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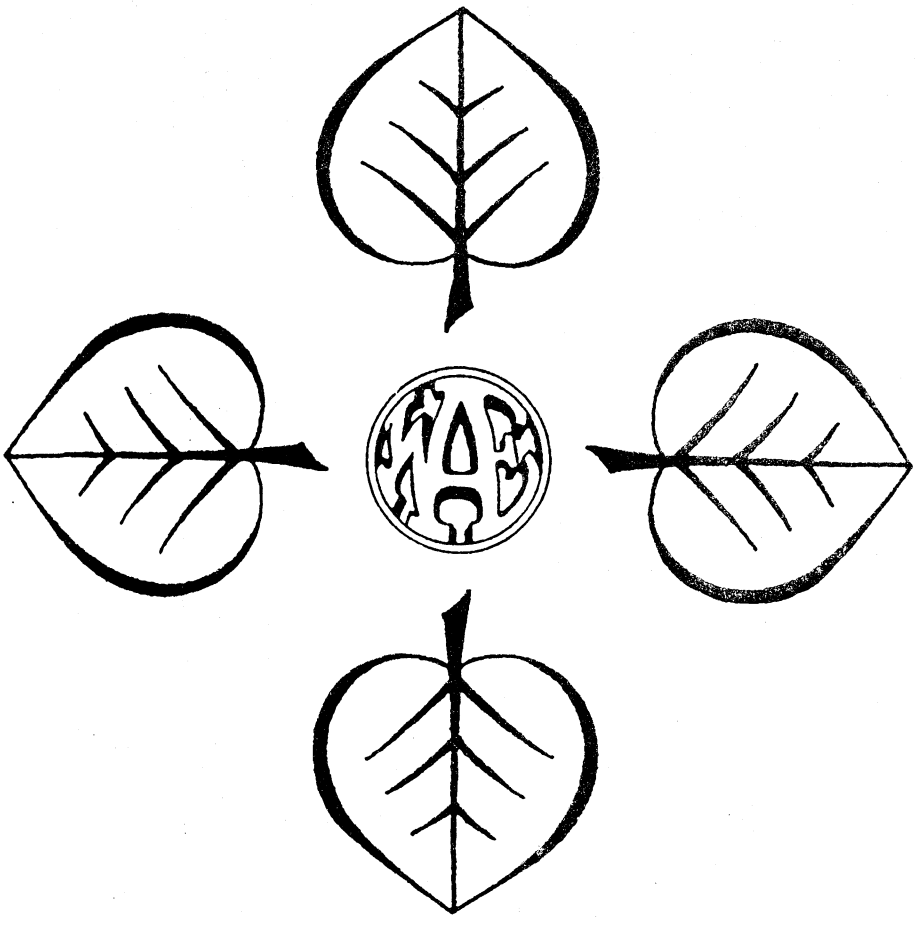

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U. S. Demand for Edible Peanuts

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Abstract

Using the cumsum squared test and data from 1965 to 1990, a structural change in the demand for edible peanuts, after the change in the peanut program in 1978, was identified. Total edible peanut demand was both price and income inelastic while elasticities varied among peanuts used in different peanut products.

Peanuts in the United States are used in food products, crushed for peanut meal and oil, and exported. The domestic food use of edible peanuts averaged 53 percent of the total use in the 1980's. Most of the peanut value in the U.S. is derived from domestic food use due to higher prices for peanuts used in the food product than the price for peanuts crushed and exported. The importance of domestic food use of peanuts is emphasized further in that it is a major component contributing to national poundage quota determination.

Estimating the demand for edible peanuts has been a focus of several studies and two general approaches have been used to estimate this demand. Song et al. and Montgomery used a single equation model to estimate the demand for edible peanuts in the U.S. as a composite commodity. In contrast, Carley, Schaub, Carley and Fletcher, and Fletcher and Carley used a multi-equation model to estimate demand for peanuts used in different peanut products for domestic food use. The multi-equation model is superior to a single equation model in which the individual demand relationships for peanuts used in the different peanut product can be estimated. This is important since peanuts used in different peanut products have different substitutes, and price and income responses of peanuts used in different peanut products could also be different.

Among the multi-equation models of demand for edible peanuts in the U.S., several important issues have not been addressed. Carley and Schaub used prices received by farmers in their demand equations. The farm price is an average price received for both domestic quota peanuts and for additionals which enter the export trade or are crushed. This price does not reflect the "true" supply-demand relationships for edible peanuts in the domestic market. The F.O.B. wholesale prices move up and down relative to the supply of domestic quota and market demand. A close relationship between prices received by farmer and prices at the wholesale level existed until 1978 (Figure 1). Then, prices at the wholesale level have fluctuated reflecting changes in demand and supply conditions while prices received by farmers move smoothly with an upward trend.

Another issue which was not addressed in Carley, Schaub, and Carley and Fletcher's study is the correlations of error terms among the demand equations for peanuts used in the different peanut products. Ordinary least squares (OLS) was used to estimate the demand equations. However, the seemingly unrelated regression (SUR) provides a more efficient estimate since the error terms across the demand equations for peanuts used in the different peanut products for domestic food use are correlated. Fletcher and Carley estimated demand for different peanut products using prices of peanuts at the manufacturer level. The demand equations were estimated simultaneously using SUR. However, the stability of coefficients of the estimated structural equations was not investigated during the estimation period (1965 to 1989).

Economic theory suggests that demand behavior is time variant. Demand relationship could vary continuously between successive time intervals as a result of episode changes in consumer tastes, advertisements, and public policy. But once the change occurs, the effect prevails and is observable over a definite time period. On the basis of the behavior of the parameters under these circumstances, a structural change is said to occur. In these instances, a "typical" time period is usually selected for analysis, and it is presupposed that the parameters of the model change a "small"

number of times within the sample period in response to forces within the model or outside of the model. If the structure has changed, the estimated equation would be a hybrid, neither applicable to the period before nor after the structural change. Yet, the equation might be incorrectly judged as acceptable according to conventional statistical tests.

The explicit recognition and parameterization of such structural changes have important implications in the peanut demand and price analysis to the extent they affect the decision made by the government policy makers and the peanut processing industry. The peanut program in the U.S. has involved in a tremendous change during the period 1965 to 1990. Structural changes in demand for edible peanuts could occur due to changes in the peanut program and/or consumer tastes.

The objective of this study was to improve the knowledge of the demand relationships for edible peanuts in the United States. The structural change on the demand for peanuts used in the different peanut product in the domestic food use was tested. The demand equations were estimated on the basis that the estimated parameters are stable in the selected sample period.

Model and Estimation Procedures

Model Specification and Data

The demand for edible peanuts is derived from the consumer demand for peanut products. Assuming that nuts (including peanuts and other nuts) are a fixed proportion in the final peanut products, demand for raw peanuts can be specified as a function of prices of final peanut products, prices of peanuts, prices of substitutes for the final peanut products and peanuts, and consumers' income. The demand for edible peanuts in this study is grouped as demand for peanuts used in peanut butter, candy, salted peanuts, roasting stocks, and other use (e.g. flour and granules). The total edible peanut demand is a summation of the demand for peanuts used in these different peanut products. Prices of the final peanut products are usually correlated with prices of peanuts and yet are not available at the aggregated level. Thus, an estimable linear demand model for peanuts used in the ith peanut products, can be represented as:

$$Q_{it} = b_i + b_i P_{it} + b_i Y_{it} + \Gamma_j P_{jt} + \epsilon_{it}$$

where Q_{it} is quantity demanded for peanuts used in product i and P_{it} is the price of peanuts used in the ith product in the t th period, respectively. Y_{it} is the income during t, P_{jt} are the prices of substitutes for peanut product i and peanuts used in producing product i (j=1,2,.... J) during t; and the error terms, ϵ_{it}.

The data in this analysis are for the marketing years 1965 to 1990 (August-July). Data on the use of primary peanut products and roasting stock peanuts were obtained from the USDA Peanut Stocks and Processing Reports. This is a report of peanut processor's use of shelled edible grade peanuts in peanut butter, salted peanuts, candy, peanut butter sandwich snacks, and other peanut products. The roasting stock data are the apparent disappearance of roasting stock peanuts (in-shell).

More than one type of peanuts is used to produce a particular type of peanut product and the quantity of peanuts used by type varies with the different peanut products. To obtain a price of peanuts used in each product, such as peanut butter, the quantity of each type of peanut used in the peanut butter in each year was multiplied by the average prices of the peanut type in that year to obtain a total value. The total value was divided by the total quantity used. Therefore, the resulting price for peanuts used in each product is a weighted price by type of peanuts.

The prices of each type of peanut used in this analysis are the average annual prices of cleaned and shelled peanuts at major shipping point in the three peanut production regions of the United States. Monthly average F.O.B. prices were obtained for medium runners in the southeast, for medium Virginias in Virginia and North Carolina, and No. 1 Spanish in the southwest (USDA Federal-State Market News, 1980-1990). Prices for Virginia fancy unshelled peanuts were used for roasting stock peanuts. The monthly prices from August to July (i.e., marketing year) were averaged

for each year. In some years monthly data were not available for every month. In those years, prices for the months available were averaged for just those months.

The average annual per capita disposable income for the U.S. population centered on January 1 was used as the income variable. Civilian population of the U.S. was used as the population variable. Price and income were adjusted to real 1982-1984 dollars using the consumer price index (CPI) for all items. To correspond with peanut price data series, the CPI for each month of the peanut marketing year, August to July, was averaged to obtain the annual CPI average for the marketing year. The quantity of peanuts used in each product in each market year was divided by the population to obtain per capita estimates of peanut consumption. The price of substitutes was not included in the estimation. The peanut butter and peanuts used in it have few substitutes. Data on prices of substitutes for candy and prices of other nuts, which could be a substitute for salted and roasting peanuts were not available. The sample statistics for the variables used in the model estimation are shown in table 1.

Identifying Points of Structural Change

Usually the points of structural change are not known precisely, yet need to be pre-specified. However, these points can be determined statistically, using a series of tests (cusum, cusum squared, and Quandt's log-likelihood) discussed in Brown, Durbin, and Evans. Among these tests cumulative sums of squared (CUSUMSQ) test is the most popular. Based on recursively computed residual, the CUSUMSQ test examines structural stability by plotting against time the values for

$$Sr = \left(\sum_{j=K+1}^{r} W_j^2\right) / \left(\sum_{j=K+1}^{T} W_j^2\right), \quad r = K+1, \ldots T;$$

where Wj's are the recursive residuals, K is the number of regressors, and T is the number of observations. The expectation of Sr, E(Sr) = (r-K)/(T-K) and the point of significance line take a form (r-K)/(T-K) $\pm$ C. The value of C is obtained from the table of significant values for CUSUMSQ test. The significance lines lie symmetrically about the mean value line, E (Sr), and when superimposed on the plot of Sr provide a basis for the test of constancy of regression. The CUSUMSQ test as well as cusum and Quandt's log-likelihood tests were applied to detect points of structural change in the demand equations for peanuts used in the different peanut products. The statistical package, TIMVAR, was used to perform these various tests.

Based on the results from the structural tests, the data set in which no structure changes occur was selected for the estimation of demand for peanuts used in the different peanut products. The five demand equations were then estimated simultaneously using SUR. The model was evaluated using mean absolute percent error (MAPE) and Theil's inequality coefficients (U_2).

Results

Plots (not included in the paper due to the page limitation) from the CUSUMSQ test indicate that the breaking points of the structural change are around 1980 for peanuts used in the peanut butter, 1979 for peanuts used in candy, 1980 for peanuts used in the salted peanut, and 1979 for peanuts used in the roasting stocks, respectively. The cusum test and Quandt's log-likelihood test show a similar result. Since the peanuts included in the other use category varies during the estimation period, no clear breaking points of the structural change were identified for peanuts used in the other category. A hypothesis that a structural change occur at 1979 was further tested by partitioning the whole data set into two sub-periods. The first period covered data from 1965 to 1978 and the second period from 1979 to 1990. OLS was run for the five demand equations in both periods. The regression results from the first period showed that all of the estimated coefficients for the peanut prices were not significantly different from zero at the 10 percent significance level. In

contrast, all but one of the estimated coefficients for the regression equation using data from 1979 to 1990 were significant at the 5 percent or less and yielded signs in accord with *a priori* expectation. These statistical results from testing structural change on demand for different peanut products were also consistent with policy changes in the peanut program. A significant change in the peanut program occurred after the Food and Agriculture Act of 1977 took effect. The peanut program switched from an acreage control to a supply management program. The market prices for edible peanuts varied with the supply condition of peanuts. Thus, peanut manufacturers faced a much more varied price after the Food and Agricultural Act of 1977.

The estimated demand equations for different peanut products using data from 1979 to 1990 are presented in table 2. They were evaluated by performing historical simulation. The values of the MAPE indicate that the model simulated the demand for peanuts used in the four major peanut products (i.e. peanut butter, salted peanuts, peanuts used in candy and roasting stocks) reasonably well with a simulation error between 3.37 to 5.06 percent. The Theil's inequality coefficient (U_2) for simulating the demand for peanuts used in the five different peanut products ranged from 0.23 to 0.74, implying that model predicated much better than a non-change prediction even with the 12.76 percent MAPE for peanuts used in the other use category.

All but one of the coefficients were statistically significant at the 5 percent significance level. The signs were as expected with all price coefficients negative except the one for peanuts used in the other category, which was not statistically significant at even the 25 percent significance level. The coefficients for the income variables were positive in accord to *a priori* expectation.

A 10 cent increase in the price of shelled peanuts would be expected to decrease the per capita demand for peanuts used in peanut butter by about 0.06 lb, salted peanuts by 0.05 lb, and roasting peanuts by 0.07 lb. Price changes would have little effect on demand for peanuts used in candy since peanuts are only one ingredient in candy. The demand for peanuts used in the other use category is solely determined by income changes.

The effects of income changes on peanut consumption vary across the different peanut products. For an increase in per capita disposable income of $1000, per capita demand for peanuts used in peanut butter increases 0.14 lb while peanuts used in salted peanuts increases 0.17 lb. For candy, roasting stocks and the other use, a $1000 increase in per capita income would expected to results in an increase in per capita demand for peanuts of 0.08 lb, 0.03 lb, and 0.04 lb, respectively.

An evaluation of the elasticities in table 2 indicates that a 10 percent increase in shelled peanut prices would reduce the demand for peanuts used in peanut butter by 1.2%, the demand for peanuts used in salted peanuts by 2%, and the demand for peanuts used as roasting stocks by 4%. Demand for peanuts in candy was the most price inelastic of the four major peanut products while roasting stock peanuts were the most price elastic. The price elasticity for total edible peanuts as an aggregated commodity was calculated as a market share weighted elasticity of individual price elasticities. This elasticity had a value of -.16, implying that demand for edible peanuts in the United States is quite price inelastic with only a 1.6% decrease in quantity demanded for a 10% increase in prices. In comparison to the Schaub's work, his price effects for peanuts used in peanut butter and salted peanuts were statistically insignificant and the peanuts used in candy had the second highest price elasticity (below roasting stock). These difference can be attributed to the price series and data period he used. Fletcher and Carley's estimation of price elasticities were similar to this study's findings except elasticity for peanuts used in candy. The price coefficient for peanuts used in candy was not statistically different from zero in their study.

The income elasticities show quite different impacts among the peanut products. The income effects on peanuts used in peanut butter and roasting stocks are the most inelastic of all the products indicating that 10% increase in income would be expected to increase demand for peanuts used in peanut butter and roasting stocks 4-5%. For a 10% change in income, the change in demand would

be 7.0% for peanuts used in candy. The coefficients of income elasticities for peanuts used salted peanuts and in the other use indicate that the demand for peanuts used in these two products is income elastic. The income elasticity for all edible peanuts, which is calculated as a market share weighted individual income elasticities for different peanut products is 0.76, implying that per capita quantity demanded for edible peanuts would increase by 7.6% with a 10% increase per capita disposable income. Schaub's income elasticities were approximately one or larger except for peanuts used in peanut butter, and roasting stocks had the highest income elasticities. This difference may be mainly attributed to Schaub not removing the population effect in his estimation, and again different peanut prices and data period he used. The estimated income elasticities for peanuts used in candy and salted peanuts in Fletcher and Carley's study were .24 and .48 , respectively. These higher elasticities related to this study's estimates may be attributed to the different time period used. The income elasticity magnitudes for peanuts used in the other peanut products in Fletcher and Carley's study are similar to those in this study.

Conclusions

The implementation of the Food and Agriculture Act of 1977 changed the supply and demand conditions for edible peanuts in the United States. These changes have resulted in different price and income responses for peanuts used in the different peanut products at the manufacturer level in the domestic food use.

Policy makers rely on the information of edible peanut demand to project the domestic food use, which in turn is utilized in determining the peanut quota level, to assess welfare effects of the peanut program on growers, consumers, and taxpayers, and to evaluate potential impacts of changes in the peanut program. The peanut processing industry uses the same information for purchasing, inventory, marketing, and pricing decisions. When policy makers and peanut manufacturing industry use the information, they should be aware of the structural change in demand for edible peanuts. The estimates of the demand relationship for edible peanuts in this study may suffer from a lack of information on prices of the substitutes for both peanuts and the final peanut products. Still, this study has improved the previous estimates of demand for edible peanuts in the United States.

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Table 1. Variable Means for Peanut Food Products, United States, 1979 to 1990 Marketing Years

Variable	Unit of measurement[b]	Mean value
Peanut butter[a]	pounds per capita	3.10
Candy	pounds per capita	1.24
Salted peanuts	pounds per capita	1.37
Roasting stock (unshelled)	pounds per capita	.86
Other uses	pounds per capita	.11
Shelled price - peanut butter	dollar per pound	.59
Shelled price - candy	dollar per pound	.60
Shelled price - salted peanuts	dollar per pound	.60
In-shell price - roasting	dollar per pound	.50
Shelled price - other uses	dollar per pound	.59
Disposable income	1000 dollars per capita	11.08

a. Includes peanut butter used in sandwiches and sandwich snacks.
b. Price and income data were adjusted to real 1982-84 dollars using the CPI for all items.

Table 2. Estimated Regression Coefficients and Elasticities Explaining Per Capita Demand for Peanut Food Products, United States, 1979 to 1990 Marketing Years

	Coefficients			Model evaluation		Elasticities	
Peanut product	Constant	Price	Income	MAPE	U_2	Price	Income
Peanut butter[a]	1.956** (.641)[b]	-.637** (.191)	.137** (0.056)	4.42	0.52	-.12	.49
Candy	.483** (.198)	-.172** (.054)	.078** (.017)	3.37	0.66	-.08	.70
Salted peanuts	-.201 (.323)	-.454** (.096)	.170** (.028)	5.06	0.48	-.20	1.34
Roasting stock	.838** (.202)	-.700** (.056)	.033* (.018)	4.68	0.23	-.40	.42
Other use	-0.371** (.075)	.025 (.268)	.042** (.043)	12.7	0.74	---	4.21

a. Includes peanut butter used in sandwiches and sandwich snacks.
b. Standard errors are in parentheses.
** Significant at the .01 level.
* Significant at the .05 level.

Figure 1. Annual Average Prices for Selected Grades of Shelled Peanuts at Major Shipping Points and Prices of Farmers' Stock Peanuts Received by Farmers, 1965 to 90