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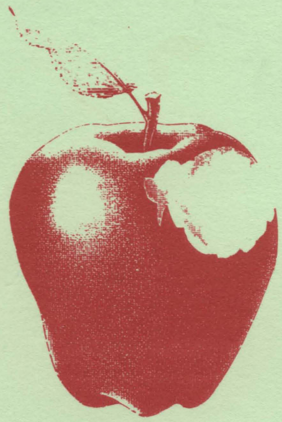
March 1993



# A Complete Systems Analysis of Nutritional Awareness and Food Demand



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# A Complete Systems Analysis of Nutritional Awareness and Food Demand

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KEYWORDS: nutritional awareness, food demand analysis, complete systems.

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# Contents

# Executive Summary

Nutrition and health issues are becoming increasingly important to American consumers. Yet, agricultural economists know relatively little about the role that such information plays in determining the demand for food. The purpose of this study is to better understand the role of nutritional awareness in food demand. A framework is presented in which neoclassical utility theory is augmented to include nutritional information. This framework is then applied empirically to estimate the demand for various food commodities.

Nutritional information is measured by four alternative methods. The first method includes intercept shifters, while the three remaining approaches utilize indices to measure nutritional information. One of these indices (the C-S index) cumulatively counts the release of ten major articles relating to nutrition and health. This index considers nutrition in a very broad context. The second index (the B-S index) is based on the release of articles which deal with the possible linkage between cholesterol and coronary heart disease; as such it considers cholesterol information specifically. This index is modeled in conjunction with a polynomial distributed lag. The third method of measuring nutritional information includes both the C-S and the B-S indices.

The demands for beef, pork, and whole milk are negatively affected by cholesterol information, while the demands for fish, poultry, lowfat milk, cheese, and frozen dairy products are positively affected. All food commodities show a highly inelastic response to the more global measure of nutritional information. The inclusion of nutritional information leads to a reduction in serial correlation problems. Failure to include nutritional information may also result in overstating the importance of habit persistence in food demand analyses.

## Acknowledgment

The authors wish to acknowledge review comments made by John Penson, Atanu Saha, and Steve Fuller.

# Introduction

Nutrition and health issues appear to be major concerns for consumers. In a recent Food Marketing Institute survey, 93 percent of respondents indicated concern about the nutritional content of foods. This concern appears to involve a few particular nutrients, most notably fat and cholesterol (Borra). In response, promotional campaigns for food products are increasing emphasis on issues pertaining to health and diet. However, relatively little has been done to include this information within food demand studies (Capps and Schmitz, Brown and Schrader). The omission of this information may lead to specification errors in demand analysis.

Erdman has labeled the period since 1977 as the Preventive Nutrition Era. The Preventive Nutrition Era began with the publication of Dietary Goals for the United States by the U.S. Senate Select Committee on Nutrition and Human Needs in 1977. It is commonly believed that this publication represents the first major publication which warns of the dangers of over-consumption of calories or nutrient elements. In the years prior to 1977, nutritionists were primarily concerned with under-consumption of nutrients.

The Preventive Nutrition Era emphasizes issues such as obesity, whereas the previous emphasis was on the establishment and attainment of Recommended Dietary Allowances (RDAs). In 1988, the U.S. Surgeon General indicated that 5 of the top 10 causes of death in the United States had been linked to the diet (U.S. Dept. of Health and Human Services). The efforts in the Preventive Nutrition Era are directed to establishing linkages between diet and health and to educating the public to these linkages. Cronin and Shaw reviewed 10 major articles published between 1977 and 1988 concerning preventive nutrition. Although the issues varied somewhat across articles, they followed a common theme of weight maintenance, limiting consumption of fats, sugars, sodium, and cholesterol; increasing consumption of fiber and complex carbohydrates; and avoidance or moderation of the consumption of alcohol.

Although much evidence has been generated to support the linkage between nutrition and health, relatively little is known about how consumers use this information. Ippolito and Mathois state (p. 20), "the improved understanding (of the role of diet and the development of chronic disease) will have little value unless consumers incorporate the new information into behavior". Traditional food demand models used by agricultural economists are based on prices and income. Nutritional awareness is not, however, dependent on these variables. If consumers do assimilate this information into their decision-making process, failure to include changes in nutritional information represents a specification error in the traditional demand models used by agricultural economists. This specification error may result in inconsistent parameter estimates and misleading inferences about food demand.

The linkage between nutritional awareness and food demand has been addressed in recent works by Brown and Schrader; Chang and Kinnucan; and Capps and Schmitz as well as others. Brown and Schrader consider the effect of information about cholesterol on the demand for shell eggs. In their paper, an index of cholesterol information is generated which is later used in the works by Chang and Kinnucan and Capps and Schmitz. The Brown and Schrader index constitutes the number of articles in the available medical literature which deal with the impact of cholesterol levels on health. This index represents the cumulative sum of all articles which establishes a link between cholesterol and heart disease. This sum is subsequently adjusted by subtracting those articles which fail to establish this link. Using this index, Brown and Schrader concluded that shell egg consumption decreased as a result of nutritional awareness, all other things held constant.

Capps and Schmitz used the same index using a demand systems framework. Annual data were used to analyze demands for beef, pork, chicken, and fish in the United States. They found that the cholesterol index had a significant positive impact on per capita fish and chicken consumption, but this index had a significantly negative impact on pork consumption. Although this index was negatively related to per capita beef consumption, it was not statistically significant.

Chang and Kinnucan expanded the Brown and Schrader index to include those journal articles not only in the United States but also in Canada. The commodities studied included butter, margarine, shortening, and salad oils. Quarterly data from the second quarter of 1973 through the third quarter of 1986 were used in this analysis. A variation of the Almost Ideal Demand System (AIDS) model, which uses consumption levels in lieu of budget shares as endogenous variables, was used. In addition to prices and income, their model included seasonality, advertising, and the cholesterol index. They concluded that the negative information in the cholesterol index out weighed the positive information from the advertising message. They were also able to show that cholesterol information had a negative affect on butter consumption but a positive affect on salad oil consumption. The effect of this information for margarine and shortening was also positive but was not statistically significant.

## Objectives

Despite the aforementioned studies, little is yet known about the role of nutritional awareness in the retail demand for food. Given that the level of health and nutrition information available to the consumer has grown substantially, more knowledge about the impact of such information on food demand is needed. If consumers are in fact responding to this information, the sharp growth in the level of information available to consumers should result in a noticeable impact on food demand. Consequently, ignoring such variables could give rise to considerable specification error in demand models.

This study is an attempt to better understand the role of nutritional awareness in food demand. Specifically, the objective of this study is to identify and assess the effects of nutritional information on specific retail food groups. The central question of this effort is simply the following: do consumers respond to nutrition and health information? In each of the models presented later, the null hypothesis that consumers do not respond to such information is tested. A positive relationship between nutrition and health information and the demand for a food would indicate that consumers are consuming more of the food item as a result of nutritional awareness, *ceteris paribus*, while a negative relationship between such information and the demand for a food would indicate a decrease in the consumption of the food item resulting from nutritional awareness.

## Approach

Nutritional awareness may affect food demand in several ways. The models developed within this study analyze two predominant methods. These are:

1. budget allocations among the major food groupings; (i.e. consume fewer meats and dairy products while consuming more fruits, vegetables, and cereal products), and
2. budget allocations within any of these major groups (i.e. for meats, consumers may consume less beef and pork while consuming more chicken and fish).

In this study, six complete demand systems are estimated. Food categories for these systems are shown in Figure 1. The first demand system examines the effect of nutritional awareness on major food groups. This model consists of the eight major food categories (fresh fruits and vegetables are combined) shown in Figure 1. This model is estimated using annual data from 1960 through 1988.

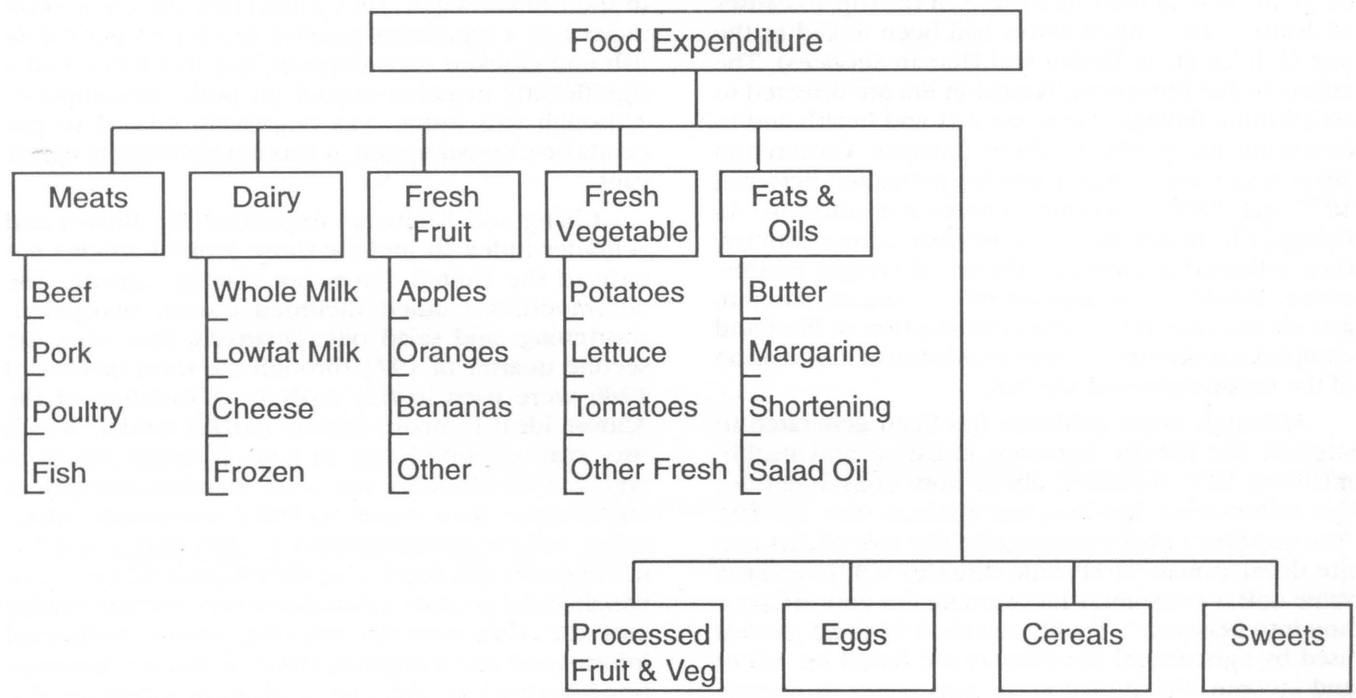


**Figure 1. Selected food categories and submodel formulations to be analyzed.**

The next five models consider reallocation within the subgroups of meat, dairy, fruits, vegetables, and fats and oils. The three remaining categories are not considered further because of the lack of data corresponding to individual food items. Quarterly data over the period from 1968 through 1988 are available for meats and thus are utilized. The other four subgroup models use only annual data due to the lack of available quarterly data.

### Overview

The theoretical framework and supporting model development are discussed in the next section. The formulations of specific models as well as descriptions of data used in these model formulations are the subject of the third section. Empirical results are presented and discussed in section four. Conclusions, summary comments, limitations, and future directions for research are addressed in the final section.

## Theoretical Development

Nutritional awareness is akin to advertising in that both provide information about products for consumers. They primarily differ in that advertising normally emphasizes a message of technical or sensual characteristics, while nutritional awareness emphasizes a message of how consumption may affect health. Because of the similarities between advertising and nutritional awareness, it seems appropriate to include nutritional awareness information in demand systems using the same basic techniques as those used successfully in the study of the effects of advertising on demand. Specifically, the use of distributed lag models may prove to be very helpful in explaining the impact of nutritional information on food demand.

This study begins by developing an appropriate empirical framework to determine the implications of nutritional awareness on food demand. Theoretical developments and functional form issues are discussed. The Almost Ideal Demand System (AIDS) is then presented. The dynamic AIDS model is used as the basic demand model throughout this study. For the purposes of this study, it is necessary to expand the AIDS model to include nutritional information as well as seasonality. These augmentations are discussed individually following a discussion of the AIDS model. This section then proceeds with a discussion of price, expenditure, and income elasticities and their associated variances. Finally, the calculation of short-run, interim, cumulative, and long-run elasticities associated with the polynomial distributed lag AIDS model is discussed.

### Theoretical Framework

The theoretical framework which is used in this study follows the framework applied by Capps and Schmitz. In this framework, the utility function in time period $t$ is expressed as

$$U_t = U[Q_t;\ \theta(r_t)], \tag{1}$$

where $\theta\ (r_t)$ reflects the preferences of the consumer with regard to commodity vector $Q_t$. This framework follows from the work of Basmann in the area of consumer demand under variable preferences. The vector $r$ represents a vector of exogenous state variables. These state variables may correspond to stocks of knowledge, psychological stocks of habits, or physical stocks of goods. This framework assumes that the formulation of consumer preferences rests in part on information about characteristics of $Q$ contained in $r$.

If the stock of knowledge is constant over time, then selection of a commodity bundle is not altered. Thus the term $\theta\ (r_t)$ may be dropped from (1) leaving the more traditional utility specification. However, if the stock of information changes over time and the information in $r$ influences the choice of commodity bundles, then failure to include this information may yield biased estimates of structural demand parameters. The information included in $r$ may explain cases of structural change in the demand for meat products that have been indicated by several studies (Nyankori and Miller; Chavas; Dahlgran; Thurman; Eales and Unnevehr; Moschini and Meilke; Goodwin; Choi and Sosin).

When modeling health and nutritional awareness, the vector $r$ may consist of information about any number of items. The awareness of nutrition and health may center predominantly on cholesterol, sodium, dietary fiber, saturated fats, and caloric intake. Importantly, the message presented by the medical profession or nutritionists may not be the same message received by consumers. It is the attitude of the consumer toward nutrition and health which determines the choice of the commodity bundle, not necessarily the factual information.

Consumer attitudes may be affected by many factors, for example advertising, which often focuses on certain aspects of nutrition. However, attitudes are unique to each individual. Thus the collection and inclusion of consumer attitudes would require considerable effort. Since practically no data currently exist in this area, the use of attitudinal variables, which are specific to individuals, would require crosssectional studies. Potential for work in this area exists, especially with the recent release of the 1987-88 Nationwide Food Consumption Survey (NFCS).

In time-series applications, proxy variables are needed for $r$. Any variable or set of variables highly correlated with $r$ is a candidate to be used as a proxy. Proxies may be advertising information or a number of different measures of scientific information about health and nutrition. The quality of each alternative depends on which sources are used most by consumers. Data on sources of consumer information about health and nutrition factors also will be available in the 1987-88 NFCS.

## Functional Form

Marshallian demand functions in compliance with (1) are given in general form as

$$q_i = q_i[P, M; \theta(r_t)]. \tag{2}$$

However, theory cannot specify a functional form for these demand functions or specify a form for the θ function. Several alternative complete demand systems are viable candidates for use in estimating (2) as well as incomplete demand systems. The Almost Ideal Demand System (AIDS) has been selected due to consistency with the theoretical framework above, its ability to deal with aggregate as well as disaggregate data, its relative ease of use (when the linear approximation is used), and its flexibility. A dynamic version of the AIDS model is also often used to circumvent potential problems of serial correlation. Furthermore, the dynamic AIDS model can allow for habitual purchase behavior which is often found in consumer demand studies.

Less is known of the form for the θ function since very little previous work has been conducted. In their study of the effects of an Alar scare in apples, van Ravenswaay and Hoehn suggest four possible ways that Alar can affect the demand for apples. Their first hypothesis assumes that consumers immediately respond to information about Alar. In this case, the appropriate model contains a binary intercept shifter variable which allows for a shift on the date the Alar scare was revealed by the media. This specification, however, fails to establish a connection between Alar information and apples. Thus three alternative hypotheses were considered. Their second hypothesis is that "a change in the safety of a product does affect consumers' purchases, but the information is eventually forgotten" (p.10). This hypothesis gives rise to the use of a distributed lag framework. Due to the similarity between information and advertising, and the success of distributed lags in advertising research, such a hypothesis seems plausible.

The third hypothesis put forth by van Ravenswaay and Hoehn is that "a change in risk information is not forgotten and affects purchases until an announcement is made that the risk has been eliminated" (p. 10). This approach in the area of nutrition would be consistent with the use of a running total of nutrition or health related articles. These running totals have been used by Brown and Schrader, Capps and Schmitz, and Chang and Kinnucan in regard to the development of the cholesterol index. The fourth hypothesis put forth involves a combination of the first hypothesis with either the second or third. In this case, "a consumer's perception of the magnitude of a safety problem may increase with subsequent announcements" (p.10).

Since little is known of the structure of θ, several alternative structures are pursued in this analysis. These include the use of binary intercept shifters, running totals, and a distributed lag model. Furthermore, the simultaneous use of a distributed lag model and a running total of articles is investigated. In essence, the hypotheses put forward by van Ravenswaay and Hoehn are adopted in this study.

## Dynamic AIDS Model

The static AIDS model was first introduced by Deaton and Muellbauer (1980b). Dynamics were later added to the static model specification by Blanciforti and Green who included a lagged quantity variable ($Q_{i,t-1}$). Later, Eales and Unnevehr incorporated dynamics by considering the change in levels of each variable instead of the variables themselves. Following the work of Anderson and Blundell, Johnson et al. presented a dynamic AIDS model with lagged budget shares instead of the lagged quantities used by Blanciforti and Green. Using the Johnson et al. approach, the dynamic AIDS model can be expressed as

$$w_{it} = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln P_{jt} + \beta_i \ln\left(\frac{X_t}{P_t}\right) + \zeta_i w_{i,t-1} + \varepsilon_{it}, \tag{3}$$

where $w_{it}$ is the budget share for good $i$ ($w_{it} = P_{it}Q_{it}/X_t$); $P_{jt}$ is the price of good $j$, $X_t$ is the total expenditure on the $N$ goods included within the system; $\varepsilon_{it}$ is a stochastic error term; and

$$\ln P_t = \alpha_0 + \sum_{j=1}^{N} \alpha_j \ln P_{jt} + \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N} \gamma_{ij} \ln P_{it} \ln P_{jt}. \tag{4}$$

The parameters which require estimation are the α's, γ's, β's, and ζ's. Due to the nonlinearity of parameters in equation (4), the AIDS model is often approximated by substituting Stone's Approximation ($\ln(P_t^*)$) for $\ln(P_t)$ where

$$\ln P_t^* = \sum_{j=1}^{N} w_{j,t-1} \ln P_{jt}. \tag{5}$$

Equation (5) includes lagged budget shares as is done by Eales and Unnevehr. This specification avoids potential problems with simultaneity bias[1]. The AIDS model with this substitution is linear in parameters and thus is commonly referred to as LA/AIDS.

[1]Simultaneity bias occurs when a change in the dependent variable ($w_i$) affects the magnitude of one of the independent regressors, in this case the budget shares in equation (5).

The integrability conditions are required to guarantee the existence of an underlying utility function. To maintain these conditions, it is necessary to impose the classical restrictions on the demand system (Deaton and Muellbauer, 1980a p. 49-50; Varian, p. 135-139). Three restrictions, often referred to as the *TRIAD*, involve three conditions. Namely, these conditions are homogeneity, Slutsky symmetry, and adding up. The first two of these three conditions require restrictions to be placed on the AIDS or LA/AIDS models (Deaton and Muellbauer, 1980a p.75-78). Homogeneity requires

$$\sum_{j=1}^{N} \gamma_{ij} = 0, \quad \forall\, i = [1 \cdots N], \tag{6}$$

while Slutsky symmetry requires

$$\gamma_{ij} = \gamma_{ji}, \quad \forall\, i, j\ ;\ (i \neq j). \tag{7}$$

Homogeneity and Slutsky symmetry restrictions remain unaltered when switching from a static to a dynamic structure. However, the adding-up restrictions are different when the dynamic AIDS model is used. In the static model, the presence of adding-up requires that one equation be dropped from the system in order to avoid a singular variance-covariance matrix. The coefficients for the omitted equation are determined by

$$\sum_{i=1}^{N} \alpha_i = 1, \quad \sum_{i=1}^{N} \gamma_{ij} = 0, \text{ and } \sum_{i=1}^{N} \beta_i = 0. \tag{8}$$

The same procedure as used in the static procedure could be used if the coefficients for the lagged budget share also were forced to sum to zero. This restriction results in some lagged terms being negative. However, the appropriate range for these coefficients lies between zero and one because they relate to habit persistence.

An alternative approach is used here. In this case, all N equations are estimated. In addition to the homogeneity and Slutsky symmetry conditions above, adding up requires

$$\sum_{i=1}^{N} \gamma_{ij}=0, \quad \sum_{i=1}^{N} \beta_i=0, \quad \sum_{i=1}^{N} (\alpha_i + \zeta_i O_i) = 1\ , \tag{9}$$

where $O_i$ represents all variables in the model except prices and expenditure. Equation (9) treats all terms other than prices and expenditure as part of the intercept.

**Augmenting the AIDS model**

Through the course of this study, the AIDS model is augmented by three different methods. These augmentations involve the addition of a Polynomial Distributed Lag (PDL) formulation, other measures of nutritional information, and seasonality. To simplify the presentation of these models, each augmentation is presented separately.

In each case, the intercept term is expanded. The homogeneity and symmetry conditions remain as previously specified while the adding up restriction is imposed by equation (9). Actually, the lagged budget share in the dynamic AIDS model already represents an augmentation of the static model. Each of the aforementioned augmentations is discussed in turn.

***The PDL/AIDS model***

The second hypothesis put forth by van Ravenswaay and Hoehn considers the possibility that consumers hear and respond to a message but forget that message over time. The incorporation of this idea of "response and decay" into empirical analyses is often done through the use of distributed lag models (Almon; Chen, Courtney, and Schmitz). The use of distributed lags has been successful in many areas, and has been especially effective in studies of advertising (Kinnucan and Forker; Baye, Jansen, and Lee). Due to similarities in the nature of messages provided by advertisers and nutritionists, one would expect that distributed lag models also may work well in the analysis of nutrition awareness and food demand.

Baye, Jansen, and Lee included a geometric lag structure for advertising within an AIDS model. The geometric lag structure allows for an initial response with geometrically declining response thereafter. Although this structure may be appropriate in the study of nutrition and food demand, one would not want to limit the response to such a geometric shape. Alternatively, one could use the polynomial distributed lag (PDL) structure developed by Almon. The PDL specification is capable of producing a geometric lag shape as well as other more flexible shapes. One of the common shapes displayed by the PDL model is a humped-shaped pattern. This shape allows a gradual response to the information followed by a gradual decline in this response. The PDL structure is preferred here since it can accommodate a geometric shape as well as other shapes such as the humped-shape.

The use of a PDL requires the analyst to specify *a priori* the length of lag and degree of polynomial. In the PDL model, the degrees of the polynomial should be less than the length of lag minus one so as to allow the PDL formulation to reduce the total number of structural parameters to be estimated. The PDL model is discussed in detail by Pindyck and Rubinfeld and by Kmenta.

The reduced-form equation for the PDL can be combined with the dynamic AIDS model in (3), giving rise to a *Polynomial Distributed Lag* augmented *Almost Ideal Demand System* or the PDL/AIDS model. The reduced-form for the PDL/AIDS becomes

$$w_{it} = \alpha_i + \sum_{j=1}^{N} \gamma_{ij} \ln P_{jt} + \beta_i \ln\left(\frac{X_t}{P_t}\right) \tag{10}$$
$$+ \zeta_i w_{i,t-1} + \sum_{d=0}^{D_i} c_{di} R_{dit} + \varepsilon_{it},$$

where $D_i$ is the degree of polynomial desired for item i, $c_{di}$ is the $d^{th}$ reduced-form coefficient for the $i^{th}$ item, and $R_{dit}$ is the $d^{th}$ lag of the information variable for the $i^{th}$ equation. The lag structure for $R_{dit}$ is calculated as

$$R_{0it} = \sum_{k=0}^{L_i} r_{t-k}, \text{ and} \tag{11}$$
$$R_{dit} = \sum_{k=1}^{L_i} k^d r_{t-k}, \quad \forall\, d = [1 \cdots D_i],$$

where $L_i$ is the length of lag associated with the $i^{th}$ item.

In the static version of the AIDS model, it is necessary to omit an equation and derive coefficient estimates for this omitted equation. This derivation is done through the use of the adding-up restrictions. When the lag structure is allowed to vary across equations, different variables are placed in each of the reduced-form equations. Considering this issue, the coefficients for the $N^{th}$ equation can be calculated as

$$c_{dN} = -\left[\frac{\sum_{i=1}^{N-1} c_{di} R_{di}}{R_{dN}}\right]. \tag{12}$$

These can only be imposed at one point, typically at the means of the data sample. In the dynamic structure, all the coefficients are estimated so this derivation is not necessary.

The structural coefficients for the PDL/AIDS can be obtained by substituting the reduced-form coefficients into

$$\omega_{li} = c_{0i} + \sum_{k=1}^{D_i} c_{ki} \cdot l^k. \tag{13}$$

These structural coefficients ($\omega_{li}$) represent the impact of the state variable on the $i^{th}$ budget share in the $l^{th}$ period.

Two additional restrictions known as head and tail restrictions are often used with a PDL. A head restriction constrains the information ($r$) included in the PDL to have no impact in the time period before its release. Thus a change in r cannot be anticipated. A tail restriction constrains this information to have no impact after $L_i$ periods have passed. Either, both, or neither of these restrictions may be used as needed for the particular modeling application. The head restriction requires

$$\omega_{-1i} \equiv \sum_{d=0}^{D_i} (-1)^d c_{di} = 0, \tag{14}$$

while the tail restriction requires

$$\omega_{(L_i+1)i} \equiv \sum_{d=0}^{D_i} (L_i+1)^d c_{di} = 0. \tag{15}$$

### *Other Nutritional Variables*

As discussed earlier, alternatives to the PDL specification also are used to determine the impact of nutritional information. These alternatives include the addition of either binary intercept shifters or continuous variables to the model.

The first method used by van Ravenswaay and Hoehn represents the most straight forward and perhaps the most naive approach to modeling a "structural change." This method simply involves the selection of critical times when structural changes may have occurred. An application of this method requires selecting appropriate times at which demand shifts may have occurred. The selection of proposed dates for structural changes is addressed in the data section. Once periods are selected, they can be incorporated into the model using binary variables. These variables would equal one if the data are from the period in question and zero otherwise. A dummy variable associated with one of these periods must be arbitrarily dropped to avoid a singular matrix resulting from the "dummy variable trap."

The third hypothesis put forth by van Ravenswaay and Hoehn calls for a continuous variable which does not allow for information decay.[2] A good example of using this hypothesis is the previously described cholesterol index developed by Brown and Schrader. An alternative and more general index also can be developed from the articles reviewed by Cronin and Shaw.

[2]Recall that the second hypothesis was the basis for applying the polynomial distributed lag model.

These ten articles represent presumably major works which lead to new understandings about nutrition and health linkages. Using the release dates of these ten articles, a new index which cumulatively counts these releases is employed in this study. The value of this index remains at zero until 1977 and increases with the release of each article until reaching the value of ten upon the release of the last article in 1988. This index is simply added to the AIDS model in the same fashion as the lagged budget share.

***Seasonality***

When quarterly or monthly data are used in demand studies, seasonality often plays a significant role. To allow for seasonality in the AIDS model and its variations, only a few adjustments need to be made. Seasonal dummies are easily added to equation (3). This augmentation results in a new $\alpha_i$ which appears as

$$\alpha_i + \sum_{h=1}^{H-1} \mu_{hi} S_{ht}, \tag{16}$$

where $H$ is the number of seasonal periods in the year; $S_{ht}$ is a binary variable equal to one if data are from period $h$ and zero otherwise; and $\mu_{hi}$ is an intercept shifter. Again, one of these dummy variables must be arbitrarily omitted to avoid the singularity problem.

**Price and Expenditure Elasticities**

The magnitude of coefficients determined in the estimation of the AIDS model are affected by the scale of the data, making interpretations and comparisons with the existing literature difficult. To help alleviate this difficulty, economists often use elasticity estimates. These elasticities are calculated from the estimates of the structural parameters, but the interpretation of these measures are not dependent on the scale of the data. Thus elasticities are useful in making comparisons with previous studies.

Green and Alston review price elasticity calculations in the AIDS and LA/AIDS models. In their discussion, Green and Alston assume that the budget shares in Stone's approximation, equation (5), are not lagged. Under this assumption, they show that

$$\frac{d\ln(P^*)}{d\ln(P_j)} = w_j + \sum_{k=1}^{N} w_k \ln(P_k)(\epsilon_{kj} + \delta_{kj}), \tag{17}$$

where $\epsilon_{kj}$ is the Marshallian cross-price elasticity and $\delta_{kj}$ is the Kronecker delta (1 if k equals j and 0 otherwise). When the budget shares in Stone's approximation are lagged, equation (17) simply equals $w_j$. Thus the formula for the Marshallian elasticities is given as

$$\epsilon_{ij} = -\delta_{ij} + \frac{\gamma_{ij} - \beta_i w_j}{w_i} \tag{18}$$

where $\delta_{ij}$ again refers to the Kronecker delta. The intercept of the AIDS model does not appear in this formula. Since each of the augmentations discussed previously are really just adjustments to the intercept, the uncompensated elasticity formula is unaffected by augmentations to the AIDS model. Compensated elasticities may be calculated from the uncompensated elasticities above by using Slutsky's equation

$$\epsilon^*_{ij} = \epsilon_{ij} + w_j \eta_i, \tag{19}$$

where $\eta_i$ is the expenditure elasticity calculated as

$$\eta_i = \left(1 + \frac{\beta_i}{w_i}\right). \tag{20}$$

One can also adjust the expenditure elasticity to an income elasticity. Using the chain rule, the income elasticity can be shown to be

$$\frac{\partial Q_i}{\partial I}\frac{I}{Q_i} = \left(\frac{\partial Q_i}{\partial X}\frac{X}{Q_i}\right)\left(\frac{\partial X}{\partial I}\frac{I}{X}\right) = \eta_i \frac{\partial X}{\partial I}\frac{I}{X}, \tag{21}$$

where $X$ is expenditure on the group and $I$ is income (Manser; Capps, Tedford, and Havlicek). The last term is an elasticity between expenditure and income. This term can be estimated using an auxiliary regression. A double log OLS regression yields such an elasticity estimate directly. This auxiliary regression appears as

$$\ln(X_t) = \alpha + \tau \ln(I_t), \tag{22}$$

where $I_t$ is a measure of income and $\tau$ is the desired elasticity estimate. The income elasticity is then calculated as $\tau\eta_i$.

Using the preceding formulae, a complete set of compensated and uncompensated price elasticities as well as expenditure and income elasticities can be calculated. These represent only point estimates. An equally important consideration is the variance associated with these estimates. Dorfman, Kling, and Sexton address the importance of generating some measure of variance associated with these elasticity calculations. The work by Dorfman *et al.* focuses on the use of boot-strapping, Taylor's series expansion, and other approaches.

Chalfant discusses a technique for estimating the associated variances for elasticity estimates in the AIDS model. Estimates of these variances may be calculated through use of the variance-covariance matrix of coefficients. The variance of the elasticity is a linear function of parameters if $w_i$ is assumed to be fixed in repeated samples. With variance and covariance estimates of the parameters, one can approximate the variance of the elasticity. Mathematically, the expression for the variance of the uncompensated price elasticity appears as

$$VAR(\epsilon_{ij}) = VAR\left[-\delta_{ij} + \frac{\gamma_{ij} - \beta_i w_j}{w_i}\right]. \tag{23}$$

Simplifying this expression, one obtains the variance of the uncompensated price elasticity

$$\begin{aligned} VAR(\epsilon_{ij}) &= \frac{1}{w_i^2} VAR(\gamma_{ij}) \\ &+ \frac{w_j^2}{w_i^2} VAR(\beta_i) - \frac{2w_j}{w_i^2} COV(\gamma_{ij}, \beta_i). \end{aligned} \tag{24}$$

Following a similar approach, the variance for the compensated elasticity can be calculated as

$$VAR(\epsilon_{ij}^*) = \frac{1}{w_i^2} VAR(\gamma_{ij}), \tag{25}$$

and the variance of the expenditure elasticity can be calculated as

$$VAR(\eta_i) = \frac{1}{w_i^2} VAR(\beta_i). \tag{26}$$

A variance associated with the income elasticity cannot be calculated since this calculation involves the product of two coefficients. The approaches discussed by Dorfman *et al.* are applicable in this circumstance. Alternatively, one could assume that the coefficient $\tau$ from equation (22) is a constant. In this case, the variance of the income elasticity would equal the variance of the expenditure elasticity times $\tau^2$.

Armed with point elasticities and variances of these elasticity calculations, one can determine whether goods are substitutes, complements, or independent. Such determinations are made by the sign of the compensated cross-price elasticities (Hicks-Allen definition). If negative, the goods are complements, if positive the goods are substitutes, and if not significantly different from zero, they are independent. To make this determination, the t-test could be used. This test is calculated as

$$t = \frac{\epsilon_{ij}^*}{\sqrt{VAR(\epsilon_{ij}^*)}}, \tag{27}$$

where t follows the t-distribution. Since this variance is only an approximation, a cutoff value of 2 can be used.

Similar tests may be used to determine whether demand is elastic or inelastic. The nature of demand elasticity is determined by whether the uncompensated own-price elasticity is greater or less than one in absolute value. Additionally, one can determine whether a good is an inferior, normal, or superior good by determining whether the income elasticity is less than zero, between zero and one, or greater than one, respectively.

**Information Elasticities**

Nutritional information has been added to the AIDS model in three different forms. Two of these forms involve the use of continuous variables. In the cases where continuous variables are used, elasticity calculations can be derived. No calculations can be given for the binary intercept shifter variables.

The simpler case involves the elasticity calculation for the C-S index. In this case, the index $C$ is common to all equations. To determine the elasticity, one must differentiate $w_i$ with respect to $C$. This is

$$\begin{aligned} \frac{\partial w_i}{\partial C} &= \frac{\partial \left[\frac{P_i Q_i}{X}\right]}{\partial C} = \\ &\frac{X\left[P_i \frac{\partial Q_i}{\partial C} + Q_i \frac{\partial P_i}{\partial C}\right] - P_i Q_i \frac{\partial X}{\partial C}}{X^2}. \end{aligned} \tag{28}$$

Assuming that prices and expenditure are independent of $C$, equation (28) can be simplified to

$$\frac{\partial w_i}{\partial C} = \frac{P_i}{X}\frac{\partial Q_i}{\partial C}. \tag{29}$$

Note that $\partial w_i/\partial C$ equals the coefficient estimate associated with $C$. We will call this coefficient $\psi_i$. Solving (29) for $\partial Q_i/\partial C$ and multiplying by $C/Q_i$ yields, at the sample means,

$$\frac{\partial Q_i}{\partial C}\frac{\bar{C}}{\bar{Q}_i} = \frac{\psi_i \bar{X}}{\bar{P}_i}\frac{\bar{C}}{\bar{Q}_i} = \frac{\psi_i \bar{C}}{\bar{w}_i}, \tag{30}$$

which gives the elasticity of $Q_i$ with respect to $C$. Specifically this measure constitutes the percentage change in quantity demanded that would result if a one percent change in awareness were to occur in that period, *ceteris paribus*.

In some cases such as advertising, it is possible that $C$ may be specific to certain equations. Thus, it may be necessary for $C$ to be noted as $C_j$. Only a slight modification is needed for a more general derivation. In the case of $C_j$, it becomes necessary to consider $\partial w_i/\partial C_j$. Noting again that expenditure and prices are exogenous, this expression can be stated as

$$\frac{\partial w_i}{\partial C_j} = \frac{P_i}{X}\frac{\partial Q_i}{\partial C_j}. \tag{31}$$

Solving for $\partial Q_i/\partial C_j$, we obtain

$$\frac{\partial Q_i}{\partial C_j} = \frac{\partial w_i}{\partial C_j}\frac{X}{P_i} = \psi_{ij}\frac{X}{P_i}. \tag{32}$$

Again, this result will be converted to an elasticity by multiplying by $C_j/Q_i$. Evaluating this at the mean, we obtain

$$\frac{\partial Q_i \bar{C}_j}{\partial C_j \bar{Q}_i} = \frac{\partial w_i}{\partial C_j}\frac{\bar{X}\bar{C}_j}{\bar{P}_i \bar{Q}_i} = \psi_{ij}\frac{\bar{C}_j}{\bar{w}_i}. \tag{33}$$

The PDL model is a dynamic structural model. Several alternative elasticity measures result from this dynamic structure. These include short-run, interim, cumulative, and long-run elasticities. Note that the $\psi$s in (33) correspond to the $\omega$s in the PDL. In the case above, one coefficient $\psi_i$ is involved per equation. In the case of a PDL, several $\psi$s are involved.

The short-run elasticity can be found by replacing the $\psi_{ij}$ in (33) with $\omega_{0i}$. Interim elasticities would be calculated by replacing $\psi_{ij}$ with $\omega_{li}$ where $l$ is the number of periods for which the interim elasticity is desired. Cumulative elasticities are calculated by replacing $\psi_{ij}$ with $(\Sigma\omega_{li})$ over the range from 0 to the number of periods for which the cumulative elasticity is to cover. A long-run elasticity is a special case of the cumulative elasticity. The long-run elasticity is the cumulative elasticity where all values of $\omega$ are included in the summation.

## Data Sources and Descriptive Statistics

The estimation of the previously mentioned econometric models require appropriate data. These data needs can be broken down into two categories: economic data and nutritional awareness data. The first section includes a discussion of price and consumption data that are typically included in a demand system. In the second section, nontraditional data used to measure the impact of nutritional awareness are discussed. Within each of these two sections, the sources of individual data series as well as any special techniques used in the collection of these series are documented. Descriptive statistics for each data series are included with each section.

### Economic Data

The estimation of a complete demand system requires information pertaining to prices, expenditures, and other variables depending on the phenomenon being investigated. The analyst gathers information about prices and consumption, and defines total expenditure to be the summation of expenditures on each item. Thus, in the complete demand system framework, expenditures are determined from prices and quantities consumed. This section documents sources of price and quantity data needed in these models. For clarity, prices and quantities for each model will be presented separately.

Throughout this discussion, prices are presented in cents per pound while quantities are presented in pounds *per capita*. For each model, issues which are specifically encountered in the development of the respective data series are discussed. Typically, for aggregate commodities, prices correspond to indices. To convert from indices to cents per pound, it is necessary to obtain one "representative" price. This representative price is then used to convert the index to cents per pound.

Obtaining a representative price can be a difficult process, especially for aggregate goods. In each case, sources for these representative prices are given as well as any other conversions which may be necessary. Quantities are normally published in pounds *per capita*, thus no conversion is necessary.

#### *Meats*

Meat is divided into four categories: beef, pork, poultry, and fish. Beef, pork, and poultry play a major role in the total food budget. Quarterly data are readily available for these commodities. Consumption data for these three commodities are taken from *Livestock and Poultry: Situation and Outlook*, which is published by the U.S. Department of Agriculture (USDA); price indices are taken from the Department of Commerce, Bureau of Labor Statistics (BLS). These indices are then converted to cents per pound using selected representative prices published by the USDA in the

*Food Consumption, Prices, and Expenditures* (FCPE) series. Representative prices for 1988 are $3.00 per pound for beef, $2.10 per pound for pork, and $1.22 for poultry.

Fish data, however, are much less readily available. The BLS publishes monthly price indices for many food items, including fish. However, no representative price is available to convert this index to price per pound. A conversion factor of $4.00 per pound for the year 1988 is used.

Quarterly fish consumption data also are not readily available. The U.S. Department of Commerce (USDC) does not publish much data pertaining to food items and the Department of Agriculture does not normally include data on fish. Annual fish consumption data (total and *per capita*) are published in FCPE. However, quarterly data are needed for fish consumption if quarterly data are to be used in the analysis. As a result, quarterly fish consumption data are generated from a variety of sources.

In generating quarterly fish consumption data, it is assumed that fish disappearance is proportional to but not necessarily equal to consumption. Fish disappearance is calculated as

$$DIS_t = LAND_t + IMP_t + STOCK_{t-1} - EXP_t - STOCK_t \tag{34}$$

where DIS is the level of disappearance in t, LAND is the reported landings, IMP is the quantity of imports, STOCK is the cold storage stocks at the end of the period, and EXP is the quantity of exports for the period.

Each of these variables is available or can be calculated on a monthly basis for the period from 1968 through 1988. They are however published in a variety of places. Landings are found in *Fishery Statistics of the United States* (USDC) over the period 1968-1979, and in *Fisheries of the United States* (USDC) over the period 1980-1988. Cold storage holdings may be found in the *Survey of Current Business*, also published by the USDC.

The USDC also publishes the value of monthly trade data, but not quantities. This situation makes the calculation of import and export data more difficult. Annual quantities are, however, published by the USDC in *Fishery Statistics of the United States*, and *Fisheries of the United States*. Again, it becomes necessary to allocate the annual quantities of imports and exports among the months. Value weights are generated by dividing the value of imports (exports) for the month by the total value of imports (exports) for the year. These weights are then adjusted by the retail price index for fish to remove seasonal price variation. The annual import and export quantities are then multiplied by these weights to determine monthly import and export levels. Mathematically, the monthly disappearance is calculated as

$$DIS_m = LAND_m + STOCK_{m-1} - STOCK_m + \frac{\left(\frac{V_{imp,m}}{V_{imp,yr}}\right)}{\left(\frac{P_{fish,m}}{P_{fish,yr}}\right)} Q_{imp,yr} - \frac{\left(\frac{V_{\exp,m}}{V_{\exp,yr}}\right)}{\left(\frac{P_{fish,m}}{P_{fish,yr}}\right)} Q_{\exp,yr}, \tag{35}$$

where $m$ is the month and $yr$ is the associated yearly total. $V_{imp,j}$ and $V_{exp,j}$ are the value of imports and exports, respectively, for either the month or the yearly total, $P_{fish,m}$ is the price of fish (the CPI for fish) for month m, and $Q_{imp,yr}$ and $Q_{exp,yr}$ is the quantity of imports and exports, respectively, for the year.

Once the monthly disappearance data are obtained, they become weights for annual consumption to generate monthly or quarterly consumption. Using these weights, monthly consumption is calculated as

$$Q_m = \frac{DIS_m}{DIS_{yr}} Q_{yr} \tag{36}$$

where Q is the quantity of consumption for the month or the year, and $DIS_{yr}$ is the summation of DIS over all the periods in the year.

This weighting procedure is used to capture the seasonal variation in consumption only. Consumption levels are still determined by the annual data published in FCPE.

This process most notably ignores aquaculture. Since weights are being generated, this procedure only causes an error to the extent that aquaculture production does not follow the same seasonal pattern of the disappearance data calculated above. The addition of this variable could add considerable difficulty due to the lack of data in this area. The benefits of this additional work at this time is considered to be minimal since only weights are desired. Thus no attempt is made to include aquacultural production.

After using this weighting procedure, quarterly price and consumption data for each of the four meat groups are obtained from the first quarter of 1968 through the last quarter of 1988. Data for these series are exhibited in Figure 2 (see Appendix A). Descriptive statistics for these series are exhibited in Table 1.

The average quarterly *per capita* expenditure on meat products over this period is $88.56. Mean prices are highest for beef and fish with fish being much more variable. The poultry price is the lowest and least variable of the meat groups. Beef enjoys the largest mean consumption, level while fish has the smallest level of consumption. The coefficient of variation (standard deviation divided by the mean times 100) is also provided in these tables. This statistic is included as another measure of variation for the data. The

| Table 1. Descriptive statistics for meats. | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | Units | Number of Obs. | Mean | Standard Deviation | Minimum | Maximum | Coef. of Variation |
| Pbeef | ¢/lb | 84 | 216.64 | 67.87 | 102.74 | 306.03 | 31.28 |
| Ppork | ¢/lb | 84 | 151.67 | 45.65 | 76.02 | 223.93 | 30.10 |
| Ppoult | ¢/lb | 84 | 93.06 | 22.23 | 55.74 | 134.67 | 23.89 |
| Pfish | ¢/lb | 84 | 215.39 | 98.74 | 78.24 | 403.57 | 45.84 |
| Qbeef | lb/cap | 84 | 20.91 | 1.62 | 17.60 | 25.10 | 7.75 |
| Qpork | lb/cap | 84 | 15.13 | 1.33 | 11.30 | 17.90 | 8.79 |
| Qpoult | lb/cap | 84 | 14.54 | 2.86 | 9.70 | 21.60 | 19.67 |
| Qfish | lb/cap | 84 | 3.20 | 0.92 | 2.03 | 5.54 | 28.75 |
| Expend | $/cap | 84 | 88.65 | 27.82 | 40.66 | 140.49 | 31.38 |

consumption levels of poultry and fish are more variable, as determined by this coefficient, than the consumption of beef and pork. Poultry products have shown substantial increases in consumption relative to other meats since the mid-1970s.

### *Dairy Products*

Dairy products correspond to the following: whole milk, lowfat milk, cheese, and frozen dairy products; frozen dairy products consist of ice cream, ice milk, and sherbet. Annual *per capita* consumption data are published in FCPE for the years 1960 through 1988. Whole milk prices are also available from FCPE, while price indices for cheese products and ice cream are available from BLS.

The lowfat milk price series is more difficult to obtain since data are not available before 1978. Gould, Cox, and Perali encountered this same difficulty. In their work, an auxiliary regression of the skim milk price on the lowfat milk price was constructed using monthly data from 1980 through 1987. They chose to omit the intercept in this auxiliary regression, since out-of-sample estimates appeared unrealistically high. An attempt was made to duplicate these results using monthly data from January 1981 through May 1986. Although similar results were obtained, a model including an intercept appears to out perform the Gould *et al.* model. This regression yields the equation

$$P_{Lowfat} = 0.8607 + \underset{(0.0428)}{0.2099}\ P_{SKIM}\ : \tag{37}$$

$$R^2 = 0.276$$
$$\textit{Std. Error of Est.} = 0.009$$

Results from this regression are used to estimate lowfat milk prices using the skim milk price series. Skim milk prices are published by the USDC for periods beginning with 1964. Before 1964, only one milk price is published. Thus this one price series is used for both whole and lowfat milk. Representative prices for 1986 are published by the USDA, ERS in *Dairy Situation and Outlook*. These prices are $1.11 per half-gallon for whole milk,$1.08 per half-gallon for lowfat milk, $2.36 per half-gallon for ice cream, and $2.60 per pound for cheese. Since quantities are in pounds, it is necessary to convert half-gallons into pounds. This conversion is done based on the weight of 8.6 pounds per gallon. Descriptive statistics are exhibited in Table 2.

The prices for whole and lowfat milk are highly collinear (r=0.998). Thus, in the graph of price data (Figure 3), they appear as one line. The quantities consumed, on the other hand, differ greatly, with a strong decrease in whole milk consumption, offset by a large increase in lowfat consumption. Cheese pro-

| Table 2. Descriptive statistics for dairy products. | | | | | | | |
|---|---|---|---|---|---|---|---|
| Variable | Units | Number of Obs. | Mean | Standard Deviation | Minimum | Maximum | Coef. of Variation |
| $P_{whole}$ | ¢/lb | 29 | 17.41 | 6.35 | 10.29 | 26.91 | 36.74 |
| $P_{lowfat}$ | ¢/lb | 29 | 17.09 | 6.37 | 9.57 | 26.57 | 37.27 |
| $P_{cheese}$ | ¢/lb | 29 | 162.93 | 78.09 | 68.92 | 274.22 | 47.93 |
| $P_{frozen}$ | ¢/lb | 29 | 33.67 | 14.07 | 19.80 | 57.90 | 41.79 |
| $Q_{whole}$ | lb/cap | 29 | 187.59 | 51.43 | 106.10 | 263.90 | 27.42 |
| $Q_{lowfat}$ | lb/cap | 29 | 55.50 | 29.80 | 13.20 | 101.60 | 53.69 |
| $Q_{cheese}$ | lb/cap | 29 | 14.83 | 5.10 | 8.30 | 24.01 | 34.39 |
| $Q_{frozen}$ | lb/cap | 29 | 26.31 | 0.80 | 24.30 | 27.70 | 3.04 |
| Expend | $/cap | 29 | 77.57 | 35.49 | 39.04 | 135.47 | 45.75 |

ducts show the greatest change in price with a sharp increase during the 1970s.

### *Vegetables*

Fresh vegetables include: potatoes, lettuce, tomatoes, and other fresh vegetables. Consumption data for each of these individual fresh items as well as total fresh consumption are published in FCPE. Price data for potatoes, lettuce, and tomatoes are also taken from FCPE. The price index for all fresh vegetables, also from FCPE, is used as the price variable for the other fresh vegetable category. Separate consumption data are available for carrots, celery, and onions. Prices for these goods are available from the USDA in *Vegetables and Specialties: Situation and Outlook Report*. Although these items are not directly represented because of their relatively small budget shares, data for these three items are used to develop the price series for other fresh vegetables.

Representative prices for vegetable items are obtained from FCPE. Prices from 1985-1988 are averaged and divided by the average price index for this same period. Representative prices for the 1985-1988 period are \$0.25 per pound for potatoes, \$0.58 for lettuce, \$0.81 for tomatoes, and \$0.26 for other fresh vegetables. Descriptive statistics for these vegetables are given in Table 3.

The consumption of potatoes show a steady decline from 1960 through 1975 but remain steady after 1975 (see Figure 4). Modest growth in the consumption of lettuce and stronger growth in the consumption of fresh vegetables has occurred since 1975. Prices for these series move in similar fashions throughout the sample period. Potatoes have the largest budget share for the first 5 years of this period. Other fresh vegetables hold the largest budget share after 1965.

### *Fruits*

Fruits consist of four fresh commodities: oranges, apples, bananas, and other fresh fruit. Price and consumption data are readily available for bananas, apples, and oranges in FCPE. The other fresh fruit category includes all citrus and noncitrus fruit except oranges, apples, and bananas. Again, as was done for vegetables, the price for fresh fruit is used as the other fresh fruit price.

Representative prices from FCPE for 1988 are \$0.73 per pound for apples, \$0.53 for oranges, and \$0.42 for bananas. The remaining fresh fruits prices given in FCPE are averaged to obtain a representative price of \$0.89 per pound. Descriptive statistics for these variables are shown in Table 4.

As was the case for vegetables, price patterns are similar for all of fresh fruits (see Figure 5). The consumption of each of these items remains relatively flat through the mid-1970s followed by slow growth for all the items except oranges. The similarity of patterns across items results in little change in the budget shares over the data period.

**Table 3. Descriptive statistics for fresh vegetables.**

| Variable | Units | Number of Obs. | Mean | Standard Deviation | Minimum | Maximum | Coef. of Variation |
|---|---|---|---|---|---|---|---|
| $P_{potatoes}$ | ¢/lb | 29 | 14.08 | 7.27 | 5.66 | 27.24 | 51.63 |
| $P_{lettuce}$ | ¢/lb | 29 | 28.60 | 16.46 | 11.11 | 68.43 | 57.55 |
| $P_{tomatoes}$ | ¢/lb | 29 | 47.44 | 20.71 | 22.71 | 87.97 | 43.66 |
| $P_{other\ vegetables}$ | ¢/lb | 29 | 27.96 | 12.72 | 12.31 | 50.61 | 45.49 |
| $Q_{potatoes}$ | lb/cap | 29 | 56.03 | 11.47 | 43.80 | 79.80 | 20.47 |
| $Q_{lettuce}$ | lb/cap | 29 | 22.30 | 1.73 | 19.90 | 25.70 | 7.76 |
| $Q_{tomatoes}$ | lb/cap | 29 | 11.66 | 1.47 | 9.60 | 15.20 | 12.61 |
| $Q_{other\ vegetables}$ | lb/cap | 29 | 35.61 | 5.72 | 27.70 | 49.90 | 16.06 |
| Expend | \$/cap | 29 | 30.14 | 16.51 | 13.48 | 69.98 | 54.78 |

**Table 4. Descriptive statistics for fresh fruits.**

| Variable | Units | Number of Obs. | Mean | Standard Deviation | Minimum | Maximum | Coef. of Variation |
|---|---|---|---|---|---|---|---|
| $P_{oranges}$ | ¢/lb | 29 | 21.42 | 13.64 | 9.38 | 53.00 | 63.69 |
| $P_{apples}$ | ¢/lb | 29 | 34.94 | 19.15 | 14.58 | 73.00 | 54.81 |
| $P_{bananas}$ | ¢/lb | 29 | 22.27 | 10.14 | 12.93 | 42.00 | 45.53 |
| $P_{other\ fruit}$ | ¢/lb | 29 | 39.00 | 22.21 | 17.24 | 89.00 | 56.95 |
| $Q_{oranges}$ | lb/cap | 29 | 14.38 | 1.65 | 11.50 | 18.60 | 11.47 |
| $Q_{apples}$ | lb/cap | 29 | 16.67 | 1.37 | 14.30 | 20.40 | 8.22 |
| $Q_{bananas}$ | lb/cap | 29 | 19.73 | 2.58 | 15.80 | 25.70 | 13.08 |
| $Q_{other\ fruit}$ | lb/cap | 29 | 31.33 | 3.11 | 25.80 | 38.10 | 9.93 |
| Expend | \$/cap | 29 | 26.26 | 16.44 | 11.69 | 64.37 | 62.60 |

### *Fats and Oils*

The fats and oils category also consists of four items: butter, margarine, shortening, and vegetable oils. Prices for these items were taken from USDA, *Oil Crops: Situation and Outlook* whenever possible. These prices are in cents per pound so no representative prices are needed. In cases of missing data, indices for butter and margarine are available from FCPE, while shortening and salad oil prices are projected from the Fat and Oil CPI in FCPE. Consumption for each of these items also is given in FCPE. Descriptive statistics are given in Table 5.

Over the data period, the consumption of salad oils and shortening has increased substantially, while the consumption of butter has decreased (see Figure 6). Butter prices show a much greater rate of growth since 1975 than the other items, offsetting its declining consumption in the determination of budget shares since that time. In the pre-1975 period, the budget share for butter dropped substantially, while shortening and salad oils experienced growth. Since 1975, budget shares have remained relatively stable, except for margarine which still exhibits a decreasing budget share.

### *Aggregate Commodities*

Aggregate commodities consist of eight food groups. Four of these are from previously defined groups: meats; dairy; fresh vegetables and fruits; and fats and oils. The remaining four categories include: processed vegetables and fruits; eggs; cereal products; and sugar and sweets. To maintain more equitable budget shares, fresh fruits and fresh vegetables were combined into one category for this model.

Data for three of the first four groups are obtained from the sources presented earlier. The consumption level of each category within a group may be summed to obtain total consumption. A major food group price may be obtained by dividing the total expenditure on all items in the group (the sum of price times quantity of each item) by the total quantity consumed. This process results in prices and quantities in the same units as in the disaggregate categories. This approach is also consistent with the weak separability assumption that the expenditure on a subgroup is determined in a previous budgeting stage.

Since quarterly data are used for meats, it is necessary to add the observations from each of the four quarters to obtain annual data. Additional data for the years 1960 through 1967, which are not included in the quarterly data, are obtained from FCPE. Data for the other categories are obtained from FCPE. No missing observations were encountered in gathering these data. Representative prices for the new categories are needed as well from FCPE. These prices per pound for 1988 are \$1.82 for processed fruits, \$0.61 for processed vegetables, \$0.94 for cereal products, \$0.37 for sweets, and \$0.37 per dozen for eggs. Egg prices are converted to a pound basis by dividing by 1.57 pounds per dozen. A weighted-average price for processed fruits and vegetables was developed from these respective prices. Descriptive statistics are shown in Table 6.

Meats are the dominate category in this model with about 45 percent of the foodbudget (see Figure 7). The remaining budget is split nearly equally among the other items, with no notable trends. Processed fruit and vegetables show a definite drop in consumption in the late 1960s, and dairy products show steady losses in consumption throughout the period. Prices for these groups show slow but steady growth through the early 1970s with accelerated growth in later periods.

## Nutritional Awareness Data

In addition to the traditional economic data previously discussed, nontraditional factors also are included in the model formulation to measure the effect of nutritional awareness. Since nutritional awareness is not directly measurable, proxy variables must be used. Three different alternatives are used in this project. These alternatives as well as data uses have been discussed in the model development section. This section only discusses the data used for these proxies.

The first alternative uses binary variables to divide time periods. These time periods are: pre-1977, 1977-1979, 1980-1983, and 1984-1988. The base period corresponds to the pre-1977 period. Three dummy

**Table 5. Descriptive statistics for fat and oils.**

| Variable | Units | Number of Obs. | Mean | Standard Deviation | Minimum | Maximum | Coef. of Variation |
|---|---|---|---|---|---|---|---|
| $P_{butter}$ | ¢/lb | 29 | 130.17 | 57.41 | 74.40 | 217.00 | 44.10 |
| $P_{margarine}$ | ¢/lb | 29 | 50.75 | 22.41 | 26.00 | 86.50 | 441.60 |
| $P_{shortening}$ | ¢/lb | 29 | 52.67 | 24.50 | 26.30 | 92.00 | 46.52 |
| $P_{salad\ oil}$ | ¢/lb | 29 | 66.72 | 32.36 | 31.59 | 118.97 | 48.50 |
| $Q_{butter}$ | lb/cap | 29 | 5.28 | 1.03 | 4.20 | 7.50 | 19.51 |
| $Q_{margarine}$ | lb/cap | 29 | 10.71 | 0.72 | 9.30 | 12.00 | 6.72 |
| $Q_{shortening}$ | lb/cap | 29 | 17.35 | 2.76 | 12.60 | 22.90 | 15.91 |
| $Q_{salad\ oil}$ | lb/cap | 29 | 17.47 | 4.89 | 9.20 | 25.00 | 27.99 |
| Expend | \$/cap | 29 | 34.76 | 19.25 | 14.49 | 66.56 | 55.38 |

Table 6. Descriptive statistics for aggregate commodities.

| Variable | Units | Number of Obs. | Mean | Standard Deviation | Minimum | Maximum | Coef. of Variation |
|---|---|---|---|---|---|---|---|
| $P_{meats}$ | ¢/lb | 29 | 139.48 | 55.62 | 72.86 | 219.96 | 39.88 |
| $P_{dairy}$ | ¢/lb | 29 | 28.09 | 14.37 | 12.73 | 52.57 | 51.16 |
| $P_{fresh\ f\&v}$ | ¢/lb | 29 | 26.90 | 14.51 | 11.50 | 56.78 | 53.94 |
| $P_{produce\ f\&v}$ | ¢/lb | 29 | 53.80 | 26.46 | 25.40 | 103.34 | 49.18 |
| $P_{fat\ and\ oil}$ | ¢/lb | 29 | 64.97 | 28.44 | 35.70 | 108.76 | 43.77 |
| $P_{eggs}$ | ¢/lb | 29 | 20.27 | 4.67 | 13.85 | 28.95 | 23.04 |
| $P_{cereal}$ | ¢/lb | 29 | 47.75 | 24.27 | 22.79 | 94.00 | 50.83 |
| $P_{sweets}$ | ¢/lb | 29 | 18.93 | 11.03 | 7.59 | 37.00 | 58.27 |
| $Q_{meats}$ | lb/cap | 29 | 206.69 | 16.42 | 173.50 | 233.28 | 7.94 |
| $Q_{dairy}$ | lb/cap | 29 | 284.23 | 16.64 | 257.67 | 309.70 | 5.85 |
| $Q_{fresh\ f\&v}$ | lb/cap | 29 | 207.71 | 13.02 | 191.20 | 236.60 | 6.27 |
| $Q_{produce\ f\&v}$ | lb/cap | 29 | 177.31 | 23.74 | 121.17 | 202.65 | 13.39 |
| $Q_{fat\ and\ oil}$ | lb/cap | 29 | 50.80 | 7.07 | 38.70 | 62.20 | 13.92 |
| $Q_{eggs}$ | lb/cap | 29 | 36.66 | 3.55 | 31.00 | 42.60 | 9.68 |
| $Q_{cereal}$ | lb/cap | 29 | 149.79 | 8.00 | 139.80 | 171.80 | 5.34 |
| $Q_{sweets}$ | lb/cap | 29 | 129.94 | 11.01 | 114.00 | 152.70 | 8.47 |
| Expend | $/cap | 29 | 670.00 | 334.81 | 297.83 | 1275.70 | 49.97 |

variables are created to "measure" structural shifts which may have occurred in these periods. A new era in the study of nutrition began in 1977, making this regime a probable period (pre versus post 1977) for structural change. In the period following 1977, ten major articles on nutrition and health were published. The time period following 1977 is divided into three periods, 1977-1979, 1980-1983, and 1984-1988. The post-1977 regime is subdivided based on the work of Cronin and Shaw (Table 7).

This first alternative considers structural change with little regard for the source of this change. An alternative approach is to generate a proxy variable for nutritional information for use in demand models. Brown and Schrader have developed such an index based on cholesterol information. This index consists of the number of articles published in medical journals which establish a link between cholesterol and heart disease, less any published articles which fail to find such a link. Data for this index are published by Brown and Schrader. Updated data for this index have been obtained from Brown and Schrader and included in this study.

The Brown and Schrader index only considers articles involving cholesterol. However, the nutritional awareness message involves many nutrients in addition to cholesterol. One could develop such an index with a broader source of nutrient elements. A simpler approach is to select a few very important articles regarding the link between nutrition and

Table 7. Articles and publication dates for articles reviewed by Cronin and Shaw.

| Article Number | Title and Organization | Year Published |
|---|---|---|
| (1) | *Dietary Goals for the United States*, 2nd ed. U.S. Senate Select Committee on Nutrition and Human Needs | 1977 |
| (2) | *Health People: Surgeon General's Report on Health Promotion and Disease Prevention*, U.S. Dept. of Health,Education and Welfare | 1979 |
| (3) | Concepts of Nutrition and Health", Council on Scientific Affairs, American Medical Association | 1979 |
| (4) | *Recommended Dietary Allowances*, 9th Ed. Committee on Dietary Allowances, Food Nutrition Board, National Research Council, National Academy of Sciences | 1980 |
| (5) | *Toward Healthful Diets*, Food and Nutrition Board, National Research Council, National Academy of Sciences | 1980 |
| (6) | *Diet, Nutrition, and Cancer*, Committee on Diet, Nutrition, and Cancer, National Research Council, National Academy of Sciences | 1982 |
| (7) | "Nutrition and Cancer: Cause and Prevention; A Special Report", American Cancer Society | 1984 |
| (8) | *Nutrition and Your Health: Dietary Guidelines for Americans*, 2nd Ed. U.S. Dept. of Agriculture and Dept. of Health and Human Services | 1985 |
| (9) | "Dietary Guidelines for Healthy American Adults", American Heart Association | 1988 |
| (10) | "NCI Dietary Guidelines: Rational", National Cancer Institute, National Institute of Health, U.S. Dept. of Health and Human Services | 1988 |

health. *Cronin and Shaw review 10 such articles.* A list of these articles as well as their date of publication is given in Table 7. An index is developed which increases from 0 to 10 as these articles are released. Since it is based on the review by Cronin and Shaw, it is referred to as the Cronin-Shaw (C-S) index. The C-S index is similar in nature to the Brown and Schrader (B-S) index but addresses nutritional awareness in a more global context. This index assumes that each article carries equal weight as does the B-S index. However, the C-S index measures nutritional awareness differently than the B-S index. Thus the two may be used simultaneously.

Relevant descriptive statistics are given for these variables in Table 8. The data forthe B-S Index are not lagged, unlike the index as published by Brown and Schrader. Furthermore, the first difference of the B-S index is used in this analysis. Brown and Schrader use the accumulation of articles, which can be considered a stock variable. In this project, a distributed lag framework is used. The framework necessitates the use of the flow of articles which corresponds to the first difference of the stock.

model indicates a problem with serial correlation. This serial correlation problem is corrected by employing a nonlinear estimation procedure in SHAZAM. Typically, when a serial correlation correction is conducted in a demand system frame work, the same value for $\rho$ is imposed on all the equations. This imposition maintains the adding-up restriction (Berndt and Savin). In the dynamic AIDS model as specified in this study, all $N$ equations are estimated. Thus unique estimates of $\rho$ are obtained for each equation in the system.

The nutritional information leads to mixed results across scenarios. When used independently, both the C-S index and B-S index have significant impacts on the consumption of meats, but this impact is in opposite directions. Yet, when the two indices are combined, neither have significant impacts. The C-S index also has a significant impact on the consumption of fresh fruits and vegetables, fats and oils, eggs, and cereal products. The C-S index indicates an increase in the consumption of eggs. This finding is contrary to the findings of Putler and of Brown and Schrader who found a decrease in egg consumption due to nutritional information.

**Table 8. Descriptiove statistics for nutritional awareness information.**

| Variable | Units | Number of Obs. | Mean | Standard Deviation | Minimum | Maximum | Coef. of Variation |
|---|---|---|---|---|---|---|---|
| L70s | Binary | 29 | 0.103 | NA | 0. | 1. | NA |
| E80s | Binary | 29 | 0.138 | NA | 0. | 1. | NA |
| L80s | Binary | 29 | 0.172 | NA | 0. | 1. | NA |
| C-S Index | Articles | 29 | 2.345 | 3.352 | 0. | 10. | 42.94 |
| B-S Index | Net Number of Article | 29 | 34.966 | 26.124 | 0. | 107. | 74.71 |

## Empirical Results

Nutritional awareness is measured by considering five different econometric scenarios. These scenarios utilize: (1) no information, (2) dummy shifters, (3) a counter of nutritional information articles (C-S Index), (4) a counter of cholesterol information articles (B-S Index) using a Polynomial Distributed Lag (PDL), (5) and a combination of these two indices. Head and tail restrictions are imposed whenever the PDL is used. Tests of these head and tail restrictions do not reject their use in any instance.

To conserve space, only the results from the best-case scenario are presented here. However, some details of other scenarios are discussed. The results pertaining to these omitted scenarios can be found in Schmitz.

### Empirical Results: Aggregate Model

The aggregate model represents the first stage of a two-stage budgeting process. As such, results from this model consider allocations among major food subgroupings. Unlike the submodels, the aggregate

The B-S Index indicates a positive impact on meat items and negative impacts on dairy products and eggs. Because the meats group includes both red and white meat products, a positive relationship is conceivable. The negative impact on dairy and eggs appears as expected in light of the high cholesterol content of these groups.

The two indices also perform well when used together. By adding the C-S index to the model which contained the B-S index, significant relationships for processed fruits and vegetables, cereal products, and sweets were evident. Meats, however, no longer show a significant response to either index. Again, due to the mixture of red and white meats in the meat category, it is not at all surprising that no significant relationships are found. The nutritional indices in the fresh fruit and vegetable equation as well as in the fats and oils equation also show no significance. This result may indicate that the response to nutritional information involves substitutions within the submodel, but may not affect the consumption of a particular group as a whole. The signs for the cereal and the sweet groups are opposite of what is expected.

The scenario involving the B-S index used alone appears to perform better than the other scenarios. Results from this model then are presented in Table A1. The compensated price, uncompensated own-price, and income elasticity estimates for this scenario are presented in Table 9, along with some results from other studies.

Blanciforti, Green, and King consider four aggregate commodities: meats; fruits and vegetables; cereals; and other foods. However, the fruit and vegetable category used by Blanciforti, et al. includes both fresh and processed items, and thus, is not directly comparable. Price elasticities for meats obtained in this study are slightly lower than those obtained by Blanciforti, while the price elasticities for cereal products are considerably lower. Income elasticity estimates are much higher in this study than those obtained by Blanciforti. The elasticities for eggs are comparable to those obtained by Huang. Price elasticities for these two studies are similar; the income elasticity for eggs from this study is 0.7, while Huang obtained an elasticity estimate of -0.03.

## Empirical Results: Submodels

### *Meats*

The meats model is the first of five second-stage or submodels to be discussed. It differs from the other models in this study in that it utilizes quarterly data over the period from 1968 through 1988. Since quarterly data are used, binary variables are included to allow for seasonality. F-tests on these shifters indicate that significant seasonal patterns are exhibited by these data.

The results for this model are affected by the inclusion of nutritional information, especially when either of the indices are included. F-tests are conducted to determine the significance of these variables. The nutritional information in each scenario used here has significant impact on the meats model. In the scenario that combines the two indices, both of these indices are significant. Furthermore, their impact is significant in each equation. In the case of the dummy shifters, the shifter for the late 1970s is not significant.

The scenarios that use the indices indicate a movement away from beef to the other three meats, most notably to poultry products. When these two indices are combined, they give mixed results. In the combined scenario, the B-S index indicates movement away from beef and pork, while the C-S index indicates movement away from beef and fish. However, the negative coefficients associated with pork and fish in these cases are not significant. The coefficients associated with the lagged budget shares decrease in magnitude from the 0.5 to 0.7 range in the base scenario (without nutritional information) to the 0.2 to 0.3 range in the combined indices scenario.

**Table 9. Selected elasticity estimates for the Aggregate Model.**

| $\varepsilon_{ij}$* Comp. El. | Meats | Dairy | Fresh F&V | Proc. F&V | Eggs | Fats & Oil | Cereals | Sweets |
|---|---|---|---|---|---|---|---|---|
| Meats | -0.151* | 0.048* | 0.005 | 0.079* | 0.010* | 0.007 | 0.020 | -0.017* |
| Dairy | 0.182* | -0.274* | -0.104* | 0.124* | 0.002 | 0.054 | -0.062 | 0.078* |
| Fresh F. & V. | 0.024 | -0.149* | -0.197 | 0.143 | -0.024 | 0.106 | -0.155 | 0.251* |
| Processed F. & V. | 0.248* | 0.103* | 0.083 | -0.871* | 0.027 | 0.023 | 0.275 | 0.114 |
| Eggs | 0.324* | 0.015 | -0.152 | 0.294 | -0.143* | -0.036 | -0.386 | 0.084 |
| Fats & Oils | 0.060 | 0.127 | 0.174 | 0.064 | -0.009 | -0.166 | -0.148 | -0.102 |
| Cereals | 0.083 | -0.068 | -0.119 | 0.366 | -0.047 | -0.070 | -0.143 | -0.002 |
| Sweets | -0.213 | 0.262* | 0.586* | 0.460 | 0.031 | -0.145 | -0.007 | -0.975[NA] |
| Uncomp. Own-Prc. | -0.590* | -0.373* | -0.271 | -1.039* | -0.155 | -0.225 | -0.253 | -1.015[NA] |
| Income | 0.742 | 0.633 | 0.673 | 0.8903 | 0.700 | 0.889 | 0.782 | 0.856 |
| Huang | | | | | | | | |
| Own-Prc | N/A | N/A | N/A | N/A | -0.15 | N/A | N/A | N/A |
| Income | N/A | N/A | N/A | N/A | -0.03 | N/A | N/A | N/A |
| Blanciforti et.al. | | | | | | | | |
| Own-Prc | -0.68 | N/A | -0.66 | N/A | N/A | N/A | -0.42 | N/A |
| Income | 0.48 | N/A | 0.47 | N/A | N/A | N/A | 0.16 | N/A |

*Indicates that elasticity estimate is significantly different from zero (not computed for income elasticities).
[NA] T-value could not be computed.

The results obtained from the combined indices case appear to perform better than results from other scenarios. Results from the combined indices scenario are presented in Table A2, while the elasticities are exhibited in Table 10. Also included in this elasticity table are estimates from Huang as well as Capps and Schmitz. The estimates from Capps and Schmitz differ from Huang in that Capps and Schmitz include nutritional information.

The addition of the nutritional information to this study results in little change in the own-price elasticity estimate for beef and lower own-price estimates for the other meats when compared with results obtained without nutritional information. Own-price elasticity estimates for poultry and pork appear to be in the general range as those obtained from other studies, while the own-price elasticities for beef and fish are slightly higher than those obtained in other studies. Income elasticities obtained for these meats are higher than those found by Huang. In general, all of the systems estimated here have larger income elasticity estimates than estimates found in other studies.

### *Dairy Products*

The dairy model performs well in each of the five scenarios. Serial correlation does not appear to be a problem, and R-square values remain high across scenarios.

With one C-S index, a significant shift away from consumption of frozen items to consumption of cheese products is evident. Although not significant, a decrease in the consumption of whole milk and an increase in the consumption of lowfat milk also is associated with the C-S index. The B-S index reveals a statistically significant shift from whole milk to lowfat milk and cheese products. This shift is consistent with the expected results.

F-tests are performed for the dairy model as they were for the meats model. The dummy-variable scenario shows no significant impacts on the system. The C-S and B-S indices perform well, both independently and jointly. Both indices have significant impacts on the dairy model when considered independently. When combined, each index remains statistically significant, and they jointly show a significant impact on each equation.

As in the meats model, the combined indices scenario offers the best results, overall. Coefficient estimates for this model are given in Table A3, while price and income elasticities are included in Table 11. The most notable impact of nutritional information on the elasticity estimates involves the own-price elasticity for lowfat milk. This estimate increases from -0.78 to -1.00 as a result of including nutritional information. The own-price elasticity of whole milk also is increased, while cheese and frozen products show a decrease in own-price elasticity as a result of this information. Results from the dairy model are compared to two studies: Huang; and George and King. Both of the comparison studies have whole and lowfat milk combined as one estimate. The elasticity estimates obtained here (near -0.75) are considerably larger than estimates obtained by either of these studies (near -0.30). This result is not unexpected since the separation of these two items yields more disaggregate commodities. Own-price elasticity estimates for cheese products obtained here are similar to those in the comparison studies, while the estimate for frozen products is similar to the estimate by George and King but considerably different from the estimate by Huang.

### *Vegetables*

The vegetable model considers the consumption of potatoes, lettuce, tomatoes, and other vegetables, each in fresh form. The base model has a lower goodness-of-fit than in the aggregate, meats, and dairy models discussed previously.

In this model, the dummy variables, as a proxy for nutrition, appear to do much better than in pervious submodels. These coefficients associated with the dummy variables are significant in nearly every case. The late 1970s and late 1980s show a significant deviation from the pre-1977 period. F-tests further

**Table 10. Selected elasticity estimates for the Meats Model.**

| Compensated elasticity | Beef | Fish | Poultry | Pork |
|---|---|---|---|---|
| Beef | -0.3677* | 0.0348 | 0.0652* | 0.2676* |
| Fish | 0.2377 | -0.3185 | 0.0108 | 0.0700 |
| Poultry | 0.2148* | 0.0052 | -0.3229* | 0.1028* |
| Pork | 0.5267* | 0.0202 | 0.0614 | -0.6083* |
| UnComp. Own-Price | -0.8949* | -0.4039 | -0.4900* | -0.8287* |
| Income | 0.6934 | 0.7659 | 0.7241 | 0.5704 |
| Huang | | | | |
| Own-Price | -0.62 | N/A | -0.53 | -0.73 |
| Income | 0.45 | N/A | 0.36 | 0.44 |
| Capps & Schmitz | | | | |
| Own-Price | -0.73 | -0.32 | -0.27 | -0.98 |
| Income | N/A | N/A | N/A | N/A |

*Indicataes that elasticity estimate is significantly different from zero (not computed for income elasticities).

| Table 11. Selected elasticity estimates for the Dairy Model. | | | | |
|---|---|---|---|---|
| Compensated elasticity | Whole | Lowfat | Cheese | Frozen |
| Whole | -0.3750* | 0.1740 | 0.0796 | 0.1214 |
| Lowfat | 0.6468 | -0.8661* | -0.4035* | -0.1842 |
| Cheese | 0.1160 | 0.1581* | -0.3125* | 0.0385 |
| Frozen | 0.4676 | -0.1909 | 0.1017 | -0.3784* |
| UnComp. Own-Price | -0.7553* | -1.0050* | -0.6665* | -0.5053* |
| Income | 0.5587 | 0.7584 | 0.7574 | 0.7181 |
| Huang | | | | |
| Own-Price | -0.26 | -0.26 | -0.33 | -0.12 |
| Income | -0.22 | -0.22 | 0.59 | 0.01 |
| George & King | | | | |
| Own-Price | -0.35 | -0.35 | -0.46 | -0.53 |
| Income | 0.20 | 0.20 | 0.25 | 0.33 |

*Indicates that elasticity estimate is significantly different from zero (not computed for income elasticities).

indicate that the binary variables have a significant explanatory role as a group on the model as well as on each equation in the model. These variables indicate a movement away from other vegetables and toward potatoes and tomatoes.

The C-S index performs in a similar fashion to the dummy shifters. In this case, a significant shift from lettuce to potatoes is indicated as well as a shift, albeit insignificant, from other fresh vegetables to tomatoes. The presence of the C-S index left the lagged budget share relatively unaffected from the base scenario. The serial correlation problem indicated in the base case is eliminated in this scenario.The B-S index does not perform as well in this model.

The B-S index is based on cholesterol information. Vegetables, as well as fruits which are discussed next, contain no cholesterol. Thus it is not surprising that this index performs poorly in these two models. However, it is included since some may consider this index as a proxy for a more global measure of nutritional awareness.

The impact of the B-S index is opposite of the dummy variable and C-S index cases. This index indicates a significant shift from tomatoes to the fresh vegetables. The B-S index does not perform any better when combined with the C-S index.

The C-S index yields better results than other scenarios in this model. Coefficient estimates for this scenario are given in Table A4. As has been the case in the earlier models, the lagged coefficients are smaller in magnitude in cases where nutritional information is included relative to the base case. This result indicates that omission of this information may lead to an over-estimation of habit persistence. The elasticity estimates for this scenario are presented in Table 12.

The own-price elasticity of potatoes when nutritional information is included is half of the estimated level when no such information is included. A decrease in own-price elasticity is evident for lettuce, while for tomatoes and other fresh vegetables, own-price elasticities are larger with the presence of nutritional information. Huang and George and King provided elasticity estimates for similar items. Estimates for potatoes and other fresh vegetables in the base-case are similar in magnitude to those obtained in these other two studies. The elasticity of tomatoes is comparable between this study and the study of George and King. Income elasticity estimates and the

| Table 12. Selected elasticity estimates for the Vegetable Model. | | | | |
|---|---|---|---|---|
| Compensated elasticity | Potatoes | Lettuce | Tomatoes | Other Vegetables |
| Potatoes | -0.0880 | 0.0130 | 0.1006* | -0.0255 |
| Lettuce | 0.0163 | -0.0152 | –0.0062 | 0.0052 |
| Tomatoes | 0.1380* | -0.0068 | -0.1639 | 0.0328 |
| Other Vegetables | -0.0197 | 0.0032 | 0.0184 | -0.0020 |
| UnComp. Own-Price | -0.1934 | -0.2937* | -0.3520* | -0.4302* |
| Income | 0.3228 | 1.0675 | 0.7909 | 1.0131 |
| Huang | | | | |
| Own-Price | -0.37 | -0.14 | -0.56 | -0.21 |
| Income | 0.16 | 0.23 | 0.46 | 0.28 |
| George & King | | | | |
| Own-Price | -0.31 | -0.14 | -0.56 | -0.21 |
| Income | 0.12 | 0.15 | 0.17 | 0.15 |

*Indicates that elasticity estimate is significantly different from zero (not computed for income elasticities).

own-elasticity estimate for lettuce also are much higher in this study than in either of the reference studies.

### *Fruits*

The fruit model consists of fresh consumption of oranges, apples, bananas, and other fresh fruits. As in the vegetable model, goodness-of-fits are low in this model, relative to the previous models. Serial correlation does not appear to be a problem. The lagged budget shares are also smaller in this model, ranging from 0.22 to 0.37.

The dummy-variable scenario shows no significance, either on an individual coefficient basis or on the basis of F-tests. The B-S index, as found in the vegetable model, also shows no significant impact on the consumption of fresh fruits, either alone or when combined with the C-S index. The C-S index is significantly positive for oranges and maintains this significant sign when combined with the B-S index. As seen in the earlier model, the coefficients associated with the lagged budget share diminish in magnitude when nutritional information is included.

Although the C-S index does not perform as well as in the previous systems, it performs better than the other nutritional measures in the fruit system. Coefficient estimates for this model are given in Table A5 while the resulting elasticities are presented in Table 13. Oranges are the most affected by the presence of this information. The own-price elasticity increases from -0.90 to -1.06 as a result of this information, while the income elasticity decreases from 0.75 to 0.53. Again, these estimates can be compared to estimates obtained from Huang and George and King. Price elasticity estimates for oranges are close to the estimate by Huang, while bananas more nearly match the estimate obtained by George and King. Own-price elasticities for other fresh fruits are much higher than those obtained in these two comparison studies. Apples provide an interesting case where the estimate obtained here (-0.40) is much higher than the -0.2 obtained by Huang but lower than the-0.72 obtained by George and King.

### *Fats and Oils*

The fats and oils model is the final submodel analyzed. This model contains four items: butter; margarine; shortening; and salad oils.

The dummy variable case appears to do quite well in the fats model. These shifters show an initial surge in the budget share for butter but decreased share in the final two time periods. The other three items show gained shares with most of these coefficients statistically significant. The late 1970s and the early 1980s show a significant deviation in shares from the pre-1977 period. The late 1980s, however, are not significantly different than the pre-1977 era. These tests also show that the impact of these shifters is significant on each equation except salad oils.

The B-S index performed better in this model than in either the fruits or the vegetables model. This index shows a significant shift from butter to shortening as well as shifts, albeit insignificant, away from margarine and toward salad oils. When combined with the C-S index, this pattern is unchanged. However, significant shifts are indicated away from margarine and toward shortening. The C-S index indicates the shift from butter to salad oils that was detected in the B-S index scenario.

As seen in each of the submodels, the lagged budget share coefficients once again have smaller magnitudes when the nutritional information is added to the system. Thus again, we should recognize the potential for over-stating the effect of habit persistence if nutritional information were not included in the model.

In this model, the dummy variables perform better than in the other scenarios considered. Coefficient estimates for this scenario are presented in Table A6 while selected elasticities are presented in Table 14. The inclusion of nutritional information results in little change in the own-price and income elasticity esti-

**Table 13. Selected elasticity estimates for the Fruit Model.**

| Compensated elasticity | Oranges | Apples | Bananas | Other Fruit |
|---|---|---|---|---|
| Oranges | -0.9927* | 0.0668 | 0.0589 | 0.8671* |
| Apples | 0.0341 | -0.1565 | -0.0143 | 0.1367 |
| Bananas | 0.0382 | -0.0182 | -0.4364* | 0.4164* |
| Other Fruit | 0.2131* | 0.0658 | 0.1576* | -0.4365* |
| UnComp. Own-Price | -1.0647* | -0.4000* | -0.6223* | -0.9351* |
| Income | 0.5335 | 0.9218 | 0.8948 | 0.9082 |
| Huang | | | | |
| Own-Price | -1.00 | -0.20 | -0.40 | -0.24 |
| Income | 0.49 | -0.35 | -0.04 | -0.35 |
| George & King | | | | |
| Own-Price | -0.66 | -0.72 | -0.61 | -0.60 |
| Income | 0.26 | 0.14 | 0.14 | 0.40 |

*Indicates that elasticity estimate is significantly different from zero (not computed for income eleaticities).

Table 14. Selected elasticity estimates for the Fats and Oils Model.

| Compensated elasticity | Butter | Margarine | Shortening | Salad Oil |
|---|---|---|---|---|
| Butter | -0.2108 | 0.0213 | 0.0282 | 0.1612 |
| Margarine | 0.0282 | -0.4762* | 0.1631 | 0.2848 |
| Shortening | 0.0227 | 0.0994 | -0.0611 | -0.0609 |
| Salad Oil | 0.1036 | 0.1382 | -0.0485 | -0.1933 |
| UnComp. Own-Price | -0.3801* | -0.6011* | -0.3756* | -0.5847* |
| Income | 0.6456 | 0.6307 | 0.9669 | 0.9589 |
| Huang | | | | |
| Own-Price | -0.17 | -0.27 | N/A | N/A |
| Income | 0.02 | 0.11 | N/A | N/A |
| George & King | | | | |
| Own-Price | -0.65 | -0.85 | -1.02 | -0.69 |
| Income | 0.32 | 0.00 | 0.03 | 0.28 |

*Indicates that elasticity estimate is significantly different from zero (not computed for income elasticities).

mates, except for butter, where the own-price elasticity decreased from -0.57 to -0.38 as a result of the nutritional information.

Again, these results are compared to the works of Huang and George and King. Own-price elasticities obtained in this study are comparable to those obtained by George and King, except for the case of shortening. George and King found the own-price elasticity of shortening to be -1.02 while this study estimates it at -0.38. Again, this study finds the income elasticity to be much higher than estimates by either Huang or George and King.

### Elasticity Estimates for Nutritional Measures

Elasticity estimates can be obtained for nutritional information as well as for prices and income. Formulas for these calculations are given in the model development section. Elasticity estimates for the best-case scenarios of each model are given in Table 15. These estimates are only calculated for the indices used in the best-case scenario. The best-case scenario for fats and oils is the dummy-shifter case, thus no elasticity estimates are available. When the PDL is used, both short-run and long-run elasticities are given.

Among the aggregate commodity groupings, the response to nutritional information, in the long-run is highest for eggs with an estimate of -0.16. The response to nutritional information for cereal and baking products and sugars and sweets is nearly as high as eggs with estimates of -0.14 and 0.15, respectively. The response for the two fruit and vegetable groups are lowest with estimates of -0.01 for both the fresh and the processed items.

In the submodel analysis, meat items have the highest responses to nutritional information. This response is greatest for fish where a 1 percent increase in cholesterol information results in a 6 percent increase in fish consumption in the long-run, *ceteris paribus*. The response for poultry and beef also are elastic where a similar 1 percent increase results in a 2 percent increase in poultry consumption and a 1.2 percent decrease in beef consumption, *ceteris paribus*.

These elasticity estimates indicate a substitution of lowfat milk for whole milk as a result of cholesterol information. A 1 percent increase in cholesterol information results in a 0.11 percent decrease in whole milk consumption and a 0.18 percent increase in lowfat milk consumption, *ceteris paribus*, in the long-run.

Subgroups for fruits and for vegetables use only the C-S index. Lettuce shows a 0.13 percent decrease in consumption resulting from a 1 percent increase in nutritional information. Meanwhile oranges and potatoes show increases of 0.11 and 0.10 percent, respectively, in response to a 1 percent increase in nutritional information.

## Concluding Comments

The groups analyzed in this study include both aggregate and disaggregate items as well as groupings of foods derived strictly from animal sources, plant sources, and both sources. Demand studies often address one of these particular groups, but seldom discuss multiple groups within one study. But to more fully understand the role of nutritional information, this information needs to be applied to a variety of different food groups.

Since these groups are diverse, it would seem unlikely that one particular nutritional measure would always work best. Each of the four measures of nutritional information performed well in certain models, while none performed particularly well in every case. One would anticipate that different groups would respond to nutritional messages in different ways. Thus, one should anticipate that different measures would perform better in some cases and worse in others.

These final pages offer a few conclusions based on the results of this study. After discussing the conclusions, limitations and areas for further research are considered, and final comments made.

| Table 15. Nutritional elasticities for the Best-Case Scenario from each model. | | | |
|---|---|---|---|
| Food Group | B-S Index Short-run | B-S Index Long-run | C-S Index |
| MAIN | | | |
| Meats | 0.015 | 0.075 | N/A |
| Dairy | -0.014 | -0.068 | N/A |
| Fresh Fruits and Vegetables | -0.002 | -0.011 | N/A |
| Produce Fruits and Vegetables | -0.003 | -0.013 | N/A |
| Fats and Oil | -0.011 | -0.055 | N/A |
| Eggs | -0.032 | -0.162 | N/A |
| Cereal and Baking Products | -0.027 | -0.135 | N/A |
| Sugar and Sweets | 0.029 | 0.147 | N/A |
| MEATS | | | |
| Beef | -0.097 | -1.169 | -0.010 |
| Fish | 0.498 | 5.974 | -0.000 |
| Poultry | 0.160 | 1.920 | 0.002 |
| Pork | -0.037 | -0.448 | 0.002 |
| DAIRY | | | |
| Whole Milk | -0.021 | -0.105 | 0.001 |
| Lowfat Milk | 0.035 | 0.176 | 0.003 |
| Cheese | 0.013 | 0.066 | 0.023 |
| Frozen Dairy Products | 0.006 | 0.031 | -0.044 |
| VEGETABLES | | | |
| Potatoes | N/A | N/A | 0.102 |
| Lettuce | N/A | N/A | -0.126 |
| Tomatoes | N/A | N/A | 0.041 |
| Other | N/A | N/A | -0.027 |
| FRUITS | | | |
| Oranges | N/A | N/A | 0.114 |
| Apples | N/A | N/A | -0.041 |
| Bananas | N/A | N/A | -0.000 |
| Other | N/A | N/A | -0.008 |
| FATS AND OILS | | | |
| Butter | N/A | N/A | N/A |
| Margarine | N/A | N/A | N/A |
| Shortening | N/A | N/A | N/A |
| Salad Oil | N/A | N/A | N/A |

## Conclusions

In studies which address the issue of structural change within food groups, nutritional information is often cited as a possible cause among a host of choices. This study uses alternative measures of nutritional information to explain these structural changes. At least one measure of nutritional information is significant in every model, holding all other factors constant. The significance of these variables certainly supports the hypothesis that nutritional information may have led to structural changes in food demand.

Failure to include nutritional information may lead to serial correlation problems in demand models. Serial correlation is often considered as an indicator that relevant variables are omitted from the model. Serial correlation is indicated in the base scenario of several models. In each of the submodels studied, at least one of the measures of nutritional information was able to circumvent serial correlation problem.

Failure to include nutritional information also may result in overstating the importance of habit persistence. The coefficients associated with lagged budget shares are interpreted as measures of habit persistence. Throughout this study, it is apparent that the inclusion of nutritional information reduced the magnitude of these coefficients. Thus failure to include this information in a dynamic setting overstates the degree of habit persistence. Heien and Durham considered habit formation, using cross-sectional data, and concluded that time series studies overstate the role of habits. Based on the results contained within this study, failure to consider nutritional factors may account for such an error.

Nutritional information appears to have a small impact on the elasticity estimates of the traditional demand variables, specifically prices and income, when used in a dynamic setting. The lagged budget shares are affected more than the traditional variables by the presence of nutritional information.

Nutritional awareness variables are significant in both the aggregate model and the submodels. Because of intergroup substitutions, the full impact of nutritional information cannot be captured by the use of these submodels alone, since submodels cannot capture the substitution among the major categories. For example, to measure the full effect of nutritional information on the consumption of beef, one must not only consider substitutions among meats, but also the change in consumption of meats vis-a-vis other items in the overall food budget. The extent of error that results from the failure to capture intergroup substitutions depends on the amount of intergroup substitution.

One must be concerned with how nutritional information is measured. In this study, intercept shifters, an index of major nutrition articles, and an index of cholesterol information are used to measure nutritional information. The variables used here provide alternative proxy variables for variables which are difficult to capture. Numerous alternatives are available. However, these alternatives may perform better or worse depending on how they are developed and applied as well as the groups being estimated. Thus, there is no best measure of nutritional awareness for all cases. In studies of this type, alternative measures should be tried and critically evaluated.

### Areas for Further Research

In this study, time-series data are used to determine the impact of nutritional information on food demand. Although helpful in determining the dynamic adjustment at a global or macro-level, it does not yield insight into household or micro-level activities. Numerous questions in this area are still left unanswered. Some of the most notable questions may be: (1) do the impacts of nutritional information differ geographically? (2) do two-income families respond differently than single-income households? (3) do white-collar families behave differently in response to nutritional information than blue-collar families? and (4) what impact does age of the household head and the number of children have on food demand response to nutritional awareness? Questions such as these require the use of cross-sectional data. The recently released 1987-88 Nationwide Food Consumption Survey provides data that may be used to address these issues.

Consumers receive information about nutrition and health factors from many different sources. Some of these sources include medical and nutrition professionals, radio, television, and printed news, advertising, food labels, and in-store promotional campaigns. The effectiveness of these alternative sources needs to be evaluated. Such an evaluation could have important impacts, especially in the areas of advertising and food labeling. This evaluation could also be used to better direct programs which are designed to educate the public about issues in nutrition and health.

### Limitations

The development of adequate measures of awareness or information is always difficult. Additional work is needed to establish better measures of nutritional awareness. The index developed by Brown and Schrader is a good idea but is really only appropriate for cholesterol. Measures which are more global in nature are needed. The C-S index is developed as an alternative in this study. This index is a simple measurement. It does, however, perform favorably when used alone as well as when used in unison with the B-S index.

Other indices could be developed in relation to numerous specific nutrients, for example fiber, saturated/unsaturated fats, sodium, and sugar. The development of such measures could improve models, such as the fruits, vegetables, and fats and oils, which respond to nutrients other than cholesterol. Furthermore, such measures would allow a disentangling of effects associated with these different nutrients, thereby allowing a better understanding of how individual products respond to new information.

A final limitation involves the distinction between commodities and products. The time-series data used in this study results in a commodity approach to the study of demand. As a result, little can be said about the behavior of individual products, the role of advertising and promotion, or potential impacts resulting from changes in product form. Such issues may play important roles in the overall impact of nutritional awareness on the demand for food. These issues can be explored but only at a product level. Scanner data may be employed in such studies to obtain the degree of disaggregation necessary to look at product level demands.

### Final Comments

The Preventive Nutrition Era as labeled by Erdman has had notable impacts on how the consumer considers what food items to purchase. Thus, the role of nutritional awareness in the determination of food demand cannot be ignored. In the time period of the 1970s and 1980s, consumer awareness has changed drastically. Such awareness is expected to continue in the future, and therefore, it is important to continue to study this dynamic adjustment process.

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# Appendix A
## Data Figures

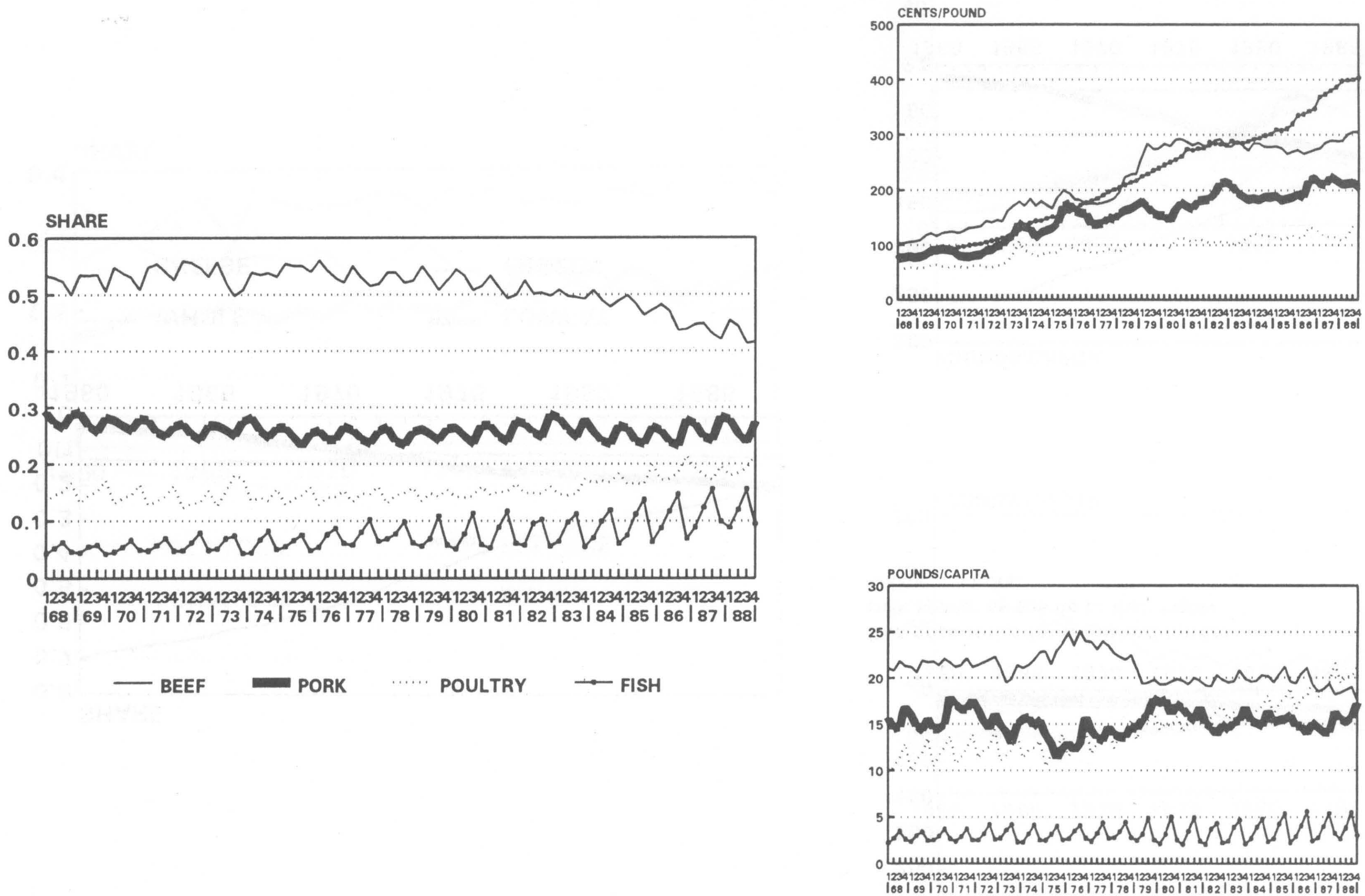
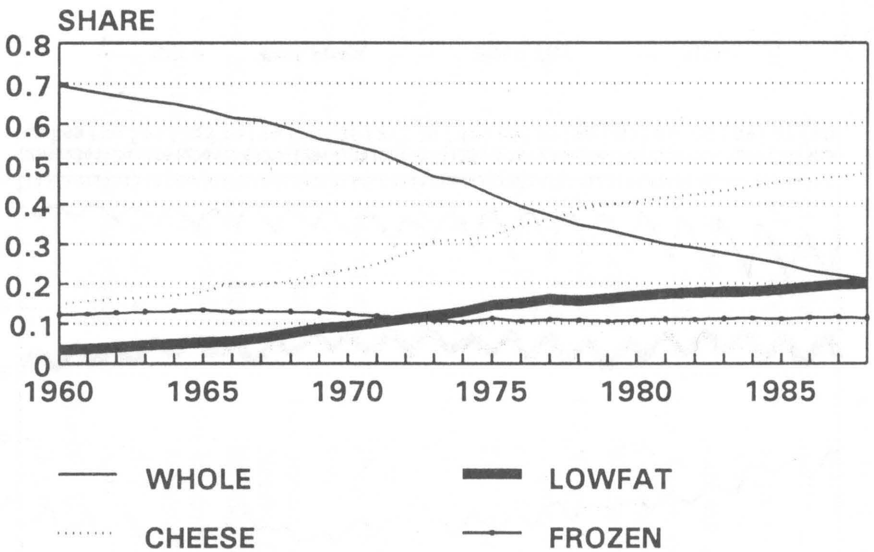
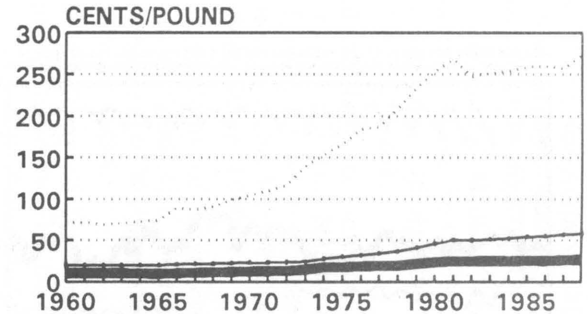



Figure 2. Prices, quantities, and budget shares for selected meat items.




The price series for whole and lowfat milk appear as one do to their highly collinear nature.

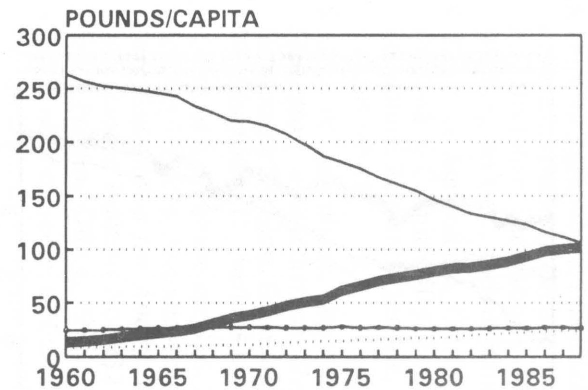



**Figure 3. Prices, quantities, and budget shares for selected dairy items.**

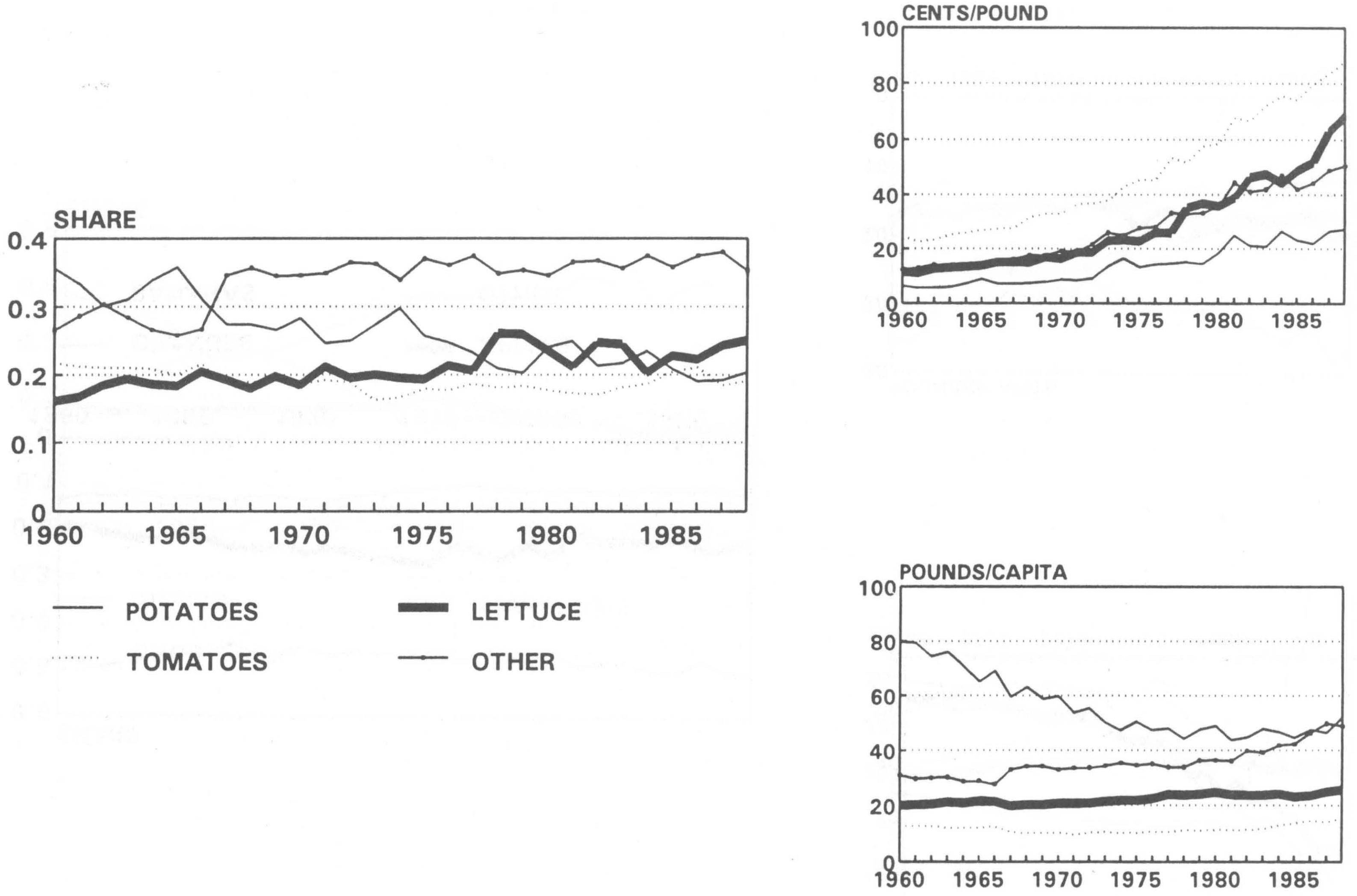



**Figure 4. Prices, quantities, and budget shares for selected vegetable items.**

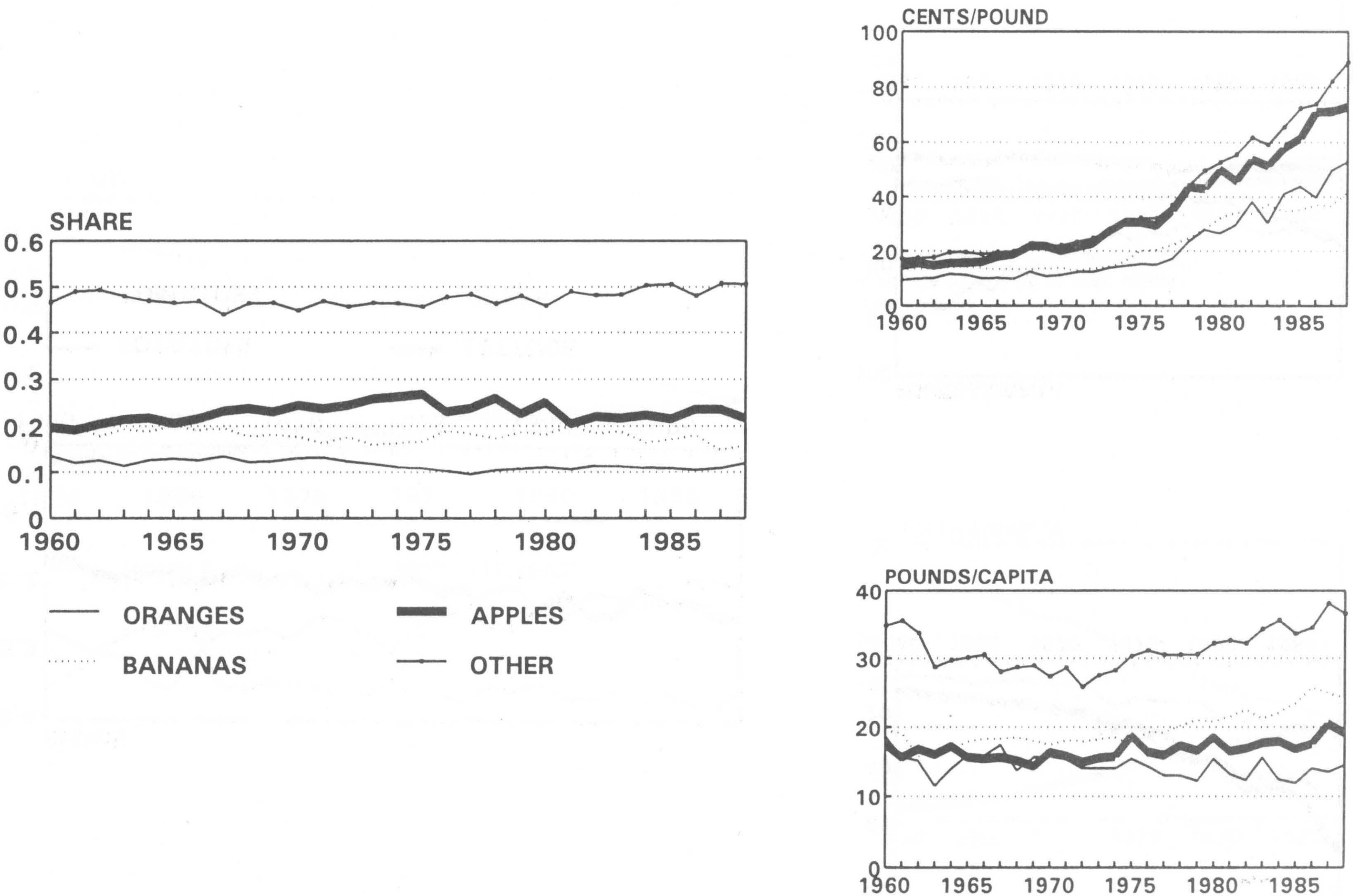



**Figure 5. Prices, quantities, and budget shares for selected fruit items.**

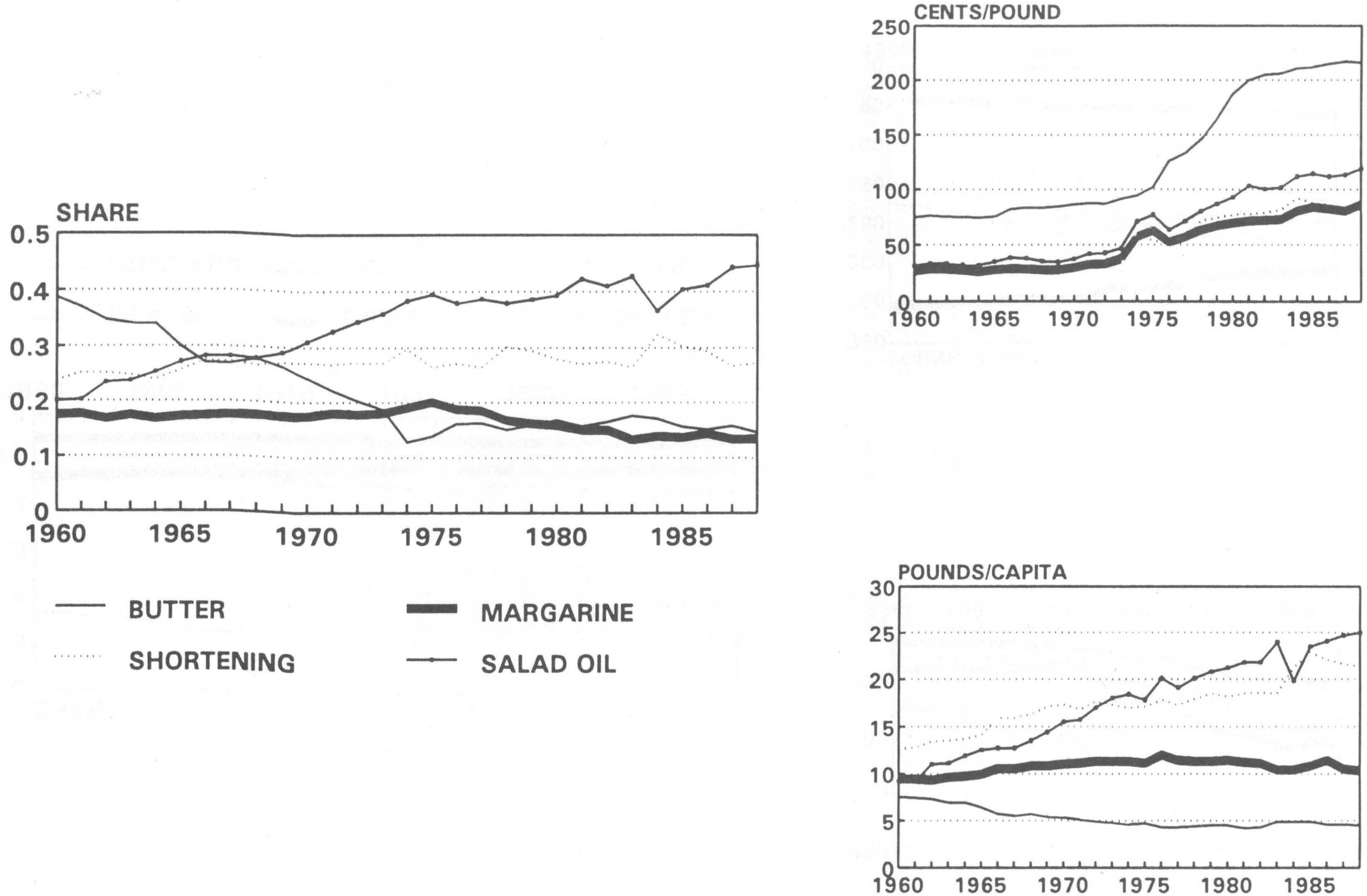



Figure 6. Prices, quantities, and budget shares for selected fat and oil items.

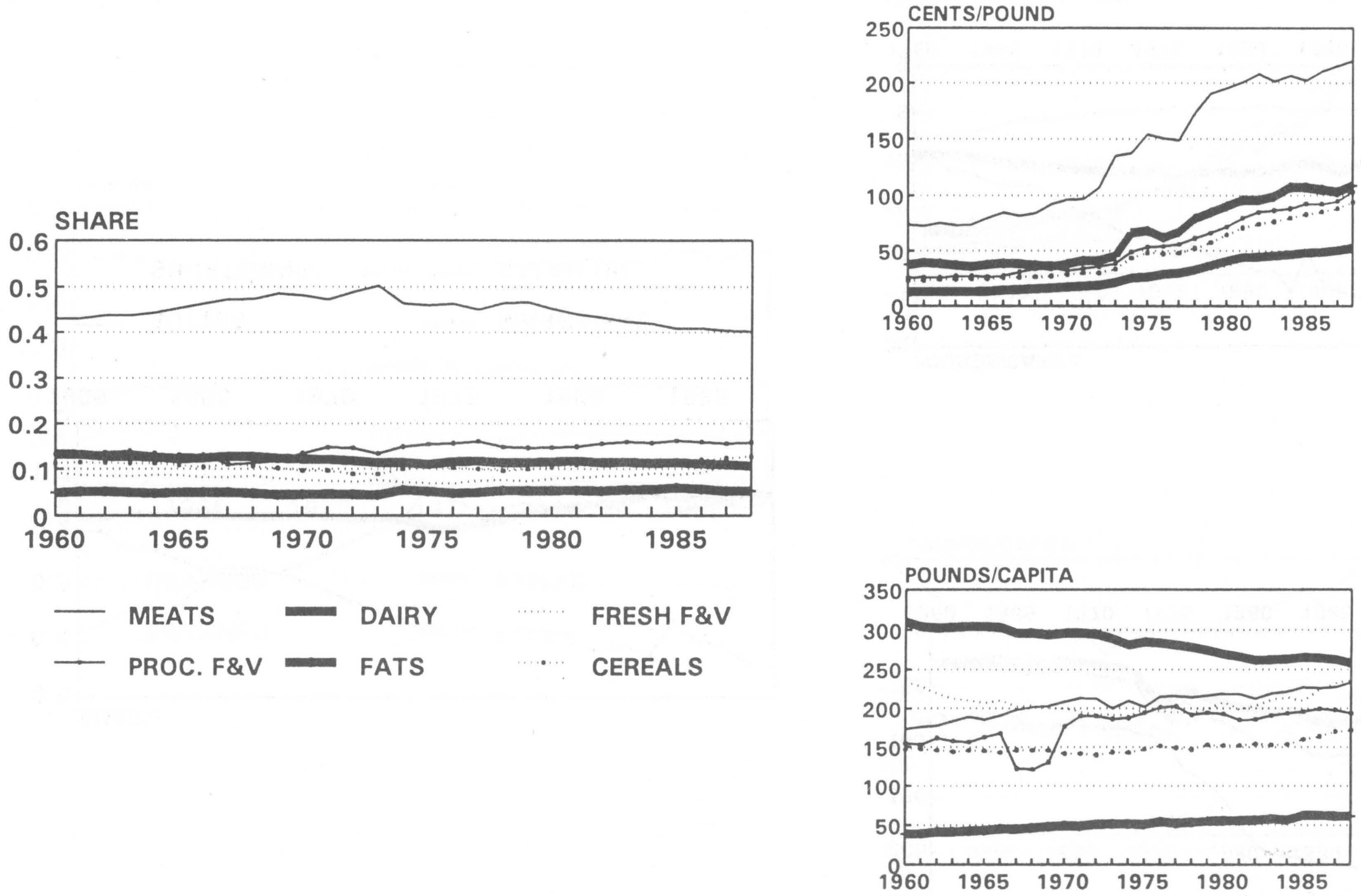



**Figure 7. Prices, quantities, and budget shares for selected aggregate commodity items.**

# Appendix B

## Coefficient Estimates of Best-Scenario Models

**Table A1. Coefficient Estimates for the Aggregate Model using the B-S Index.**

| | Meats | Dairy | Fresh Fruit & Veg. | Processed Fruit & Veg. | Eggs | Fats | Cereals | Sweets |
|---|---|---|---|---|---|---|---|---|
| Const | 0.22512* | 0.35097* | 0.23217* | -0.05598 | 0.03102* | -0.03110 | 0.08385* | 0.02812 |
| | (0.08180) | (0.00917) | (0.04537) | (0.08131) | (0.01679) | (0.03339) | (0.04591) | (0.02908) |
| Meats | 0.17969* | -0.03175* | -0.03512* | -0.02880* | -0.00165 | 0.01968* | -0.03926* | -0.02343* |
| | (0.01247) | (0.00307) | (0.00948) | (0.01349) | (0.00208) | (0.00463) | (0.00867) | (0.00521) |
| Dairy | -0.03175* | 0.07200* | -0.02209* | -0.00226 | -0.00136 | 0.00043 | -0.02005* | 0.00509* |
| | (0.00307) | (0.00535) | (0.00394) | (0.00679) | (0.00172) | (0.00345) | (0.00643) | (0.00286) |
| Fresh F.&V. | -0.03512* | -0.02209* | 0.05952* | -0.00001 | -0.00309 | 0.00461 | -0.02165* | 0.01783* |
| | (0.00948) | (0.00394) | (0.01326) | (0.01447) | (0.00200) | (0.00537) | (0.00990) | (0.00615) |
| Proc. F.&V. | -0.02880* | -0.00226 | -0.00001 | -0.00205 | 0.00199 | -0.00401 | 0.02393 | 0.01122 |
| | (0.01349) | (0.00679) | (0.01447) | (0.03334) | (0.00328) | (0.00774) | (0.01994) | (0.02151) |
| Eggs | -0.00165 | -0.00136 | -0.00309 | 0.00199 | 0.01111* | -0.00114 | -0.00649* | 0.00064 |
| | (0.00208) | (0.00172) | (0.00200) | (0.00328) | (0.00091) | (0.00169) | (0.00319) | (0.00167) |
| Fats | -0.01968* | 0.00043 | 0.00461 | -0.00401 | -0.00114 | 0.03964* | -0.01290 | -0.00694 |
| | (0.00463) | (0.00345) | (0.00537) | (0.00774) | (0.00169) | (0.00633) | (0.00973) | (0.00507) |
| Cereals | -0.03926* | -0.02005* | -0.02165* | 0.02393 | -0.00649* | -0.01290 | 0.08046* | -0.00403 |
| | (0.00867) | (0.00643) | (0.00990) | (0.01994) | (0.00319) | (0.00973) | (0.02444) | (0.00835) |
| Sweets | -0.02343* | 0.00509* | 0.01783* | 0.01122 | 0.00064 | -0.00694 | -0.00403 | -0.00037 |
| | (0.00521) | (0.00286) | (0.00615) | (0.02151) | (0.00167) | (0.00507) | (0.00835) | NA |
| Expend | -0.01044 | -0.01988* | -0.00946* | 0.02453* | -0.00104 | 0.00860* | 0.00307 | 0.00464 |
| | (0.00788) | (0.00091) | (0.00436) | (0.00783) | (0.00150) | (0.00268) | (0.00441) | (0.00950) |
| LAG(w) | 0.13358* | 0.20705* | 0.20052* | 0.10377* | 0.07618 | 0.08616 | 0.09236 | 0.05787 |
| | (0.03722) | (0.04151) | (0.05627) | (0.04916) | (0.07482) | (0.06538) | (0.05847) | (0.08592) |
| B-S(0) | 0.00143* | -0.00036* | -0.00004 | -0.00009 | -0.00013* | -0.00009 | -0.00065 | 0.00023 |
| | (0.00060) | (0.00011) | (0.00031) | (0.00074) | (0.00007) | (0.00018) | (0.00040) | (0.00030) |
| B-S(1) | 0.00107* | -0.00027* | -0.00003 | -0.00007 | -0.00010* | -0.00006 | -0.00049 | 0.00017 |
| | (0.00045) | (0.00008) | (0.00023) | (0.00055) | (0.00005) | (0.00014) | (0.00030) | (0.00022) |
| B-S(2) | -0.00036* | 0.00009* | 0.00001 | 0.00002 | 0.00003* | 0.00002 | 0.00016 | -0.00006 |
| | (0.00015) | (0.00003) | (0.00008) | (0.00018) | (0.00002) | (0.00005) | (0.00010) | (0.00007) |
| RHO | 0.55839* | 0.31806* | 0.51228* | 0.57772* | 0.86378* | 0.55045* | 0.55153* | 0.75694* |
| | (0.04706) | (0.08379) | (0.06792) | (0.04781) | (0.07093) | (0.10524) | (0.08627) | (0.05537) |
| R-Square | 0.9570 | 0.9743 | 0.9038 | 0.8114 | 0.9955 | 0.9136 | 0.9163 | 0.8912 |
| RUNS | -0.1839 | -0.1319 | -0.9402 | -2.7586* | -0.9402 | 1.0155 | -1.6617 | 0.1986 |
| Durbin-h | 2.0393* | 0.9821 | 0.7360 | 2.0763* | 2.7652* | -0.8294 | 1.2488 | 0.8246 |

*Coefficient or test significant at the $\alpha = 0.10$ level.

**Table A2. Coefficient Estimates for the Meats Model using the Combined Indices.**

| | Beef | Fish | Poultry | Pork |
|---|---|---|---|---|
| Const | 0.25415* | -0.05247 | 0.04598 | -0.46523* |
| | (0.06630) | (0.06114) | (0.04022) | (0.05633) |
| Beef | 0.06212* | -0.02042* | -0.04586* | 0.00416 |
| | (0.01633) | (0.01162) | (0.00885) | (0.00957) |
| Fish | -0.02042* | 0.04539* | -0.01079 | -0.01418* |
| | (0.01162) | (0.01392) | (0.00776) | (0.00847) |
| Poultry | -0.04586* | -0.01079 | 0.08093* | -0.02428* |
| | (0.00885) | (0.00776) | (0.00988) | (0.00743) |
| Pork | 0.00416 | -0.01418* | -0.02428* | 0.03430* |
| | (0.00957) | (0.00847) | (0.00743) | (0.01009) |
| Expend | 0.01655* | 0.01050 | 0.01209* | -0.03914* |
| | (0.00883) | (0.00857) | (0.00594) | (0.00663) |
| Q2 | -0.01937* | 0.02072* | 0.01407* | -0.01551* |
| | (0.00335) | (0.00281) | (0.00227) | (0.00209) |
| Q3 | -0.02835* | 0.03469* | 0.01173* | -0.01741* |
| | (0.00324) | (0.00331) | (0.00222) | (0.00243) |
| Q4 | -0.02792* | -0.01328* | 0.02844* | 0.01413* |
| | (0.00311) | (0.00386) | (0.00209) | (0.00272) |
| LAG(w) | 0.29200* | 0.25169* | 0.28479* | 0.28229* |
| | (0.05767) | (0.06086) | (0.05674) | (0.06432) |
| B-S(0) | -0.00011* | 0.00008* | 0.00006* | -0.00002 |
| | (0.00004) | (0.00003) | (0.00002) | (0.00003) |
| B-S(1) | -0.00009* | 0.00007* | 0.00005* | -0.00002 |
| | (0.00004) | (0.00003) | (0.00002) | (0.00002) |
| B-S(2) | 0.00002* | -0.00001* | -0.00001* | 0.00000 |
| | (0.00001) | (0.00000) | (0.00000) | (0.00000) |
| C-S Index | -0.00607* | -0.00038 | 0.00366* | 0.00295* |
| | (0.00096) | (0.00084) | (0.00058) | (0.00071) |
| R-Square | 0.9338 | 0.8979 | 0.9305 | 0.8421 |
| RUNS | -0.8019 | 0.2410 | -0.6148 | -1.7182 |
| Durbin-h | 1.7496 | -1.2970 | 2.0307* | 1.6628 |

*Coefficient or test significant at the $\alpha = 0.10$ level.

| Table A3. Coefficient Estimates for the Dairy Model using the Combined Indices. | | | | |
|---|---|---|---|---|
| | **Whole** | **Lowfat** | **Cheese** | **Frozen** |
| Const | 0.88083*<br>(0.32099) | -0.11372<br>(0.16008) | -0.47194*<br>(0.24886) | -0.00124<br>(0.07755) |
| Whole | 0.07834<br>(0.08322) | 0.02373<br>(0.04952) | -0.10397*<br>(0.02814) | 0.00190<br>(0.02780) |
| Lowfat | 0.02373<br>(0.04952) | 0.00152<br>(0.03499) | 0.01136<br>(0.01676) | -0.03661*<br>(0.01689) |
| Cheese | -0.10397*<br>(0.02814) | 0.01136<br>(0.01676) | 0.11702*<br>(0.02676) | -0.02440*<br>(0.01020) |
| Frozen | 0.00190<br>(0.02780) | -0.03661*<br>(0.01689) | -0.02440*<br>(0.01020) | 0.05911*<br>(0.01259) |
| Expend | -0.07114*<br>(0.04035) | 0.01744<br>(0.02391) | 0.04401<br>(0.03762) | 0.00969<br>(0.01156) |
| LAG(w) | 0.74366*<br>(0.07134) | 0.82786*<br>(0.09549) | 0.66307*<br>(0.09027) | 0.52521*<br>(0.09709) |
| B-S(0) | -0.00195*<br>(0.00059) | 0.00095*<br>(0.00040) | 0.00093*<br>(0.00056) | 0.00015<br>(0.00022) |
| B-S(1) | -0.00146*<br>(0.00044) | 0.00071*<br>(0.00030) | 0.00070*<br>(0.00042) | 0.00011<br>(0.00017) |
| B-S(2) | 0.00049*<br>(0.00015) | -0.00024*<br>(0.00010) | -0.00023*<br>(0.00014) | -0.00004<br>(0.00006) |
| C-S Index | 0.00011<br>(0.00138) | 0.00010<br>(0.00099) | 0.00217*<br>(0.00132) | -0.00154*<br>(0.00064) |
| R-Square | 0.9989 | 0.9966 | 0.9975 | 0.9405 |
| RUNS | -1.6617 | 0.5745 | -1.6617 | 0.6330 |
| Durbin-h | 1.5410 | -0.7823 | 0.0853 | -1.2354 |

*Coefficient or test significant at the $\alpha = 0.10$ level.

| Table A4. Coefficient Estimates for the Vegetable Model using the C-S Index. | | | | |
|---|---|---|---|---|
| | **Potatoes** | **Lettuce** | **Tomatoes** | **Other Fresh** |
| Const | 1.33030*<br>(0.19485) | -0.33548*<br>(0.10584) | 0.02781<br>(0.13436) | -0.43303*<br>(0.20011) |
| Potatoes | 0.17011*<br>(0.02476) | -0.05128*<br>(0.01374) | -0.02355*<br>(0.01300) | -0.09527*<br>(0.02680) |
| Lettuce | -0.05128*<br>(0.01374) | 0.16218*<br>(0.01749) | -0.04116*<br>(0.01556) | -0.06974*<br>(0.02327) |
| Tomatoes | -0.02355*<br>(0.01300) | -0.04116*<br>(0.01556) | 0.12303*<br>(0.02741) | -0.05832*<br>(0.02834) |
| Fresh | -0.09527*<br>(0.02680) | -0.06974*<br>(0.02327) | -0.05832*<br>(0.02834) | 0.22333*<br>(0.05102) |
| Expend | -0.15623*<br>(0.02662) | 0.06937*<br>(0.01577) | -0.00255<br>(0.01753) | 0.08941*<br>(0.03086) |
| LAG(w) | 0.37085*<br>(0.07063) | 0.41519*<br>(0.06858) | 0.47066*<br>(0.09025) | 0.40708*<br>(0.07208) |
| C-S Index | 0.00826*<br>(0.00243) | -0.00823*<br>(0.00165) | 0.00230<br>(0.00170) | -0.00272<br>(0.00312) |
| R-Square | 0.9341 | 0.9148 | 0.7569 | 0.8461 |
| RUNS | -0.6663 | -0.0269 | -2.8335* | -3.2122* |
| Durbin-h | 1.1136 | 0.7200 | 0.9298 | 1.9195 |

*Coefficient or test significant at the $\alpha = 0.10$ level.

| Table A5. Coefficient Estimates for the Fruit Model using the C-S Index. | | | | |
|---|---|---|---|---|
| | **Oranges** | **Apples** | **Bananas** | **Other Fresh** |
| Const | 0.35594* | 0.07573 | 0.12752 | 0.26259* |
| | (0.08154) | (0.10499) | (0.08585) | (0.12647) |
| Oranges | -0.01278 | -0.01888 | -0.01412 | 0.04578 |
| | (0.02134) | (0.01989) | (0.01163) | (0.03757) |
| Apples | -0.01888 | 0.14051* | -0.04434* | -0.07729 |
| | (0.01989) | (0.03264) | (0.01678) | (0.05047) |
| Bananas | -0.01412 | -0.04434* | 0.06900* | -0.01054 |
| | (0.01163) | (0.01678) | (0.01522) | (0.02421) |
| Fresh | 0.04578 | -0.07729 | -0.01054 | 0.04205 |
| | (0.03757) | (0.05047) | (0.02421) | (0.09429) |
| Expend | -0.04476* | 0.01497 | -0.00616 | 0.02363 |
| | (0.01245) | (0.01811) | (0.01379) | (0.01842) |
| LAG(w) | 0.21666* | 0.18567* | 0.18591* | 0.16151 |
| | (0.10640) | (0.09772) | (0.09516) | (0.09912) |
| C-S Index | 0.00413* | -0.00279 | -0.00000 | -0.00120 |
| | (0.00160) | (0.00240) | (0.00172) | (0.00256) |
| R-Square | 0.6635 | 0.7592 | 0.6564 | 0.6556 |
| RUNS | -0.0269 | 1.7106 | 0.5413 | 0.9532 |
| Durbin-h | -0.1225 | -1.0855 | -1.0012 | -0.6929 |

*Coefficient or test significant at the α = 0.10 level.

| Table A6. Coefficient Estimates for the Fats and Oils Model using Dummy Shifters. | | | | |
|---|---|---|---|---|
| | **Butter** | **Margarine** | **Shortening** | **Salad Oil** |
| Const | 0.32706* | 0.38824* | 0.00283 | -0.14781 |
| | (0.10909) | (0.09127) | (0.09364) | (0.11842) |
| Butter | 0.12515* | -0.03178* | -0.05367* | -0.03970 |
| | (0.02816) | (0.01034) | (0.02301) | (0.02817) |
| Margarine | -0.03178* | 0.05939* | -0.01814 | -0.00947 |
| | (0.01034) | (0.02858) | (0.01681) | (0.03052) |
| Shortening | -0.05367* | -0.01814 | 0.18155* | -0.10973* |
| | (0.02301) | (0.01681) | (0.03834) | (0.04099) |
| Salad Oil | -0.03970 | -0.00947 | -0.10973* | 0.15890* |
| | (0.02817) | (0.03052) | (0.04099) | (0.06163) |
| Expend | -0.05041* | -0.04102* | 0.04199* | 0.04944* |
| | (0.01868) | (0.01331) | (0.01771) | (0.02209) |
| LAG(w) | 0.55645* | 0.38284* | 0.26516* | 0.44587* |
| | (0.09562) | (0.11305) | (0.11371) | (0.10995) |
| L70s | -0.02537* | 0.00892* | 0.02291* | 0.00731 |
| | (0.01191) | (0.00417) | (0.00888) | (0.01181) |
| E80s | -0.03870* | 0.01400* | 0.01380 | 0.02908* |
| | (0.01461) | (0.00521) | (0.00895) | (0.01377) |
| L80s | -0.00387 | 0.02677* | -0.01734 | 0.02191 |
| | (0.02708) | (0.01208) | (0.01871) | (0.02593) |
| R-Square | 0.9765 | 0.9498 | 0.7128 | 0.9682 |
| RUNS | -0.4171 | 2.1628 | -1.3188 | 0.5413 |
| Durbin-h | 1.5482 | -1.8480 | -0.3307 | -0.8280 |

*Coefficient or test significant at the α = 0.10 level.