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# A Reexamination of Consumer Buying Behavior for Beef, Pork, and Chicken

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The objective of this study is to estimate demand parameters for beef, pork, and chicken using budget share equations derived from the translog indirect form of the utility function for the period 1965-81. Estimates of uncompensated direct and cross price elasticities, expenditure and income elasticities, and Allen elasticities are then used to make inferences concerning changes in consumer behavior in the purchases of beef, pork, and chicken. When pressure on real income forces reductions in total expenditures for meats, the brunt of the reduced consumption will be felt by beef; pork consumption will decrease slightly; and consumption of chicken may actually increase.

Identifying factors influencing consumer behavior, estimating the magnitude of these factors and forecasting the probable effects of changes in these factors on consumption patterns have been traditional topics of attention in the agricultural economics profession. Consumer buying behavior with respect to meat has exhibited marked and somewhat unexpected changes in recent years (Chavas; Braschler). Industry groups seek a better understanding of the relationships involved in order to formulate their production and sales policies. Economists have sought to provide explanations, but the results forthcoming from traditional least squares demand equations have been ambiguous and inconsistent with theory (Chang, p.

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355). Alternative procedures, which may be more consistent with consumer behavior and the underlying utility theory, appear to hold promise of improved estimates of the parameters involved.

A particular problem has been the persistent appearance of negative cross price elasticities between beef and its substitutes in demand formulations (Hayenga and Hacklander, 1970; Logan and Boles; Leuthold and Nwagbo). Since beef, pork, and chicken are competitors for the consumers' food dollar, such results have usually been considered contrary to theory. Frequently such findings have been dismissed as statistical aberrations, but Hayenga and Hacklander (1970, 1971) propose a theoretical explanation of a negative cross price elasticity between beef and pork based on the possible complementarity between these meats. The present study observes a negative cross price relationship between both beef and pork and beef and chicken, and suggests a theoretical validation of the finding based upon the relationship between the Allen elasticities of substitution and the expenditure elasticities.

As suggested above, several studies of

the demand for meat have appeared in the literature.<sup>1</sup> Most of the early demand studies employed linear or logarithmic formulations of the demand relationships. There is growing evidence suggesting that these functional forms are not appropriate from the standpoint of the underlying constraints being placed on the demand parameters (Chang; Pope *et al.*).

The objective of this study is to empirically analyze the demands for beef, pork, and chicken, using budget share equations derived from the translog indirect form of the utility function for the period 1965–81. Alternative formulations of the basic model, including habit formation and shifts in the budget share equations, will be tested. Estimates of uncompensated direct and cross price elasticities, expenditure and income elasticities, and Allen elasticities of substitution will be derived for selected years and used to make inferences concerning changes in consumer behavior in the purchases of beef, pork, and chicken.

The methodology used in this study is not new. In fact, the method has been applied to estimating demand parameters for meats (Christensen and Manser, 1977). The perceived advantage of the approach is that it is more consistent with theory than traditional linear or logarithmic formulations. Thus, it is more useful in sorting out the various responses which characterize purchasing decisions for meat. The major contribution of this study is toward an increased understanding of consumers' changing behavior in meat purchases, a phenomenon which has continued to puzzle livestock groups and economists.

### Theoretical Considerations

Considerable attention has been directed toward the theory of demand and its

relevance to applied demand analysis. Brown and Deaton and Barten and Bohm in their surveys of models of consumer behavior outline the history of these developments and provide a good review of the theory of consumer demand and its relevance to applied work. Of primary concern is that the formulation of the demand relationships be consistent with utility maximization. Tests of the theory of demand have, for the most part, centered around the additivity and homotheticity restrictions on the utility function. These are important because of the implied restrictions on price and expenditure elasticities (Christensen and Manser, 1975). The restrictions placed on demand elasticities by the additivity constraint are discussed by Theil (1967), Goldberger, and Houthakker and are summarized by Christensen and Manser (1975).

### Empirical Model

Following the framework developed by Christensen and Manser (1977), the budget share equations for beef (b), pork (p) and chicken (c) for the unrestricted translog indirect form of the utility function, where  $B_{ij} = B_{ji}$ , can be written as:<sup>2</sup>

$$\frac{P_{it}Q_{it}}{M_t} = w_{it} = \frac{A_i + \sum_j B_{ij} \ln P_j^*}{\sum_j A_j + \sum_j \sum_i B_{ij} \ln P_j^*} \quad (1)$$

where  $M = \sum_{i=1}^3 P_i Q_i$ ,  $P_i^* = \frac{P_i}{M}$ ,  $P_i =$  retail

<sup>2</sup> The translog utility function can be written in either direct or indirect forms. See Christensen *et al.* for these forms and the corresponding budget share equations. Since prices are usually considered exogenous in explaining consumer behavior, the indirect form is employed in the study. This also provides justification for estimating the demand relationships without considering simultaneity (Pope *et al.*; and Chang). The unrestricted form is used because results of research on the demand for meats reported by Christensen and Manser (1975) rejected the additivity and homotheticity restrictions. In the current study, a shortcoming is that these and other restrictions on demand were not tested.

<sup>1</sup> In addition to those already identified, other meat demand studies include: Breimyer; Fox; Fuller and Ladd; Schultz; Tomek; and Working.

prices,  $Q_i$  = per capita consumption,  $A_i$  and  $B_{ij}$  are parameters.

Because of the budget constraint, two of the above budget share equations are independent. It is assumed that the share equations have additive disturbances with a joint normal distribution, mean zero and constant covariance. Thus, given the disturbances of any two equations, the disturbance of the remaining share equation can be determined from the budget constraint. In addition, the budget share equations are homogeneous of degree zero in the parameters. A normalization,  $\sum_j A_j = 1$ , is required for estimation. The above basic model is used to incorporate habit formation and/or shifts in the budget shares.

*Habit Formation*

Manser; Lamm; Green *et al.*; Pope *et al.*; and more recently, Blanciforti, have included the influence of habit formation in demand systems. In general, this dynamic form of demand has provided better approximations to consumer behavior than the static formulation. The budget share equations for the above basic model extended to allow for habit formations take the following form (Manser):

$$w_{it} = \frac{A_i + H_i Q_{it-1} + \sum_j B_{ij} \ln P_j^*}{\sum_j A_j + \sum_j H_j Q_{jt-1} + \sum_j \sum_i B_{ij} \ln P_j^*} \quad (2)$$

Again, to facilitate estimation, the normalizations  $\sum_j A_j = 1$  and  $\sum_j H_j Q_{jt-1} = 0$  are imposed (Lamm).

*Shifts in the Budget Shares*

There is evidence which suggests a structural change in the demand for meats since the mid-seventies (Chavas; Braschler) which is not explicitly accounted for

in the basic budget shares model.<sup>3</sup> To account for this apparent structural change, and to perhaps better explain consumer behavior, a dummy variable (taking on a value of 0 for 1965-74 and 1 for 1975-81) was added to each budget share equation. The normalization  $\sum_j D_j = 0$  is imposed to assure that the budget shares sum to unity.<sup>4</sup>

**Data and Estimation Approach**

Annual data for the period 1965-81 were used to estimate the parameters of the budget share equations.<sup>5</sup> Price and per capita consumption statistics were obtained from standard USDA sources. Following Christensen and Manser (1975), for convenience in estimation, the  $P_{it}^*$  series were scaled with 1967 = 1.0. While the parameter estimates of the budget share equations are not invariant to such scaling, the resulting elasticities are invariant to scaling (Christensen and Manser, 1977).

In the formulations of the above budget share equations it is hypothesized that de-

<sup>3</sup> For the period 1965-81, ordinary least squares was employed in a preliminary analysis to test the significance of a shift variable (0 for 1965-74 and 1 for 1975-81) in demand equations for each of the meats under investigation. Coefficients obtained for the shift variable indicate that there has been a significant shift in the demand relationships for each of the three meats, which were not accounted for by prices of substitutes and per capita disposable income, during the period 1975-81. These results differ from those reported by Chavas in that in addition to beef and chicken, the demand for pork also exhibits a structural change.

<sup>4</sup>  $D_j$  is the coefficient associated with the dummy variable in budget share equation  $j$ .

<sup>5</sup> One reason for selecting this time period was based on the changes in price spread measurements for beef and pork and the data series which reflect these changes, 1965 to present (Duewer). Also, Chavas, using a Kalman filter specification, analyzed U.S. meat demand in the 1970s and identified a structural change for beef and poultry in the last part of the decade.

TABLE 1. Parameter Estimates for Alternative Formulations of the Budget Share Equations.

Parameter	No Shift Var. No Habit Form.	No Shift Var. Habit Formation	Shift Variable No Habit Form.	Shift Variable Habit Formation
$A_b$	0.5618 (143.095) <sup>a</sup>	0.5925 (28.4571)	0.5587 (165.103)	0.5944 (36.5024)
$A_p$	0.3219 (116.554)	0.3318 (35.3226)	0.3241 (130.759)	0.3377 (50.6873)
$B_{bb}$	0.5982 (0.4974)	0.2298 (0.1815)	1.6574 (1.6607)	0.6751 (0.5891)
$B_{bp}$	0.4750 (0.7303)	0.2911 (0.4221)	1.0467 (1.9506)	0.5373 (0.8597)
$B_{bc}$	0.2159 (0.9464)	0.1722 (0.7188)	0.3956 (2.1568)	0.2427 (1.1372)
$B_{pp}$	0.3469 (0.9661)	0.2492 (0.6535)	0.6733 (2.3458)	0.3960 (1.1565)
$B_{pc}$	0.1746 (1.4630)	0.1520 (1.200)	0.2432 (2.3509)	0.1583 (1.3008)
$B_{cc}$	0.0367 (0.7187)	0.0288 (0.5367)	0.1008 (2.9813)	0.0724 (1.7789)
$H_b$		-0.00038 (-1.5111)		-0.00044 (-2.3087)
$H_p$		-0.00017 (-1.1457)		-0.00024 (-2.1296)
$D_b$			0.0103 (2.1173)	0.0124 (2.2389)
$D_p$			-0.0152 (-3.9546)	-0.0154 (-4.1548)
$\Sigma e_{bt}^2$	$0.1043 \times 10^{-3}$	$0.1264 \times 10^{-3}$	$0.7964 \times 10^{-4}$	$0.9513 \times 10^{-4}$
$\Sigma e_{pt}^2$	$0.5650 \times 10^{-4}$	$0.5602 \times 10^{-4}$	$0.4290 \times 10^{-4}$	$0.3932 \times 10^{-4}$

<sup>a</sup> Numbers in parentheses are ratios of the estimated coefficient to the asymptotic standard error.

cisions made by consumers, in their purchases of beef, pork, and chicken, respectively, are each influenced by the same factors: own price, prices of substitutes, and income or total expenditures. In addition, it is plausible to assume that there may be common factors that affect decisions by consumers that are not captured in the equations. Thus, the disturbance terms of the various equations are correlated, indicating the influence of these common factors. To account for this in the estimation process, and given that the model is nonlinear in the parameters, the iterative version of Zellner's seemingly unrelated regression (IZEF) procedure is employed. Capps has shown that the IZEF technique is generally preferred over the

maximum likelihood procedure, an alternative to IZEF for estimating nonlinear demand systems.

### Parameter Estimates

Since only two of the three budget share equations specified above are independent, i.e., the variance-covariance matrix of disturbances is singular, the chicken equation is deleted. In the absence of autocorrelation, the estimated results are invariant to the choice of which equation is deleted (Berndt and Savin). The estimated coefficients, the ratios of the estimated coefficients to their standard error (Kmenta, p. 584), and the error sums of squares

**TABLE 2. Test Statistics for Habit and Shift Effects.**

Null Hypothesis	Degrees of Freedom	$\chi^2$ <sup>a</sup>	$\chi^2_{0.005}$
$H_0: H_i; D_i = 0$	4	19.842	14.860
$H_0: D_i = 0$	2	18.118	10.597
$H_0: H_i = 0$	2	5.398	10.597

<sup>a</sup>  $2(\frac{\max_{w/o} LL - \max_w LL}{w})$  where LL is the log likelihood function without (w/o) restrictions and with (w) restrictions under the null hypothesis is distributed asymptotically as  $\chi^2$  with the number of degrees of freedom equal to the number of restrictions to be tested.

for four alternative model formulations are presented in Table 1.

To test for habit and shift effects, the likelihood ratio test is used (Theil 1971, pp. 396-97). Appropriate chi-square test statistics and the critical chi-square values are presented in Table 2. The null hypothesis of no habit formation cannot be rejected in any of the cases considered, with or without a shift effect.<sup>6</sup> The null hypothesis of no shift effect is rejected. As

<sup>6</sup> This finding is at variance with results from previous studies which address habit formation in meats, e.g., Pope *et al.*; and is also at odds with those studies which have addressed habit formation in general and for other goods (Johnson *et al.*). One possible explanation for this result is that since many of the ratios of the estimated coefficients to the asymptotic standard errors are low (except in the model including the shift effect but no habit formation), the effects of collinearity among independent variables may be present. While diagnosing the presence of collinearity or assessing its effects is difficult (Belsley *et al.*, p. 96), inspection of the correlation matrix of independent variables reveals that the correlation coefficient between  $\ln P_p^*$  and  $\ln P_c^*$  is 0.74, where  $P_i^*$  are scaled. Selected correlation coefficients between  $\ln P_i^*$  and lagged consumption (reflecting habit formation) are -0.61, -0.72 and -0.90. Correlation coefficients of these magnitudes suggest that collinearity may not be of serious concern, at least on a pair-wise basis except when lagged consumption is incorporated into the model. This may, at least partially, account for the inference of no habit formation. Another possible explanation is that the indirect translog demand system is inappropriate in this application. In any event, the result of no habit formation in meats must be viewed with caution.

a result, the model formulation including the shift effect but no habit formation is used for further analyses.<sup>7</sup> Using the normalizations  $\sum_j A_j = 1$  and  $\sum_j D_j = 0$ ,  $A_c = 0.1172$  and  $D_c = 0.0049$ .<sup>8</sup>

**Elasticities**

In this section uncompensated direct and cross price elasticities, expenditure and income elasticities and Allen elasticities of substitution are presented. The appropriate formulas follow (Christensen and Manser, 1977):

$$E_{ii} = -1 + \frac{B_{ii}/w_i - \sum_j B_{ji}}{1 + \sum_i \sum_j B_{ij} \ln P_j^*};$$

$$E_{ij} = \frac{B_{ij}/w_i - \sum_j B_{ji}}{1 + \sum_i \sum_j B_{ij} \ln P_j^*};$$

$$E_{IM} = 1 + \frac{-\sum_j B_{ij}/w_i + \sum_i \sum_j B_{ji}}{1 + \sum_i \sum_j B_{ij} \ln P_j^*};$$

$$S_{ij} = \frac{E_{ij} + w_i E_{IM}}{w_j}$$

<sup>7</sup> Theil (1980, p. 154) suggests that autocorrelation could be a problem when using the translog approach and urges users of this approach to provide evidence of autocorrelation, or its absence. Accordingly, regressions of the residuals on their lagged values were estimated for each period to obtain estimates of the first-order autocorrelation coefficient, rho, and the accompanying t-value. From these results, it was concluded that the disturbance terms from each of the equations are serially independent. In addition, parameter estimates of the budget share equations were invariant with respect to which equation was deleted. This also implies that the disturbance terms are serially independent (Berndt and Savin).

<sup>8</sup>  $\text{Var } A_c = \text{Var } A_b + \text{Var } A_p + 2 \text{Cov}(A_b, A_p) = 0.000004$  or standard error = 0.002.  $\text{Var } D_c = \text{Var } D_b + \text{Var } D_p + 2 \text{Cov}(D_b, D_p) = 0.000028$  or standard error = 0.0053.

**TABLE 3. Estimated Uncompensated Direct Price and Cross Price Elasticities—Beef (b), Pork (p), and Chicken (c).**

	Budget Share Eq. w/Shift Variable 1965–81			
	1965	1970	1975	1980
$E_{bb}$	-1.063	-1.312	-1.166	-1.389
$E_{pp}$	-0.940	-0.754	-0.872	-0.691
$E_{cc}$	-0.934	-0.738	-0.841	-0.682
$E_{bp}$	-0.043	-0.206	-0.111	-0.255
$E_{bc}$	-0.015	-0.074	-0.039	-0.092
$E_{pb}$	0.060	0.310	0.146	0.398
$E_{pc}$	0.0007	0.042	0.012	0.059
$E_{cb}$	0.123	0.724	0.402	0.911
$E_{cp}$	0.036	0.356	0.182	0.461

A rough estimate of the income elasticities ( $E_{iY}$ ) for each meat is given by (Manser, p. 887):

$$E_{iY} = \frac{\partial Q_i}{\partial Y} \frac{Y}{Q_i} = \frac{\partial Q_i}{\partial M} \frac{M}{Q_i} \frac{\partial M}{\partial Y} \frac{Y}{M} = E_{iM} E_{MY}$$

In order to estimate  $E_{iY}$ , an auxiliary equation is needed which expresses the expenditure for beef, pork, and chicken (M) as a function of disposable income (Y). The estimated auxiliary equation and summary statistics follow:

$$\begin{aligned} \hat{M} &= 31.3284 + 0.0356Y \\ R^2 &= 0.97 \\ F &= 562.92. \end{aligned}$$

Since elasticities generally vary over time, elasticities are calculated for five year intervals for the period 1965–81. Uncompensated direct and cross price elasticities are presented in Table 3. Expenditure and income elasticities and the Allen elasticities of substitution are displayed in Table 4.

### Evaluation and Discussion of Results

Consistent with theoretical expectations, all estimates of direct price elasticities are negative. However, the estimates for beef tend to be larger than those usually reported. One explanation for the

**TABLE 4. Estimated Expenditure and Income Elasticities and Allen Elasticities of Substitution—Beef (b), Pork (p), and Chicken (c) from Budget Share Equations.**

	Expenditure Elasticities			
	1965	1970	1975	1980
$E_{bM}$	1.121	1.592	1.317	1.737
$E_{pM}$	0.880	0.402	0.714	0.233
$E_{cM}$	0.775	-0.343	0.257	-0.691
Income Elasticities <sup>a</sup>				
$E_{bY}$	0.824	1.261	1.125	1.567
$E_{pY}$	0.647	0.318	0.610	0.210
$E_{cY}$	0.570	-0.272	0.219	-0.623
Allen Elasticities of Substitution <sup>b</sup>				
$S_{bp}$	0.989	0.943	0.973	0.924
$S_{bc}$	0.998	0.924	0.973	0.889
$S_{pc}$	0.885	0.781	0.819	0.778

<sup>a</sup>  $E_{iY} = E_{iM} E_{MY}$ ;  $E_{MY} = 0.735, 0.792, 0.854, 0.902$  for 1965, 1970, 1975, 1980, respectively, and are calculated from the auxiliary equation previously presented.

<sup>b</sup>  $S_{ij} = S_{ji}$ , e.g.,  $S_{bp} = S_{pb}$ .

atypical estimates is that the additivity constraint has not been imposed. Christensen and Manser (1975, p. 429) found that this constraint, implicit in many previous studies, tends to lower the estimates of direct price elasticities for meat. Excepting  $E_{bp}$  and  $E_{bc}$ , the estimated cross price elasticities exhibit positive relationships, which is generally expected for substitute commodities.

As previously noted,  $E_{bp}$  and  $E_{bc}$  estimates suggest a negative relationship between prices of pork and chicken and quantity of beef demanded. Since beef and pork and beef and chicken are usually considered competitors for the consumer food dollar, this result appears to conflict with theory.

While cross price elasticity is the most commonly used measure of the possibilities for substitution between two commodities, it is not entirely satisfactory (Tomek and Robinson, 1981, p. 51). It measures the gross effect of a change in the price of one commodity on the quantity consumed of another commodity, and

thus confounds the income and substitution effect. A more desirable measure of substitutability would be one which does not contain an income effect (Hirshleifer, p. 125). Such a measure is Allen's elasticity of substitution.<sup>9</sup> It is a weighted price elasticity computed along an indifference curve and measures the strength of the substitution relationship between two goods. It is derived from compensated demand functions in which income is not an argument. These relationships follow from the Slutsky equation.

It is suggested that the negative cross price elasticities in this and other studies may have perfectly reasonable economic explanations. Using the Allen elasticity of substitution in conjunction with the expenditure elasticity, makes it possible to sort out the income and substitution effects which tend to be confounded in the cross price elasticity measure.

When two goods are competitive in consumption, the Allen elasticity of substitution is positive, and when the two goods are complementary, it is negative. Allen (p. 513) states that one or both of the cross price elasticities  $E_{ji}$  and  $E_{ij}$  (Table 3) can be negative if the expenditure elasticity  $E_{im}$  or  $E_{jm}$  (Table 4) is positive and greater than the Allen elasticity of substitution (Table 4). This is a situation in which the income effect dominates the substitution effect, and appears to be the case applicable to beef; i.e., when the price of chicken or pork decreases, more beef is consumed.

In summary, it is possible for the cross price elasticities (gross effects) to be negative for competing goods. Thus, when the price of commodity  $j$  increases, the consumption of both  $i$  and  $j$  will be adversely affected if the negative real income effect

dominates the positive substitution effect. In the case of competing goods, such a relationship is dependent on the relative magnitudes of the direct price and expenditure elasticities, i.e., the homogeneity condition. For example, if for a normal good  $i$ , the expenditure elasticity is greater than the absolute value of the direct elasticity, one or more of the cross price elasticities is/are negative. In the specific case described in this analysis, the reported results appear to depend on a further condition being met, as follows:

$$E_{im} > |E_{ij}| > 1 > |E_{ji}|.$$

That is, one of the two goods, say good  $i$ , must have a direct price elasticity which is in the elastic range but smaller in absolute value than its expenditure elasticity, while the other good (good  $j$ ) must have a direct price elasticity which is in the inelastic range. These relationships are required in order that a reduction in the price of good  $i$  will increase expenditures for that good, while a reduction in the price of good  $j$  will yield the savings necessary to increase the consumption of good  $i$ . Thus,  $E_{ij}$  can be negative while  $E_{ji}$  is positive. The practical consequences of these relationships with regard to consumer purchasing behavior for beef, pork, and chicken are discussed below.

### Implications

The large expenditure elasticities for beef, when compared with the magnitude of the Allen elasticities of substitution for beef, suggest that the effect on quantity of beef demanded via changes in real income is stronger than the substitution effect. As a result, for a decrease (increase) in the price of chicken or pork, beef consumption increases (decreases). For the period of analysis, this impact on beef consumption is greater for a change in the price of pork than for a change in the price of chicken.

The effects of changes in beef prices on

<sup>9</sup> Allen elasticities of substitution are used in lieu of compensated demand elasticities because the former is not only useful for comparing goods as to whether they are substitutes or complements, but also how strongly they are one or the other (Layard and Walters, p. 142).



chicken and pork consumption exhibit a direct relationship. That is, if the price of beef decreases (increases) the quantities of pork and chicken demanded decrease (increase). A change in the price of beef affects the consumption of chicken more than that of pork.

Regarding beef consumption, the results of this study suggest that consumers are very responsive to changes in the price of beef and to changes in real income. The finding of negative relationships between the price of substitute meats and the consumption of beef suggests that when the prices of pork or chicken decline (increase), consumers operating on a relatively fixed meat budget, have more (less) money left to spend on beef. This reflects the dominance of the income effect over the substitution effect.

When the price of pork or chicken declines, both having own price elasticities less than unity (inelastic), consumption will increase less than proportionally to the decline in price, and expenditures for these products will decline. Savings will accrue to consumers, and given the much higher expenditure elasticities for beef as compared to pork and chicken, these savings are likely to be diverted to the purchase of more beef. In this case, the expenditure elasticity for beef ( $E_{bM}$ ) is much higher than the Allen elasticities of substitution ( $S_{bp}$  or  $S_{bc}$ ) and the income effect is clearly dominant. The effect does not appear to work in the opposite direction because the demand for beef is elastic and when price of beef declines, increases in beef consumption will be more than proportional to the decline in price, and expenditures for beef will actually increase. Thus, there are no budget savings from beef to be diverted to pork and chicken.

The substitutability among the meats based on price (as indicated by the Allen elasticities) is roughly similar among all pairs. However, when pressure on real income forces reductions in total expenditures for all meats, the brunt of the re-

duced consumption will be felt by beef; pork consumption will decrease slightly; and consumption of chicken may actually increase.

The significance of the shift effect suggests that variables other than prices of the respective meats are important in explaining variations in the respective budget shares. Additional research is needed to isolate the variables responsible for the structural changes, identified by Chavas and Braschler, in the demands for selected meats observed both in the current work and in earlier studies.<sup>10</sup>

### Concluding Remarks

The use of appropriate theoretical constructs is a fundamental prerequisite to sound applied econometric analyses. In the case of demand analysis, depending on how the model is formulated and the restrictions placed on the underlying utility function, elasticity estimates can vary substantially. Several approaches have been used to model consumer behavior. Among these include: the Rotterdam model (Theil, 1965), the almost complete system (Heien, 1965), the almost ideal demand system (Deaton and Muellbauer, 1980a, 1980b) and the translog indirect model (Christensen *et al.*). With the proliferation of these and other models which purport to represent consumer behavior, it is perhaps time for a critical evaluation of each of these models from the standpoint of its theoretical merits, as well as a comparison of results generated from each.

With respect to the model used in this study, the following caveats are in order.

<sup>10</sup> More recently, Moschini and Meilke concluded that the evidence of structural change in the demand for beef is weak and suggest that the recent decline in beef consumption may be due to changed market conditions. If this is the case, results presented in this paper suggest that prices of commodities other than substitutes might be useful in explaining the apparent shifts in demands for beef, pork, and chicken.

The demand functions from the translog indirect model are complicated and difficult to estimate. The translog formulation is a flexible functional form which has merit. However, the price paid for flexibility is the large number of parameters to be estimated, which limits the number of goods which can be analyzed. In addition, the quality of the approximation of the indirect utility function appears to be sensitive to the selection of the year in which  $P_{ii}^*$  is set equal to 1 (Theil, 1980, p. 156).

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