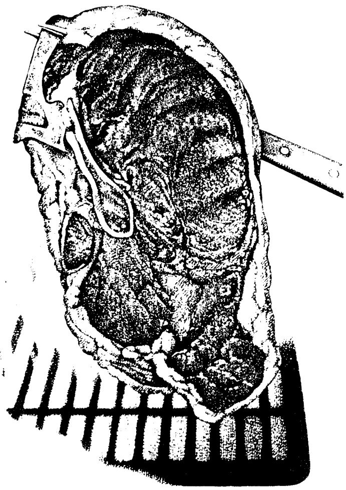
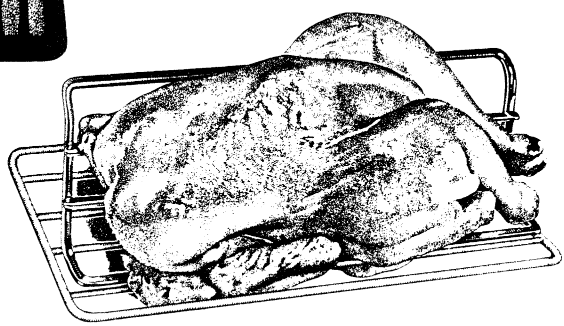
An Analysis of Preference Shifts in Beef and Chicken Demand





Technical Bulletin T-168
June 1990

Agricultural Experiment Station
Division of Agriculture
Oklahoma State University

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In recent years, much debate has centered upon the apparent substitution of chicken for beef in the American diet. Prior to 1976, per-capita consumption in both chicken and beef exhibited almost steady upward trends. By 1976 annual beef consumption had reached 94.4 pounds per capita, and annual broiler consumption had grown to 39.9 pounds per capita. From 1976 to 1988, broiler consumption increased to 61.5 pounds, but beef consumption declined to 72.7 pounds. During this same period, beef prices increased by 72%, whereas retail broiler prices increased by only 40%.

The decline in beef consumption has been thought by some to have derived from a shift in consumer preferences in favor of chicken. This supposed shift is thought to have been motivated either by an increased demand for convenience foods, or by dietary concerns, primarily concerns over the high fat and cholesterol content of beef. However, the decline is thought by others to have resulted from the reduction in the price of chicken relative to the price of beef. The reduced relative price of chicken is attributed to increased efficiencies in the production and marketing of chicken. Hence, in the first case the decline in beef consumption is thought to have derived from a preference shift, whereas in the later case the decline is thought to originate from a rightward shift in the supply of chicken.

This paper presents an empirical analysis of preference shifts using a relative price function. Evidence of a preference shift is shown in this analysis to be relatively weak, thus indicating that a rightward shift in the supply of chicken is the more plausible of the above explanations for the observed decline in beef consumption.

Previous Studies

The possibilities of structural shifts in meat demand have been the focus of numerous studies utilizing a broad spectrum of methodologies. Unfortunately, the conclusions of these studies are in much disagreement.

Haidacher, et al conducted a study of meat demand using cross-section data. Data from food consumption surveys in 1965 and 1977-78 were used to calculate income elasticities for various aggregate and disaggregate meat items. Income elasticity estimates calculated using the 1965 data were compared with estimates obtained from

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the 1977-78 data to determine if statistically significant shifts had occurred. Significant shifts were found in a few disaggregate groups; however, significant shifts were not found for aggregate beef, aggregate pork, or aggregate chicken.

Chavas examined annual data from 1950 to 1979. With use of random coefficients models of meat demand it was concluded that structural shifts had occurred in both beef and poultry demand in the late 1970s; however, pork demand was found to be structurally stable.

Moschini and Meilke (1984) examined quarterly data from 1966 to 1981. Box-Cox transforms were used to estimate beef demand functions, which were then examined for structural shifts. Tests of structural shifts based upon recursive residuals failed to reject the hypothesis that beef demand had been structurally stable. However, Chow tests indicated that structural shifts possibly occurred in the early 1970s. The authors concluded that, overall, the evidence of structural change in beef demand was weak. However, these same authors have more recently (1989) arrived at different conclusions from an almost ideal demand system with gradually switching parameters. The system included demand equations for beef, pork, chicken, and fish, and was estimated using quarterly data from 1967 through 1987. The analysis indicated that structural shifts had occurred in the mid 1970s.

Wohlgenant estimated a beef demand function using a Fourier flexible form which was fitted to annual data from 1947 through 1983. No parameter instabilities were found in this function; however, it was shown that parameter instabilities would be indicated under a more restrictive functional specification. It was suggested that functional misspecification had mislead preceding studies to the conclusion of structural instability.

Thurman estimated a log-log poultry demand equation using annual data from 1955 to 1981. Chow tests were then used to test the stability of the equation. It was concluded that a structural shift in poultry demand had occurred in the early 1970s.

Chalfant and Alston have approached the problem using a nonparametric procedure based upon revealed preference theory. The procedure searches for inconsistencies in revealed preferences across various time periods. The discovery of an inconsistency would indicate a preference shift. No inconsistencies were found in annual data from 1947 through 1983; thus, the hypothesis of structurally stable meat demand could not be rejected.

Eales and Unnevehr estimated almost ideal demand systems both for aggregate meat groups and disaggregate meat products. The analysis was based upon annual data from 1965 through 1985. It was concluded that structural shifts have occurred in the demand for disaggregate meat products, but that these shifts are concealed in the aggregate meat data. The authors suggested that the apparent shifts are better explained by increased demand for convenience foods than by dietary concerns.

A Test of Preference Shifts Using Relative Prices.

The most common approach toward locating preference shifts is to search for instabilities in the parameters of the demand functions. Indeed, an analysis of demand stability was conducted in all of the above mentioned studies except that of Chalfant and Alston. Though this approach is theoretically sound, its empirical implementation is limited by the fact that complete specification of econometric models of demand functions will generally require an unmanageable number of regressors. Except under very restrictive utility functions, each individual commodity demand will be a function of prices for all goods in the commodity bundle. Similarly, complete specification of each inverse or price-dependent demand will generally require all quantities. When numerous commodities are consumed, data limitations and multicollinearity will forbid efficient estimation of demand functions or inverse demand functions over such a large number of regressors. Consequently, it becomes very difficult to formulate econometric models of demand that are both estimable and completely specified, or at least without extreme aggregation. Of course, failure to include all relevant regressors in the econometric models will generally lead to biased estimators and distorted test results.

Under certain conditions to be mentioned shortly, the difficulty mentioned above can be circumvented with use of relative price functions. By "relative price function" is meant a function specifying the ratio of two commodity prices. From consumer theory any ratio of consumer-good prices should equal the ratio of the corresponding maginal utilities. Hence, if P_i and P_j denote prices for the ith and jth commodities, then we must have:

$$P_i / P_j = U_i / U_j = R_{ij}$$

where U_i and U_j denote the ith and jth marginal utilities, and R_{ij} is here defined as the (i,j) relative price function.

Suppose now that there exists a representative utility function that is weakly separable with beef, pork, and chicken comprising a separable group; hence, the utility function takes the form:

$$U = F[U^1(q_b,q_p,q_c),U^2(\ldots),,,U^g(\ldots)]$$

where q_b, q_p, and q_c are consumption levels of beef, pork, and chicken. Other goods in the commodity bundle enter through the arguments of $U^2,,,U^g$. If we let P_b and P_c denote the prices of beef and chicken, then a necessary condition for utility maximization is:

$$P_b/P_c = U^1_b(q_b,q_p,q_c)/U^1_c(q_b,q_p,q_c) = R(q_b,q_p,q_c)$$

where U^1_b and U^1_c denote the derivatives U^1 with respect to q_b and q_c. Because of the separability assumption, the above price ratio may be specified with only three consumption variables. Moreover, if the market supplies of these commodities are perfectly inelastic, then the parameters of R may, under general conditions, be consistently and efficiently estimated using single-equation estimation techniques. Tests for preference shifts may then be conducted by testing the stability of the parameters of R.

The empirical advantages here offered by relative prices under separability quickly disappear once market supplies are made to have nonzero elasticities. In these cases, consistent and efficient estimation of the relative price functions would require simultaneous estimation with the supply functions. However, the corresponding econometric system would be one equation short of completeness. Were we to complete the system by including a consumer budget constraint, then we would be effectively back to a system of supplies and demands.

Attempts to determine the appropriate model for R began with estimation of a translog function with least squares. Statistically insignificant terms were deleted to obtain the final model. The function was fitted to quarterly data from the first quarter of 1964 through the last quarter of 1988. Quarterly data were chosen because supplies of beef, pork, and chicken are largely predetermined within quarters; consequently, the assumption of perfectly inelastic market supplies should be reasonably accurate. While this assumption is admittedly approximate to reality, it is felt to be at least as reasonable as the assumption of perfectly elastic supplies made in many of the previous studies. The translog function was chosen because of its versatility in the approximation of nonlinear functions.

Five dummy variables were included in the original model. Three of these were included to account for quarterly seasonality. The other two dummies were included to account for distortions in the meat markets occurring in 1973. These distortions included a consumer boycott against meat in the second quarter, and the imposition of wholesale and retail price ceilings in both the second and third quarters. Pork and broiler prices exhibited explosive upward movements in the third quarter after price ceilings were lifted in July, indicating that the price ceilings were indeed binding. Beef prices increased in the third quarter to a lesser extent, primarily because ceilings on beef prices were not lifted until September. It should be observed that none of the previous studies attempted to account for these distortions.

The first model had the form:

$$P_{bc} = a + a_2d_2 + a_3d_3 + a_4s_2 + a_5s_3 + a_6s_4 + b_bq_b + b_pq_p + b_cq_c + b_{bb}q_b^2 + b_{pp}q_p^2 + b_{cc}q_c^2 + b_{bp}q_bq_p + b_{bc}q_bq_c + b_{pc}q_pq_c + u$$

where: P_{bc} is the difference between the log of retail price of choice beef in cents per pound and the log of retail price of young chickens in cents per pound. q_b, q_p, and q_c are logs of consumption levels of beef, pork, and chicken, all in retailed pounds per capita. s_2, s_3, and s_4 are dummy variables included to account for seasonality. s_2 is equal equal to zero except for second quarter observations where it is equal to one. s_3 and s_4 are similarly defined. d_2 is a dummy variable equalling one in the second quarter of 1973 and zero elsewhere; d_3 is a similarly defined dummy variable for the third quarter of 1973. u is the disturbance term. All data were taken from Livestock and Poultry: Situation and Outlook Report.

An ordinary least squares estimate of the above equation produced residuals having highly significant autocorrelation, as measured by the Durbin-Watson test. The autocorrelations and partial autocorrelations of the residuals indicated the presence of a first-order autoregressive process in the disturbances. There was no evidence of fourth-order terms, though this is commonly expected of quarterly data. The model was reestimated under the assumption of AR(1) disturbances using nonlinear least squares. All terms proved insignificant at the five percent level except the autoregressive parameter and the dummy variables accounting for the 1973 distortions. A third model was then obtained by deleting all of the second-order terms from the second model. This model was also estimated with nonlinear least squares under the assumption of AR(1) disturbances. All terms in the third model proved significant except the dummy variables accounting for seasonality. The fourth and final model was obtained by deleting the seasonality dummies. The parameter estimates for the final model are reported in Table 1. The estimate of the autoregressive parameter is reported under "AR1." Apart from the intercept, all estimates were found to be significant and of the expected sign. Under general assumptions, the T statistics reported here are asymptotically distributed according to the standard normal distribution if the corresponding parameter is equal to zero. Autocorrelations and partial autocorrelations for the residuals of this model were calculated for up to fifteen lags. These all had absolute values less than twice their respective standard errors. The Box-Pierce statistics also proved insignificant for up to fifteen lags. Hence, one cannot reject the hypothesis that the disturbances follow a white noise process.

Table 1. Estimate of Relative Price Function for Beef and Chicken, 1964-88

Parameter		Estimate	T
a		1.03971	1.87
a_2		-.10686	-2.94
a_3		-.24178	-6.41
b_b		-.53158	-4.43
b_p		.32079	4.23
b_c		.28679	3.61
AR1		.91954	23.81
total sum of squares:	2.9176		
error sum of squares:	.1555		
number of observations:	100		
estimates standard error:	.0411		

The stability of the parameters in the latter model was tested using the Chow test under the assumption of a single and contemporaneous shift in all parameters, except the dummy parameters and the parameter of the AR process in the disturbances. The shift was placed at the end of 1976. This is approximately the point at which the trend reversal in beef consumption is observed in the data. The nonlinear least squares estimates for the model having the incorporated shifts are reported in Table 2. Shift parameters are denoted the same as the corresponding base parameters, but preceded by "D". The base parameter estimates pertain through 1976. After 1976, the appropriate parameter estimates are obtained by adding the base parameter and shift parameter estimates.

Table 2. Estimate of Relative Price Function for Beef and Chicken with Parameter Shifts, 1964-88

Parameter	Estimate	T
a	1.58023	2.14
D_a	-1.11065	-.98
a_2	-.11459	-3.00
a_3	-.25206	-6.34
b_b	-.64205	-3.53
Db_b	.21049	.85
b_p	.29244	2.72
Db	.04930	.31
b_c	.24427	2.19
Db_c	.12212	.71
AR1	.93563	27.06

total sum of squares:	2.9176
error sum of squares:	.1521
number of observations:	100
estimates standard error:	.0416

All estimates for the shift parameters are statistically insignificant at the five percent level. The log-likelihood ratio statistic was used to test the composite hypothesis that all four of the shift parameters are equal to zero. Under rather general conditions, the log-likelihood ratio is asymptotically distributed as a chi-squared variate with four degrees of freedom if the maintained hypothesis is true. The statistic evaluated to 2.21, which is again insignificant at the five percent level.

Conclusions

Though certain studies have offered some support to the contention that the recent decline in beef consumption has derived from a preference shift in favor of chicken, these studies have generally attempted to identify preference shifts through instabilities in the parameters of meat demand functions. This approach is afflicted by the fact that proper specification of meat demand functions will theoretically require the inclusion of all commodity prices among the regressors. However, if the meats comprise a weakly separable group, then the relative price functions for the meats may be completely specified using only the consumed quantities for the meats. If it is also true that the market supplies for the meats are perfectly inelastic, then the relative price functions should be easier to estimate than the demand functions. A test of preference stability may then be conducted by testing for instabilities in the parameters of the relative price functions. Using this approach with the relative price function for beef and chicken, little evidence is found indicating structural instabilities in beef and chicken demand, or at least by the log-likelihood ratio test.

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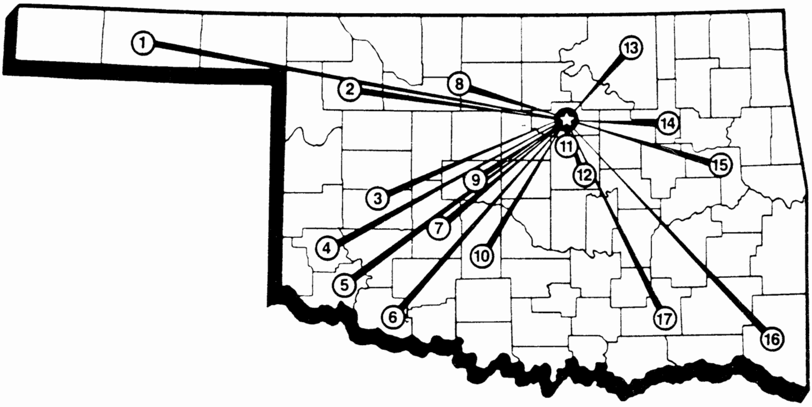

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