DEMAND FOR BEEF AND CHICKEN PRODUCTS:
SEPARABILITY AND STRUCTURAL CHANGE

by

James S. Eales
and
Laurian J. Unnevehr

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Several studies have indicated that the recent shift from beef to poultry in consumption is not entirely due to changes in relative prices or income (Braschler, Chavas, Cornell and Sorenson, Dahlgran, Hudson and Vertin, Moschini and Meilke, Nyankori and Miller, Frank, Thurman). Most studies of structural change have focused on red meat consumption; only Thurman has looked closely at the poultry market and no one has considered poultry products. Yet the mix of chicken products marketed changed dramatically during the last 20 years and should have influenced aggregate meat demand. The share of broiler slaughter marketed as whole birds declined from 74 percent in 1965 to 28 percent in 1985, while cut up parts and processed chicken products increased from 26 to 72 percent. As whole birds are inferior goods and cut-up parts and processed chicken are normal goods (Haidacher, et al.), the shift in chicken product mix away from whole birds should have caused the apparent preference for total chicken to increase.

In this paper we address two related questions. First, do consumers allocate expenditures among meats by animal origin or by product type in making consumption decisions? Second, does disaggregation of meat into products in a meat demand model give insights into the causes of structural change? In order to answer these questions, two meat demand systems are estimated with the Almost Ideal Demand System (AIDS) of Deaton and Muellbauer. The first system includes aggregate chicken, beef, and pork; the second system disaggregates chicken into whole birds and parts/processed products, and beef into hamburger and table cuts.

Tests of weak separability are performed for various groups of meat products in order to understand how consumers allocate their meat expenditures. If meat products are not weakly separable by animal type, such as "beef" and "chicken", then it is better to disaggregate meats into their constituent products to understand preference changes.

All demand equations are then tested for structural change. One hypothesis is that changes in the mix of different products is a major cause of structural change. For example, if an exogenous shift in aggregate chicken demand is observed, and none is found in either chicken product, then the change in product mix, rather than preferences, is causing the apparent shift in total chicken. An alternative hypothesis is that an aggregate shift is reflected in preference changes in the product demand equations, and these changes may be concentrated in particular product types.

The AIDS Model

The AIDS model[1] (Deaton and Muellbauer, 1980a) has several theoretical and empirical advantages. It satisfies the axioms of choice exactly, allows consistent aggregation of micro level demands up to a market demand function, and it does not require preferences to be additive. It has been applied to economy level data by Deaton and Muellbauer (1980a) and Blanciforti, et al.; to food groupings by Blanciforti, et al. and Capps, et al.; and to meats by Chalfant and Alston.

Detailed derivations of the model are available in Deaton and Muellbauer (1980a and 1980b). Briefly the general form of the derived share equations is:

$$1)\ w_i = a_i + \sum_j \gamma_{ij}\ln(p_j) + \beta_i \ln(X/P) \qquad \text{for all } i$$

where w_i is the expenditure share of the ith commodity, p_j are prices, X is total expenditure on all commodities in the system, and

$$2)\ \ln(P) = \alpha_0 + \sum_i \alpha_i \ln(p_i) + 1/2*\sum\sum_{ij} \gamma_{ij}\ln(p_i)\ln(p_j)$$

is a price index. The basic demand restrictions: adding up, homogeneity, and symmetry, are all expressible in terms of the model's coefficients:

$$3)\ \sum_i \alpha_i = 1 \quad \sum_i \gamma_{ij} = 0 \quad \sum_i \beta_i = 0 \qquad \text{(adding up)}$$

$$\sum_j \gamma_{ij} = 0 \qquad \text{(homogeneity)}$$

$$\gamma_{ij} = \gamma_{ji} \qquad \text{(symmetry)}$$

and may be imposed or tested. Since many previous studies of meat demand have found dynamics to be important (Pope, et al.; Chavas; Blanciforti, et al.) we follow Deaton and Muellbauer and use the first difference form of Equation 1[2], that is:

$$4)\ \Delta w_i = \sum_j \gamma_{ij}\Delta\ln(p_j) + \beta_i \Delta\ln(X/P) \qquad \text{for all } i.$$

As it stands the system of equations (4) is nonlinear. A final simplification is to approximate ln(P) in Equation 2 with Stone's price index. (Although Stone's index is $\ln(P) = \Sigma_j w_{jt}\ln(p_{jt})$, we use $\Sigma_j w_{jt-1}\ln(p_{jt})$ to avoid simultaneity problems.) With this simplification, the system of equations (4) is linear in the parameters and the approximation will be excellent as long as prices are collinear (Deaton and Muellbauer pp. 316-7).

It has been suggested elsewhere that changes in income distribution may have affected aggregate meat demand during the last 15 years (Unnevehr).

The AIDS system allows for correction of the total expenditure variable to reflect changes in the distribution of expenditures. Average expenditure, X, is divided by an index, k, to obtain the representative budget level, X^o, where (Deaton and Muellbauer, 1980a, pp 314-315):

$$k = Z/H;$$

$$\ln Z = - \Sigma_i s_i \ln(s_i);$$

where s_i is the share of income of household group i and H is the number of household groups. The k index is identical to Theil's entropy measure of equality and decreases as inequality increases. Therefore representative expenditure will be larger as inequality increases. In our final estimation, X in Equation 4 is replaced by X^o.

Both aggregated and disaggregated chicken and beef are estimated in the AIDS model together with pork, other foods, all other goods, and total expenditures. The use of total per capita expenditures instead of just meat expenditures allows us to make broad tests for separability, to correct for income distribution effects, and to estimate expenditure elasticities that are comparable with other results. It also makes calculation of compensated elasticities possible.

The model was estimated using iterative Zellner's Seemingly Unrelated Regressions model (1962, 1963) with the other goods equation dropped due to the adding up restriction (Deaton and Muellbauer, 1980a; Berndt and Savin). Tests of homogeneity and symmetry in the first difference AIDS models were not rejected (insignificant at the .05 level), so these restrictions were imposed. In preliminary estimation of the static AIDS model (Equation 1), the homogeneity condition was rejected. (This was another motivation for using the first difference form of the model.)

Tests for Separability and Structural Change

The concept of separability in demand is based on the intuitive notion that the maximization of utility over all the commodities is too large a problem to be handled at once. Therefore, consumers are assumed to budget expenditures in stages; first, expenditures are divided among broad categories such as food, housing, entertainment, and transportation; then group expenditures are further allocated among commodities within these groups.

The necessary and sufficient conditions for weak separability are that the marginal rates of substitution between goods which are separable from a third good must be independent of changes in that third good's quantity (Leontief; Sono). Goldman and Uzawa have shown that this is equivalent to the condition that the off-diagonal term in the Slutsky substitution matrix is proportional to the income derivatives of the two separable goods, i.e. if goods i and j are in separable groups r and s, respectively, then

$$5)\qquad S_{ij} = \Theta^{rs} \frac{\partial Q_i}{\partial X} \frac{\partial Q_j}{\partial X} \qquad \text{for all } i \in r \;\&\; j \in s$$

where S_{ij} is the appropriate element in the Slutsky substitution matrix, Qs are quantities consumed, and Θ^{rs} is a factor of proportionality between groups r and s. Intuitively, the compensated effects of price changes of goods in other groups are only felt through the reallocation of expenditures among groups.

In empirical demand analysis it is often assumed that the commodities of interest are "weakly separable" from other goods in order to minimize the number of variables. The justification for including only goods which are close substitutes or complements is that excluded goods have been deferred to other groups by the consumer at a higher branch of the utility tree. The commodities of interest are then weakly separable from other goods (see Deaton and Muellbauer, 1980b, p 124). For example, if meats are weakly separable from other goods, it is valid to estimate a meat demand system based only on meat prices and expenditures. However, weak separability is necessary but not sufficient for the stage of the budgeting process where total expenditures are allocated to broad groups of commodities based solely on aggregate prices and quantities. The existence of the aggregate goods used in empirical analysis also requires the sub-utility function for within-group allocation to be homothetic (Green; Gorman). This implies that all within-group expenditure elasticities are one, a result which is unlikely in most data.[3]

Thus, tests of weak separability have limitations. A failure to reject weak separability for a particular commodity grouping does not guarantee the legitimacy of the aggregates. For instance, suppose that the separability of chicken products and beef products from each other and the other product categories is not rejected. This does not imply the legitimacy of a demand system for meat based on the aggregates, "chicken" and "beef." Still, a test of weak separability does provide useful information, when certain groupings are clearly rejected.

Several consumption studies have tested for separability among broad aggregate groups (eg. Jorgenson and Lau; Bieri and de Janvry). No one has tested for separability within groups of meat products in the U.S., although Pudney tested an a priori grouping, as well as several "optimal" groupings, of twenty meat products using data from the U.K. National Food Survey.

Pudney rejected weak separability in all cases.

To test for weak separability in this study, a number of a priori groupings of the meat commodities are specified, and the parameter restrictions implied by each grouping are then tested using an adjusted nonlinear Wald test[4]. An a priori set of utility trees to examine is specified based on economic intuition and the data available (Table 1). For example, the first tree in Table 1 is pictured in Figure 1. Other goods and food are the only separable groups. In this case, Θ^{rs} in Equation 5 takes only one value, giving the relationship between the food group, r, and the non-food group, s. The presence of six commodities within the food group for this example means there are fifteen (6!/4!2!) different ways of calculating Θ^{rs}. However, of the fifteen possible restrictions only four are independent. A rejection of these four restrictions demonstrates that the separability inherent in the tree is not supported by the data. A failure to reject provides some insight into the potential existence of aggregate commodities.

The actual test would then be made up of restrictions based on Equation 5, above. In generic form the restrictions for commodities i and j in group r and k in group s would have the form:

$$6)\quad \frac{S_{ik}}{\partial Q_i / \partial X} = \frac{S_{jk}}{\partial Q_j / \partial X} \qquad \text{for all } i,j \in r \ \& \ k \in s$$

For the parameters of the AIDS model this restriction implies:

Table 1. Potential Utility Trees

UTILITY TREE	# OF COM-MOD. GRPS	WHOLE BIRDS[1]	PARTS & PROCSSD	HAMB-URGER	TABLE CUTS	PORK	NON-MEAT FOOD	NON-FOOD COMMOD.
1	2	A	A	A	A	A	A	B
2	5	A	B	A	B	C	D	E
3	5	A	A	B	B	C	D	E
4	3	A	B	A	B	B	B	C
5	4	A	B	A	B	B	C	D
6	4	A	B	A	B	A	C	D

[1] In each tree, all commodities with the same letter are assumed to belong to the same group. Commodities with different letters are weakly separable.

Figure 1.

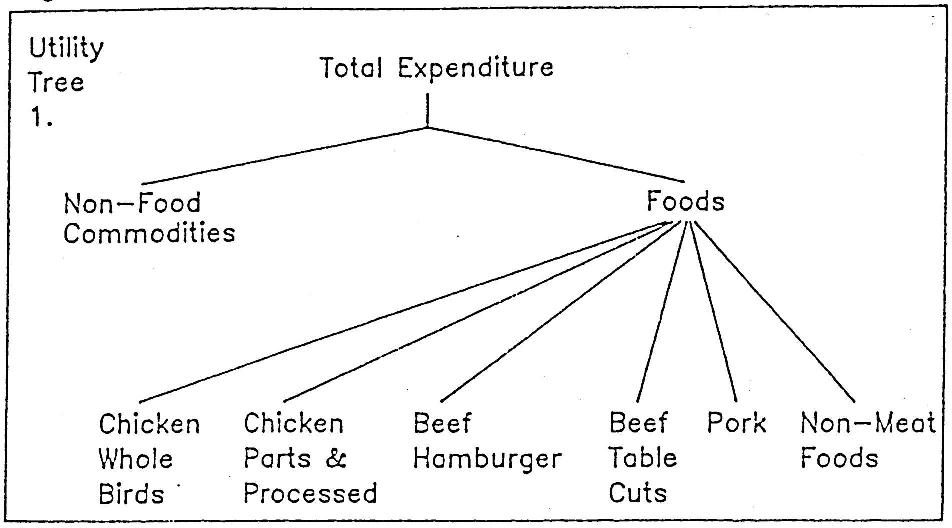


Figure 2.

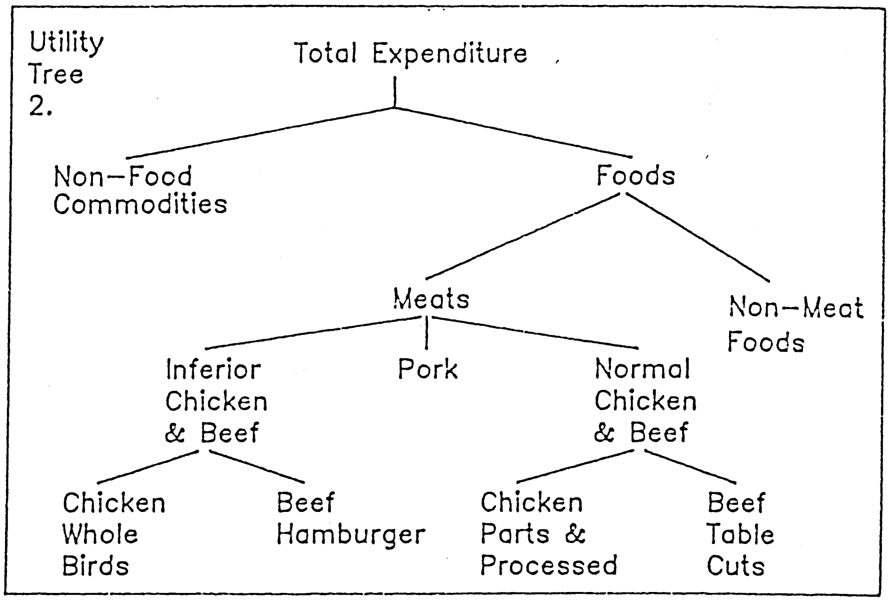
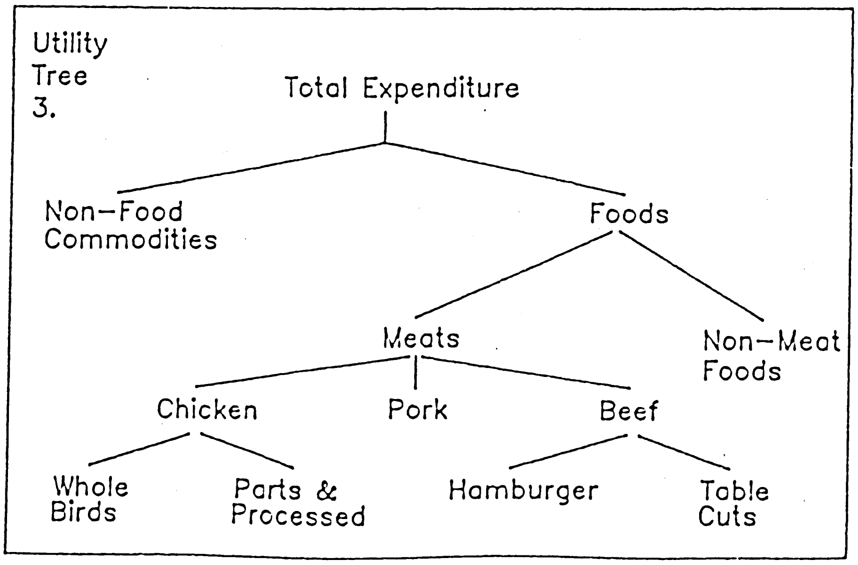


Figure 3.



$$7)\quad \gamma_{ik}(\beta_j + w_j) - \gamma_{jk}(\beta_i + w_i) + (w_i\beta_j - w_j\beta_i)(w_k - \beta_k \ln(X/P)) = 0$$

$$\text{for all } i,j \in r \ \& \ k \in s$$

which is tested locally at the mean shares.

Small sample properties of the Wald test are unknown. The Monte Carlo evidence indicates that the empirical size of the test statistic may be a great deal smaller than the nominal size, i.e. the Type I error is too small (Gregory and Veall; Laitinen; Bera, et al.). The recommendation in this case is often to apply an appropriate degrees of freedom correction to the statistic and then use the cutoff of the appropriate F distribution (Judge, et al.). The adjusted test seems to give Type I error which is closer to that which is specified in finite samples. Both tests are presented in the results.

In contrast to separability, the concept of structural change does not have a strong theoretical foundation. Evidence of change in parameters may not indicate an actual change in preferences but simply mis-specification of the model. Non-parametric estimates of demand and estimates of highly flexible functional forms have brought into question earlier findings of structural change in red meats (Chalfant and Alston; Wohlgenant, 1985).[5] In this paper, we take a naive approach to structural change. Changes in parameters of standard models, such that they are no longer reliable forecasters, are assumed to reflect a shift in the underlying structure of demand.

The tests for structural change look for both gradual and one-time only shifts in the demand curve. A test of gradual, exogenous shifts in our dynamic model merely requires that a intercept be included in Equation 4.

The coefficient of the intercept then indicates the exogenous shift in demand. As other studies of structural change have frequently reported a one-time shift in red meat demand around 1974, we tested for a one time shift in the mid-seventies by including an intercept dummy. In contrast to previous studies of structural change, these tests focus on exogenous shifts in the demand curve rather than on changes in individual parameters. A multivariate Chow test that would also allow the slopes to change would be preferable, but data limitations make this test of dubious value in this instance.

Econometric tests detect statistically significant shifts in parameters but reveal nothing about the causes. This type of search for change is thus a confession of ignorance (Chalfant and Alston). In the present case, however, the a priori hypothesis is that changes in the mix of different products within meat aggregates is at the root of changes in meat demand structure. This is tested by separation of chicken and beef into their constituent products. For example, if the intercept dummy is significant in the aggregate chicken equation, indicating a one time shift in demand, but is not significant in either of the chicken product equations, then the change in chicken product mix is causing the apparent shift in aggregate chicken demand and there is no real change in preference for chicken. Alternatively, if there is a corresponding structural change in one or both of the chicken product equations, then consumer preferences for chicken have changed.

Data

Annual data covering the period 1965 through 1985 are used in the estimation. Retail-weight meat consumption data, retail prices of beef and pork, the non-food CPI, and food CPI are from various issues of Food Consumption, Prices and Expenditures (USDA). Personal consumption expenditures and food expenditures are the latest revised series obtained directly from the Department of Commerce. The food CPI and food expenditures are converted to a non-meat foods basis. Total expenditures are adjusted to representative expenditures with a k index calculated from the distribution of family incomes reported by the U.S. Bureau of the Census.

Beef is disaggregated into hamburger and table cuts according to fed and non-fed slaughter from Livestock Slaughter, following the procedure suggested by Wohlgenant (1986). The breakdown of federally inspected broiler slaughter by product type is from various issues of Poultry Slaughter. Total chicken consumption per capita is allocated among product type based on the proportions in the federal slaughter.

Data on the retail price of whole birds is obtained from Food Consumption, Prices and Expenditures (USDA). The retail chicken parts and aggregate chicken prices are derived as follows. Wholesale prices of whole birds and various chicken parts are obtained from Poultry Market Statistics. A weighted-average wholesale parts price is calculated based on the proportion of different parts obtained from a whole bird. This wholesale parts price is converted to a retail parts price based on the relationship between the wholesale and retail prices of whole birds. An aggregate chicken price is then constructed from a quantity share weighted average of the retail whole and parts prices. This chicken price is more comparable to the beef and pork retail prices, which are both weighted averages of the retail prices of different cuts, than the whole bird retail price that has been used in past analysis.

Results

Results for the aggregate and disaggregated meat models are reported in Tables 2 and 3; compensated elasticities are in Tables 4 and 5. In the aggregate model, the coefficients are reasonable in signs and magnitude, and significant for the most part. The significant complementarity of other goods in chicken and pork equations are exceptions. The equations in the disaggregated model are respecified with aggregate chicken split into whole birds and cut up parts plus processed consumption; aggregate beef is divided into hamburger and table cuts. The results for this model also have reasonable signs and magnitude, but there are fewer significant price elasticities.[6] The disaggregated model reveals more complex relationships among the meat products than the aggregate model.

The results for aggregate chicken and beef reflect the underlying elasticities of their constituent products and for chicken, the changing share of products over time. The average own-price elasticities for both aggregate chicken and beef (Table 4) are smaller in absolute value than the own-price elasticities of their respective products (Table 5). The average own-price response for each meat aggregate is reduced by the substitution between products. Cross-price substitution effects between the two chicken products and between the two beef products are all significant and fairly large.

Table 2. Aggregate Meat Model[1]

	Chicken	Beef	Pork	Food	Other	Expenditures	Intercept	Average Budget Share	R^2	Durbin Watson
Chicken	.377* (.022)	.124* (.042)	.007 (.023)	-.180* (.087)	-.328* (.078)	-.247* (.108)	.008* (.003)	.0052	.959	1.68
Beef	.124* (.042)	1.043* (.288)	.413* (.127)	-.817 (.543)	-.763 (.524)	-1.624 (.845)	.000 (.025)	.0248	.632	2.03
Pork	.007 (.023)	.413* (.127)	.315* (.102)	.014 (.318)	-.749* (.308)	-.973 (.491)	-.008 (.014)	.0135	.672	2.94
Food	-.180* (.087)	-.817 (.543)	.014 (.318)	4.589* (1.952)	-3.606* (1.852)	-8.858* (2.340)	-.010 (.068)	.1646	.610	2.80

[1] All coefficients are multiplied by 100 for ease of presentation. Figures in parentheses are standard errors.

* Significant at a .05 level.

Table 3. Disaggregated Meat Products Model[1]

	Whole Birds	Parts & Processed	Hamburger	Table Cuts	Pork	Non-Meat Food	Other	Expenditures	Intercept	Average budget share	R^2	Durbin Watson
Whole Birds	.088 (.061)	.116* (.037)	.163* (.043)	-.047 (.073)	-.053 (.035)	.097 (.146)	-.365* (.127)	-.339 (.192)	-.003 (.005)	.0027	.750	2.37
Parts & Processed	.116* (.037)	.097* (.029)	-.030 (.029)	-.057 (.051)	.076* (.025)	-.310* (.098)	.108 (.086)	-.043 (.128)	.016* (.004)	.0025	.824	2.26
Hamburger	.163* (.043)	-.030 (.029)	-.739* (.151)	.757* (.163)	.285* (.094)	.264 (.427)	-.701 (.393)	-1.199 (.746)	.015 (.022)	.0047	.146	2.92
Table Cuts	-.046 (.073)	-.057 (.051)	.757* (.164)	.572 (.333)	-.087 (.113)	-1.172 (.618)	.033 (.523)	1.136 (.815)	-.044 (.023)	.0201	.696	2.31
Pork	-.053 (.035)	.076* (.025)	.285* (.094)	-.087 (.113)	.585* (.071)	-.151 (.294)	-.656* (.259)	-1.294* (.487)	.003 (.014)	.0135	.710	2.73
Non-Meat Foods	.097 (.146)	-.310* (.098)	.265 (.427)	-1.172 (.618)	-.151 (.294)	5.204* (2.419)	-3.934 (2.096)	-9.435* (2.644)	.001 (.077)	.1646	.545	2.69

[1] All coefficients are multiplied by 100 for ease of presentation. Figures in parentheses are standard errors.

* Significant at a .05 level.

Table 4. Compensated Aggregate Meat Elasticities[1]

	CHK	BF	PK	FD	OTH	EXP
Chicken	-0.276	0.250	0.021	-0.258	-0.210	0.527
Beef	0.052	-0.570	0.171	-0.273	-0.035	0.344
Pork	0.007	0.314	-0.762	0.056	-0.336	0.278
Food	-0.008	-0.038	0.007	-0.642	0.160	0.479

[1] In the AIDS model the compensated elasticities are given by:

$$e_{ij}^{*} = \frac{\gamma_{ij}}{w_i} - \delta_{ij} + w_j\left[\frac{\beta_i}{w_i} + 1\right]$$

where δ_{ij} is the Kronecker delta and the average budget shares in Tables 1 and 2 are used.

Table 5. Compensated Disaggregated Meat Products Elasticities[1]

	WHL	P&P	HB	TC	PK	FD	OTH	EXP
Whole Birds	-0.677	0.426	0.600	-0.176	-0.198	0.317	-1.540	-0.248
Parts & Processed	0.464	-0.610	-0.117	-0.210	0.315	-1.101	1.086	0.827
Hamburger	0.346	-0.069	-2.593	1.593	0.590	0.310	-2.750	-1.573
Table Cuts	-0.019	-0.024	0.384	-0.684	-0.022	-0.325	1.256	1.565
Pork	-0.039	0.057	0.212	-0.064	-0.565	-0.105	-0.455	0.040
Non-Meat Foods	0.007	-0.018	0.018	-0.063	-0.003	-0.614	0.099	0.427

[1] In the AIDS model the compensated elasticities are given by:

$$e_{ij}^{*} = \frac{\gamma_{ij}}{w_i} - \delta_{ij} + w_j \left[\frac{\beta_i}{w_i} + 1 \right]$$

where δ_{ij} is the Kronecker delta and the average budget shares in Tables 1 and 2 are used.

The income results for individual meat products agree with cross-section results (Haidacher, et al.). Whole birds and hamburger are inferior goods, and chicken parts/processed and beef table cuts are normal goods. Aggregate beef and chicken income effects are dominated by the income elasticities of the normal products.[7]

The average cross-price elasticities between chicken and beef in Table 4 are primarily due to the strong cross-price effects between hamburger and whole birds (Table 5). The significant cross-price effect between aggregate beef and pork is due to the substitution between hamburger and pork. Although cross-price substitution is not significant between aggregate chicken and pork, it is significant between chicken parts/processed and pork.

Separability tests using the results of the disaggregated model show how consumers approach the allocation of the meat budget. The set of utility trees tested for weak separability are in Table 1, and trees 1, 2 and 3 are illustrated in Figures 1 to 3. The results of the Wald tests of the separability restrictions are in Table 6. Due to the tendency of Wald tests to over-reject in finite samples, focus may be more appropriately placed on the adjusted Wald results. Trees 3, 4, 5, and 6 are rejected at a five percent level of significance. Trees 1 and 2 are not rejected.

In tree 3 (Figure 3), which is rejected, products are grouped according to animal origin.[8] Trees 1 and 2 are not rejected and these allow consumers to choose among products across animal origin. In tree one the budget is allocated between foods and non-foods; and within foods among non-meats and all meat products at one level (Figure 1). Tree two consists of four budget allocation stages (Figure 2). In the first stage, expenditure is allocated

Table 6. Weak Separability Test Results

UTILITY TREE	WALD TEST	DF	.05 CUTOFF	ADJUSTED[1] WALD TEST	DF1	DF2	.05 CUTOFF
1	6.648	5	11.070	.945	5	81	2.34
2	531.413	11	19.675	34.326	11	81	1.94
3	48.299	11	19.675	3.120	11	81	1.94
4	64.901	11	19.675	4.192	11	81	1.94
5	25.049	9	16.919	1.978	9	81	2.02
6	55.438	9	16.919	4.377	9	81	2.02

1 The Adjusted Wald Statistic is calculated:

$$W^* = \frac{W/q}{MT/(MT-K)}$$

where W is the regular Wald statistic, q is the number of restrictions in the test, M is the number of equations in the system, T is the number observations, and K is the number of free parameters in the system (see Judge, et al. p 475).

between non-food and food and in the second stage between meats and non-meat foods. At the third stage consumers allocate within meats among three groups: pork, lower quality chicken and beef, and higher quality chicken and beef. At the final stage, within the normal and inferior meat categories, consumers allocate between products.

The results of the separability tests suggest that consumers choose among meat products rather than among meat aggregates of a particular animal origin. In tree 2, for example, the marginal rate of substitution between whole birds and hamburger is independent of changes in quantities consumed of either table cuts or parts/processed. These results call into question the usefulness of analyzing demand for aggregate beef or chicken. They suggest that a full understanding of meat demand or tests for structural change requires analysis of a disaggregated meat products model.

Before looking at the tests for structural change, it should be noted that the AIDS can impose restrictions on the evolution of elasticities with changes in real expenditures (Wohlgenant,1984), and these might bias the trend variable results. For the AIDS model Wohlgenant shows that:

$$8)\quad \partial e_{ii}/\partial \ln(X) = (1 + e_{ii})(1 - e_{i})$$

where e_{ii} and e_{i} represent own-price and expenditure elasticities, respectively. An aggregate commodity such as food, which is inelastic with respect to both own-price and income, will become less price elastic in the AIDS model as income grows. For less aggregated commodities, such as whole birds or hamburger, the magnitudes and even the signs of the elasticities cannot be specified a priori, so that the partial derivative in Equation 8 can have any sign. Examination of Table 4 indicates that aggregate meats will become less price elastic as income grows. In the disaggregated results (Table 5), however, both hamburger and table cut beef become more price elastic as expenditures increase. As the sign of the partial derivative in Equation 8 is not fixed for disaggregated commodities, the exogenous trends in the AIDS are not artifacts imposed by the functional form[9].

Evidence regarding structural change in the aggregated and disaggregated models is found in the intercept results in Tables 2 and 3. The intercept is equivalent to a time trend in the static model, because it allows for exogenous growth or decline in the share of each of the commodities, in addition to the effects of changes in relative prices and income. In the aggregate model, the intercept is significant only in chicken, where it is large and positive. This indicates rapid growth in the share of chicken independent of relative price movements. In other meats and foods the exogenous factors have been static or shown a small decline over time. In the disaggregated model, the intercept is significant, large, and positive only in the chicken part/processed equation, while whole birds and beef table cuts declined. Thus the apparent growth in aggregate chicken is due to growth in the demand for parts/processed.

A second test for structural change examines whether there was a shift in demand in the mid 1970's. An intercept dummy which equals one from 1965 through 1974 and zero thereafter is included. In general the parameter results were very similar, so only intercept and dummy estimates for aggregate meats and the four products are reported in Table 7. In aggregate meats, the dummy is significant and negative in the chicken share equation, indicating that exogenous demand growth was slower before 1974 than after

Table 7. Structural Change in Demands for Aggregated and Disaggregated Meat Products

	CHK	WHL BRDS	PARTS & PRC	BEEF	HAMB-URGER	TBL CUTS	PORK	NON-MEAT FOOD
INTRCPT[1]	.013*	.001	.017*	-.049*	.005	-.070*	-.004	.028
	(.003)	(.007)	(.005)	(.023)	(.030)	(.026)	(.018)	(.097)
D74	-.010*	-.008	-.002	.109*	.024	.078*	.019	-.086
	(.005)	(.007)	(.005)	(.031)	(.040)	(.034)	(.024)	(.132)

[1] Coefficients and standard errors are multiplied by 100 for ease of presentation.

* Significant at a .05 level.

1974. Both dummy and constant are significant in aggregate beef, and their coefficients indicate that beef share increased before 1974 and declined afterwards. The dummy is insignificant in pork and other foods.

Dummy and intercept results in the disaggregated model show that change in total beef demand growth was a result of similar underlying changes in demand for table cuts. Demand for table cuts declined after 1974, while demand for hamburger did not decline. The two chicken product equations show no shift in growth rate in the mid-1970s. Changes in shares of chicken products are explained by movements in relative prices and income, and constant exogenous growth in demand for parts. The apparent shift in growth of aggregate chicken after 1974 can be explained by the increased share of parts in total chicken over time.[10]

Intercept results in the disaggregated model indicate that there was significant exogenous growth in demand for parts/processed, while demand for whole birds declined. It is interesting to look at what chicken budget shares and consumption would have been in 1985 if preferences had remained constant. The following shows the 1985 budget share and quantity consumed, if 1985 prices and incomes prevailed but there had been no exogenous growth in demand:

	1965		1985 Actual		1985 Preference Constant	
	Share	Qty	Share	Qty	Share	Qty
Whole	.0038	24.7	.0011	16.3	.0017	25.9
Parts	.0016	8.6	.0035	41.8	.0003	3.6
Total	.0054	33.3	.0046	58.0	.0020	29.5

This comparison reveals that the shift in preferences towards parts and processed products has been extremely important. Without the change in preferences, consumption of total chicken would have been virtually the same in 1985 as it was in 1965. Proportion of whole to total chicken would have increased slightly, while the proportion of parts/processed to total chicken would have declined. The predicted decline in parts/processed is due to the increase in the parts price relative to the whole bird price over this time period.

Conclusions

Two dynamic Almost Ideal Demand Systems, one for aggregate meats and one for disaggregated meat products, are estimated. The results reveal how demand for aggregate beef and chicken reflects the more varied demand for their constituent products. These time-series estimates confirm cross-section results that hamburger and whole birds are inferior goods, and chicken parts and beef table cuts are normal goods. Results also showed that most cross-price substitution between beef and chicken is due to substitution between whole birds and hamburger. This finding agrees with Wohlgenant's (1986) disaggregated estimates of beef demand, which showed that most beef-poultry substitution is between hamburger and poultry.

Tests for structural change in the aggregate meats with this particular model and data set showed that there was a preference shift away from beef and towards chicken after 1974. These results are roughly consistent with the findings of other studies of structural change. Most other researchers found that in the mid-1970s beef demand became less elastic with respect to own-price (Chavas, Nyankori and Miller) and income (Chavas, Nyankori and Miller, Frank, Hudson and Vertin) while chicken became a stronger substitute for beef (Braschler, Moschini and Meilke, Frank) or more responsive to income (Chavas, Hudson and Vertin). Previous tests for structural change in aggregate meat models generally indicate a saturated market for beef and an increased preference for chicken after 1974.

Tests for weak separability among meat products, however, suggests that tests for structural change in the aggregate meats may be biased. The hypothesis that consumers allocate expenditures first to animal product aggregates such as beef or chicken, and then among products within an aggregate was rejected. In the budget allocation trees not rejected, consumers allocate expenditure across all meat products at once or between high quality and low quality products from different animals. Use of aggregate chicken and beef in demand estimation could bias estimation of demand parameters and hence tests for structural change.

As the separability results suggest, tests for structural change in disaggregated products reveal a different picture of preference changes than the aggregate model. Two types of significant shifts in meat demand were identified in meat products: an exogenous constant annual 6.4 percent growth in demand for chicken parts/processed from 1965 to 1985, and a 3.5 percent decline in demand for beef table cuts after 1974. Over the entire period, demand for whole birds declined slightly and demand for hamburger increased slightly.

Structural change in aggregate beef demand reflected the decline in table cut demand. Aggregate chicken changes, however, followed both the increase in parts/processed demand and the change in the mix of chicken products marketed. An apparent increased rate of growth in aggregate chicken demand after 1974 is due to the larger share of parts/processed in aggregate chicken after 1974, rather than an increased rate of change in preference.

Product equations revealed two other features of structural change. First, they show that timing of structural change in beef and chicken differed. Change in chicken demand has been on-going for the past twenty years while change in beef demand occurred after 1974. Second, although most beef-chicken cross-price substitution takes place between hamburger and whole birds, the change in preferences since 1974 has led to substitution of chicken parts for beef table cuts. Thus cross-price effects are important for inferior meat products, but preference shifts are important in explaining changes in demand for high quality meat products.

The concentration of the beef-poultry preference shift in particular products calls into question the hypothesis that health concerns have been the driving force behind the shift from beef to chicken (Chavas). A shift in demand due purely to health concerns would have led to growth in whole birds and a decline in hamburger, which we did not find. While awareness of cholesterol may be greater among consumers of high quality meats, the shift from beef table cuts to chicken parts/processed must also have been due to growth in demand for convenience. Significant growth in parts/processed may have been fostered by growth in fast food outlets as suggested by Wohlgenant (1986).

Growth in the preference for chicken parts/processed has been extremely important in explaining observed chicken quantities consumed. If preferences had remained constant between 1965 and 1985, quantities of whole birds and parts consumed would have remained virtually the same. Increased demand for convenience seems to be an intuitively plausible explanation for the growth in chicken parts demand, as the value of time for the principal meal preparer has increased during the last 25 years. Between 1960 and

1985, the proportion of women who work outside the home increased from 35 percent to 50 percent, households headed by women increased from 18 percent to 28 percent, and single person households increased from 13 percent to 24 percent of all households (U.S. Bureau of the Census). These trends should have increased the demand for embodied services in food products. The findings here suggest that the chicken industry has successfully taken advantage of these changing preferences through marketing new products. Therefore, product development must play an important role in any effort to stimulate beef demand.

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NOTES

1. Other functional forms have been advocated for the meat complex. In the current context a primary concern is the aggregation of demand across products. The consistent aggregation of micro level to market demand property of the AIDS model removes a possible source of aggregation bias.

2. Blanciforti, et al. assumed a different form for the dynamic adjustment in demand which led to including a lagged dependent variable on the right hand side of Equation (1). Such a formulation of the present model produced similar, but marginally inferior results.

3. Somewhat less restrictive conditions, under which aggregation is "almost" correct, are discussed in Deaton and Muellbauer (1980b, pp 129-133).

4. The Wald test is chosen because it allows us to use the unrestricted coefficients, which are easier to estimate. The intuition is that if the restrictions are true, then the unrestricted coefficients should come close to satisfying the restrictions. Other tests, such as the Likelihood Ratio test, would require that we re-estimate the model with the restrictions imposed. The two tests are asymptotically equivalent.

5. Thurman notes that non-parametric tests that do not support structural change do not rule it out either.

6. The Durbin-Watson statistics (DW), while having unknown distributions in multi-equation models, indicate some negative autocorrelation in the residuals, particularly in pork, food, and hamburger. Berndt and Savin show that such negative autocorrelation must take a form which is consistent with the adding-up property of expenditure-share demand systems. (For an

empirical application to meat, see Bewley and Young.) The indication of negative autocorrelation could be the result of the first difference form of the model, but this does not appear to be the case. It stems instead from large (three or more standard errors from zero) residuals in many of the equations in 1975. Dummying out this particular observation produced DWs close to two in all equations, except for other foods. The effects on the model's parameters were marginal, in terms of magnitudes, signs, and significance. The problem with such a solution is that it deprives the model of what may be significant information and so the results without the dummy are reported.

7. Use of representative expenditure, X^o, rather than average expenditure, X, does not appreciably alter the overall statistical performance of the model, perhaps because the two are very highly correlated at .9995. The lack of significant differences between the two series may be due to the use of only five household income groups available in aggregate data to construct the k index. Although the differences were not significant, the expenditure elasticity estimated with X^o was slightly smaller for chicken and slightly larger for beef, as predicted by Unnevehr's findings.

8. Several other tree configurations in which meat products were grouped by animal origin were tested. All were rejected and tree 3 is representative.

9. The disaggregated system was re-estimated as a Rotterdam system to further examine the influence of functional form. In the Rotterdam system, the partial derivative of the own price elasticity with respect to income is $e_{ii}(1-e_i)$. Hence, the Rotterdam system implies the opposite reaction of price response to changes in income than in the AIDS model for many values

of elasticities. Estimated elasticities from the Rotterdam model are very close to those in the AIDS model. The separability results were qualitatively similar, with the Wald test rejecting only the trees which separated by animal type as represented by tree 3, but the unadjusted Wald test no longer rejected any of the specifications. It should be pointed out that, since the Rotterdam demand system aggregates to homothetic preference structures, test of weak separability are actually test of strong separability, which is not true in the AIDS model. Therefore, the differing test results could be anticipated. The structural change results were identical with those of the AIDS model.

10. The weighted sum of the intercepts in the whole and parts/processed equations increases from .003 before 1974 to .008 after 1974. The average weights for the period before 1974 were 66 percent whole birds and 34 percent parts/processed, and for the years after 1974 the average weights changed to 45 percent whole birds and 55 percent parts/processed.