University of Tennessee, Knoxville
TRACE: Tennessee Research and Creative Exchange

Bulletins

AgResearch

3-1992

Nonparametric Testing for Structural Change in the Demand for Selected Dairy Products

University of Tennessee Agricultural Experiment Station

Scott Bevins

Kim Jensen

Follow this and additional works at: https://trace.tennessee.edu/utk_agbulletin

Part of the Agriculture Commons

Recommended Citation

University of Tennessee Agricultural Experiment Station; Bevins, Scott; and Jensen, Kim, "Nonparametric Testing for Structural Change in the Demand for Selected Dairy Products" (1992). *Bulletins.*
https://trace.tennessee.edu/utk_agbulletin/437

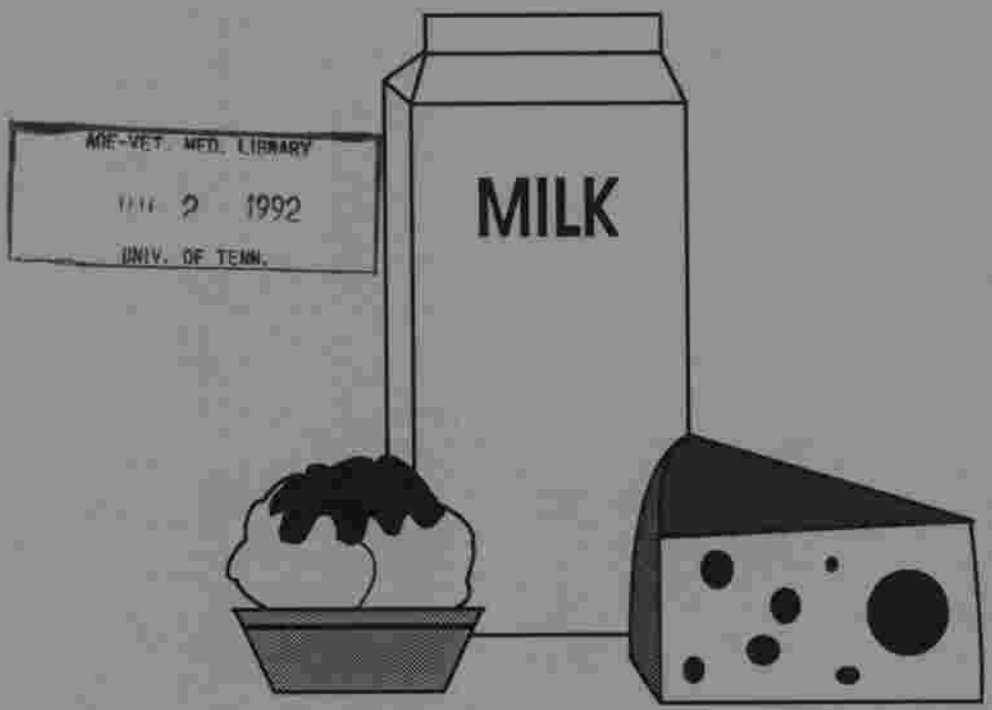
The publications in this collection represent the historical publishing record of the UT Agricultural Experiment Station and do not necessarily reflect current scientific knowledge or recommendations. Current information about UT Ag Research can be found at the UT Ag Research website.
This Bulletin is brought to you for free and open access by the AgResearch at TRACE: Tennessee Research and Creative Exchange. It has been accepted for inclusion in Bulletins by an authorized administrator of TRACE: Tennessee Research and Creative Exchange. For more information, please contact trace@utk.edu.

STACKS
S
115
.E32
1992
NO.682

Bulletin 682
March 1992

Nonparametric Testing for Structural Change in the Demand for Selected Dairy Products

Scott Bevins
Kim Jensen



AGR-VET. MED. LIBRARY
1992
UNIV. OF TENN.

The University of Tennessee
Agricultural Experiment Station
Knoxville, Tennessee
Don O. Richardson, Dean

Nonparametric Testing for Structural Change in the Demand for Selected Dairy Products

Scott Bevins
Kim Jensen

Bulletin 682, March 1992
The University of Tennessee
Agricultural Experiment Station
Knoxville, Tennessee
D.O. Richardson, Dean

Scott Bevins is a former Graduate Research Assistant and Kim Jensen is an Assistant Professorin the Department of Agricultural Economics and Rural Sociology, University of Tennessee, Knoxville.

*Approved for publication in September, 1991.

Table of Contents

Introduction 1

Objectives 1

Methodology 1

Parametric Testing for Structural Change 2

Nonparametric Testing for Structural Change 3

Data 5

Results 5

Beverages 6

Fats and Oils 6

Conclusions 10

References 12

Appendix 15

List of Tables

Table 1. Summary of Test Results for Revealed Preferences Within the Beverages Group, 1967-1986 7

Table 2. Summary of Test Results for Revealed Preferences Within the Butter, Margarine, and Salad and Cooking Oils Group, 1967-1986 9

Appendix Table 1. Location of Violations Within the Beverages Group, 1967-1986 16

Appendix Table 2. Location of Violations Within the Butter, Margarine, and Salad and Cooking Oils Group 1967-1986 18

Abstract

This study estimates whether structural change has occurred in the demand for whole milk, lowfat milk, juices, and other beverages and in the demand for butter, margarine, and salad and cooking oils between 1967 and 1986. A nonparametric approach is used, since it does not require a priori imposition of a functional form on the data in order to perform the tests. The results from these tests fail to reject that consumption patterns for whole milk and lowfat milk are consistent with stable preferences. Consumption patterns for whole milk, lowfat milk, and juices exhibit few violations from consistency with stable preferences. Inclusion of other beverages introduces numerous violations into the data. Consumption patterns for butter, margarine, and oils exhibit violations from consistency with preferences, however the violations are small in magnitude.

Introduction

Since the 1960's, overall consumption of dairy products has remained fairly constant, however, the types of dairy products consumed have changed. For example, per capita consumption of whole milk declined, while consumption of lowfat milk increased. Consumption of alternative beverages such as juices and soft drinks increased. The consumption of butter declined somewhat over the last 20 years, but consumption of margarine remained fairly constant. However, consumption of salad and cooking oils increased markedly.

A number of studies have attributed the decline in whole milk consumption to consumer concerns about cholesterol and saturated fat intake (Haidacher, Blaylock, and Myers; Hettinga; Smith, Herrmann, and Warland). These heightened concerns about limiting fat and cholesterol intake levels in the diet while maintaining adequate intake of other nutrients, such as calcium, have been linked to increasing consumption of lowfat milk and decreasing consumption of whole milk (Haidacher, Blaylock, and Myers; Hettinga; Smith, Herrmann, and Warland; Smith and Yonkers; Vassavada and Smith). Increased expenditure on food away from home has been cited as a contributor to the growing consumption of soft drinks and declining consumption of milk (Sullivan).

Results from cross-sectional and time-series studies of the demand for dairy products (Boehm; Gould, Cox, and Perali; Haidacher, Blaylock, and Myers; Heien and Wessells) have shown that milk consumption is higher in households with children and young people. Population shifts toward a higher proportion in older age groups could have a negative impact on the demand for milk. Gould, Cox, and Perali also found that other factors, such as increasing educational level and income, could also shift consumption away from whole milk to lowfat milk.

Increased expenditure on food away from home and heightened consumer concerns about health have also been cited as contributors to declining consumption of butter (Heien and Wessells; Haidacher, Blaylock, and Myers; Hettinga; Smith, Herrmann, and Warland). In a study of U.S. demand for fats, Gould, Cox, and Perali found that increases in average education levels and increases in the proportion of non-white population positively influence the demand for vegetable oils and shortenings and negatively influence the demand for butter and lard. The older segment of the population was found to consume more butter, perhaps because of consumption habits.

Several changes in consumption patterns suggest that there may have been structural change in the demand for milk and alternative beverages and in the demand for butter and other fats. The demographic impacts on consumption measured in cross-sectional studies and time-series studies suggest that, as the demographics of the population continue to change, consumption of these foods and beverages may be affected. Finally, as a larger proportion of food expenditure occurs away from home, the demand for whole milk and butter may continue to decline.

Objectives

While all of these trends point toward the possibility of structural change in demand, evidence supported with empirical tests for structural change is needed. Therefore, the objective of this study is to estimate whether or not structural change has occurred in the demand for selected dairy products. As part of this objective, nonparametric tests are conducted for evidence of structural change within the demand for dairy products. Evidence of structural change is tested in two groupings of dairy products. These are consumption of whole milk, lowfat milk, juices, and other beverages and consumption of butter, margarine, and salad and cooking oils. These groupings are tested because of the data availability for these products and also because of the major changes in consumption patterns among them.

Methodology

The identification of the origin and the time at which structural change in demand for a given commodity occurs is very difficult to determine. Such structural changes are the result of changes in the utility function that replace a set of demand functions of a portion or all of its parameters (Haidacher; Chavas). Consequently, a number of different methodologies have been used to test for and incorporate structural change into demand functions. These methodologies are reviewed for studies of various food commodities that incorporate structural change. These commodities include meats, such as beef, pork, and poultry, and butter, fats, and oils.

Parametric Testing for Structural Change

Evidence of structural change may come from a number of parametric methods. One method for obtaining evidence of structural change is to test a model with parameters that are invariant with respect to time. If the model fails a given set of tests, this is used as evidence of structural change. Other studies have introduced time-varying parameters into a model. If the parameters are significant, then the assumption is made that structural change has occurred.

Examples of studies that estimated static models of the demand for food products and then tested for structural change from these models include Chang and Kinnucan, Braschler, and Haidacher. Chang and Kinnucan tested for structural change in Canadian demand for butter and other fats using the Chow test. The test was used to determine whether or not estimated demand coefficients for butter and other fats were changing over time. Chang and Kinnucan concluded that an advertising program had increased the demand for butter and decreased the demand for margarine. Braschler also used the Chow test, finding evidence of structural change in the demand for red meats during the 1970's. The Chow test is performed by first dividing the observations into two segments (Chow). The first n observations are used to fit an estimated regression. Then, a regression is fit to the total pooled sample (n + m) observations. The test statistic is used to evaluate whether or not m observations come from the same population as n. The test statistic is: where $\mathbf{e}_1$ are the residuals from the regression on the first n observations, and **e** are the residuals from the regression on the pooled observations, and **k** is the number of explanatory variables. The **F** statistic

$$F = \frac{(e'e - e'_1 e_1)/m}{e'_1 e_1 / (n-k)}$$

is distributed as F with (m, n-k) degrees of freedom.

In his study, Haidacher used an indirect approach for assessing structural change in the demand for food commodities, rather than incorporating time varying parameters. Haidacher proposed that if a postulated demand structure reflected the true demand structure, then values simulated from the postulated demand structure would be the same as the realized values if no structural changes in demand had occurred. Given that this assumption is correct, then errors between simulated values and actual values provide a rough estimate of the outer bound of structural change. Haidacher introduced a constant term, $\tilde{s}_i$ into each equation, such that:

$$\dot{q}_{it} = \sum_{j=1}^{n} e_{ij} \dot{p}_{jt} + \eta_i \dot{m}_t + \tilde{s}_i$$

where

$$\dot{q}_{it} = \Delta q_{it} / q_{it}, \dot{p}_{it} = \Delta p_{it} / p_{it}, \dot{m}_t = \Delta m_t / m_t.$$

The price elasticities are $\mathbf{e}_{ij}$ and the income elasticity vector is η_i. An interpretation of $\tilde{s}_i$ that if the changes in prices and incomes are equal to 0, then quantity will change by $\tilde{s}_i$ for each unit change in **t**. Therefore, $\tilde{s}_i$ provides a rough estimate of the bounds of structural change over time. Using observations from 1950 to 1977, Haidacher estimated $\tilde{s}_i$'s of -1.6, 1.2, and -6.4 for red meat, poultry, and fish respectively.

Eales and Unnevehr estimated an Almost Ideal Demand System for beef and chicken products demand. They used a first difference of the share equation, such that:

$$\Delta w_i = \sum_j \gamma_{ij} \Delta \ln (p_j) + \beta_i \Delta \ln (X/P),$$

where $\mathbf{w}_i$ is the expenditure share allocated to the ith commodity in a group, $\mathbf{p}_j$ are prices, and **X** is expenditure on all commodities in a group. Eales and Unnevehr tested for two types of structural change: gradual and discrete. The test for gradual structural change was performed by incorporating an intercept term into the share equations. Significance of the estimated coefficient of the intercept term was used as an indication of exogenous structural change. Eales and Unnevehr found evidence of structural change in demand with preferences shifting away from beef to chicken after 1974. To test for a one-time shift, an intercept dummy was incorporated into the equations. Moschini and Meilke also modified a static Almost Ideal Demand System to estimate demand for meat aggregates, using a gradual switching regression. Moschini and Meilke also concluded that preferences shifted away from beef toward chicken during the mid-1970's.

Choi and Sosin, in order to measure structural changes in the demand for meats, interjected time-dependent parameters into a translog model. Choi and Sosin concluded that the parameters of the model were time-dependent, and reflected the occurrence of a shift in the demand for red meat during the 1970's. Other studies incorporating time-varying parameters into food demand systems include studies by Wohlgenant and Chavas. Wohlgenant and Chavas also found evidence of structural change in the demand for meats.

Nonparametric Testing for Structural Change

Parametric methodologies usually assume that the functional form of the selected utility function is correct. As Chalfant and Alston point out, selection of the incorrect functional form can introduce results that may give the appearance that structural change has occurred, when it may not have. Therefore, indicators of structural change may be the product of specification choices.

A nonparametric approach for testing for structural change involves testing for revealed preference [Chalfant and Alston; Varian (1983)]. To test for the stability of demand, the null hypothesis is that observed data conform to the restrictions implied by stable well-behaved preferences. If this is the case, then prices and expenditures explain consumption patterns. The test for revealed preference is applied to the data without imposing an assumed functional form for demand. Chalfant and Alston applied nonparametric tests to meat consumption and prices data. These tests failed to reject the null hypothesis that meat consumption was explained by prices and expenditures.

A nonparametric approach is used in this study to test for evidence of structural change in dairy products demand. The approach is used because it allows for testing for revealed preference, but does not impose an a priori assumed functional form for demand upon the data.

If the data, consisting of prices and consumption quantities, adhere to the behavior of a stable demand function, then the data should conform to a given set of criteria. These criteria are that the data do not violate the Weak Axiom of Revealed Preference (WARP) and do not violate the Strong Axiom of Revealed Preference (SARP). Violations of WARP and SARP suggest that factors other than changes in prices and expenditures have influenced changes in consumption patterns.

Let $\mathbf{P}_a$ be a vector of prices for bundle **a** and $\mathbf{Q}_a$ be the quantity vector for bundle **a**. The cost of purchasing bundle **a** is then represented by $\mathbf{P}_a'\mathbf{Q}_a$ or Φ_{aa}. Suppose that **a** is the bundle of **N** goods purchased for a given time period and that **b** is the bundle of **N** goods purchased during another time period. According to the WARP, bundle **a** is revealed preferred to any other bundle **b** that could have been purchased (abbreviated **aRb**), if bundle **b** was affordable at period **a** prices, but bundle **a** was selected instead. If **aRb**, assuming the data behave according to WARP, then **b** will never be revealed preferred to **a**. The Weak Axiom of Revealed Preference is violated if any bundle **b** is also revealed preferred to bundle **a**. Satisfaction of WARP implies homogeneity of degree zero of the demand function and that demand relations are single valued (for any price-income vector, a single consumption point is chosen).

If the number of bundles is greater than two, then it also becomes necessary to test for transitivity under the Strong Axiom of Revealed Preference. Transitivity implies that if **aRb** and **bRc**, then **aRc**. For example, if **aRb**, **bRc**, and **cRa**, there is intransitivity of preferences. Satisfaction of SARP implies nonintersecting indifference curves.

A matrix, Φ, can be used to test for the consistency of consumption behavior with WARP and SARP. The matrix for bundles **a** and **b** is:

$$\begin{bmatrix} \Phi_{aa} & \Phi_{ab} \\ \Phi_{ba} & \Phi_{bb} \end{bmatrix}$$

When $\Phi aa > \Phi ab$, **aRb**.

A convenient representation of the matrix Φ, is found by dividing each element of the matrix by the diagonal element in the same row. For example, each element in the row with Φ_{aa}, would be divided by Φ_{aa}. This representation allows comparison of the affordability of the bundle actually purchased at **a**, with alternative bundles, **b** and **c**. The matrix is calculated as:

$$\Gamma = \begin{bmatrix} \frac{\Phi_{aa}}{\Phi_{aa}} & \frac{\Phi_{ab}}{\Phi_{aa}} & \frac{\Phi_{ac}}{\Phi_{aa}} \\ \frac{\Phi_{ba}}{\Phi_{bb}} & \frac{\Phi_{bb}}{\Phi_{bb}} & \frac{\Phi_{bc}}{\Phi_{bb}} \\ \frac{\Phi_{ca}}{\Phi_{cc}} & \frac{\Phi_{cb}}{\Phi_{cc}} & \frac{\Phi_{cc}}{\Phi_{cc}} \end{bmatrix}$$

For purposes of convenience, each quotient can be abbreviated. For example,

$$\Gamma_{ab/aa} = \frac{\Phi_{ab}}{\Phi_{aa}}$$

Suppose that $\Gamma_{ab/aa}$ is less than one. This indicates that the bundle purchased at time **b** was affordable at time period **a**, although it was not purchased at time period **a**. Therefore, if $\Gamma_{ab/ab} < 1$, then **aRb**. Given this representation, violation of WARP would occur, for example, if $\Gamma_{ab/aa}$ and $\Gamma_{ba/bb}$ were both greater than one, or were both less than one. An example violation of SARP would be if , $\Gamma_{ab/aa}$, $\Gamma_{bc/bb}$, and $\Gamma_{ca/cc}$ were all less than one.[1] Orderings of preference may be generated from the Γ matrix by examining elements in each row that are less than one.

A drawback of using a nonparametric test is that there is no method to measure the power of the test. Furthermore, the power of this type of test may be diminished when there is a strong trend in expenditures (Chalfant and Alston). However, the ability of parametric methods to pick up substitution effects is also diminished when there is a strong trend in expenditures (Pitts and Herlihy). When overall consumption is rising rapidly over time, the budget lines rarely cross. Therefore, few violations of revealed preference will be detected.

A large increase in real expenditures over time will be evidenced in the Γ matrix. The result will be a much greater number of elements of with values greater than one above the diagonal than below the diagonal. Moving across the rows of Γ beyond the diagonal, each element compares the cost of bundles purchased in later time periods, if they were purchased at an earlier time period's prices, with actual expenditures in the earlier time period. If real expenditures are rising over time, then the cost of purchasing the later bundles at the earlier time period's prices should be greater than actual expenditures in the earlier time period. For example, if real expenditures were rising, a likely situation might be that $\Phi_{ab} > \Phi_{aa}$, so that $\Gamma_{ab/aa} > 1$. However, $\Gamma_{ba/bb}$ might likely be less than one.

If there is evidence of a strong trend in expenditures, Chalfant and Alston suggest adjusting the data for real expenditures. Observed quantities can be replaced by a quantity adjusted by the growth in real expenditures. The percentage difference between expenditures in time period t and the minimum for the sample is used to adjust the observed quantity. These adjusted quantities are then used to calculate the elements of Φ. The quantities should then lie along closer budget lines, such that these budget lines may cross.

A potential source of error when using this test for structural change (which can also be a potential source of error when using a parametric test) is that the grouping of commodities chosen for the test may produce results which appear as structural change. Selection of the correct commodities to be included in the group is of great importance. Therefore, for each grouping, components of the group are deleted to test for their impact on the number of violations.

For each of the beverages groupings and fats and oils groupings, the matrices Φ and Γ are calculated. Using these matrices, tests are performed for violation of WARP and SARP within each grouping of dairy products. Each matrix is a 20 by 20 matrix, dimensioned, i=1...20, j=1...20, since the years 1967 through 1986 are used. Adjusted data are also tested for violations of WARP and SARP.

The groupings of dairy products used in the tests for structural change place heavy emphasis on the assumption of weak separability and two stage budgeting for the groups of products. Two stage budgeting results as consumers decide first how best to budget their incomes among each individual group of like-commodities and secondly, how best to allocate within each group of like-commodities. For example, consumers first allocate their income among beverages, fats and oils, cereals, and a number of other broad food groupings. They then are assumed to allocate expenditures within each grouping, such as allocation of beverage expenditures among different types of beverages. The use of two stage budgeting relies on weak separability because: 1) it is assumed that the set of commodities within the group has common characteristics that suffice in distinguishing commodities within the group from commodities outside the group and 2) it is assumed that the marginal rate of substitution between any two commodities in the beverages or the fats and oils grouping is independent of the quantity of commodities not included in that particular group in question (Johnson, Hassan, and Green).

The groupings used in this study were based on comparable characteristics and similarity of use by the consumer. They were also selected due to their similarity to groupings used in past studies, so that comparison of results could be made.

---

[1] In this example, if $\Gamma_{ba/bb}$, $\Gamma_{cb/cc}$, and $\Gamma_{ac/aa}$ were all greater than one, the data would be consistent with WARP, but violate SARP. Therefore consistency with WARP constitutes a necessary, but insufficient condition for utility maximization.

The number of possible combinations of foods and beverages that could be tested for separability is quite large. It is beyond the scope of this study to test all possible combinations.[2]

Data

U.S. per capita consumption for each of the commodities are from Food Consumption, Prices, and Expenditures, 1964-88. Per capita consumption of beverages is expressed in gallons per year. Per capita consumption of fats and oils is expressed in pounds per year. Use of average per capita consumption limits the study to testing for violations from stable well-behaved preference on the part of an "average" or "representative" consumer. It is assumed that aggregation conditions hold so that the average may be used.

Price series are derived by extending prices for each of the commodities within a single year with price index series for each of the respective commodities. Prices are from Food Consumption: Households in the U.S., Seasons and Year 1977-78 and from Food Consumption, Prices, and Expenditures, 1964-88. Price indexes are from Food Consumption, Prices, and Expenditures, 1964-88 and U.S. Bureau of Labor Statistics. All prices are deflated by the Consumer Price Index (1982-84=100).

The beverages data are comprised of whole milk, lowfat milk, juices, and other beverages. Other beverages consist primarily of carbonated soft drinks, coffee, and tea. The fats and oils group consists of three commodities: butter, margarine, and salad and cooking oils. The consumption of lowfat milk is represented by an aggregation of one percent, two percent, and skim milk. Use of aggregate commodities, such as other beverages, juices, salad and cooking oils, or lowfat milk assumes that the composite commodity theorem holds. Thus, it is assumed that the aggregate demand for a group of commodities behaves as a single commodity (Henderson and Quandt).

Because a price index was not available for skim milk or juices during the two year period 1978-79, prices were estimated. The missing skim milk prices are estimated based on their historical relationship with whole milk prices. The missing retail juice prices are estimated based on historical wholesale juice prices.[3]

Results

Summaries of the results from the nonparametric tests of the beverages and fats and oils data are presented in Tables 1 and 2.[4] Table 1 summarizes the test results for revealed preference within the beverages group, while Table 2 summarizes results within the fats and oils group.

Each table is divided into two sections, one displaying the analyses of the unadjusted data, while the other section displays that of the adjusted data. Within each section, the number of elements above and below the diagonal that are greater than one is shown. The number of violations of the Weak Axiom of Revealed Preference and the location of the violations in the data series is presented. The size of the largest violation of the Weak Axiom of Revealed Preference for each of the groupings is also presented. The pairs of ratios which constitute the largest violation of the Weak Axiom are presented by row and column. For example, if a violation occurs between the pair of years 1967 and 1986, the ratios are presented in the order

$\Gamma_{'67,'86/'67,'67} = \mathbf{P}_{'67}\mathbf{Q}_{'86} / \mathbf{P}_{'67}\mathbf{Q}_{'67}$ followed by

$\Gamma_{'86,'67/'86,'86} = \mathbf{P}_{'86}\mathbf{Q}_{'67} / \mathbf{P}_{'86}\mathbf{Q}_{'86}$.

---

[2] The methodology used in this study can also be used to test for weak separability. If a subset of the goods satisfies the Generalized Axiom of Revealed Preference, while an aggregate of these goods along with other goods still meets the consistency property, then a utility function exists which rationalizes the data and is weakly separable in these goods [Varian (1983) and Belongia and Chalfant].

[3] Retail prices of skim milk are regressed on the prices of whole milk using the available data. Whole milk prices for the missing years are then used in conjunction with the estimated regression coefficients to make projections of retail skim milk prices. Retail prices of juices are regressed on wholesale prices. Wholesale prices for the missing years are used with the estimated regression coefficients to project retail juice prices for the missing years. These particular price series were selected based on their similar behavior to the retail price series of skim milk and juices.

[4] The summary tables are derived from the matrices of expenditure ratios for each of the commodity groupings. For the purposed of brevity, the tables of matrices for each of the groupings are not presented within this document. However, these tables are available from the authors.

Whether or not the data are consistent with the Strong Axiom of Revealed Preference is also displayed in Tables 1 and 2. The data are checked for intransitivity of preferences by ordering the bundles according to the elements in each row of the Γ matrix that are greater or less than one. If the data show consumption patterns that are intransitive, then the data are considered inconsistent with SARP. None of the groupings of beverages or fats and oils, which do not violate WARP, violate SARP.

Tables of the locations of all violations of the Weak Axiom of Revealed Preference within the groupings are presented in the Appendix. The locations of violations in the beverages data are displayed in Table A.1 and locations of the violations in the fats and oils data are displayed in Table A.2.

Beverages

Presented in Table 1 and Table A.1, when all beverages (whole milk, lowfat milk, juices, and other beverages) are included in the group, the unadjusted data show 18 violations of WARP. The violations appear between pairs consisting of 1967 and each of the years: 1973, 1976, 1985, and 1986. Violations also occur between 1968 and 1973 and 1968 and 1986, and between pairs consisting of 1969 and 1970, 1974, 1979, 1985, and 1986. Other violations are between 1970 and 1979, 1970 and 1985, and 1970 and 1986, 1971 and 1986, 1974 and 1986, 1975 and 1986, and between 1977 and 1980. When all beverages are included in the group, the unadjusted data exhibit the largest violation between the pair of years 1967 and 1986, yielding values of .9339 and .9941.

Each of the component beverages is deleted from the beverages group to check for its impact on the data meeting the criteria of revealed preference. When each of the beverages is deleted from grouping of unadjusted data, the restricted group still violates WARP and SARP. Two exceptions are when juices and other beverages are deleted, restricting the grouping to whole milk and skim milk and when lowfat milk is deleted, restricting the grouping to whole milk, juices, and other beverages. Neither of these groupings violated WARP or SARP. Although addition of juices into the grouping with whole and lowfat milk introduces five violations into the unadjusted data, as presented in Table 1, the largest violation is by less than one percent. The violations in grouping of whole milk, lowfat milk, and juices are between consumption in the years 1967 and 1972, 1968 and 1977, 1970 and 1976, 1970 and 1977, and 1973 and 1975.

It should be noted that there has been a strong growth in expenditures on other beverages, which primarily consist of carbonated soft drinks, coffee, and tea. When the other beverages are deleted from the beverages grouping, there are only 28 ratios with values greater than one above the diagonal in the unadjusted data. While there was substantial growth in lowfat milk expenditures, whole milk expenditures declined. Notably, as presented in Table 1, if whole milk is deleted from the beverages grouping, there are 178 ratios with values greater than one above the diagonal. Furthermore, if lowfat milk is deleted from the beverages grouping, there are only 20 ratios with values greater than one above the diagonal.

Since a strong trend in expenditures may overshadow substitution effects when the unadjusted results for data with strong expenditure trends reveal no violations, the adjusted data should also be evaluated. The only grouping for which unadjusted and adjusted data exhibit no violations of revealed preference is the grouping of whole milk and lowfat milk. Inclusion of juices along with whole and lowfat milk introduces six violations. However, the violations are all by less than four percent.

Fats and Oils

Results from the nonparametric tests of the butter, margarine, and salad and cooking oils data are displayed in Table 2 and Table A.2. The tests reveal eight violations of WARP in the unadjusted matrix of the original group (butter, margarine, and salad and cooking oils), but each violation is by less than two percent. The results in Table A.2 show the violations of WARP in the unadjusted data are between consumption bundles in 1968 and 1971, 1968 and 1974, 1968 and 1975, 1968 and 1977, 1969 and 1974, 1969 and 1975, 1969 and 1977, and 1971 and 1974.

Each of the fats and oils is deleted from the group to check for its impact on the data meeting the criteria of revealed preference. Displayed in Table 2, with the exception of butter, when each of the fats and oils is deleted, the existing group still violates WARP and SARP. When margarine is excluded, there are seven violations of WARP and SARP. If salad and cooking oils are excluded, there are six violations of WARP. Although there are violations in each of the unadjusted groupings, except margarine and salad and cooking oils, none of the violations is by greater than two

Table 1. Summary of Test Results for Revealed Preference Within the Beverages Group, 1967-1986.

Grouping	Unadjusted Data					Adjusted Data				
	Number of $\Gamma_{ij/ii}$ in Relation to Diagonal **Above**	**Below**	Number of Violations of WARP	Location, Size of Largest Violation	Consistency of Data With SARP	Number of $\Gamma_{ij/ii}$ in Relation to Diagonal **Above**	**Below**	Number of Violations of WARP	Location, size of Largest Violation	Consistency of Data With SARP
Whole Milk, Lowfat Milk, Juices, and Other Beverages	47	131	18	'67 and '85; .9339 .9941	NO	62	126	2	'74 and '86; .9961 .9949	NO
Whole Milk, Lowfat Milk, and Juices	28	159	5	'70 and '77; .9903 .9920	NO	160	24	6	'70 and '78; .9636 .9912	NO
Whole Milk, Lowfat Milk, and Other Beverages	27	160	3	'75 and '86; .9963 .9990	NO	64	120	6	'67 and'86; .9190 1.9965	NO
Lowfat Milk, Juices, and Other Beverages	178	16	4	'74 and '77; 1.0306 1.0040	NO	50	141	1	'84 and '86; 1.0051 1.0022	NO

Table 1. Continued.

Grouping	Unadjusted Data					Adjusted Data				
	Number of $\Gamma_{ij/ii}$ in Relation to Diagonal **Above**	**Below**	Number of Violations of WARP	Location, Size of Largest Violation	Consistency of Data With SARP	Number of $\Gamma_{ij/ii}$ in Relation to Diagonal **Above**	**Below**	Number of Violations of WARP	Location, size of Largest Violation	Consistency of Data With SARP
Whole Milk, Juices, and Other Beverages	20	170	0	___	YES	61	130	1	'69 and '70; 1.0006 1.0011	NO
Whole Milk and Lowfat Milk	6	184	0	___	YES	179	11	0	___	YES
Lowfat Milk and Juices	186	7	3	'76 and '78; 1.0108 1.0096	NO	106	110	28	'75 and '85; 1.0045 1.1295	NO
Whole Milk and Juices	7	183	2	'85 and '86; 1.0028 1.0010	NO	162	19	9	'70 and '79; .9764 .9268	NO

Table 2. Summary of Test Results for Revealed Preference Within Butter, Margarine, and Salad and Cooking Oils, 1967-1986.

Grouping	Unadjusted Data					Adjusted Data				
	Number of $\Gamma_{ij/ii}$ in Relation to Diagonal		Number of Violations of WARP	Location, Size of Largest Violation	Consistency of Data With SARP	Number of $\Gamma_{ij/ii}$ in Relation to Diagonal		Number of Violations of WARP	Location, Size of Largest Violation	Consistency of Data With SARP
	Above	**Below**				**Above**	**Below**			
Butter, Margarine, and Salad and Cooking and Oils	166	16	8	'68 and '75; .9964 .9819	NO	103	86	1	'69 and '86; .9948 .9924	NO
Butter and Margarine	53	142	6	'74 and '83 .9923 .9871	NO	126	61	5	'69 and '73 .9998 .9872	NO
Butter and Salad and Cooking Oils	166	17	7	'69 and '74; .9813 .9963	NO	98	89	3	'69 and '86; .9949 .9898	NO
Margarine and Salad and Cooking Oils	181	9	0	___	YES	95	94	1	'68 and '83; .9987 .9975	NO

percent.

Summarized in Table 2, the groups that include salad and cooking oils exhibit a large number of elements greater than above the diagonal. The original group contains 166 elements having values greater than one above the diagonal; the group excluding butter has 181; and the group excluding margarine has 166. However, when salad and cooking oils are excluded from the grouping, the number of elements greater than one above the diagonal is reduced to 53. Thus, strong growth in expenditures on salad and cooking oils is evidenced.

With the exception of the group excluding salad and cooking oils, the groups of adjusted data show few violations. The group excluding salad and cooking oils yields five violations. The results in Table A.2 show the violations occurring for the pairings 1967 and 1979, 1968 and 1980, 1969 and 1973, 1973 and 1981, and 1982 and 1984. The largest violation occurs between 1969 and 1973, and consists of the ratios .9872 and .9998. None of the violations in any of the adjusted groupings of fats and oils is by greater than two percent.

Conclusions

The nonparametric test conducted in this study fails to reject the hypothesis that whole milk and lowfat milk consumption patterns are consistent with stable preferences under utility maximization. Therefore, prices and expenditures explain changes in consumption patterns among these beverages. Addition of juices into the grouping produces violations. However, they are small in magnitude. When other beverages are incorporated into the group, numerous violations are introduced.

The fact that inclusion of other beverages introduces numerous violations could have two possible implications. These results could imply that other beverages should not be included in the group with whole milk, lowfat milk, and juices. However, the results could also imply that other beverages may be the source of structural change within overall beverages demand. While the inclusion of other beverages does introduce violations, the magnitude of the violations are fairly small. As shown in Table 1, the largest violation is by less than seven percent. The majority of the violations are by less than two percent. According to Varian (1985) and Chalfant and Alston, inconsistencies that are small in magnitude could be the result of measurement errors in the data.[5]

Past studies of the demand for various dairy products have hypothesized that factors other than prices and expenditures influence the demand for milk. As these factors change over time, a structural change in the demand for milk would be evidenced. Based upon this hypothesis, Boehm, Heien and Wessells, and Gould, Cox, and Perali incorporated demographics, such as household size, number of household members by age and sex, educational levels, region, tenancy, and race into their models of dairy products demand. The results from Gould, Cox, and Perali's time-series study of the demand for milk and other beverages, indicated that an aging of the population would shift the demand for milk. The results from cross-sectional studies of demand have also shown significant impacts of age upon the demand for fluid milk (Boehm and Heien and Wessells). With a decline in the number of teenagers and children in the household, a decrease in the consumption of fluid milk is projected. Gould, Cox, and Perali attributed the negative impacts of an aging of the population upon the demand for whole milk to heightened concerns about the nutritional value of foods and beverages. Furthermore, Gould, Cox, and Perali and Boehm found that educational levels had a significant impact on the level and type of fluid milk consumed, with increased educational levels contributing to increased consumption of lowfat milk and decreased consumption of whole milk.

While each of the aforementioned studies of the demand for fluid milk found that nonprice and nonexpenditure variables were important in explaining consumption patterns, the results from this study do not suggest the necessity of including these types of variables, especially when other beverages are omitted. Therefore, if the correct functional form is specified, then a static model of the demand for whole milk, lowfat milk, and juices could be adequate. Only when other beverages are included does evidence appear suggesting that prices and expenditures are inadequate for explaining consumption.

---

[5] Varian (1985) describes a methodology for testing for consistency when measurement errors are present. However, the methodology is beyond the scope of this study.

If the violations introduced by including other beverages in the grouping signal structural change, this would be consistent with findings from previous studies. For example, Sullivan found that as consumers' incomes increase, there is a tendency to substitute other beverages for milk with meals away from home. Furthermore, Heien and Wessells noted that a higher proportion of food expenditures away from home had a negative impact on milk. The results from Gould, Cox, and Perali's study showed that increasing educational levels had a positive impact on the consumption of other beverages.

The results from the nonparametric tests on the grouping of butter, margarine, and salad and cooking oils show violations of the criteria for utility maximization under stable preferences. Inclusion of butter into the groupings introduces violations. However, the violations are small in magnitude. Therefore, the violations could be the result of measurement errors in the data. Provided the functional form is correctly specified, prices and expenditure data for butter, margarine, and salad and cooking oils could be sufficient for explaining consumption behavior. These findings are contrary to those by Gould, Cox, and Perali who found that factors, such as increased educational levels would decrease the demand for butter and increase the demand for margarine, and that the oldest age grouping had the highest per capita consumption of butter. Furthermore, as with milk, Heien and Wessells attributed the decline in the consumption of butter to a higher proportion of food expenditures away from home.

When evaluating the results from nonparametric testing conducted in this study, it should be noted that this is just a partial analysis, and not all possible substitutes and complements for these foods and beverages are considered in the testing. Groupings are limited to those similar to ones used in past econometric studies of the demand for these foods and beverages. Therefore, the analysis relies heavily on the assumption of at least weak separability. It is beyond the scope of this study to perform separability tests for all possible combinations of foods and beverages that are potentially related to the consumption of the ones considered in this study.

It is also important to note that the data used in this study are aggregates and are to represent the "average" consumer. It is possible that negative impacts on consumption created by one demographic factor within the population could be offset by positive impacts from another. Therefore, the tests from these data are only capable of revealing violations in overall consumption from patterns that are consistent with utility maximization. This limitation makes comparison with results from cross-sectional studies difficult.

References

Belongia, M. and J. Chalfant. "The Changing Empirical Definition of Money: Estimates from a Model of the Demand for Money Substitutes." J. of Political Economy 97(1989): 387-97.

Boehm, W. T. "The Household Demand for Major Dairy Products in the Southern Region." South. J. Agr. Econ. 7(1975): 187-96.

Braschler, Curtis. "The Changing Demand Structure for Pork and Beef in the 1970's: Implications for the 1980's." South. J. Agr. Econ. (1983): 105-10.

Chalfant, J. A. and J. M. Alston. "Accounting for Changes in Tastes." J. of Political Economy 96(1988): 391-410.

Chang, Hui-Shung and Henry Kinnucan. "Advertising and Structural Change in the Demand for Butter in Canada." Canadian J. Agr.Econ. publication forthcoming.

Chavas, Jean-Paul. "Structural Change in the Demand for Meat." Am. J. Agr. Econ. 65(1983): 148-53.

Choi, S. and K. Sosin. "Testing for structural Changes in Tastes." Am. J. Agr. Econ. 72(1990): 227-36.

Chow, G. "Tests of Equality Between Sets of Coefficients in Two Linear Regressions." Econometrica 28(1960): 591-605.

Eales, J. and L. Unnevehr. "Demand for Beef and Chicken Products: Separability and Structural Change." Am. J. Agr. Econ. 70(1988):521-32.

Gould, B. W., T. L. Cox, and F. Perali. "Demand for Food Fats and Oils: The Role of Demographic Variables and Government Donations." Am. J. Agr. Econ. 73(1991): 212-21.

_____. "The Demand for Fluid Milk Products in the U.S.: A Demand Systems Approach." West. J. Agr. Econ. 15(1990): 1-12.

Haidacher, R. C. "Assessing Structural Change in the Demand for Food Commodities." South. J. Agr. Econ. 15(1983): 31-37.

Haidacher, R. C., J. R. Blaylock, and L. H. Myers. "Consumer Demand for Dairy Products." Agr. Econ. Rep. No. 586, U.S. Department of Agriculture, Economic Research Service, March 1988.

Heien, D. M. and C. R. Wessells. "The Demand for Dairy Products: Structure, Prediction, and Decomposition." Am. J. Agr. Econ. 70 (1988): 219-28.

Henderson, J. and R. Quandt. Microeconomic Theory: A Mathematical Approach. Third Edition. New York: McGraw-Hill Book Company, 1980.

Hettinga, D. H. "Why Alter Milk Composition." J. Dairy Sci. 72(1989): 2790-99.

Johnson, S. R., Z. A. Hassan, and R. D. Green. Demand Systems Estimation. First Edition. Ames Iowa: Iowa State University Press, 1984.

Moschini, G. and K. Meilke. "Modeling the Pattern of Structural Change in U.S. Meat Demand." Am. J. Agr. Econ. 71(1989): 253-61.

Pitts, E. and P. Herlihy, "Perverse Substitution Relationships in Demand Studies: The Example of Butter and Margarine." J. Agr. Econ. 33(1982): 37-46.

Putnam, J. J. Food Consumption, Prices, and Expenditures,1966-1987. Statist. Bull. No. 773, U.S. Department of Agriculture, Economic Research Service, Washington DC, January 1989.

Smith, B. J. and Yonkers, R. D. "The Importance of Cereal to Fluid Milk Consumption." Market. Res. Rep. No. 7, Dept. of Agricultural Economics and Rural Sociology, Agricultural Experiment Station, Pennsylvania State University, February 1990.

Smith, B. J., R. O. Herrmann, and R. H. Warland. "Milk Consumption and Consumer Concerns about Fat, Cholesterol, and Calories." Market. Res. Rep. No. 8, Dept. of Agricultural Economics and Rural Sociology, Agricultural Experiment Station, Pennsylvania State University, February 1990.

Sullivan, G. D. "What's Behind Milk Price Movement?" Economic Review (January/February 1990): 34-41.

U.S. Department of Agriculture, Food Consumption: Households in the U.S., Seasons and Year 1977-78, NFCS 1977-78. Report No. H-6. Washington, D.C., August 1983.

Varian, Hal R. "Nonparametric Tests of Consumer Behavior." Review of Economic Studies 50(1983): 99-110.

_____. "Nonparametric Analysis of Optimizing Behavior with Measurement Error." J. Econometrics 30(1985): 445-58.

Vassavada, P. C. and D. E. Smith. "Symposium: Health Related Aspects of Milk and Milk Products." J. Dairy Sci. 70(1987): 381-82.

Wohlgenant, M.K. "Estimating Cross Elasticities of Demand for Beef." West. J. Agr. Econ. 10 (1985): 322-29.

APPENDIX

Table A.1. Location of Violations Within the Beverages Group, 1967-1986.

Grouping	Unadjusted Data: Location of Violations	Adjusted Data: Location of Violations
Whole Milk, Lowfat Milk, Juices, and Other Beverages	'67 and '73; '67 and '76; '67 and '85; '67 and '86; '68 and '73; '68 and '86; '69 and '70; '69 and '74; '69 and '79; '69 and '85; '69 and '86; '70 and '79; '70 and '85; '70 and '86; '71 and '86; '74 and '86; '75 and '86; '77 and '80	'74 and '86; '76 and '86
Whole Milk, Lowfat Milk, and Juices	'67 and '72; '68 and '77; '70 and '76; '70 and '77; '73 and '75; '75 and '86; '78 and '85; '79 and '86	'70 and '75; '70 and '78; '70 and '79; '71 and '79; '72 and '79; '73 and '78
Whole Milk, Lowfat Milk, and Other Beverages	'75 and '86; '78 and '85; '79 and '86	'67 and '85; '67 and '86; '74 and '84; '74 and '85; '74 and '86; '75 and '85
Lowfat Milk, Juices, and Other Beverages	'74 and '77; '75 and '77; '76 and '79; '76 and '84	'84 and '86

Table A.1 Continued.

Grouping	Unadjusted Data Location of Violations	Adjusted Data Location of Violations
Whole Milk, Juices, and Other Beverages	----	'69 and '70
Whole Milk and Lowfat Milk	----	----
Lowfat Milk and Juices	'76 and '78; '77 and '81; '82 and '84	'67 and '83; '68 and '80; '68 and '82; '68 and '84; '68 and '85; '69 and '82; '69 and '84; '69 and '85; '70 and '83; '71 and '83; '72 and '75; '72 and '80; '72 and '82; '72 and '83; '73 and '80; '73 and '82; '73 and '84; '73 and '85; '74 and '82; '74 and '84; '74 and '85; '75 and '80; '75 and '83; '75 and '85; '76 and '83; '77 and '82; '77 and '84; '77 and '85
Whole Milk and Juices	'74 and '75; '85 and '86	'70 and '73; '70 and '78; '70 and '79; '71 and '78; '70 and '79; '72 and '78; '72 and '79; '73 and '78; '73 and '79

Table A.2. Location of Violations Within Butter, Margarine, and Salad and Cooking Oils, 1967-1986.

Grouping	Unadjusted Data	Adjusted Data
	Location of Violations	Location of Violations
Butter, Margarine, and Salad and Cooking Oils	'68 and '71; '68 and '74; '68 and '75; '68 and '77; '69 and '74; '69 and '75; '69 and '77; '71 and '74	'69 and '86
Margarine and Salad and Cooking Oils	----	'69 and '83
Butter and Salad and Cooking Oils	'68 and '74; '68 and '75; '68 and '77; '69 and '74; '69 and '75; '70 and '73; '71 and '74	'67 and '71; '67 and '81; '69 and '86
Butter and Margarine	'74 and '77; '74 and '78; '74 and '83; '74 and '84; '75 and '80; '83 and '84	'67 and '79; '68 and '80; '69 and '73; '73 and '81; '82 and '84

THE UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION
KNOXVILLE, TENNESSEE 37996-4500

E11-0415-00-014-92

Agricultural Committee, Board of Trustees
Joseph E. Johnson, President of the University;
Amon Carter Evans, Chairman;
L. H. Ivy, Commissioner of Agriculture, Vice Chairman;
Houston Gordon, R. B. Hailey, William Johnson, Jack Dalton;
D. M. Gossett, Vice President for Agriculture

STATION OFFICERS

Administration

Joseph E. Johnson, President
D. M. Gossett, Vice President for Agriculture
D. O. Richardson, Dean
T. H. Klindt, Associate Dean
J. I. Sewell, Associate Dean
William L. Sanders, Statistician

Department Heads

H. Williamson, Jr., Agricultural Economics and Rural Sociology
Fred D. Tompkins, Agricultural Engineering
K. R. Robbins, Animal Science
Bonnie P. Riechert, Communications
Carroll J. Southards, Entomology and Plant Pathology
Hugh O. Jaynes, Food Technology and Science
George T. Weaver, Forestry, Wildlife, and Fisheries
James D. Moran III (Associate Dean), Human Ecology
G. D. Crater, Ornamental Horticulture and Landscape Design
John E. Foss, Plant and Soil Science

BRANCH STATIONS

Ames Plantation, Grand Junction, James M. Anderson, Superintendent
Dairy Experiment Station, Lewisburg, H. H. Dowlen, Superintendent
Forestry Experiment Station: Locations at Oak Ridge, Tullahoma,
and Wartburg, Richard M. Evans, Superintendent
Highland Rim Experiment Station, Springfield, D. O. Onks, Superintendent
Knoxville Experiment Station, Knoxville, John Hodges III, Superintendent
Martin Experiment Station, Martin, H. A. Henderson, Superintendent
Middle Tennessee Experiment Station, Spring Hill, J. W. High Jr., Superintendent
Milan Experiment Station, Milan, John F. Bradley, Superintendent
Plateau Experiment Station, Crossville, R. D. Freeland, Superintendent
Tobacco Experiment Station, Greeneville, Philip P. Hunter, Superintendent
West Tennessee Experiment Station, Jackson, James F. Brown, Superintendent

Printed on recycled paper