10
B1625	-3.279	46.203	-0.07
α17	-106.290	45.303	-2.35
A17	3.048	1.177	2.59
B1717	-30.146	22.358	-1.35
B1718	-16.247	13.975	-1.16
B1719	36.286	10.794	3.36
B1720	25.611	14.750	1.74
B1721	-71.162	28.299	-2.51
B1722	-5.640	6.783	-0.83
B1723	-73.714	30.210	-2.44
B1724	-17.366	5.243	-3.31
B1725	110.052	34.162	3.22
α18	140.931	45.958	3.07
A18	-0.760	1.181	-0.64
B1818	-84.703	17.985	-4.71
B1819	-32.557	11.068	-2.94
B1820	-59.980	12.891	-4.65
B1821	26.081	21.377	1.22
B1822	-0.321	6.773	-0.05
B1823	128.883	27.033	4.77
B1824	25.557	5.347	4.78
B1825	-40.273	32.121	-1.25
α19	186.900	62.555	2.99
A19	-2.225	1.625	-1.37
B1919	-49.408	19.525	-2.53
B1920	-32.728	11.827	-2.77
B1921	-30.915	14.481	-2.13
B1922	2.469	8.469	0.29
B1923	-10.133	23.378	-0.43
B1924	1.935	6.617	0.29
B1925	-85.105	34.215	-2.49

Table 3--continued.

Parameter	Estimate	Approximate Std. Error	T-Ratio
α20	143.711	49.332	2.91
A20	-1.113	1.284	-0.87
B2020	-85.650	18.682	-4.58
B2021	74.681	20.178	3.70
B2022	-32.787	6.996	-4.69
B2023	394.733	26.992	14.62
B2024	6.076	5.525	1.10
B2025	-305.490	33.089	-9.23
α21	133.759	63.343	2.11
A21	-1.808	1.643	-1.10
B2121	147.789	50.757	2.91
B2122	-34.080	9.276	-3.67
B2123	309.742	45.068	6.87
B2124	-4.237	7.527	-0.56
B2125	-409.430	50.106	-8.17
α22	10.372	34.000	0.31
A22	-0.080	0.901	-0.09
B2222	1.581	6.908	0.23
B2223	-97.398	14.343	-6.79
B2224	7.350	4.177	1.76
B2225	111.499	20.058	5.56
α23	567.769	102.667	5.53
A23	-8.501	2.678	-3.17
B2323	1280.800	79.242	16.16
B2324	-21.589	10.834	-1.99
B2325	-1387.100	70.307	-19.73
α24	-25.537	27.318	-0.93
A24	0.660	0.726	0.91
B2424	-7.800	4.511	-1.73
B2425	67.085	15.209	4.41
α25	-601.720	152.455	-3.95
A25	32.298	3.908	8.27
B2525	747.563	118.449	6.31
θ	-2.121	0.005	-427.41

Own-Price Effects

To be consistent with general demand theory, it is anticipated that the price parameters associated with left-hand-side variables should be negative (an inverse own-price effect). This means that if the price of a good increases, the quantity consumed should decrease. For this model, 12 of the 25 food items had a negative own-price parameter while the other 13 were positive.

If one looks at the positive own-price parameters, there are several explanations which might be used to rationalize this curious outcome. Most of the dairy products (fresh milk and cream, butter, cheese, and frozen dairy) have a positive own-price coefficient. This could be due to the fact that the dairy industry has been under a price support system for many years. Therefore, the prices which are reported for dairy products may not be an accurate representation of the true market price. Another reason for positive own-price effects for several of the commodities is that these commodities are used to produce other foods for consumption. Products like butter, margarine, eggs, flour and cereal, and sugar are all used to produce other consumable foods, therefore confounding the own-price effect. For soft drinks, the explanation could be the ever-changing face of soft drinks. Over the past few years, the variety of soft drinks available has increased, more diet soft drinks have appeared on the markets to replace other non-caloric drinks, and recently there has been an introduction of soft drinks with real fruit juice. An equally plausible explanation for the positive own-price effects is that the model does not give a complete or necessarily accurate representation of a household's demand for food.

The t-ratios for the individual own-price parameters ranged from |16.16| to |.12|. The four largest (absolute) t-values were for fresh milk and cream (16.16), beef and veal (-12.51), pork (-12.45), and poultry (-9.99). The values in parentheses represent the t-ratios for the own-price parameter mentioned. As noted above, the parameter estimate for milk was positive. It is also the parameter with the highest significant t-ratio for its own-price. Along with the explanation already presented about the uniqueness of fresh milk and cream, the parameter may be picking up the influence of other things besides the price of milk and cream, such as location within the United States, ethnic background, and habits.

The three smallest (absolute) values were for margarine (.12), other sugar (.17), and dry beans, field peas, and nuts (.23). Again, the values in parentheses represent the t-ratios associated with the own-price parameters. There are not many uses for sugar and margarine besides their use in the preparation of other food commodities; therefore, it is not surprising that their own-price effects are not significantly different from zero. The nonsignificance of the dry beans, field peas, and nuts coefficient may be due in part to the fact that these items (except for nuts) usually are only consumed as part of a complete meal. Perhaps the qualities of dry beans, field peas, and nuts should be included in processed vegetables since they are so closely related.

Cross-Price Effects

In general, at least half of the 24 cross-price parameters were significant for most of the individual demand equations. The five equations which had the most significant cross-price parameters were for frozen dairy (23), other sugar (19), processed fruit (19), fresh milk and cream (19), and soft drinks (20). The value in parentheses is the number of parameters which were significant for that particular equation. For frozen dairy, the only cross-price parameter not significant was for dark green and deep yellow vegetables. Frozen dairy products could be thought of as a proxy for all desserts which are usually enjoyed after most meals.

While the own-price parameter for other sugar was not significant, the demand for other sugar has 19 cross-prices that are significant. As explained previously, sugar is not generally eaten by itself, but is used in the preparation of other foods; thus the large number of significant cross-price effects is not surprising. As would be expected for substitute products, the three meats (beef and veal, pork, and chicken) had positive cross-price coefficients among each other.

Seven demand equations had fewer than 13 significant cross-price parameters: beef and veal (12), fish (11), fresh citrus fruit (6), other vegetables (11), potatoes (10), dry beans, field peas, and nuts (12), and coffee, tea, and cocoa (8). The values in parentheses correspond to the number of statistically significant cross-price parameter estimates. For the two items with the fewest significant cross-price parameters -- fresh citrus fruit and coffee, tea, and cocoa -- there are few complements or substitutes. The cross-price parameters which were significant in the demand equation for fresh citrus fruit were substitutes. Most of the commodities which have significant cross-price effects with coffee, tea, and cocoa are food items used to produce desserts (i.e., eggs, flour and cereal, other dairy, and sugar).

Income Effect

Significance of the parameter θ suggests diminishing marginal utility of money income, as often asserted. Recall from equation [3.2] that the first order condition gives the marginal utility of money income as $\delta Lu/\delta\lambda=(1+\theta Y)=\lambda$. Since θ is significant, with a t-ratio of -427.41, and Y is a positive variable, then the change in λ as Y changes (change in marginal utility of money income) is significant.

Average Age Effect

It should be noted that over time the average age of the food-consuming population has been increasing. Therefore, the parameter estimates obtained must take this into consideration. That is, the average-age parameter is capturing more information than just the effects of average age. This variable could be accounting for such things as changes in technology associated with food (convenience foods), household appliances (microwaves, food processors), changes in the family work force (mothers working), and other unaccounted for effects that are correlated with time.

For those average-age parameters that were significant and negative, the implication is that people consume less beef, other meat, fish, margarine, cheese, frozen dairy, and milk as they get older. Food items with a positive age effect were butter, flour and cereal, other sugar, fresh noncitrus fruit, dark green and deep yellow vegetables, and soft drinks. These positive age-related products are often thought of as luxury items.

Results of Model Two

The performance of model two seems fairly reliable; that is, the estimated equations did an adequate job of explaining the data. Using the estimated shadow prices and constructed starting values, the model converged after six iterations.

Model two hypothesized that households consume foods for the nutrients present. The demand equation derived by simultaneously solving the first order conditions of the Lagrangian utility function is

$$Z_t = \gamma + CS_t + (1+\theta Y_t)\ D'\rho_t \qquad [4.3]$$

where t=1,...,29; other variables and parameters are as described in Chapter 3 and Table 4 of this chapter.

As with model one, the equations estimated were constructed so that the parameter matrix associated with prices was symmetric in the cross-price effects, i.e., $D_{ij}=D_{ji}$:

$$Z_{1t} = \gamma_1 + C_1S_t + (1+\theta Y_t)*(D_{11}*\rho_{1t}+D_{12}*\rho_{2t}+\ldots+D_{1\ 16}*\rho_{16t})$$

$$Z_{2t} = \gamma_2 + C_2S_t + (1+\theta Y_t)*(D_{12}*\rho_{1t}+D_{22}*\rho_{2t}+\ldots+D_{2\ 16}*\rho_{16t}) \qquad [4.4]$$

• •

$$Z_{16t} = \gamma_{16} + C_{16}S_t + (1+\theta Y_t)*(D_{1\ 16}*\rho_{1t}+D_{2\ 16}*\rho_{2t}+\ldots+D_{16\ 16}*\rho_{16t})$$

It is noted that some of the estimated shadow prices for the individual nutrients are <u>not</u> positive, unlike the prices for individual food items. This may be explained by considering that the nutrients with negative prices are associated with foods which people do not particularly like to eat. People may consume food with a high content of a particular nutrient but not derive pleasure from the food (e.g., brussels sprouts, liver, eggs).

Tables 4, 5, and 6 show the results received from the nonlinear seemingly unrelated regression of model two. Table 4 describes the variables and parameters used in the estimations. The results are presented in Table 5, and Table 6 gives the individual parameter estimates, standard errors, and the t-ratios.

Table 4. Definitions of variables for model two.

Variable	Definition
γ_i	Intercept (i=1,...,16; j=1,...,16)
C_i	Average age parameter for the i^{th} nutrient
D_{ij}	Parameter on shadow prices (i=j, own price; i≠j, cross-price)
Z1	Protein
Z2	Fat
Z3	Carbohydrates
Z4	Calcium
Z5	Phosphorus
Z6	Iron
Z7	Magnesium
Z8	Vitamin A
Z9	Thiamine
Z10	Riboflavin
Z11	Niacin
Z12	Vitamin B6
Z13	Vitamin B12
Z14	Vitamin C
Z15	Zinc
Z16	Cholesterol

Table 5. Nonlinear seemingly unrelated regression summary of residual errors for model two.

Equation	DF Model	DF Error	SSE	MSE	Root MSE	R-Square
Z1	10.56	18.44	143.603	7.789	2.791	0.943
Z2	10.56	18.44	1762.660	95.602	9.778	0.913
Z3	10.56	18.44	2701.380	146.516	12.104	0.898
Z4	10.56	18.44	928.741	50.372	7.097	0.751
Z5	10.56	18.44	547.083	29.672	5.447	0.340
Z6	10.56	18.44	41576.680	2255.010	47.487	0.969
Z7	10.56	18.44	2628.630	142.570	11.940	0.315
Z8	10.56	18.44	33662.580	1825.770	42.729	0.766
Z9	10.56	18.44	5625.340	305.103	17.467	0.851
Z10	10.56	18.44	3965.590	215.082	14.666	0.383
Z11	10.56	18.44	280921.550	15236.420	123.436	0.982
Z12	10.56	18.44	2879.020	156.150	12.496	0.861
Z13	10.56	18.44	63320.930	3434.360	58.603	0.654
Z14	10.56	18.44	2090.130	113.363	10.647	0.912
Z15	10.56	18.44	41395.210	2245.160	47.383	0.935
Z16	10.56	18.44	36852.250	1198.770	44.708	0.880

Table 6. Nonlinear seemingly unrelated regression parameter estimates for model two.

Parameter	Estimate	Approximate Std. Error	T-Ratio
$\gamma 1$	415.652	190.118	2.19
C1	-1.152	5.120	-0.22
D11	17.058	65.067	0.26
D12	64.872	136.611	0.47
D13	-300.380	143.743	-2.09
D14	167.777	114.900	1.46
D15	23.322	98.578	0.24
D16	-1350.200	835.028	-1.62
D17	-106.220	172.245	-0.62
D18	-1258.500	777.210	-1.62
D19	-158.820	165.781	-0.96
D110	-234.840	134.018	-1.75
D111	-2295.400	1000.510	-2.29
D112	-220.480	89.102	-2.47
D113	-1916.700	825.014	-2.32
D114	-42.497	105.921	-0.40
D115	-959.050	760.167	-1.26
D116	216.189	154.889	1.40
$\gamma 2$	-504.350	461.797	-1.09
C2	30.910	12.530	2.47
D22	952.312	648.779	1.47
D23	-2322.700	514.515	-4.51
D24	1077.410	245.495	4.39
D25	366.732	216.345	1.70
D26	-8401.100	2377.770	-3.53
D27	-421.300	470.986	-0.89
D28	14763.570	2555.240	5.78
D29	-2207.100	440.826	-5.01
D210	-656.680	352.534	-1.86
D211	-13771.000	2943.740	-4.68
D212	21.355	225.704	0.09
D213	-78.967	2180.940	-0.04
D214	1007.500	266.389	3.78
D215	1016.880	1786.900	0.57
D216	-79.120	407.034	-0.19
$\gamma 3$	1425.620	551.040	2.59
C3	5.684	14.761	0.39
D33	-187.150	618.751	-0.30
D34	-586.040	281.053	-2.09
D35	-465.470	229.660	-2.03
D36	-2072.900	2357.730	-0.88
D37	-721.050	479.234	-1.50

Table 6--continued.

Parameter	Estimate	Approximate Std. Error	T-Ratio
D38	-10068.000	2378.540	-4.23
D39	373.506	503.936	0.74
D310	-238.380	367.738	-0.65
D311	-1953.800	2913.820	-0.67
D312	-482.200	256.060	-1.88
D313	-2635.100	2382.780	-1.11
D314	-456.870	328.575	-1.39
D315	-4993.300	1854.400	-2.69
D316	310.637	490.120	0.63
$\gamma 4$	5.824	356.956	0.02
C4	6.023	9.679	0.62
D44	77.079	259.432	0.30
D45	104.035	200.279	0.52
D46	533.517	1408.380	0.38
D47	152.224	324.938	0.47
D48	-1276.200	1502.630	-0.85
D49	-304.370	319.825	-0.95
D410	-126.140	275.480	-0.46
D411	4368.050	1720.210	2.54
D412	279.643	165.312	1.69
D413	-689.380	1575.650	-0.44
D414	248.685	202.237	1.23
D415	2214.550	1342.070	1.65
D416	257.176	319.688	0.80
$\gamma 5$	549.407	269.478	2.04
C5	-1.158	7.279	-0.16
D55	-5.076	171.868	-0.03
D56	-1750.000	1293.460	-1.35
D57	-38.737	295.321	-0.13
D58	-1638.100	1309.470	-1.25
D59	-443.400	258.629	-1.71
D510	-311.970	230.557	-1.35
D511	-881.690	1454.250	-0.61
D512	-99.841	130.577	-0.76
D513	-2500.500	1344.120	-1.86
D514	99.985	157.910	0.63
D515	-552.500	1192.290	-0.46
D516	329.043	225.588	1.46
$\gamma 6$	12155.880	2617.980	4.64
C6	-143.000	70.386	-2.03
D66	-55503.000	15822.180	-3.51

Table 6--continued.

Parameter	Estimate	Approximate Std. Error	T-Ratio
D67	-6640.100	2912.140	-2.28
D68	-44399.000	12933.980	-3.43
D69	-2842.600	2552.450	-1.11
D610	-7597.100	1989.310	-3.82
D611	-67654.000	17294.970	-3.91
D612	-6263.100	1272.690	-4.92
D613	-49945.000	12532.740	-3.99
D614	-3202.300	1548.890	-2.07
D615	-46401.000	10622.660	-4.37
D616	5697.920	2061.840	2.76
$\gamma 7$	2552.820	570.662	4.47
C7	-33.595	15.371	-2.19
D77	-1152.900	703.233	-1.64
D78	-4974.300	2663.440	-1.87
D79	-66.508	554.377	-0.12
D710	-154.430	430.115	-0.36
D711	-7480.200	3268.910	-2.29
D712	-661.640	277.962	-2.38
D713	-3809.100	2578.670	-1.48
D714	-845.340	334.135	-2.53
D715	-2908.600	2183.000	-1.33
D716	1142.380	478.896	2.39
$\gamma 8$	4375.170	2538.100	1.72
C8	-48.076	68.917	-0.70
D88	-41865.000	20066.100	-2.09
D89	-4996.800	2305.730	-2.17
D810	-6962.100	2022.300	-3.44
D811	-38328.000	14727.480	-2.60
D812	-652.390	1162.000	-0.56
D813	-39158.000	13917.110	-2.81
D814	-1330.400	1558.200	-0.85
D815	-17842.000	10082.720	-1.77
D816	1012.300	1907.760	0.53
$\gamma 9$	-834.010	715.595	-1.17
C9	46.096	19.400	2.38
D99	-1868.700	899.826	-2.08
D910	-1227.600	498.010	-2.46
D911	-1324.400	3282.910	-0.40
D912	-256.820	329.169	-0.78
D913	-7763.300	2539.200	-3.06
D914	676.863	373.656	1.81

Table 6--continued.

Parameter	Estimate	Approximate Std. Error	T-Ratio
D915	-2374.900	2000.710	-1.19
D916	-518.740	740.078	-0.70
$\gamma 10$	796.148	484.924	1.64
C10	2.193	13.187	0.17
D1010	-1004.700	431.273	-2.33
D1011	-4272.600	2349.260	-1.82
D1012	-450.610	228.006	-1.98
D1013	-6818.900	2203.250	-3.09
D1014	247.288	266.477	0.93
D1015	-4993.300	1704.160	-2.93
D1016	565.755	477.627	1.18
$\gamma 11$	6562.570	3768.180	1.74
C11	146.717	101.621	1.44
D1111	-148731.000	23856.110	-6.23
D1112	-11976.000	1882.360	-6.36
D1113	-52809.000	14835.950	-3.56
D1114	-6865.100	2101.670	-3.27
D1115	-60483.000	12605.620	-4.80
D1116	4881.190	3362.420	1.45
$\gamma 12$	1667.630	451.639	3.69
C12	-22.598	12.074	-1.87
D1212	-994.320	229.119	-4.34
D1213	-3961.600	1345.540	-2.94
D1214	-747.790	236.713	-3.16
D1215	-4998.400	1155.580	-4.33
D1216	215.876	398.940	0.54
$\gamma 13$	9759.240	2792.310	3.50
C13	-187.410	75.007	-2.50
D1313	-26444.000	18723.900	-1.41
D1314	-1822.400	1620.050	-1.12
D1315	-38257.000	11181.250	-3.42
D1316	313.189	2300.070	0.14
$\gamma 14$	1179.250	543.582	2.17
C14	-16.207	14.430	-1.12
D1414	-1394.300	320.179	-4.35
D1415	-1617.100	1316.830	-1.23
D1416	704.887	399.799	1.76

Table 6--continued.

Parameter	Estimate	Approximate Std. Error	T-Ratio
$\gamma 15$	9245.110	2290.650	4.04
C15	-126.950	61.180	-2.08
D1515	-36625.000	10247.690	-3.57
D1516	3311.190	1827.090	1.81
$\gamma 16$	3019.980	875.007	3.45
C16	-39.331	24.241	-1.62
D1616	1908.790	1340.980	1.42
Θ	-2.220	0.095	-23.43

Own-Price Effects

As with model one, to conform to general demand theory, negative own-price parameters are anticipated. Of the 16 own-price parameters, 4 were positive and 12 were negative. All of the significant parameter estimates were negative (iron, vitamin A, thiamine, riboflavin, vitamin B6, vitamin C, and zinc). With the specification of the variables for model two, there is more of an opportunity for substitutability than in model one. That is, to obtain the desired nutrients, a household has many choices among foods.

The four nutrients with the lowest t-ratio for their own-price coefficient were protein (.26), carbohydrates (-.30), calcium (.30), and phosphorus (-.03). The values in parentheses represent the t-ratio for that particular nutrient. These low t-ratios could be due in part to the fact that little information was available until recently concerning the important contributions of these nutrients to good health (e.g., that calcium helps in the prevention of osteoporosis).

Cross-Price Effects

There are 15 cross-price effects associated with each nutrient equation. Six of the equations contained seven or more significant cross-price parameters. These were the demand equations for fat (7), iron (10), vitamin A (7), niacin (10), vitamin B6 (7), and vitamin B12(8). The value in parentheses represents the number of significant cross-price parameter estimates. It has been known for many years that these nutrients help prevent certain diseases. Most of the significant cross-price parameter estimates were negative, suggesting that a majority of nutrients complement each other. This is consistent with the general notion that some nutrients require the presence of other nutrients to provide the greatest benefit.

The regression results suggest that the model does an excellent job of describing the demand for iron and niacin. Not only do the iron and niacin equations possess 10 significant cross-price effects, but their own-price coefficients are significant and negative.

Income Effect

As in model one, an estimate of the marginal utility of money is not obtained. The value for θ in model two (-2.20152) is very close to that of model one (-2.12075). The coefficient θ for model two is again statistically significant, which allows us to deduce that the marginal utility of money income diminishes as expenditures on non-food items increase.

Average Age Effect

The same considerations are relevant for model two as for model one regarding the average age effect. The statistically significant average-age parameter estimates suggest that more fat and thiamine and less iron, magnesium, vitamin B12, and zinc are consumed as average age increases. Part of the explanation for the consumption of more fat on the part of older households could be that consumption patterns from past years have not changed in spite of new knowledge about the detrimental health effects of high fat diets.

Concluding Remarks

The results suggest that models one and two provide a fair representation of the consumer food choice problem. A more complete model, including both taste and nutrient considerations, would probably yield stronger results. Such a comprehensive model would allow one to more rigorously test the hypotheses that households consume food for pleasure as well as for the nutrient content. Undoubtedly nutrition is a significant, but only partial, explanation of the household food choice/demand problem.

CHAPTER 5

CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

Consumer demand for food is more complex than historically believed. It has long been known that households consume food items for the pleasures associated with taste, odor, and appearance of the food. In recent years, however, an increase in awareness about proper nutrition and good health is adding a new dimension to consumer food demand. Nutrition is not only important for its effects upon health, but there are many government programs and policies which directly or indirectly affect the nutrient intake of consumers. It is believed that these programs and policies will become more nutritionally oriented in the future (Leathers, 1979).

The objectives of this study were: (1) to obtain a flexible approximation of the household's preference function yielding choice functions, which would facilitate estimation and hypothesis testing, and (2) to learn in what ways taste and nutrient content affect the demand for food and, more fundamentally, to determine whether or not nutrient content is a significant determinant of consumer food demand. The construction of the models also provided a mechanism to test the effects of the average age of the U.S. population upon consumer demand.

The hypothesized models were based on the theory of household production. Household production theory was preferred over linear programming given the question to be addressed. Specifically, an objective of the study was to address the issue: *Do nutrients matter in household food consumption?* -- rather than: *If we assume that the household seeks to obtain the recommended daily allowance of the major known nutrients, what is the set of foods that will achieve this at least cost?*

The theory of household production is an extension of constrained-utility-maximization theory. The extension beyond utility theory relies on the assumptions argued by Becker (1965) and Muth (1966) as well as Lancaster (1966). That is, Becker and Muth argued that consumers purchase the necessary items to prepare an edible meal, e.g., food, household utensils, and time. Thus, the food item is thought of as an input rather than a final consumption good. Along the same lines, Lancaster argued that the characteristics of the food items are what yield the utility of food, not the food *per se*.

A quadratic functional form was chosen for its ability to approximate a flexible functional form in the demand parameters associated with food quantities and nutrients. The quadratic function also gives a closed form expression for the resulting demand function, even though the estimable demand systems are incomplete. Finally, a quadratic model allows the inclusion of normal-infinite income effects through the inclusion of only one additional parameter.

Estimation of the full theoretical model which incorporated both pleasure and nutrient value in determining food demand was beyond the scope of this study. However, it was possible to examine two sub-models. Model one hypothesized that households consume food for the pleasures associated (taste, odor, etc.) with consumption. The hypothesis of model two was that households consume food for the nutrient content only.

From the Lagrangian functions of the sub-models, reduced-form demand equations were derived by simultaneously solving the first order conditions of each model. Since the reduced-form demand equations were severely nonlinear in the parameters, the individual demand equations were solved for food and nutrient quantities given a value for non-food expenditures.

The data sets used in the estimation consisted of U.S. per capita consumption of 25 food quantities, U.S. weighted retail price indices of food items for urban wage earners and clerical workers, U.S. per capita consumption of 16 nutrients in foods available for consumption, estimated shadow prices for nutrient intake values, average age of the U.S. population, and U.S. expenditures on non-food items.

For nonlinear estimation, it is important to have reliable starting values. Since the exact data desired for use in the two models was not available, several procedures were run on the individual demand equation sets to obtain reliable starting values for the final estimation of each model.

Model One Results

The results obtained from the seemingly unrelated regression estimation of model one parameters were reasonable, but not as theoretically consistent as was originally expected. Of the 25 own-price effects, 13 were positive. Several confounding relationships were noted among the own-price parameters that were positive. For example, many of the individual dairy products had positive own-price coefficients (fresh milk and cream, butter, cheese, and frozen dairy). It was also found that several products which are used in the production of consumable goods, but that are not generally eaten by themselves (butter, margarine, eggs, flour and cereal, and sugar) had positive own-price coefficients.

For most of the 25 food quantity equations estimated, at least half of the 24 cross-price effects were significant. The signs on the cross-price parameter estimates were generally consistent with *a priori* expectations, i.e., the cross-price effects for the most part were consistent with presumed substitution and complementarity relationships among the food items. For example, this was demonstrated in the pairwise cross-price effects between beef and veal, pork, and chicken.

The parameter estimate which was directly related to the marginal utility of money income was found to be positive and significantly different from zero as expected. For several food items the average-age parameter was significant, and negative. The results indicated that people consume less beef, other meat, fish, margarine, cheese, frozen dairy, and milk as they get older. Food items with a positive age effect were butter, flour and cereal, other sugar, fresh noncitrus fruit, dark green and deep yellow vegetables, and soft drinks.

Model Two Results

The final results obtained from the seemingly unrelated regression estimation for model two were not as strong as hoped in some areas. Unlike the prices associated with the food items, the shadow prices of nutrients were not necessarily positive. This may be explained by considering that the nutrients with negative prices are associated with foods which people do not particularly like to eat (for example, brussels sprouts, liver, and eggs). Only four of the 16 own-price parameter estimates were positive. One of the weak areas of the second model was in the cross-price effects. Of the 16 nutrient equations, only six contained at least seven or more significant cross-price parameters.

The estimated parameter related to the marginal utility of money income for model two was significant and very close to the corresponding parameter estimate in model one. The significant parameter estimates for the average-age variable in each nutrient equation suggested that more fat and thiamine and less iron, magnesium, vitamin B12, and zinc are consumed as average-age increases.

Suggestions for Further Research

This study represents but a step into a new area of consumer demand. There are very few studies which have examined the proposition that both taste and nutrition influence the food choices that households make. The next logical step in continuing this line of inquiry would be to formulate a comprehensive econometric model where both taste and nutrient content are represented concurrently. The performance of such a model could then be compared with that of the two sub-models reported in this study. It seems likely that such a comprehensive model would better explain and predict consumer response than either of the individual models considered thus far.

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APPENDIX

APPENDIX

The purpose of this appendix is to describe how the data used in this study was constructed for the models which were estimated. In particular, this appendix includes the following:

(1) Concise definitions of the variables used and the sources from which the series were obtained.

(2) Discussions of problems that were encountered in constructing the different data series and descriptions of the methods used to circumvent these problems.

(3) The data series actually used to estimate the empirical models.

Construction of the Data Series

U.S. Per Capita Consumption of Food in Pounds, 1953-1981

In general, most of the quantities presented in Table 7 come from U.S. Department of Agriculture publications. The publications began in 1965 with the title U.S. Food Consumption, and currently have the title Food Consumption, Prices, and Expenditures.

Given the 1953-1981 time span used, a consistent historical data series was difficult to obtain. Over time, the data reported in the publication were changed due to new administrations and funding problems. Therefore, some of the data used are not taken directly from the publication. Explanations of why and how the problem data were constructed to form a consistent data series are discussed. The problem data are discussed in the order in which they appear in Table 7.

The quantity data for other meat was consistent and complete until the actual quantities for game birds, mammals and commercially raised rabbits, and canned meat were no longer reported beginning in 1979. The value of 2.5 pounds per year was used for the missing years; this value was constant in the reported data from 1962 to 1978. The quantities of fish excludes game fish consumption. The content of duck and geese in the quantity of poultry is estimated at 0.4 pounds per year.

When tabulating the values for flour, cereal, and pasta for the years 1953-1964, individual values for pasta were not available and were presumed to be included in the total for flour and cereal products.

Frozen yogurt was not included in the frozen dairy section until 1981. The total for other dairy was determined by taking the difference between total dairy and fresh milk and cream, butter, cheese, and frozen dairy to avoid double-counting. The value for total dairy was obtained from published data except for the years 1953-1963. These values were estimated due to a definitional change for fresh milk and cream in 1980. Total dairy product quantities, used for 1953-1963, were equal to total dairy products (excluding butter) in the U.S. Department of Agriculture's <u>U.S. Food Consumption</u>, Statistical Bulletin No. 364, minus the difference between the new and old definition of fresh milk and cream. (The differences in the definitions of new and old fresh milk and cream will be discussed later.)

The series for other sugar was not consistent because the series for individual sugar items (corn syrup, corn sugar, and honey) from 1953-

1959 was reported in wet weight, while the new series (1965-1981) was reported in dry weight. For the years 1960-1966, there was an overlap in publications; that is, different data for the items needed were reported differently, for corn syrup, corn sugar, and honey. Thus those years were used as the sample period for a regression equation to estimate the equivalent dry weights for 1953-1959. Three separate regressions were run on the subcategories of total sugar (corn syrup, corn sugar, and honey). The regression equations were:

Corn syrup (dry) = .80349*(wet)............... R^2 = .99971

Corn sugar (dry) = .14185 + .882*(wet)........ R^2 = .99914

Honey (dry) = .11071 + .75*(wet)......... R^2 = .78750

The values obtained from these regression equations were then added together to obtain the new series for other sugar. The total actually used does not include the estimated amount of sugar used in soft drinks, which will be explained later.

The total for fresh noncitrus fruit is the summation of the quantities of individual items listed directly from the publications, except for apples. The data series for apples was inconsistent between overlapping years in different publications; therefore, the years 1953-1959 were predicted. The sample period used was 1960-1966 from USDA Statistical Bulletin No. 364 (old) and No. 694 (new). The estimated equation was

Apple(new) = -2.0321 + 1.0623*(old)........... R^2 = .95923

For the years 1960-1965, the values for "fresh dark green and deep yellow vegetables" and "fresh other vegetables" are the simple average of the data from USDA Statistical Bulletin No. 364 and No. 694. The subcategory of potatoes in "potatoes and sweet potatoes" was predicted for the years 1960-1981. Again, the reported data between publications were not consistent, but contained no explanation for the changes. The sample period was again 1960-1965 from USDA Statistical Bulletin No. 364 (old) and No. 694 (new). The estimated equation was

Potato(old) = 58.765 + .47838*(new)............. R^2 = .7360

The subcategory of sweet potatoes for the years 1960-1965 was the simple average of the data from the two publications (Statistical Bulletin No. 364 and No. 694).

The subcategory of chilled fruit juices in "processed fruit" for the years 1952-1954 was predicted because data were not reported for those years. The estimated equation was

Chilled juice = 450.68 + .23007*(year) - 1.4406*D(1963-1964)
+ .13825*(canned fruit juice)...... R^2 = .96325

where D = dummy variable for the years 1963-1964.

Also under "processed fruit," the subcategory frozen citrus juice was predicted for the years 1953-1960 because of inconsistency in the data series between publications. The sample years 1960-1966 come from USDA Statistical Bulletin No. 364 (old) and No. 694 (new). The estimated equation was

Frozen citrus juice(new) = 1.034 + .8391*(old)... R^2 = .9842

The subcategory frozen vegetables for "processed vegetables" is the summation of the individual items from the publications except for the "other" category. Again, there was inconsistency between publications. The sample years were 1960-1966 with the data coming from the same two publications as mentioned above. The estimated equation was

Other(new) = .3901 + .880(old)................. R^2 = .9911

For the years 1953-1963, the subcategory peanuts in "dry beans, field peas, and nuts" included only peanuts (shelled basis) and after 1963 included salted, in-shell, peanut butter, candy, and sandwich snacks. These values were reported as they appeared in the publications.

As mentioned earlier, the definition for fresh milk and cream changed. The sample period used is from 1960-1979 using Statistical Bulletin No. 656 (old) and No. 694 (new). For the years 1952-1969, the predicted values (using expected values) are from the equation

E[milk(new)] = -66.164 + 1.1443*(old)........... R^2 = .98743

u(t) = .84243*(t-1) + e(t)

For the years 1980-1985, the old definition is predicted from the new (using observed) using the inverse of the above relationship.

To determine the amount of sugar consumed from soft drinks, it was necessary to first estimate the quantities (in gallons) of soft drinks consumed for the years 1953-1959, as these data were not reported. The estimated equation was

ln(soft drink) = -.12442*10^6 - 9.5515*(year)

+ .18882*10^5*[ln(year)].......... R^2 = .99275

The second step was to change gallons to pounds to be consistent with the other quantities reported in the data set. This was done by weighing several soft drink cans before and after consumption. The gallons were converted to pounds by multiplying them by 8.883. The final step was to estimate how much sugar was used in soft drinks. The years 1960-1980 provided quantities of sugar used for soft drinks; therefore, the following equation was used:

Sugar = 1.7456 + .00553*(soft drink pounds)

- .00033*D(s.d. pls)...................... R^2 = .98071

where D = dummy variable for soft drink pounds.

U.S. Weighted Retail Price Indices for
Urban Wage Earners and Clerical Workers,
1953-1981 (1967=100)

The data used to construct the price series came from the Bureau of Labor Statistics, Handbook of Labor Statistics, 1978 for the years 1953-1977 and CPI Detailed Report for the years 1978-1981. As with the quantity data, the individual items were not always consistent for the entire series. For some, the base year of 1967 changed to 1977; for others, the actual prices were not directly reported. The individual items which were not directly obtained from the publications are discussed in the order in which they appear in Table 9.

The CPI for other fats was not reported. The only CPI values available were for all fats and oils, margarine, salad dressing (Italian), and cooking oil. With these variables, the prices for other fats were constructed. First, an equation was estimated which indicated the relationship between all fats and oils, margarine, salad dressing, and cooking oil for the sample period 1964-1977; viz.,

All Fats = .25165*(margarine) + .32795*(salad dressing)

+ .42051*(cooking oil)................. R^2 = .99961

The coefficients from this regression were then used to estimate prices for other fats as follows:

1953-1963, (all fats and oils - .25165*margarine)/.74846

1964-1977, (.32795*salad dressing + .42051*cooking oil)/.74846

1978-1981, 1.909*(other fats, oils & salad dressings 12/77=100)

where .74846 = (.32795 + .42051), a combination of the estimates in the previous equation
190.9 = (.32795*168.6 + .42051*208.3)/.74846
168.6 = Salad dressing CPI for 12/77 (1967=100)
208.3 = Cooking oil CPI for 12/77 (1967=100)

For the years 1978-1981 the value for cheese, frozen dairy, and evaporated milk were scaled by the CPI/100 for December 1977 (1967=100). That is, for cheese the scaled value was 2.093. The price for frozen dairy was constructed using the CPI's for ice cream and for the years 1978-1981 scaled by 1.726. Evaporated milk was used for the prices of other dairy with the years 1978-1981 scaled by 2.238. The CPI for other sugar used the definition "sugar and sweets" from the publications. The publications did not have individual values for fresh citrus fruit and fresh noncitrus fruit. A regression was run on all fresh fruit, apples, bananas, oranges, grapefruit, grapes, strawberries, watermelon, and fresh orange juice for the sample period 1953-1977; viz.,

All fruit = .33688*(apple) + .18*(banana) + .271624*(orange) + .015*(grapefruit) + .11342*(grape) + .0584*(strawberry) + .01168*(watermelon) + .0132(fresh orange juice)............................... R^2 = .9994

The coefficients from the regression were then used to calculate the prices for fresh citrus fruit and fresh noncitrus fruit as follows:

Fresh citrus = [.27162*(orange) + .015*(grapefruit)]/(.27162+.015)

Fresh noncitrus = [.33688*(apple) + .18*(banana) + .11342(grape) + .0584*(strawberry)]/(.33688+.18+.11342+.0584)

The CPI for carrots was used to represent the CPI for dark green and deep yellow vegetables. There was no specific value for other vegetables, so it was estimated or constructed from a nonlinear regression. A nonlinear regression (quadratic in the coefficients) was used because a linear model yielded negative coefficients. The variables in the regression were all vegetables, potatoes, onions, cabbage, carrots, lettuce, tomatoes, celery, asparagus, cucumbers, green peppers, and spinach for the sample period 1953-1977. The resulting equation was

All vegetables = 1.1642*(potatoes) + .2899*(onions)
+ .2864*(lettuce) + .5317*(tomatoes) + .5837*(celery)
+ .1355*(asparagus) + .5373*(cucumber) + .5387*(green peppers).................................. $R^2 = .9996$

The coefficients for cabbage, carrots, and spinach were essentially zero; therefore, they were not included in the equation. The remaining coefficients were then used in the equation for other vegetables, i.e.,

Other vegetables = .2899*(onions) + .2864*(lettuce)
+ .5317*(tomatoes) + .5837*(celery)

A regression was also run to generate a CPI for processed fruit and processed vegetables since they were reported as a single CPI. The variables in the equation were fruit cocktail, peaches, canned orange juice, canned peas, canned tomatoes, canned corn, dry beans, and frozen orange juice for the sample period 1953-1963. The resulting equation was

Processed fruit & vegetables = .12213*(fruit cocktail)
+ .28248*(peaches) + .18362*(canned orange juice)
+ .076354*(canned peas) + .14217*(canned tomatoes)
+ .054591*(canned corn) + .09994*(dry beans)
+ .038712*(frozen orange juice)........... $R^2 = .9843$

The coefficients from the regression for processed fruit and vegetables were used in the equation for the CPI for processed fruit and processed vegetables:

Processed fruit = [.12213*(fruit cocktail) + .28248*(peaches) + .18362*(canned orange juice) + .038712*(frozen orange juice)]/(.12213 + .28248 + .18362 + .038712)

Processed vegetables = [.076354*(canned peas) + .14217*(canned tomatoes) + .054591*(canned corn)]/(.076354 + .14217 + .054591)

The years 1978-1981 for dried beans (other canned and dried vegetables) were scaled by the CPI/100 = 2.809 for December 1977 (1967=100).

The CPI for fresh milk and cream was calculated by

1953-1963, FMC = .520678*(FGM) + .479322*(FDM)

1964-1973, FMC = .457666*(FGM) + .352026*(FDM) + .190308*(FSM)

1974-1981, FMC = .637860*(FGM) + .621400*(FSM)

where FMC = Fresh whole grocery milk
FDM = Fresh whole delivered milk
FSM = Fresh skim milk

The CPI for coffee, tea, and cocoa came from the CPI reported for canned and bagged coffee for the years 1953-1977 and roasted coffee for the years 1978-1981. The CPI for soft drinks came from the CPI for cola drinks during the years 1953-1977 and cola drinks (excluding diet cola) for 1978-1981.

The CPIs for all food items were weighted in order to satisfy the equality M = P′X-Y, where M is disposable income and Y is expenditures on non-food items. That is, the summation of each price times its corresponding CPI must equal expenditures on all food items. This was accomplished by running a regression on per capita food expenditures and the summation of individual quantities times corresponding CPIs for each year. This produced the weights by which the individual CPIs were multiplied to change them to retail price indices.

Estimated Shadow Prices for Nutrients, 1953-1981

As stated in Chapter 2, there are no direct measurements for the prices associated with nutrients. Using duality theory, shadow prices for nutrients were generated. A linear regression was estimated for each year. Specifically, $P=N\rho$, where P = deflated consumer price indices, N = nutrients contained in one unit of food, and ρ = shadow price for nutrients. The OLS estimator is $\rho_t = (N_t N_t)^{-1} N_t P_t$. The estimated value for ρ was then used for the price associated with nutrients. The values for N were obtained from Nancy Raper, nutritionist with the U.S. Department of Agriculture, Human Nutrition Information Service, Washington, D.C. (Table 11).

U.S. Per Capita Disposable Income and Food Expenditures and Aggregate Retail Price Indices, 1953-1981 (1967=100) (Table 12)

Per Capita Disposable Income
1946-1987, Economic Report of the President, 1988

Per Capita Food Expenditure
1946-1987, Economic Report of the President, 1988

Non-Food CPI
1946-1987, Economic Report of the President, 1988

Average Age
1946-1987, Economic Report of the President, 1988

Table 7. U.S. per capita consump

Year	<-------------------------------------					
	1	2	3	4	5	6	7
1953	69.9	59.1	17.4	11.4	27.1	8.5	8.
1954	71.9	55.8	17.2	11.2	28.5	8.9	8.
1955	72.4	62.1	17.7	10.5	26.7	9.0	8.
1956	74.6	62.5	17.8	10.4	30.0	8.7	8.
1957	72.8	56.8	17.1	10.2	31.8	8.3	8.
1958	67.4	56.0	16.2	10.6	34.4	8.3	9.
1959	66.8	62.8	17.0	10.9	35.6	7.9	9.
1960	69.4	60.3	17.0	10.3	34.5	7.5	9.
1961	70.5	57.7	17.2	10.7	37.8	7.4	9.
1962	70.8	59.1	17.2	10.6	37.3	7.3	9.
1963	73.9	60.7	17.2	10.7	37.9	6.9	9.
1964	78.2	60.7	16.7	10.5	38.7	6.9	9.
1965	77.9	54.7	16.2	10.8	41.1	6.4	9.
1966	80.8	54.4	16.6	10.9	43.8	5.7	10.
1967	82.0	60.0	17.1	10.6	45.4	5.5	10.
1968	84.2	61.4	17.0	11.0	45.0	5.7	10.
1969	84.7	60.5	15.6	11.2	47.1	5.4	10.
1970	86.4	62.3	16.6	11.8	48.8	5.3	10.
1971	85.6	68.3	16.6	11.5	49.0	5.1	10.
1972	87.3	62.9	16.2	12.5	51.1	4.9	11.
1973	82.0	57.3	14.7	12.8	49.4	4.8	11.
1974	87.5	61.8	15.2	12.1	49.9	4.5	11.
1975	91.3	50.7	14.4	12.2	49.0	4.7	11.
1976	97.7	53.7	14.7	12.9	52.2	4.3	12.
1977	95.0	55.8	14.4	12.7	53.6	4.3	11.
1978	89.6	55.9	13.7	13.4	56.3	4.4	11.
1979	79.7	63.8	13.4	13.0	60.9	4.5	11.
1980	78.0	68.3	13.4	12.8	61.0	4.5	11.
1981	78.7	65.0	13.3	12.9	62.9	4.3	11.

[a]SOURCES:

(1) Food consumption prices and expenditure
Agriculture, Agriculture Economic Repor

(2) Food consumption prices and expenditure
Agriculture, Statistical Bulletin No. 6

(3) Food consumption prices and expenditure
Agriculture, Statistical Bulletin No. 7

(4) Food consumption prices and expenditure
Agriculture, Statistical Bulletin No. 7

[b]FOOD QUANTITY COLUMN DESCRIPTIONS: Refer to

Table 7--Continued.

FOOD QUANTITY COLUMN DESCRIPTIONS:

(1) Beef and Veal

(2) Pork

(3) Other Meat [lamb, mutton, edible offals, game birds and mammals, commercially raised rabbits, and canned meat]

(4) Fish [fresh and frozen fish and shellfish, canned salmon, sardines (pilchard and herring), tuna, shellfish, and game fish]

(5) Poultry [chicken, turkey, duck, and geese]

(6) Butter

(7) Margarine

(8) Other Fats [lard, shortening, edible tallow, cooking and salad oils]

(9) Eggs

(10) Cheese [American (cheddar, Colby, washed curd, stirred curd, and Monterey Jack); other (provolone, Romano, Parmesian, mozzarella, ricotta, Swiss, brick, Muenster, cream, Neufchatel, blue, Edam, and Gouda)]

(11) Flour, Cereal, Pasta [white and whole-wheat flour, semolina and durum flour, rye and buckwheat flour, rice (milled basis) corn flour and meal, hominy and grits, corn starch, oat and barley products; pasta products (macaroni, spaghetti, and other macaroni products)]

(12) Frozen Dairy [ice cream, sherbet, ice milk, mellorine, and frozen yogurt]

(13) Other Dairy [evaporated and condensed milk, and dry milk products]

(14) Other Sugar [corn sweeteners (high fructose, glucose, dextrose), edible syrups, and honey]

(15) Fresh Citrus Fruit [oranges, tangerines, tangelos, lemons and limes, and grapefruit]

(16) Fresh Non-citrus Fruit and Melons [apples, apricots, avocados, bananas, cherries, cranberries, figs, grapes, nectarines, peaches, pears, pineapple, plums and prunes, strawberries, papaya, and kiwi; watermelon, cantaloupe, and honeydew]

(17) Fresh Dark Green and Deep Yellow Vegetables [broccoli, carrots, escarole, kale, green peppers, spinach]

(18) Fresh Other Vegetables [tomatoes, artichokes, asparagus, beans (snap and lima), beets, brussels sprouts, cabbage, cauliflower, celery, corn, cucumbers, eggplant, garlic, lettuce, onions and shallots, and peas (green in shell)]

(19) Potatoes and Sweet Potatoes [canned, frozen, and fresh potatoes used in other processed mixtures, flour, dehydration, chips, and shoestring potatoes; fresh and canned sweet potatoes]

(20) Processed Fruit [canned juice (orange, grapefruit, blended orange/grapefruit, lemon/lime, tangerine, apple, fruit nectars, grape, pineapple, and prune), chilled juice (orange and grapefruit), frozen fruit (blackberries, raspberries, strawberries, blueberries, other berries, apples, apricots, cherries, grapes and pulp, peaches, plums, prunes, and pineapple), frozen citrus juice (orange juice and orange juice used in blends), canned and chilled fruit (apples and apple sauce, apricots, berries, cherries, cranberries, figs, salad and cocktail), peaches (including spiced cling peaches), pears, pineapple, plums and prunes, and olives; and dried fruit (apples, apricots, dates, figs, peaches, pears, prunes, and raisins and currants)]

(21) Processed Vegetables [canned--tomatoes (whole, catsup and chili sauce, paste and sauce, pulp and puree, tomato and other vegetable juices), carrots, pumpkin and squash, spinach, asparagus, beans, beets, corn, peas, pickles, and sauerkraut; frozen (broccoli, carrots, peas, carrots, pumpkin squash, spinach, collards, kale, mustard and turnip greens, asparagus, beans, brussels sprouts, cauliflower, corn, peas, and succotash)]

(22) Dry Beans, Field Peas, and Nuts [tree nuts (almonds, filberts, pecans, walnuts, Brazil, pignolia, pistachios, chestnuts, cashews, macadamias, and miscellaneous tree nuts); coconut (desiccated); peanuts (shelled basis, salted, in-shell, peanut butter, candy, and sandwich snacks)]

(23) Fresh Milk and Cream [plain whole milk, cream, specialties (cream, milk-cream mixtures, sour cream, eggnog, and yogurt); and other milk beverages (low-fat, skim, buttermilk, and chocolate milk)]

(24) Coffee, Tea, and Cocoa [coffee (instant and regular), tea (leaf equivalent), and cocoa (80 percent of bean equivalent)]

(25) Soft Drinks

Table 8. Data sources for U.S. per capita consumption by food group category.

Item No.	Food	Year	Page	Publication*
1	Beef & Veal	1953-1964	59	A
		1965-1985	11	F
2	Pork	1953-1964	59	A
		1965-1985	11	F
3	Other Meat	1953-1964	59	A
		1965-1985	11	F
4	Fish	1953-1964	60	A
		1965-1985	13	F
5	Poultry	1953-1964	61	A
		1965-1985	14	F
6	Butter	1953-1964	62	A
		1965-1985	16	F
7	Margarine	1953-1964	64	A
		1965-1985	18	F
8	Other Fats	1953-1964	64	A
		1965-1985	18	F
9	Eggs	1953-1964	61	A
		1964-1985	14	F
10	Cheese	1953-1964	62	A
		1965-1985	16	F
11	Flour, Cereal & Pasta	1953-1964	83	A
		1965-1985	30-31	F
12	Frozen Dairy	1953-1964	63	A
		1965-1985	16	F
13	Other Dairy	1952-1985	--Calculated--	
14	Other Sugar	1953-1959	--Predicted--	
		1960-1964	25	C
		1965-1985	33	F

Table 8--continued.

Item No.	Food	Year	Page	Publication*
15	Fresh Citrus Fruit	1953-1964	68	A
		1965-1985	19	F
16	Fresh Noncitrus Fruit & Melons	1952-1964	65 & 69	A
		1965-1985	19 & 24	F
	[apples]	1953-1959	--Predicted--	
		1960-1964	10	C
		1965-1981	19	F
17	Fresh Dark Green and Deep Yellow Vegetables	1952-1964	74	A
		1965-1981	17	C
18	Fresh Other Vegetables	1952-1964	75-77	A
		1965-1981	17-19	C
19	Potatoes & Sweet Potatoes			
	[potatoes]	1953-1965	82	A
		1966-1981	--Predicted--	
	[sweet potatoes]	1953-1964	82	A
		1965-1981	22	C
20	Processed Fruit			
	[canned fruit juice]	1953-1964	71	A
		1965-1981	21	F
	[chilled fruit juice]	1953-1954	--Estimated--	
		1955-1964	71	A
		1965-1981	21	F
	[frozen fruit]	1953-1964	72	A
		1965-1981	22	F
	[frozen citrus fruit]	1953-1960	--Predicted--	
		1961-1964	72	A
		1965-1981	21	F
	[canned & chilled fruit]	1953-1964	70	A
		1965-1981	20	F
	[dried fruit]	1953-1964	73	A
		1965-1981	30	F

Table 8--continued.

Item No.	Food	Year	Page	Publication*
21	Processed Vegetables			
	[canned vegetables]	1952-1964	78	A
		1965-1981	20	C
	[frozen vegetables]	1953-1964	79	A
		1965-1981	21	C
22	Dry Beans, Field Peas & Nuts			
	[dry edible beans]	1953-1964	82	A
		1965-1981	30	D
	[field peas]	1953-1964	82	A
		1965-1981	30	D
	[tree nuts]	1953-1963	86	A
		1964-1981	44	E
	[coconut]	1953-1963	86	A
		1964-1981	44	E
	[peanuts]	1953-1963	86	A
		1964-1981	45	E
23	Fresh Milk & Cream	1953-1959	--Predicted--	
		1960-1979	7	C
		1980-1981	--Predicted--	
24	Coffee, Tea & Cocoa	1953-1965	85	A
		1966-1981	35	F
25	Soft Drinks	1953-1959	--Predicted--	
		1960-1965	27	C
		1966-1981	36	F

*Publication Source Codes (see following page)

Table 8--Continued.

Publication Source Codes:

A = U.S. Department of Agriculture, Economic Research Service, Food Consumption, Prices, and Expenditures (1909-1966), USDA/ERS Agricultural Economic Report No. 138 (Washington, DC: U.S. Government Printing Office, July 1968).

B = U.S. Department of Agriculture, Economic Research Service, Food Consumption, Prices, and Expenditures (1960-1979), USDA/ERS Statistical Bulletin No. 656 (Washington, DC: U.S. Government Printing Office, February 1981).

C = U.S. Department of Agriculture, Economic Research Service, Food Consumption, Prices, and Expenditures (1960-1981), USDA/ERS Statistical Bulletin No. 694 (Washington, DC: U.S. Government Printing Office, November 1982).

D = U.S. Department of Agriculture, Economic Research Service, Food Consumption, Prices, and Expenditures (1963-1983), USDA/ERS Statistical Bulletin No. 713 (Washington, DC: U.S. Government Printing Office, November 1984).

E = U.S. Department of Agriculture, Economic Research Service, Food Consumption, Prices, and Expenditures (1964-1984), USDA/ERS Statistical Bulletin No. 736 (Washington, DC: U.S. Government Printing Office, December 1985).

F = U.S. Department of Agriculture, Economic Research Service, Food Consumption, Prices, and Expenditures (1965-1985), USDA/ERS Statistical Bulletin No. 749 (Washington, DC: U.S. Government Printing Office, January 1987).

Table 9. Real weighted U.S. ret
earners and clerical w

Year	<------ 1	2	3	4	5	6
1953	0.342	0.390	0.354	0.342	0.635	0.3
1954	0.335	0.410	0.351	0.350	0.584	0.3
1955	0.330	0.351	0.327	0.341	0.605	0.3
1956	0.318	0.326	0.313	0.333	0.518	0.3
1957	0.337	0.371	0.335	0.334	0.500	0.3
1958	0.377	0.379	0.363	0.342	0.474	0.3
1959	0.390	0.339	0.362	0.350	0.434	0.3
1960	0.369	0.328	0.344	0.341	0.429	0.3
1961	0.363	0.343	0.345	0.348	0.387	0.3
1962	0.372	0.342	0.344	0.359	0.404	0.3
1963	0.359	0.326	0.335	0.350	0.389	0.3
1964	0.345	0.320	0.332	0.338	0.376	0.3
1965	0.366	0.369	0.354	0.352	0.392	0.3
1966	0.386	0.443	0.391	0.375	0.414	0.3
1967	0.379	0.379	0.379	0.379	0.379	0.3
1968	0.377	0.363	0.367	0.368	0.373	0.3
1969	0.399	0.380	0.378	0.373	0.380	0.3
1970	0.403	0.391	0.391	0.398	0.365	0.3
1971	0.398	0.335	0.369	0.415	0.348	0.3
1972	0.432	0.385	0.392	0.449	0.349	0.3
1973	0.480	0.474	0.452	0.477	0.453	0.3
1974	0.423	0.405	0.400	0.472	0.369	0.2
1975	0.392	0.453	0.388	0.468	0.374	0.2
1976	0.366	0.444	0.397	0.505	0.346	0.3
1977	0.345	0.398	0.374	0.530	0.330	0.3
1978	0.396	0.415	0.404	0.536	0.335	0.3
1979	0.455	0.382	0.418	0.528	0.317	0.3
1980	0.412	0.317	0.371	0.496	0.285	0.3
1981	0.365	0.305	0.343	0.472	0.262	0.3

[a] FOOD QUANTITY COLUMN DESCRIPTIONS: Refer to

SOURCE: U.S. Department of Labor, Bureau of

Table 9--Continued.

FOOD QUANTITY COLUMN DESCRIPTIONS:

(1) Beef and Veal

(2) Pork

(3) Other Meat [lamb, mutton, edible offals, game birds and mammals, commercially raised rabbits, and canned meat]

(4) Fish [fresh and frozen fish and shellfish, canned salmon, sardines (pilchard and herring), tuna, shellfish, and game fish]

(5) Poultry [chicken, turkey, duck, and geese]

(6) Butter

(7) Margarine

(8) Other Fats [lard, shortening, edible tallow, cooking and salad oils]

(9) Eggs

(10) Cheese [American (cheddar, Colby, washed curd, stirred curd, and Monterey Jack); other (provolone, Romano, Parmesian, mozzarella, ricotta, Swiss, brick, Muenster, cream, Neufchatel, blue, Edam, and Gouda)]

(11) Flour, Cereal, Pasta [white and whole-wheat flour, semolina and durum flour, rye and buckwheat flour, rice (milled basis) corn flour and meal, hominy and grits, corn starch, oat and barley products; pasta products (macaroni, spaghetti, and other macaroni products)]

(12) Frozen Dairy [ice cream, sherbet, ice milk, mellorine, and frozen yogurt]

(13) Other Dairy [evaporated and condensed milk, and dry milk products]

(14) Other Sugar [corn sweeteners (high fructose, glucose, dextrose), edible syrups, and honey]

(15) Fresh Citrus Fruit [oranges, tangerines, tangelos, lemons and limes, and grapefruit]

(16) Fresh Non-citrus Fruit and Melons [apples, apricots, avocados, bananas, cherries, cranberries, figs, grapes, nectarines, peaches, pears, pineapple, plums and prunes, strawberries, papaya, and kiwi; watermelon, cantaloupe, and honeydew]

(17) Fresh Dark Green and Deep Yellow Vegetables [broccoli, carrots, escarole, kale, green peppers, spinach]

(18) Fresh Other Vegetables [tomatoes, artichokes, asparagus, beans (snap and lima), beets, brussels sprouts, cabbage, cauliflower, celery, corn, cucumbers, eggplant, garlic, lettuce, onions and shallots, and peas (green in shell)]

(19) Potatoes and Sweet Potatoes [canned, frozen, and fresh potatoes used in other processed mixtures, flour, dehydration, chips, and shoestring potatoes; fresh and canned sweet potatoes]

(20) Processed Fruit [canned juice (orange, grapefruit, blended orange/grapefruit, lemon/lime, tangerine, apple, fruit nectars, grape, pineapple, and prune), chilled juice (orange and grapefruit), frozen fruit (blackberries, raspberries, strawberries, blueberries, other berries, apples, apricots, cherries, grapes and pulp, peaches, plums, prunes, and pineapple), frozen citrus juice (orange juice and orange juice used in blends), canned and chilled fruit (apples and apple sauce, apricots, berries, cherries, cranberries, figs, salad and cocktail), peaches (including spiced cling peaches), pears, pineapple, plums and prunes, and olives; and dried fruit (apples, apricots, dates, figs, peaches, pears, prunes, and raisins and currants)]

(21) Processed Vegetables [canned--tomatoes (whole, catsup and chili sauce, paste and sauce, pulp and puree, tomato and other vegetable juices), carrots, pumpkin and squash, spinach, asparagus, beans, beets, corn, peas, pickles, and sauerkraut; frozen (broccoli, carrots, peas, carrots, pumpkin squash, spinach, collards, kale, mustard and turnip greens, asparagus, beans, brussels sprouts, cauliflower, corn, peas, and succotash)]

(22) Dry Beans, Field Peas, and Nuts [tree nuts (almonds, filberts, pecans, walnuts, Brazil, pignolia, pistachios, chestnuts, cashews, macadamias, and miscellaneous tree nuts); coconut (desiccated); peanuts (shelled basis, salted, in-shell, peanut butter, candy, and sandwich snacks)]

(23) Fresh Milk and Cream [plain whole milk, cream, specialties (cream, milk-cream mixtures, sour cream, eggnog, and yogurt); and other milk beverages (low-fat, skim, buttermilk, and chocolate milk)]

(24) Coffee, Tea, and Cocoa [coffee (instant and regular), tea (leaf equivalent), and cocoa (80 percent of bean equivalent)]

(25) Soft Drinks

Table 10. U.S. per capita total nutrients available for consumption, 1952-1981.

Year	Nutrients[a] 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1952	343.10	521.95	1408.90	354.05	551.15	5840.00	1277.50	3029.50	693.50	879.65	7300.00	660.65	3175.50	383.25	4088.00	2102.40
1953	343.10	514.65	1401.60	346.75	547.50	5876.50	1266.55	3066.00	675.25	876.00	7446.00	671.60	3285.00	386.90	4197.50	2084.15
1954	343.10	514.65	1376.05	343.10	543.85	5767.00	1241.00	2993.00	660.65	861.40	7373.00	664.30	3248.50	379.60	4197.50	2069.55
1955	346.75	525.60	1368.75	350.40	551.15	5840.00	1248.30	3029.50	678.90	868.70	7446.00	671.60	3321.50	383.25	4234.00	2073.20
1956	350.40	529.25	1372.40	350.40	554.80	5913.00	1261.90	3066.00	682.55	876.00	7592.00	671.60	3358.00	372.30	4307.00	2084.15
1957	343.10	511.00	1350.50	346.75	547.50	5803.50	1248.30	2993.00	664.30	865.05	7555.50	664.30	3248.50	383.25	4197.50	2040.35
1958	339.45	511.00	1361.45	343.10	540.20	5767.00	1230.05	2920.00	664.30	854.10	7519.00	653.35	3175.50	365.00	4124.50	2003.85
1959	346.75	529.25	1361.45	343.10	547.50	5803.50	1251.95	2993.00	682.55	865.05	7701.50	664.30	3248.50	372.30	4197.50	2018.45
1960	350.40	540.20	1361.45	339.45	547.50	5913.00	1241.00	2920.00	700.80	861.40	7847.50	675.25	3248.50	375.95	4197.50	1985.60
1961	350.40	536.55	1357.80	335.80	547.50	5949.50	1237.35	2847.00	693.50	857.75	7884.00	671.60	3248.50	368.65	4234.00	1963.70
1962	350.40	536.55	1357.80	339.45	547.50	5986.00	1230.05	2847.00	700.80	865.05	7920.50	664.30	3248.50	368.65	4234.00	1963.70
1963	354.05	543.85	1346.85	335.80	547.50	6022.50	1230.05	2883.50	700.80	861.40	7993.50	671.60	3285.00	350.40	4307.00	1941.80
1964	357.70	554.80	1350.50	335.80	551.15	6059.00	1233.70	2810.50	700.80	868.70	8103.00	675.25	3394.50	343.10	4343.50	1952.75
1965	350.40	547.50	1350.50	332.15	543.85	5913.00	1222.75	2810.50	675.25	843.15	8103.00	664.30	3248.50	346.75	4270.50	1908.95
1966	354.05	558.45	1354.15	332.15	547.50	5913.00	1230.05	2847.00	675.25	846.80	8249.00	686.20	3321.50	354.05	4343.50	1905.30
1967	361.35	565.75	1365.10	328.50	551.15	6132.00	1237.35	2847.00	711.75	861.40	8468.00	697.15	3394.50	372.30	4416.50	1941.80
1968	365.00	576.70	1376.05	332.15	554.80	6241.50	1251.95	2956.50	715.40	868.70	8614.00	708.10	3431.00	383.25	4489.50	1949.10
1969	365.00	573.05	1390.65	328.50	554.80	6241.50	1237.35	2883.50	711.75	861.40	8650.50	711.75	3504.00	386.90	4453.00	1912.60
1970	365.00	584.00	1383.35	324.85	547.50	6278.00	1233.70	2920.00	711.75	861.40	8723.50	719.05	3431.00	394.20	4526.00	1919.90
1971	368.65	587.65	1394.30	328.50	551.15	6351.00	1241.00	2883.50	726.35	865.05	8796.50	726.35	3431.00	401.50	4562.50	1938.15
1972	365.00	587.65	1390.65	324.85	547.50	6278.00	1244.65	2920.00	704.45	861.40	8796.50	719.05	3394.50	408.80	4562.50	1905.30
1973	361.35	569.40	1412.55	324.85	543.85	6278.00	1259.25	2883.50	697.15	850.45	8650.50	708.10	3285.00	408.80	4453.00	1810.40
1974	361.35	573.05	1379.70	313.90	536.55	6241.50	1230.05	2956.50	719.05	857.75	8906.00	711.75	3358.00	408.80	4489.50	1821.35
1975	361.35	554.80	1390.65	317.55	536.55	6278.00	1344.65	2883.50	719.05	868.70	9015.50	715.40	3285.00	430.70	4489.50	1766.60
1976	372.30	580.35	1430.80	324.85	551.15	6460.50	1266.55	2956.50	766.50	912.50	9599.50	730.00	3358.00	427.05	4672.00	1781.20
1977	368.65	569.40	1434.45	321.20	547.50	6387.50	1244.65	2847.00	762.85	894.25	9453.50	733.65	3358.00	434.35	4599.00	1770.25
1978	365.00	576.70	1419.85	317.55	540.20	6278.00	1233.70	2847.00	755.55	886.95	9453.50	722.70	3212.00	427.05	4526.00	1773.90
1979	368.65	591.30	1449.05	317.55	543.85	6351.00	1251.95	2956.50	781.10	897.90	9599.50	737.30	3285.00	438.00	4489.50	1806.75
1980	365.00	591.30	1434.45	313.90	536.55	6278.00	1230.05	2847.00	788.40	883.30	9417.00	730.00	3212.00	438.00	4453.00	1784.85
1981	365.00	594.95	1438.10	310.25	536.55	6314.50	1241.00	2883.50	777.45	872.35	9490.00	722.70	3248.50	430.70	4453.00	1762.95

[a]NUTRIENTS:

(1) Protein
(2) Fat
(3) Carbohydrates
(4) Calcium
(5) Phosphorus
(6) Iron
(7) Magnesium
(8) Vitamin A
(9) Thiamine
(10) Riboflavin
(11) Niacin
(12) Vitamin B-6
(13) Vitamin B-12
(14) Vitamin C
(15) Zinc
(16) Cholesterol

SOURCE: From information supplied by Nancy Raper, Human Nutrition Information Service, U.S. Department of Agriculture, 6505 Belcrest Road, Hyattsville, MD 20782 (April 1986).

Table 11. Estimated shadow prices for nutrients, 1953-1981.

Year	Nutrients[a] 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1953	-0.734	0.110	0.074	-0.018	1.001	0.041	-0.263	-0.007	-0.264	0.106	0.038	0.166	-0.007	0.228	-0.075	0.005
1954	-0.310	0.112	0.077	0.070	0.489	0.030	-0.177	-0.007	-0.216	0.134	0.030	0.181	-0.007	0.224	-0.060	0.008
1955	0.222	0.108	0.085	0.099	-0.071	0.014	-0.069	-0.009	-0.181	0.173	0.013	0.244	-0.007	0.213	-0.040	0.013
1956	0.869	0.097	0.086	0.177	-0.865	-0.015	0.087	-0.009	-0.089	0.225	-0.003	0.270	-0.007	0.218	-0.006	0.024
1957	0.733	0.104	0.083	0.120	-0.646	-0.008	0.042	-0.008	-0.100	0.222	-0.000	0.243	-0.008	0.222	-0.013	0.019
1958	1.022	0.097	0.088	0.130	-0.966	-0.021	0.107	-0.009	-0.060	0.234	-0.008	0.284	-0.006	0.232	0.000	0.024
1959	0.745	0.097	0.089	0.236	-0.838	-0.006	0.054	-0.009	-0.078	0.178	-0.003	0.305	-0.005	0.206	-0.006	0.021
1960	0.367	0.093	0.085	0.217	-0.474	0.009	-0.020	-0.008	-0.120	0.163	0.002	0.305	-0.009	0.213	-0.017	0.016
1961	0.612	0.097	0.085	0.269	-0.719	0.007	0.023	-0.009	-0.096	0.160	-0.004	0.296	-0.004	0.219	-0.014	0.017
1962	0.728	0.095	0.082	0.269	-0.735	0.007	0.022	-0.008	-0.100	-0.158	-0.004	0.327	-0.004	0.208	-0.020	0.014
1963	0.854	0.095	0.090	0.150	-0.761	-0.003	0.060	-0.010	-0.078	0.164	-0.010	0.251	-0.002	0.269	-0.007	0.015
1964	0.911	0.089	0.093	0.360	-1.089	-0.002	0.088	-0.020	-0.059	0.153	-0.010	0.345	-0.001	0.247	-0.007	0.020
1965	0.590	0.095	0.089	0.482	-0.966	0.016	0.028	-0.010	-0.098	0.128	-0.002	0.435	-0.002	0.191	-0.022	0.019
1966	1.148	0.097	0.085	0.418	-1.340	-0.005	0.123	-0.011	-0.042	0.174	-0.012	0.391	-0.002	0.219	-0.006	-0.024
1967	1.244	0.090	0.092	0.647	-1.779	-0.014	0.180	-0.011	-0.012	0.153	-0.014	0.473	-0.000	0.165	0.007	0.030
1968	1.806	0.085	0.093	0.454	-1.995	-0.033	0.259	-0.011	0.002	0.234	-0.029	0.505	-0.003	0.184	0.013	0.029
1969	1.142	0.090	0.085	0.459	-1.365	-0.003	0.119	-0.011	-0.063	0.156	-0.013	0.461	-0.001	0.187	-0.011	0.024
1970	0.017	0.085	0.089	0.978	-1.397	0.008	0.063	-0.011	0.008	-0.059	0.012	0.445	0.004	0.152	0.020	0.034
1971	0.853	0.087	0.090	0.818	-1.712	-0.009	0.152	-0.010	-0.006	0.032	-0.001	0.434	0.002	0.165	0.015	0.026
1972	0.750	0.086	0.091	0.846	-1.713	-0.010	0.154	-0.010	0.007	0.025	-0.002	0.506	0.002	0.138	0.017	0.026
1973	0.465	0.086	0.087	0.991	-1.727	-0.004	0.117	-0.012	0.017	-0.006	0.008	0.565	0.002	0.142	0.016	0.036
1974	1.038	0.106	0.119	0.879	-1.981	-0.018	0.239	-0.012	0.018	0.023	-0.009	0.574	0.004	0.092	0.018	0.028
1975	0.954	0.106	0.130	0.905	-1.977	-0.021	0.190	-0.012	0.036	0.058	-0.003	0.527	0.002	0.117	0.021	0.028
1976	0.318	0.094	0.108	1.126	-1.788	-0.011	0.151	-0.012	0.043	-0.063	0.014	0.492	0.004	0.096	0.020	0.041
1977	-0.246	0.097	0.100	1.268	-1.700	-0.005	0.126	-0.013	0.023	-0.067	0.029	0.422	0.004	0.114	0.028	0.045
1978	0.161	0.106	0.112	1.179	-1.933	-0.022	0.174	-0.015	0.051	-0.020	0.020	0.446	0.004	0.145	0.039	0.042
1979	0.148	0.108	0.104	0.985	-1.509	-0.001	0.110	-0.016	-0.017	-0.017	0.014	0.411	0.004	0.144	0.023	0.030
1980	0.005	0.087	0.117	1.050	-1.641	-0.020	0.149	-0.011	0.042	-0.059	0.018	0.396	0.004	0.106	0.045	0.036
1981	-0.342	0.087	0.113	1.166	-1.504	-0.008	0.108	-0.014	0.052	-0.117	0.019	0.468	0.007	0.094	0.037	0.038

[a]NUTRIENTS:

(1) Protein
(2) Fat
(3) Carbohydrates
(4) Calcium
(5) Phosphorus
(6) Iron
(7) Magnesium
(8) Vitamin A
(9) Thiamine
(10) Riboflavin
(11) Niacin
(12) Vitamin B-6
(13) Vitamin B-12
(14) Vitamin C
(15) Zinc
(16) Cholesterol

Table 12. Per capita disposable income and food expenditures and aggregate retail price indices (1967 = 100.0).

Year	Per Capita Disposable Income	Per Capita Food Expenditures	Non-Food CPI	Real Non-Food Expenditures	Average Age
1953	1592.5	408.3	79.0	.150	32.0
1954	1597.9	409.8	79.5	.150	31.9
1955	1680.2	413.4	79.7	.159	31.8
1956	1761.4	422.7	81.1	.165	31.8
1957	1825.2	436.7	83.8	.166	31.7
1958	1857.8	445.4	85.7	.165	31.6
1959	1937.8	453.8	87.3	.170	31.5
1960	1986.5	457.7	88.8	.172	31.5
1961	2034.9	461.6	89.7	.175	31.4
1962	2124.0	466.9	90.8	.183	31.4
1963	2197.2	472.9	92.0	.187	31.4
1964	2352.4	493.0	93.2	.200	31.4
1965	2505.4	529.8	94.5	.210	31.5
1966	2675.5	554.5	96.7	.219	31.5
1967	2828.7	565.1	100.0	.226	31.7
1968	3037.3	605.9	104.4	.233	31.8
1969	3240.1	643.9	110.1	.236	32.0
1970	3489.8	693.0	116.7	.240	32.1
1971	3740.7	710.3	122.1	.248	32.2
1972	4000.1	755.1	125.8	.258	32.3
1973	4482.1	831.0	130.7	.279	32.5
1974	4855.6	926.8	143.7	.273	32.8
1975	5291.4	1012.6	157.1	.272	33.0
1976	5744.9	1083.3	167.5	.278	33.2
1977	6262.7	1161.9	178.4	.286	33.4
1978	6969.0	1267.8	191.2	.298	33.6
1979	7683.9	1409.9	213.0	.295	33.7
1980	8421.3	1532.8	244.0	.282	33.9
1981	9244.9	1636.0	270.6	.281	34.0