THE DEMAND FOR BUTTER, MARGARINE, AND OILS: A NONPARAMETRIC TEST FOR EVIDENCE OF STRUCTURAL CHANGE

Kim Jensen and Scott Bevins

Abstract

The objective of this study was to determine whether structural change in the demand for butter, margarine, and salad and cooking oils occurred between 1967 and 1986. A nonparametric method, which does not require that a functional form be imposed on the data, was used to test for violations from stable, well-behaved preferences. Violations were found, but they were small in magnitude. Therefore, the results failed to show strong evidence that consumption patterns for butter, margarine, and oils were inconsistent with stable preferences.

Key words: fats and oils demand, structural change, nonparametric testing

Since the 1960s, per capita consumption of butter has declined, while the per capita consumption of margarine has remained fairly constant. During this same time period, per capita consumption of salad and cooking oils, consisting of vegetable oils, has increased markedly. Consumer concerns about cholesterol and saturated fats intake have been cited as a primary contributor to the changing consumption patterns for butter and other dairy products in the United States (Haidacher, Blaylock, and Meyers; 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 influence the demand for vegetable oils and shortenings positively and influence the demand for butter and lard negatively. The older segment of the population was found to consume more butter, perhaps due to consumption habits fixed prior to heightened health concerns about saturated fats intake. Heien and Wessells also found that demographic changes have impacted the demand for butter negatively. In addition, results from their study showed that a decreasing proportion of meals eaten at home have a negative impact on the demand for butter.

Changing consumption patterns and the results from the aforementioned studies tend to suggest that there may be structural change occurring in the demand for butter, margarine, and oils. While overall fats consumption has been increasing, consumption of butter has declined. Demographic impacts measured in previous studies of demand show that as the demographics of the population continue to change, butter demand may decline and margarine and oils demand may increase. Finally, as a larger proportion of food expenditures occur away from home, the demand for butter may decline.

Although each of these trends may reflect structural change in the demand for butter, margarine, and oils, further evidence supported with empirical tests for structural change is needed. Therefore, the objective of this study was to evaluate whether or not structural change has occurred in the demand for butter, margarine, and oils. Evidence of structural change implies that static models of the demand for butter, margarine, and oils, which incorporate only prices and expenditures, are inadequate for explaining changes in consumption. If the data violated restrictions implied by stable, well-behaved preferences, this provided evidence of possible structural change.

METHODOLOGY

Evidence of structural change in demand may come from a number of parametric and nonparametric methods. Parametric tests may be performed on demand models with estimated parameters that are invariant with respect to time. If the estimated static model proves to be inadequate based on the test criterion, this is used as evidence of structural change. Examples include use of results from the Chow test as evidence or use of results from autocorrelation diagnostics as evidence. Time-varying parameters may also be included in a model and then tested for significance (see Choi and Sosin).

Use of parametric tests is problematic, as Chalfant and Alston pointed out, because these tests rely upon

Kim Jenson is an Assistant Professor and Scott Bevins is a Research Assistant in the Department of Agricultural Economics and Rural Sociology, University of Tennessee, Knoxville.

the assumption that the functional form selected for use in the estimated demand system is the correct specification. Therefore, the test is actually of a joint hypothesis of stability and functional form. However, selection of the incorrect functional form can produce results that give the appearance of structural change. To avoid the limitations resulting from testing a joint hypothesis, a nonparametric test for structural change was used in this study. The nonparametric test does not require that a functional form be imposed on the data *a priori*.

In order to test for the stability of demand, the null hypothesis is that observed data conform to the restrictions implied by stable, well-behaved preferences (Chalfant and Alston; Varian 1983). Given that the data, consisting of prices and consumption quantities, adhere to the behavior of a stable demand function, then the data should not violate the criteria set forth in either the Weak Axiom of Revealed Preference (WARP) or the Strong Axiom of Revealed Preference (SARP). Violation of WARP and SARP suggests that factors other than changes in prices and expenditure, such as structural change factors, have influenced consumption patterns.

Suppose that the cost of purchasing bundle **a** is represented by $\mathbf{P_a}'\mathbf{Q_a}$ or Φ_{aa}, where $\mathbf{P_a}$ is a vector of prices for bundle **a** and $\mathbf{Q_a}$ is the quantity vector for bundle **a**. Let **a** be a bundle of **N** goods purchased in a given time period, and **b** be a bundle of **N** goods purchased in another time period. If bundle **b** was affordable at period **a** prices, but bundle **a** was selected instead, then bundle **a** is revealed preferred to any other bundle **b** (denoted **a***R***b**), because Φ_{ab} represents the cost of purchasing bundle **b** at time period **a**'s prices, when $\Phi_{aa} > \Phi_{ab}$, **a***R***b**. Given that the data behave according to WARP, then **b** will never be revealed preferred to **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).

When the number of bundles to be tested is greater than two, then it is also necessary to test for consistency with the Strong Axiom of Revealed Preference. Consistency with SARP implies transitivity of preferences such that if **a***R***b** and **b***R***c**, then **a***R***c**. For example, if **a***R***b**, **b***R***c**, and **c***R***a**, there is intransitivity of preferences. Satisfaction of SARP reflects nonintersecting indifference curves.

Consistency of consumption behavior with WARP and SARP can be tested using a matrix, Φ. An example matrix for bundles **a**,**b**, and **c** is as follows:

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

An alternative representation of Φ, suggested in Chalfant and Alston, is found by dividing each element of the matrix by the main diagonal element in the same row. For example, each element in the row with Φ_{aa}, would be divided by Φ_{aa}. Comparisons of the affordability of the bundle actually purchased at **a**, with alternative bundles, **b** and **c**, can be made from this matrix. Each quotient can be restated for purposes of brevity. For example,

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

When $\Gamma_{ab/aa}$ is less than one, the bundle purchased at time **b** was affordable at time period **a**, although it was not actually purchased at time period **a**.

A disproportionate number of elements of the Γ matrix with values greater than one either above the diagonal or below the diagonal indicates a large increase in expenditures or a large decrease in expenditures. If real expenditures are increasing over time, then the cost of purchasing the later bundles in the earlier time period's prices should be greater than actual expenditures in the earlier time period. Hence, there will be a large number of elements with values greater than one above the diagonal.

Evidence of substitution effects may be diminished when there is a strong trend in expenditures (Pitts and Herlihy). Chalfant and Alston suggest adjusting the data if there is evidence of a strong trend in expenditures. The percentage difference between real 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.[1] The adjusted quantities should lie along closer budget lines. Therefore, these budget lines may cross.

Selection of the commodities to be included in the group is of great importance. A potential source of error, beyond mathematical form selected for a demand function, is selecting the incorrect grouping of commodities chosen for the test. Use of an incorrect grouping could also produce results that appear as structural change. Therefore, in this study, subgroupings of data, generated by deleting each one of the commodities in turn, were also tested for violations of WARP and SARP.

[1] Use of the adjusted real expenditures implies assumption of an expenditure elasticity of one.

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

For this analysis, U.S. per capita consumption for each of the commodities was taken from *Food Consumption, Prices, and Expenditures, 1964-88.* Per capita consumption of fats and oils was expressed in pounds per year.[2] Price series were derived by extending prices of the commodities within a single year using price indices for each of the respective commodities. Prices were from *Food Consumption: Households in the U.S., Seasons and Year 1977-78.* Price Indices were from *Food Consumption, Prices, and Expenditures, 1964-88* and the U.S. Bureau of Labor Statistics. Real expenditures were calculated by deflating prices with the Consumer Price Index (1982-84 = 100).

The matrices Γ were calculated for each of the possible subgroupings of butter, margarine, and salad and cooking oils. Using these matrices, tests were performed for violation of WARP and SARP within each subgrouping. Each matrix was dimensioned i =1...20 and j=1...20, because the years 1967 through 1986 were used. When there was evidence of a strong trend in real expenditures, the adjusted data were tested for violations.

RESULTS

Summarized results from the nonparametric tests of the fats and oils data are displayed in Tables 1 and 2.[3] Results from tests of each of the subgroupings are included to show the impact of deleting each of the commodities upon the occurrence of violations. Each table is divided into two sections, one displaying the analyses of the unadjusted data, while the other section presents analyses of the adjusted data.

The number of elements above and below the diagonal with values greater than one is presented in Table 1. The number of violations of WARP and whether the data are consistent with SARP are also presented in Table 1. Each occurrence of a situation such as **a*R*b** and **b*R*a** is counted as one violation of WARP. Table 1 also displays the location and size of the largest violation of WARP in the data series. The pairs of ratios constituting the largest violation of the Weak Axiom are presented by row and column.[4] The locations of the violations are presented in Table 2.

As reflected in the number of elements greater than one above the diagonal of each of the Γ matrices in which salad and cooking oils were included, there has been strong upward growth in expenditures on salad and cooking oils (Table 1). The group containing butter, margarine, and salad and cooking oils exhibited 166 elements having values greater than one above the diagonal; the group excluding butter exhibited 181; and the group excluding margarine exhibited 166. When salad and cooking oils were

[2] Since average per capita consumption was used, the analysis is limited to testing for violations from stable well-behaved preference on the part of an "average" or "representative" consumer.

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

[4] Suppose a violation occurs between the pair of years 1968 and 1985. The ratios would be presented in the order $\Gamma_{'68,'85/'68,'68} = P_{'68}'Q_{'85} / P_{'68}'Q_{'68}$ followed by $\Gamma_{'85,'68/'85,'85} = P_{'85}'Q_{'68} / P_{'85}' Q_{'85}$.

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

Grouping	Unadjusted Data: Location of Violations	Adjusted Data: 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
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
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 '83
Margarine and Salad and Cooking Oils	—	'69 and '83

omitted from the grouping the number of elements greater than one above the diagonal decreased to 53. Given the strong growth in expenditures on salad and cooking oils, and the downward trend in expenditures on butter, the adjusted data were also tested.

The tests reveal eight violations of WARP in the unadjusted matrix of the group containing butter, margarine, and salad and cooking oils. The violations of WARP were 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 (Table 2). While there were eight violations, each violation was by less than 2 percent.

With the exception of butter, when each of the fats and oils was deleted, the existing group still violated WARP and SARP. When margarine was excluded, there were seven violations. If salad and cooking oils were excluded, there were six violations. Although there were violations in each of the unadjusted groupings, except the grouping of margarine and salad and cooking oils, none of the violations was by more than 2 percent.

The groups of adjusted data exhibited few violations, except for the group that excluded salad and cooking oils. The group excluding salad and cooking oils exhibited five violations. Presented in Table 2, the violations occurred for the pairings 1967 and 1979, 1968 and 1980, 1969 and 1973, 1973 and 1981, and 1982 and 1984. The largest violation, consisting of the ratios .9872 and .9998, occured between 1969 and 1973 (Table 1). All of the violations in any of the adjusted groupings of fats and oils were by less than 2 percent.

The results from the adjusted data should be interpreted with some caution because these results rely on the assumption of a unitary expenditure elasticity. This assumption may not be accurate. Notably, the unadjusted and adjusted expenditures on butter, margarine, and oils increased over the sample period. Therefore, the adjustment appears not to have reduced adequately the quantities consumed of butter, margarine, and salad and cooking oils. The unadjusted expenditures on butter and margarine decreased over the sample period, while the adjusted expenditures increased. This suggests that the adjusted consumption quantities were too large.

CONCLUSIONS

Results from past studies have suggested that factors other than prices and expenditures strongly influence the demand for butter, margarine, and other oils. These factors include changing demographics, lifestyles, and health concerns. Empirical estimates from parametric studies have been used to make projections of future trends in the demand for butter and other fats. Citing factors such as growing concerns about cholesterol and saturated fats intake, changing lifestyles, increased education levels, and aging of the population, some studies have projected future declines in demand for butter and increases in demand for vegetable fats, such as margarine and salad and cooking oils.

If non-price, non-expenditure factors have a significant impact on consumer behavior, changes in these factors over time would be expected to be evidenced as structural change in the demand for butter, margarine, and salad and cooking oils. During the time period examined in this study, consumption of butter decreased, while consumption of salad and cooking oils increased. During the 1970s and 1980s, the prices of salad and cooking oils and margarine fell relative to the price of butter. However, there were violations of the restrictions implied by stable, well-behaved preferences within all of the groups containing butter consumption. The group containing margarine and salad and cooking oils consumption exhibited only one violation in the adjusted data and none in the unadjusted data. Therefore, the source of violations in the other groups was consumption patterns for butter.

If the violations in the groups containing butter are attributed to sources other than measurement error, this result could have two possible implications. One possible implication is that butter does not belong in the group with margarine or cooking oils. The other possible implication is that structural change in the demand for the other groupings may be attributable to structural changes in the demand for butter. This finding would support those from other parametric studies, such as Gould, Cox, and Perali's, which found parametric evidence of declining demand for butter.

While there were violations in the data, the violations were of fairly small magnitude. Varian (1985) and Chalfant and Alston propose that inconsistencies that are small in magnitude could be the result of measurement errors in the data. Given the small magnitude of the violations in any of the groupings, the results from the nonparametric tests provided insufficient evidence to reject strongly the hypothesis of stable preferences in any of the groupings.

REFERENCES

Chalfant, J. A. and J. M. Alston. "Accounting for Changes in Tastes." *J. Pol. Econ.*, 96(1988):391-410.

Choi, S. and K. Sosin. "Testing for Structural Change in the Demand for Meat." *Am. J. Agr. Econ., 72(1990):227-236.*

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): 212-221.

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

Heien, D. M. and C. R. Wessells. "The Demand for Dairy Products: Structure, Prediction, and Decomposition." *Am. J. Agr. Econ.*, 70(1988):219-228.

Hettinga, D. H. "Why Alter Milk Composition." *J. Dairy Sci.*, 72(1989):2790-2799.

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.* Washington D. C.: Stat. Bull. No. 773, U.S. Department of Agriculture, Economic Research Service. January 1989.

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

U.S. Department of Labor, Bureau of Labor Statistics. *Consumer Price Index,* Washington, D.C., various issues, January 1967-1988.

U.S. Department of Labor, Bureau of Labor Statistics. *Monthly Labor Review,* Washington, D.C., various issues, January 1968-1988.

Varian, H. R. "Non-parametric Tests of Consumer Behavior." *Rev. Econ. Studies,* 50(1983):99-110.

———. "Non-parametric Analysis of Optimizing Behavior with Measurement Error." *J. Econometrics,* 30(1985):445-458.