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NATIONAL AND REGIONAL HOUSEHOLD DEMANDS FOR MEATS AND SEAFOOD IN THE U.S.: A COMPLETE SYSTEMS APPROACH

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ABSTRACT

A complete systems approach is employed to identify and evaluate the factors which affect the at-home consumption of meats and seafood in the U.S. Brown and Heien's S_1-branch system is estimated using a full information maximum likelihood algorithm. The source of data is the 1972-73 BLS Consumer Expenditure Survey.

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Introduction

Rampant increases in the prices of food and nonfood items, dramatic changes in lifestyles, and salient changes in household characteristics distinguish to some extent the 70's and, thus far the 80's, from past decades. The purpose of this paper is to present a complete demand systems approach to identify and assess the factors which affect the at-home consumption of various meats and seafood in the U.S. Special attention is given to meats and seafood since these commodities generally account for 25 to 30 percent of each food dollar in the consumer's budget. The next section of this paper deals with the empirical model, the data base, and the estimation procedure. The third section contains the statistical results and the economic analyses. Concluding comments follow in the fourth section.

The Empirical Model, the Data Base, and the Estimation Procedure

The Empirical Model

The S_1-branch system [5] is employed which permits a fine classification of commodities where other systems allow only a broad classification. The utility function for the S_1-branch system is given by:

$$U = \sum_{s=1}^{S} \left[\sum_{j \in s}^{G_s} \beta_{sj} (q_{sj} - \gamma_{sj})^{\rho_s} \right]^{w_s/\rho_s}, \text{ where } \sum_{s=1}^{S} w_s = 1 \qquad (1)$$

U is strongly separable with respect to the branches $G_1,\ldots,G_s$. The marginal rate of substitution between any two goods in different branches is independent of any goods from other branches.

The set of demand functions attributable to the constrained maximization of U is given by:

$$q_{si} = \gamma_{si} + \left(\frac{\beta_{si}}{p_{si}}\right)^{\sigma_s} \left(\sum_{j\varepsilon s}^{G_s} \left(\frac{\beta_{sj}}{p_{sj}}\right)^{\sigma_s} p_{sj} \right)^{-1} w_s \left(y - \sum_{r=1}^{S} \sum_{j\varepsilon r}^{G_r} p_{rj}\, \gamma_{rj} \right) \quad (2)$$

γ_{si} is a "subsistence," or "threshold" quantity parameter for good i within group G_s. $(p_{si}\gamma_{si})$ represents the expenditure for this basic level of consumption. The remaining income, the supernumerary income, is allocated to the various commodities. w_s denotes the share of the supernumerary income to the supernumerary commodities, $(q_{si}-\gamma_{si})$, in group G_s. β_{si} reflects the importance of particular commodities within branches in the generation of utility. The branch elasticities of substitution, $\sigma_1,\ldots,\sigma_s$, indicate the degree of substitutability among commodities in the particular branch of interest.[1] The following restrictions apply: $w_s>0$, $\beta_{si}>0$, $(q_{si}-\gamma_{si})>0$, and $\sigma_s>0$ for all i,s.

Commodities included in the branches are: branch 1--ground beef, roasts, steaks, pork, poultry, other meats, and seafood; branch 2--food away from home and other foods; and branch 3--fuels for home heating and gasoline. Other foods is an aggregate commodity which consists of cereal and bakery products, dairy products, prepared food, fruits, and vegetables. Commodities were assigned into separable groups on an intuitive basis.

To bring household characteristics into the S_1-branch system, the "translating" technique of Pollak and Wales [11] is employed. Socioeconomic and demographic factors operate through a particular subset of the parameters of the demand functions, and the functional form relating these parameters to the household characteristics is specified.[2]

The socioeconomic and demographic characteristics are regions, location of residence, and family size. The regions considered are the Northeast, North Central, South, and West. Location of residence is represented by SMSA's of one million and over, 400,000-999,999, 50,000-399,999, and urban and rural areas outside SMSA's. The family size and location of residence factors are incorporated in the S_1-branch system by formulating the following linear function:

$$\gamma_{si}=\tau_{0si}+\tau_{1si}D_1+\tau_{2si}D_2+\tau_{3si}D_3+\tau_{4si}\text{Famsize for all si, } i\varepsilon G_s, s=1,\ldots,S \quad (3)$$

where

$$D_1 = \begin{matrix}1 \text{ if household in SMSA with population 1,000,000 and over}\\ 0 \text{ otherwise}\end{matrix}$$

$$D_2 = \begin{matrix}1 \text{ if household in SMSA with population 400,000-999,999}\\ 0 \text{ otherwise}\end{matrix}$$

$$D_3 = \begin{matrix}1 \text{ if household in SMSA with population 50,000-399,999}\\ 0 \text{ otherwise}\end{matrix}$$

Famsize = family size

The Data Base

The source of data is the 1972-73 Bureau of Labor Statistics Consumer Expenditure Survey. The data sample includes the following: (1) households which report the socioeconomic and demographic characteristics

of family size, location of residence, and region; (2) households which report expenditures of at least one meat and seafood commodity; and (3) households which report expenditures of food away from home, other foods, fuels for home heating, and gasoline. Due to the unavailability of household budget data for housing, medical services, durables, and other items, these goods and services are ignored. The total number of observations in the sample is 4041. However, for the purpose of validation, this sample is decomposed into two random samples of almost equal size. Implicit prices for meats and seafood are derived from expenditure and quantity data compiled in the survey. Price indices are employed for gasoline, fuels for home heating, food away from home, and other foods due to the unavailability of quantity data for these commodities.

The Estimation Procedure

The S_1-branch system is a complete set of highly nonlinear demand functions. Let e_{si} denote the disturbance term of the i^{th} demand equation in the s^{th} branch. It is assumed that $E(e_{si})=0$ and $E(e_{si}e_{rj})=w_{si,rj}$. Non-zero contemporaneous covariances both between errors for commodities in the same branch and between errors for commodities from different branches are permitted. The variance-covariance matrix of the disturbance terms is given by $\Omega=[w_{si,rj}]$, and in this system, Ω is singular.

To take into account parameter nonlinearity, cross-equation correlation, and variance-covariance singularity of the error terms, a full information maximum likelihood (FIML) algorithm written by Bard [1] is employed. To overcome the singularity of Ω, one commodity is deleted

from the commodity set, and the Bard algorithm maximizes the likelihood function associated with the remaining n-1 commodities.[3] Several researchers [2,5,11] have demonstrated that the final parameter estimates are invariant with respect to the deletion of any particular commodity. The set of parameter estimates satisfies the likelihood equation with probability one as $n \to \infty$, converges in probability to the true set of parameters, and possesses the BAN (best asymptotically normal) property.

Statistical Results and Economic Analyses

For each of the random samples, estimates are obtained of own-price and cross-price elasticities, income elasticities, family size elasticities, marginal budget shares, and systems parameters for regions of the U.S. and the U.S. as a whole.[4] Although the patterns are similar, a different set of estimates is associated with each region. With such a mass of results, it is next to impossible to discuss meaningful relationships in great detail. For conciseness, this paper concentrates only on certain general points.

The own-price elasticities for the commodities for the respective samples and regions are exhibited in Table 1. All the direct-price coefficients are negative in conjunction with theoretical expectations. In particular, the own-price elasticities for the meat and seafood commodities and for food away from home exceed unity. Consequently, price increases lead to more than equivalent reductions in purchases at the retail level. Such elastic responses may be attributable in part to the level of disaggregation of the commodities and to the type of data.

Table 1. Own-Price Elasticities; S_1 Branch System; With Household Characteristics.[a]

	U.S.		Northeast Region		North Central Region		South		West	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
Ground Beef	-1.8073	-1.4876	-1.7896	-1.7559	-1.5207	-1.3785	-1.6280	-1.5969	-1.3672	-1.3130
Steaks	-1.7794	-1.7826	-1.4398	-1.7397	-1.8175	-1.8671	-1.8822	-1.6307	-1.4771	-1.7690
Roasts	-1.9940	-1.7804	-1.6846	-1.8662	-2.0096	-1.8051	-1.5975	-1.8246	-2.0579	-1.8890
Poultry	-1.1348	-1.291	-1.2572	-1.2484	-1.1674	-1.2812	-1.3179	-1.2631	-1.2788	-1.3822
Pork	- .8201	-1.4553	-1.7197	-1.4715	-1.1406	-1.4464	-1.5654	-1.5079	- .6712	-1.7290
Other Meats	-1.2693	-1.3618	-1.5473	-1.4194	-1.4159	-1.3683	-1.5010	- .9687	-1.3907	-1.6400
Seafood	-1.8168	-2.5164	-2.0598	-1.7716	-2.5414	-1.5881	-2.5868	-2.7956	-1.3689	-1.8055
Food Away From Home	-1.2924	-1.214	-1.1894	-1.3638	-1.3606	-1.1088	-1.1766	-1.2144	-1.1042	-1.2068
Other Foods	- .94609	- .94568	- .91695	-1.0209	- .9526	- .90980	- .93382	- .95688	- .90401	- .88308
Gas, Electricity, and Other Fuels	- .82619	- .85046	- .9334	- .93798	- .9287	- .89778	- .88826	- .83694	- .90173	-1.0124
Gasoline	- .70328	- .75669	- .92676	- .87132	- .83089	- .70467	- .80272	- .88438	- .85557	- .96969

Source: [6].

[a]Since the variances of the sampling distributions of these elasticities have not been explicitly derived, the investigation of their statistical reliability through formal tests of significance is precluded.

Estimates based on cross-sectional data typically represent long-run behavior, and the level of disaggregation of the meat and seafood products increases the number of substitutable products. Specifically, household purchases of ground beef, steaks, roasts, and seafood are the most responsive to own-price changes.

The income elasticities for the commodities for each sample and region are shown in Table 2. Technically, in this application, the income elasticities are truly expenditure elasticities. All the income coefficients are positive which indicates the various commodities are normal goods. Further, the income elasticities for the meat and seafood products and food away from home exceed unity. Hence, these commodities are superior goods since households' expenditures on such items increase more than proportionately with increases in income. Interestingly, the same commodities that are the most responsive to own-price changes (ground beef, steaks, roasts, and seafood) are also the most responsive to income changes.

The influence of substitutes and complements is for the most part weak. The various meat and seafood products are net substitutes and interchange probably occurs for the sake of variety and economy. Food consumed away from home is a net substitute for ground beef, steaks, roasts, poultry, pork, and other meats consumed at home. On the other hand, food consumed away from home is a net complement for seafood consumed at home. Other foods are net substitutes for the meat and seafood commodities. However, the consumption of the meat and seafood products are independent of changes in the prices of fuels for home heating and

Table 2. Income Elasticities; S_1 Branch System; With Household Characteristics.[a]

	U.S.		Northeast Region		North Central Region		South		West	
	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2	Sample 1	Sample 2
Ground Beef	2.09101	1.13977	1.39963	1.26815	1.49423	1.10657	1.21364	1.31946	1.45406	.88941
Steaks	2.03051	1.40213	1.13531	1.28789	1.79559	1.53959	1.44499	1.36405	1.56310	1.25978
Roasts	2.28992	1.38776	1.34022	1.39786	1.99222	1.47493	1.20075	1.52325	2.20909	1.29974
Poultry	1.27419	1.00233	.991553	.91559	1.13237	1.04099	.99991	1.04710	1.34241	.965370
Pork	.92379	1.13666	1.38423	1.08556	1.10515	1.18718	1.20061	.78742	.69684	1.21657
Other Meats	1.47155	1.0371	1.21336	1.02695	1.39034	1.09306	1.11092	1.26563	1.48466	1.11062
Seafood	2.13639	1.92366	1.60484	1.26389	2.51582	1.25667	1.92137	2.32105	1.46783	1.20934
Food Away From Home	1.03111	1.13973	1.13734	1.20550	1.15179	1.11356	1.11799	1.08524	1.01674	1.26802
Other Foods	.714856	.843673	.830898	.858145	.752853	.869376	.846599	.818664	.795724	.861472
Gas, Electricity, and Other Fuels	.770961	.897649	.881467	.907620	.808927	.928376	.90380	.848699	.848424	.894873
Gasoline	.802578	.915345	.953765	.920062	.773167	.819899	.927310	.977545	.857741	.841111

Source: [6].

[a]Since the variances of the sampling distributions of these elasticities have not been explicitly derived, the investigation of their statistical reliability through formal tests of significance is precluded.

gasoline. Since energy prices have risen sharply over the past few years, more perspective in regard to consumer purchases of meats and seafood in response to such price changes may be in order.

Between 1960 and 1976, average household size in the U.S. fell from 3.33 to 2.91 persons, and available evidence substantiates the persistence of this trend. With reductions in household size, consumers generally purchase less ground beef and poultry, and they consume more steaks, roasts, pork, other meats, seafood, and food away from home. Household purchases of steaks, roasts, seafood, and food away from home are the most sensitive to changes in household size.

The influence of location of residence on the household consumption of meat and seafood products and food away from home is not so clear cut. Although location of residence affects such household consumption patterns, the trends are not uniform across the U.S. The marginal budget shares stipulate the amount consumers spend on the consumption of goods and services with the receipt of an extra dollar of income. Out of unit increases in income, households allocate 6.8 (8.1) to 11.4 (11.2) cents for meat and seafood products, 4.8 (5.0) to 7.2 (7.0) cents for away-from-home consumption, 4.5 (4.6) to 6.9 (6.5) cents for other foods, 9.3 (9.2) to 12.3 (11.1) cents for fuels for home heating and gasoline, and 62.2 to 74.8 cents for savings and for other goods and services.

Since a complete system of elasticities of the commodities is at hand, knowledge of the magnitude and direction of retail price changes, income changes, and changes in household characteristics allows a determination of the commodities that fair best or worst in terms of quantities

demanded and total revenue. To project changes in quantities demanded and total revenue on the basis of calculated coefficients, appropriate assumptions about changes in exogenous forces are necessary. This application stipulates that the changes in prices, incomes, and family size occurring from January 1978 to July 1979 will persist.[5]

The percentage changes in quantities demanded of meat and seafood commodities and food away from home and the percentage changes in total revenue are depicted in Table 3. Consumers shift away to some degree from purchases of food away from home, ground beef, steaks, roasts, and other meats to purchases of poultry, pork, and seafood. The total revenue to retailers from sales of steaks, poultry, pork, other meats, seafood, and food away from home increases, while the total revenue to retailers from sales of ground beef and roasts decreases. Pork, poultry, and seafood fair best in terms of quantities demanded and total revenue, whereas ground beef and roasts fair worst. The analysis indicates a dramatic decrease in the at-home consumption of beef, a slight decrease in the at-home consumption of other meats and in food consumed away from home, and a slight increase in the at-home consumption of pork, poultry, and seafood for the short term. Such shifts in consumer demands may potentially effect adjustments in the meat and seafood industry. The severity of the adjustments depends on whether the demand shifts are permanent or ephemeral and on the points of location on the beef and pork cycles. The growth in the food away from home market may not reach the record levels set in the past. Competition may intensify among establishments with the likely result of an increase in market share by multi-unit firms.

Table 3. Percentage Changes in Quantities Demanded of Meat and Seafood Commodities and Food Away From Home and Percentage Changes in Total Revenue.

	U.S.		Northeast Region		North Central Region		South		West	
	QD[a]	TR[b]	QD	TR	QD	TR	QD	TR	QD	TR
Ground Beef	-36.0 to -40.3	-14.7 to -20.4	-43.7 to -44.0	-25.0 to -25.4	-36.2 to -37.0	-15.0 to -16.0	-37.0 to -39.4	-16.0 to -19.2	-33.0 to -35.9	-10.7 to -14.6
Steaks	-13.9 to -17.2	.4 to 4.4	-12.5 to -14.5	3.6 to 6.1	-15.3 to -15.7	2.2 to 2.7	-15.4 to -18.5	-1.2 to 2.5	-13.1 to -19.1	-1.9 to 5.3
Roasts	-30.3 to -30.5	-10.8 to -11.0	-30.1 to -30.8	-10.5 to -11.4	-29.0 to -34.2	-9.1 to -15.8	-27.2 to -31.5	-6.8 to -12.3	-31.5 to -33.1	-12.3 to -14.4
Poultry	1.5 to 2.4	9.7 to 10.7	1.6 to 2.5	9.8 to 10.8	.8 to 3.0	9.0 to 11.3	2.5	10.8	1.4 to 2.9	9.6 to 11.2
Pork	1.9 to 8.7	7.4 to 14.6	9.2 to 9.4	15.1 to 15.3	2.8 to 7.6	8.4 to 13.4	7.9 to 10.2	13.7 to 16.2	0.0 to 10.6	5.4 to 16.6
Other Meats	-.8 to -4.4	8.7 to 12.8	-3.3 to -3.7	9.5 to 9.9	-2.3 to -5.4	7.6 to 11.1	-4.7 to -7.2	5.5 to 8.4	-2.3 to -8.1	4.5 to 11.1
Seafood	-1.3 to -4.2	6.3 to 12.2	1.7 to 2.8	9.5 to 10.7	-.8 to 2.3	6.8 to 10.2	3.8 to 3.9	11.8 to 11.9	-4.9 to -6.7	2.7 to 12.3
Food Away From Home	-4.5 to -6.8	7.5 to 10.1	-6.6 to -7.6	6.5 to 7.7	-5.9 to -6.5	7.8 to 8.5	-6.4 to -6.9	7.3 to 7.9	-0.6 to 0.0	7.6 to 9.7

Source: [6].

[a] Quantity demanded.

[b] Total revenue.

Concluding Comments

The S_1-branch system appears to present a realistic picture of national and regional demand patterns for meats and seafood in the U.S. However, the own-price, and income elasticities of this complete system are in disagreement to some extent with the own-price and income elasticities of the popular George and King [8] and Brandow [4] studies. The demand for the meat and seafood commodities are sensitive to own-price changes, income changes, and family size changes. The influence of substitutes and complements, regions, and location of residence, although of import, in terms of magnitude are of less consequence. Energy price changes have hardly any influence on the consumption of the respective meat and seafood commodities and food consumed away from home. Overall, the paper provides potentially useful information for the meat and seafood industry and to some degree the food services sector.

FOOTNOTES

[1]The parameters $\rho_1,\ldots,\rho_s$ in U are related to $\sigma_1,\ldots,\sigma_s$ as follows: $\rho_s = 1 - 1/\sigma_s$.

[2]A second approach, advanced by Lau, Lin, and Yotopoulos [9] and Parks and Barten [10], stipulates embedding household characteristics into the utility function.

[3]The Bard program employs the Davidon-Fletcher-Powell method [7] of the maximization of the likelihood function. Several practitioners [3,7] have presented proofs of a number of theorems to show that the algorithm always converges.

[4]Due to space limitations, the cross-price elasticities, family size elasticities, marginal budget shares, and systems parameters for each sample and region are not shown.

[5]The percentage changes in prices, income, and family size for this period are based on Department of Commerce statistics.

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