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# Heteroscedasticity in Broiler Meat Expenditure Pattern Estimation

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This study presents the empirical results of estimating the household broiler meat expenditure pattern in the western region using the 1977-78 United States Department of Agriculture Nationwide Food Consumption Survey. The effects of assuming homoscedasticity and heteroscedasticity in the tobit model on resulting estimates are discussed in terms of estimated coefficients, marginal effects, and elasticities. Based on the strength of the sample data, the results suggest that specification of the homoscedastic model should be rejected in favor of the heteroscedastic model, implying that the validity of homoscedasticity should not be routinely accepted without testing when applying tobit procedure to analyze survey data.

*Key words:* broiler meat, elasticity, error specification, heteroscedasticity, tobit.

In a recent survey article, Amemiya examines and assesses the current development of tobit models and various estimation methods for these models. He suggests that the increase in the availability of microsample survey data and the advance in computer technology have contributed to the growing attention received by the tobit model. The tobit model, named after Tobin's pioneer development of a hybrid procedure of probit analysis and multiple regression, is particularly useful when analyzing economic survey data. A common characteristic of cross-sectional survey data is that the dependent variable is often observed to be clustered at a limiting value for a substantial number of responses. For example, in analyzing household expenditures on durable goods, Tobin noted that such expenditures cannot be negative and that not all the households purchase a durable good at a given point in time. Therefore, the sample data contain a large number of zero expenditures for nonpurchasing households, which violates the basic assumption in the ordinary least squares (OLS) regression and, hence, renders OLS inappropriate for statistical estimation and inference.

A growing body of literature reveals that the tobit model has been applied over a wide range of socioeconomic research (Fair; Lane; Stephenson and McDonald; Thraen, Hammond, and Buxton). However, in applications of the tobit model, constant error variance typically has been assumed and specified. Few studies (Bomberger and Denslow; Fishe, Maddala, and Trost; Smith and Maddala; Warner) considered the implications of heteroscedasticity. While the consequences of incorrectly specifying homoscedasticity in linear regression are well known and can be easily overcome, the results of misspecification in the tobit model, such as heteroscedasticity, have not received much attention in the applied literature.

Using a simple model with a constant and one regressor, Hurd has shown that under the incorrect assumption of constant variance from a truncated sample, the maximum likelihood estimates are not only inconsistent but also biased and the asymptotic bias may be substantial even with a modest presence of heteroscedasticity. A similar result was obtained by Maddala and Nelson, who suggested that if heteroscedasticity is ignored, the resulting estimates of the tobit model are not consistent. Some additional evidence presented by Arabmazar and Schmidt is somewhat more optimistic—suggesting that heteroscedasticity of given severity causes less inconsistency and

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The authors gratefully acknowledge the constructive comments of the *Journal* reviewers.

asymptotic biases in the tobit model than in the truncated case.

Fishe, Maddala, and Trost have shown that ignoring heteroscedasticity resulted in underestimation of the income elasticity of restaurant expenditures. In analyzing the demand for money and other assets, Bomberger and Den-slow found that the wealth effect is underes-timated and the income effect is overestimated when heteroscedasticity is ignored in the tobit model. Unfortunately, as Maddala and Nelson point out, much remained to be said about the direction of bias even when special assumptions are made about the residual variances. The effects of heteroscedastic variances on re-sulting parameter estimates appear to be an issue which can be ascertained only through empirical investigation.

The objective of this study is to estimate a tobit model which examines the effects of income and other socioeconomic characteristics on household expenditure for broiler meat in the western region based on the 1977-78 U.S. Department of Agriculture (USDA) Nation-wide Food Consumption Survey (NFCS). The tobit model is used because it accounts simultaneously for the effects of the socioeconomic characteristics on the magnitude of broiler meat expenditures as well as the probability of expending on broiler meat. The probability measure derived from the tobit results provides additional information which can be used to develop more effective marketing and advertising strategies. Furthermore, the study also tests the validity of a heteroscedastic specification with regard to the variance of the tobit model. The results of homoscedastic and heteroscedastic tobit models are presented and compared to determine the effects of assuming heteroscedastic variance on the resulting pa-rameter estimates.

## Model Specification and Procedure

The tobit model is specified as

$$(1) \quad Y_i = X_{ji}\beta_j + U_i, \quad \text{if RHS} > 0 \\ = 0 \quad \text{otherwise,} \\ i = 1, 2, \dots, n, \quad j = 1, 2, \dots, k,$$

where  $Y_i$  is an  $n \times 1$  vector representing ob-servations of the dependent variable;  $X_{ji}$  is an  $n \times k$  matrix consisting of observations for the  $k$  independent variables;  $\beta_j$  represents a  $k \times 1$

vector of unknown parameters associated with the independent variables; and  $U_i$  are residuals such that  $N(0, \sigma^2)$  is assumed. Note that in the following presentation, subscripts are omitted for simplicity when appropriate. Tobin has shown that the unconditional expected value of  $Y$  in equation (1),  $E(Y)$ , is

$$(2) \quad E(Y) = X\beta F(z) + \sigma f(z),$$

where  $z = X\beta/\sigma$ , and  $f(z)$  and  $F(z)$  are the unit normal density function and cumulative normal distribution, respectively. However, if the "true" model is heteroscedastic, with pa-rameters  $\sigma_i$  and  $\beta_0$ , the "true" expected value for  $Y$  becomes

$$(3) \quad E(Y) = X\beta_0 F(X\beta_0/\sigma_i) + \sigma_i f(X\beta_0/\sigma_i).$$

Hence, equation (2) is misspecified, and the square root of variance,  $\sigma_i$ , in equation (3) is the source of biased and inconsistent estimates of the unknown parameters.

In applying the tobit model, most studies have conveniently assumed a homoscedastic error structure such that residual variance in equation (1) is a constant. The validity of such an assumption is rarely tested. One apparent reason for overlooking the problem of heteroscedasticity in the tobit model appears to be the lack of statistical computer software which estimates parameters in a tobit model and tests for the presence and nature of heteroscedas-ticity. Recently, Nelson suggested a  $m$ -statistic for testing general misspecification in the tobit model. Although the  $m$ -statistic proposed by Nelson can be computed from the results of the tobit estimates, the test result indicates only whether or not the model under consideration is misspecified. This is because the  $m$ -statistic test does not require the specification of an alternative hypothesis and, hence, failure to pass the test can mean any model misspecifications other than misspecifying error struc-ture.

Alternatively, an assumption with respect to heteroscedastic error structure can be incorporated in the model specification and sim-taneously tested using the maximum likeli-hood procedure (Fishe, Maddala, and Trost). Following Fishe, Maddala, and Trost, the problem of testing a heteroscedastic tobit model can be treated as a hypothesis testing problem rather than a test to determine the "true" mod-el. Similar to the procedure of correcting het-eroscedasticity in the OLS model, some spe-cific assumptions about the nature and forms

of heteroscedastic variance are required in the specification of a heteroscedastic tobit model.

Based on Rutenmiller and Bowers, Fiske, Maddala, and Trost suggest an estimator for the tobit model such that the error variance in equation (1) is specified as

$$(4) \quad \sigma_i^2 = (r + \tilde{X}_{ji}\delta_j)^2,$$

where  $\tilde{X}_{ji}$  may be some subset of the independent variables. From equation (4), it follows that if  $\delta_j = 0$ , then the model reduces to a homoscedastic specification. Within this context, a test for the null hypothesis of  $\delta_j = 0$  is an appropriate test to detect the presence of heteroscedasticity. Furthermore, a likelihood ratio test can be formulated to test for alternative model specifications (Maddala).<sup>1</sup>

Although the specification of equation (4) represents only a limited number of alternatives that may be assumed with respect to the nature of heteroscedasticity in relation to equation (1) and test for its presence, equation (4) provides a general form of heteroscedastic variance structure that is usually found in empirical applications. Furthermore, the incorporation of equation (4) into equation (1) is rather easy to implement in the estimation procedure.

In specifying the statistical model for empirical estimation, the dependent variable is the weekly household broiler meat expenditures. Among various household socioeconomic characteristics, income and household size and composition have been shown to be important factors influencing household food expenditures (Haidacher et al.; Huang and Raunikar; Salathe). In order to capture the possible nonlinear effect of income on broiler meat expenditures, a logarithmic transformation of the income variable is specified. The effect of variations in household size and composition on household broiler meat expenditures is controlled in the model by including a set of age-sex classification variables which represent the number of persons in each classification for the household. The effect of economy of scale due to household size is represented by the square of household size variable. The effect of consuming food away from home

is hypothesized to have a negative effect on household broiler meat expenditures. This effect is captured in the model by including a number of meals eaten away from home variable. Variables representing the race, degree of urbanization, and wife's employment status are entered as dummy variables.

Without any a priori knowledge concerning the nature of heteroscedasticity, equation (4) is specified to include all the independent variables postulated for equation (1). Hypothesis testing with respect to  $\delta_j = 0$  in equation (4) is then used to determine the presence and structure of the heteroscedastic variance for equation (1) in the final estimation of the model.

Given the model specification of equations (1) and (4), the likelihood function can be formulated and solved for the unknown parameters of  $\beta$ s,  $r$ , and  $\delta$ s. The formation of the likelihood function and its first-order derivatives with respect to the unknown parameters can be found elsewhere in the literature (Maddala) and are omitted here for the sake of brevity.

## The Data

The 1977-78 USDA Nationwide Food Consumption Survey is the source of data used in this study. The NFCS data consist of approximately 15,000 households in the United States across the four census regions. A subsample of 1,645 households from the western region is used for this analysis. An advantage of using a regional sample is that it provides a more homogenous group of households on the basis of geographic location. Using a regional sample would also facilitate a more comprehensive comparison of broiler meat expenditure patterns among households in different regional locations than if the regional variations in expenditure patterns are simply treated as shifting parameters. Furthermore, the use of a regional sample substantially reduces the magnitude of the nonlinear estimation problem in the sense that fewer parameters and observations are involved.

Sample households used in the statistical analysis were checked for completeness and consistency of information reported in the survey. The major criterion is to select households that reported after-tax income. Unlike previous studies (Huang and Raunikar; Salathe), the after-tax income rather than the before-tax

<sup>1</sup> The likelihood ratio statistic is defined as  $-2(\log L^* - \log L)$ , where  $\log L^*$  and  $\log L$  are the maximum of the log likelihood function of the homoscedastic and heteroscedastic models, respectively. The likelihood ratio statistic is distributed asymptotically as  $\chi^2$ , with degrees of freedom equal to the difference in the numbers of parameters in the two models.

**Table 1. Sample Means and Standard Deviations, Western Region, U.S., 1977-78**

Variable	Limit Sample	Nonlimit Sample	Total Sample
Broiler meat expenditures (\$/wk)	.0 (.0) <sup>a</sup>	2.35 (1.59)	1.18 (1.63)
Household after-tax income (\$/wk)	234.27 (175.37)	238.58 (162.48)	236.44 (178.62)
Household size	2.65 (1.60)	2.98 (1.64)	2.82 (1.62)
Household age-sex composition:			
Male adult $\geq$ 35 years	.524 (.512)	.513 (.521)	.519 (.517)
Female adult $\geq$ 35 years	.574 (.521)	.587 (.519)	.581 (.520)
19 $\leq$ male adult $\leq$ 34 years	.318 (.509)	.343 (.512)	.331 (.510)
19 $\leq$ female adult $\leq$ 34 years	.382 (.550)	.438 (.539)	.410 (.545)
13 $\leq$ male $\leq$ 18 years	.168 (.488)	.180 (.480)	.174 (.483)
13 $\leq$ female $\leq$ 18 years	.147 (.424)	.203 (.501)	.175 (.465)
6 $\leq$ child $\leq$ 12 years	.315 (.690)	.371 (.735)	.343 (.713)
Child $\leq$ 5 years	.226 (.557)	.344 (.707)	.286 (.639)
Meals eaten away from home (no./wk)	.433 (.536)	.344 (.463)	.388 (.502)
Wife employed (%)	26.81	25.24	26.02
Black household (%)	2.69	7.49	5.11
Rural household (%)	14.93	11.59	13.25
No. of households	817	828	1,645

Source: Compiled from the 1977-78 USDA Nationwide Food Consumption Survey.

<sup>a</sup> Numbers in parentheses are standard deviations.

income is used to measure the effect of income on variations of household broiler meat expenditure in this analysis. The choice of using the after-tax income slightly reduces the number of households available for analysis due to nonreporting status. With the relatively large sample size used in the study, the loss of a few degrees of freedom due to the use of the after-tax income variable appears to be inconsequential from the standpoint of statistical estimation. More important, since after-tax income provides a better approximation for measuring the household's disposable income than before-tax income, after-tax income theoretically provides the more accurate measurement for the income effect.

Summary statistics of sample data distinguished between limit and nonlimit observations are presented in table 1. Of the subsample, 828 households, or 50.33%, reported broiler meat expenditures during a one-week survey period. Among the households that reported broiler meat expenditures, household

expenditures for broiler meat averaged about \$2.35 per household per week. Comparison of household socioeconomic characteristics between the limit and nonlimit samples yields some interesting insights. Table 1 indicates that households reporting expenditures for broiler meat, on average, tend to be larger in size and report fewer meals away from home than households in the survey reporting no expenditures for broiler meat. Furthermore, a far greater proportion, 7.49%, in the nonlimit sample are black households compared with 2.69% in the limit sample.

## Results and Discussion

The results of the tobit model, assuming a homoscedastic variance, are presented in table 2. In general, most of the estimated parameters are statistically different from zero at least at the .10 significance level. Although the sign associated with the employment status of wife

Table 2. Regression Results of Tobit Models for Broiler Meat Expenditures per Household per Week in the Western Region, U.S., 1977-78

Variable	Homoscedastic Tobit Model	Heteroscedastic Tobit Model
Constant	-1.964	-2.069
Black household ( $X_1$ )	1.633** <sup>a</sup> (5.129) <sup>b</sup>	1.559** (4.439)
Rural ( $X_2$ )	-.609** (-2.737)	-.526** (-2.595)
Wife employed ( $X_3$ )	-.219 (-1.215)	-.237 (-1.367)
Household size square ( $X_4$ )	-.022 (-1.002)	-.052* (-1.829)
Male adult $\geq 35$ years ( $X_5$ )	.520** (2.223)	.524** (2.259)
Female adult $\geq 35$ years ( $X_6$ )	.698** (2.936)	.974** (3.836)
19 $\leq$ male adult $\leq$ 34 years ( $X_7$ )	.652** (2.851)	.651** (2.682)
19 $\leq$ female adult $\leq$ 34 years ( $X_8$ )	.664** (2.915)	.806** (3.274)
13 $\leq$ male $\leq$ 18 years ( $X_9$ )	.424* (1.712)	.600** (2.184)
13 $\leq$ female $\leq$ 18 years ( $X_{10}$ )	.852** (3.368)	.919** (3.230)
6 $\leq$ child $\leq$ 12 years ( $X_{11}$ )	.506** (2.593)	.596** (2.587)
Child $\leq$ 5 years ( $X_{12}$ )	.570** (2.926)	.809** (3.631)
Meals eaten away from home ( $X_{13}$ )	-.912** (-5.300)	-1.007** (-5.712)
Log (income) ( $X_{14}$ )	.187 (1.456)	.214* (1.803)
Standard error of estimates ( $\sigma$ )	2.665	2.605 <sup>c,d</sup>
Log maximum likelihood value	-1,013.49	-990.07

<sup>a</sup> Single asterisk indicates significant at the .10 significance level; double asterisk indicates significant at the .05 significance level.

<sup>b</sup> Numbers in parentheses are asymptotic *t*-ratios.

<sup>c</sup>  $\sigma = 2.514 + .339X_1 + .055X_4 - .469X_6 - .434X_9 - .570X_{12}$ .  
(1.398) (5.170) (-3.241) (-2.228) (-5.415)

<sup>d</sup> Evaluated at the means of the sample.

was negative as expected, the results suggest that the impact of employed wife on household expenditures for broiler meat was not statistically significant. Similarly, the results indicate that household disposable income and the square of household size also do not have any significant effects on broiler meat expenditures.

That the employed wife and income variables have no significant impact on household expenditures for broiler meat is somewhat surprising. One possible explanation could be that wife employment, income level, and meals eaten away from home are closely related and, hence, it is difficult to measure statistically the contribution of each variable separately. The results indicate that household age-sex composition is an important factor that explains

variations of broiler meat expenditures among sample households.

To test the assumption of homoscedastic variance postulated in equation (1), a heteroscedastic tobit model based on the specification of equation (4) was estimated. Initially, all the independent variables specified in equation (1) were assumed to contribute to the heteroscedastic variance of equation (4). To test the null hypothesis of the homoscedastic model against the alternative heteroscedastic specification, the likelihood ratio test is used. The result indicates that the likelihood ratio statistic of 57.26 is greater than the critical value of the chi-square distribution,  $\chi^2(14, .01) = 29.141$ , for rejecting the null hypothesis. Thus, the likelihood ratio test suggests that the homoscedastic tobit model should be rejected in

favor of the heteroscedastic tobit model. Furthermore, the results suggest that the source of the heteroscedasticity can be attributed mostly to the variations of the household characteristics. The evidence suggests that residual variances of equation (1) are significantly related to race, square of household size, adult female  $\geq$  thirty-five years, male person between thirteen and eighteen years, and child under six years.

Based on these preliminary results, the heteroscedastic tobit model was reestimated with equation (4) respecified to include only the subset of those independent variables found to have significant influence on the residual variances. The resulting likelihood ratio test fails to reject the hypothesis that the two specifications of the heteroscedastic tobit model were significantly different at the .10 significance level. Parameter estimates of the resulting heteroscedastic tobit model are also presented in table 2 for purpose of comparison.

The results of the heteroscedastic model are similar to those of the homoscedastic model. The signs are all consistent and most of the estimated coefficients are fairly close between the two models. Except for the race and urbanization variables, the magnitudes of the estimated coefficients for the heteroscedastic model are all greater than those obtained from the homoscedastic model. Most important, the results suggest that the heteroscedastic tobit estimator is more efficient than the homoscedastic tobit estimator. Most of the estimated coefficients obtained from the heteroscedastic model are associated with greater *t*-values than those of the homoscedastic model. While the household size squared and income variables were found to be statistically not significant at the .10 significance level under the homoscedastic assumption, the results show that both variables are statistically significant at the .10 significance level when heteroscedastic variance is assumed. Overall, the standard error of estimates for the heteroscedastic model when evaluated at the means is found to be slightly smaller than that of the homoscedastic model (table 2).

Results presented in table 2 suggest that the assumption of homoscedastic variance for the sample data used in this analysis may not be realistic or valid. The results indicate that the variance of broiler meat expenditures is not constant and is significantly associated with certain household characteristics, such as

household size and age-sex composition of the household members. Specifically, household size squared, female adult  $\geq$  thirty-five years, male between thirteen and eighteen years, and child under six years are all highly significant in explaining the residual variances of household expenditures for broiler meat.

## Implications

The regression parameters presented in table 2 cannot be directly interpreted in the same manner as those obtained from an OLS model. The reason for this is evident from equations (2) and (3), where the expected value of equation (1) is no longer the  $X\beta$  as in the case of OLS regression. To assess the marginal effects of the independent variables on the dependent variable, partial derivatives of equations (2) and (3) must be evaluated. Furthermore, the magnitudes of the expected value depend not only on the level that the dependent variable is greater than zero but also the probability that the dependent variable is greater than zero. Thus, the effect of a given change of an independent variable on household broiler meat expenditures is affected by both the level of positive expenditures and the probability that the expenditure levels are greater than zero, or the probability of market entry.<sup>2</sup> For purpose of comparison, the marginal effects associated with each independent variable derived from both homoscedastic and heteroscedastic models are presented in table 3.

Comparisons between the homoscedastic and heteroscedastic models reveal some interesting observations. For example, results of the heteroscedastic model suggests female adult

<sup>2</sup> Mathematically, equation (3) can be expressed as

$$E(Y) = F(Z)E(Y^*),$$

where  $E(Y^*) = E(Y|Y > 0)$  is the conditional expected value of  $Y$ , or the expected value of  $Y$  for observations above the limit. Thus, the partial derivative of  $E(Y)$  with respect to  $X_i$  is

$$(5) \quad \partial E(Y)/\partial X_i = F(Z)(\partial E(Y^*)/\partial X_i) + E(Y^*)(\partial F(Z)/\partial X_i),$$

where

$$(6) \quad \partial E(Y^*)/\partial X_i = \beta_i[1 - Zf(Z)/F(Z) - f(Z)^2/F(Z)^2] + \delta_i[1 + Zf(Z)/F(Z) + Z^2f(Z)/F(Z)], \text{ and}$$

$$(7) \quad \partial F(Z)/\partial X_i = (\beta_i - \delta_i)Zf(Z)/\sigma.$$

Substituting (6) and (7) into (5), one obtains

$$(8) \quad \partial E(Y)/\partial X_i = \beta_i F(Z) + \delta_i F(Z).$$

Furthermore, it is noted that when  $\delta_i = 0$ , all the second terms in equations (6), (7), and (8) vanished and equations (6), (7), and (8) reduced to a homoscedastic model.

**Table 3. Estimated Marginal Effects of Household Socioeconomic Characteristics on Broiler Meat Expenditures and Changes in Probability of Market Entry, Western Region, U.S., 1977-78**

Variable	Homoscedastic Tobit Model		Heteroscedastic Tobit Model	
	Marginal Effect (\$)	Change in Probability (%)	Marginal Effect (\$)	Change in Probability (%)
Black household	1.018	23.2	1.159	20.0
Rural	-.380	-8.7	-.341	-7.5
Wife employed	-.137	-3.1	-.154	-3.4
Household size <sup>a</sup>	-.077	-1.8	-.038	-2.9
Male adult $\geq$ 35 years <sup>b</sup>	.402	9.2	.493	8.7
Female adult $\geq$ 35 years <sup>b</sup>	.513	11.7	.611	17.6
19 $\leq$ male adult $\leq$ 34 years <sup>b</sup>	.484	11.0	.575	10.5
19 $\leq$ female adult $\leq$ 34 years <sup>b</sup>	.491	11.2	.675	12.7
13 $\leq$ male $\leq$ 18 years <sup>b</sup>	.342	7.8	.381	12.1
13 $\leq$ female $\leq$ 18 years <sup>b</sup>	.609	13.9	.749	14.3
6 $\leq$ child $\leq$ 12 years <sup>b</sup>	.393	9.0	.539	9.7
Child $\leq$ 5 years <sup>b</sup>	.433	9.9	.466	15.8
Meals eaten away from home	-.569	-13.0	-.653	-14.3
Income <sup>c</sup>	4.9E - 04	.01	5.8E - 04	.01

Note: Evaluated at the means of the total sample.

<sup>a</sup> Represents the economy of scale effect due to change in household size.

<sup>b</sup> Adjusted for the economy of scale effect.

<sup>c</sup> Adjusted for the partial derivatives of logarithmic transformation.

$\geq$ thirty-five years has the greatest impact on the probability of market entry than any members of the household, while the homoscedastic model indicates that this is the case with female between thirteen and eighteen years. Furthermore, the heteroscedastic model suggests that an additional child under six years would increase the probability of market entry considerably more than it would increase the expenditure as compared with those of the homoscedastic model. Given that female adults are usually the food preparer of the household and that small children do not consume much food and households with small children are likely to eat more meals at home, the results of the heteroscedastic model appeal to logic as well as reality over those of the homoscedastic model.

The estimated marginal effects indicate that black households, on average, spent about \$1.16 more on broiler meat per week than did nonblack households and that the probability of a black household entering the broiler meat market is about twenty percentage points greater than a nonblack household (heteroscedastic model). In addition to the race variable, addition of female adult  $\geq$ thirty-five years, child under six years, and meals eaten

away from home are found to have the greatest impacts on the probability of market entry. The results suggest that each additional meal eaten away from home reduces household expenditures for broiler meat by about 65¢.

Generally, greater impacts are exerted by adults than children and by female than male members of the household unit. The finding of greater impact on household broiler meat expenditures by adult female appears quite reasonable and can be attributed to the adult female usually being the meal preparer of the household. Therefore, other things being held constant, the presence of an adult female is likely to increase the probability of eating at home and, consequently, increases household expenditures for broiler meat. Furthermore, the results show a consistent pattern of greater marginal effects being associated with female sex characteristic of household members. This evidence appears to imply that females may have a stronger preference for broiler meat than males.

To examine further the effects of heteroscedasticity on the tobit results, the elasticities for selected household characteristics are computed for both models and presented in table 4. The elasticities are decomposed into two

**Table 4. Estimated Elasticities of Selected Household Characteristics for Broiler Meat Expenditures, Western Region, U.S., 1977-78**

Variable	Homoscedastic Tobit Model			Heteroscedastic Tobit Model		
	Total	Conditional	Market Entry	Total	Conditional	Market Entry
(%)						
Male adult $\geq$ 35 years	.136	.060	.076	.159	.089	.070
Female adult $\geq$ 35 years	.194	.085	.109	.220	.062	.158
19 $\leq$ male adult $\leq$ 34 years	.104	.045	.059	.118	.064	.054
19 $\leq$ female adult $\leq$ 34 years	.131	.057	.074	.172	.092	.080
13 $\leq$ male $\leq$ 18 years	.039	.017	.022	.041	.008	.033
13 $\leq$ female $\leq$ 18 years	.069	.030	.039	.081	.042	.039
6 $\leq$ child $\leq$ 12 years	.088	.048	.049	.115	.064	.051
Child $\leq$ 5 years	.081	.036	.045	.083	.013	.070
Meals eaten away from home	-.144	-.063	-.081	-.157	-.071	-.086
Household income	.076	.033	.043	.086	.039	.047

Note: Evaluated at the means of the total sample.

components representing conditional and market entry elasticities.<sup>3</sup> The conditional elasticity indicates the proportion of changes in household broiler meat expenditures that accrues to changes in expenditure level if it is positive. The market entry elasticity indicates the proportion of change in household broiler meat expenditures which is accounted for because of change in the probability of market entry.

Although there are substantial differences in model formulations, sample data and estimation procedure between this study and previous studies, the income elasticity derived in this study appears to be in agreement with those reported in previous studies. Under the assumption of homoscedasticity, Haidacher et al. reported an income elasticity of .04 on household expenditures for chicken and Salathe estimated income elasticity varying from .034 to .0931 on household expenditures for poultry.

The derived elasticities offer interesting observations. In general, under the assumption of homoscedasticity, the estimated total elas-

ticities are all smaller in magnitude than those obtained under the assumption of heteroscedasticity. Although the total elasticities do not seem to differ greatly between the two models, variations among the component elasticities suggest that implications to be drawn from these results may be quite different. In the homoscedastic model, the results suggest that market entry effect is predominant in accounting for the effect of change in socioeconomic characteristics on household expenditures for broiler meat. In contrast, results of the heteroscedastic model indicate that the importance of market entry effect relative to the conditional effect may vary considerably among different socioeconomic characteristics. For example, the heteroscedastic model suggests that the proportional changes of female adults and children under six years will have much greater impacts on market entry than on conditional expenditure level as compared with the homoscedastic model.

## Conclusion

In this study, the household expenditure pattern for broiler meat in the western region is examined using the tobit procedure. Although similar models have been developed previously, the validity of homoscedastic error specification was never investigated and tested. Given the nature of survey data, it is often assumed that the error term is heteroscedastic when the OLS procedure is used to estimate regression parameters. However, this practice

<sup>3</sup> From equation (5), the elasticity with respect to  $X_j$  can be expressed as

$$\begin{aligned}\eta_j &= [\partial E(Y)/\partial X_j][X_j/E(Y)] \\ &= [F(Z)(\partial E(Y^*)/\partial X_j)[X_j/F(Z)E(Y^*)] \\ &\quad + [E(Y^*)(\partial F(Z)/\partial X_j)][X_j/F(Z)E(Y^*)] \\ &= [\partial E(Y^*)/\partial X_j][X_j/E(Y^*)] + [\partial F(Z)/\partial X_j][X_j/F(Z)],\end{aligned}$$

where the first term is referred to as conditional elasticity and the second term is referred to as market entry elasticity. For ease of computation  $\eta_j$  and market entry elasticity may be obtained from equations (8) and (7), respectively. The conditional elasticity is then obtained as the difference between  $\eta_j$  and market entry elasticity.

does not seem to be always followed when a tobit model is estimated.

The study suggests that a general specification concerning the nature of residual variances may be assumed and incorporated in the tobit model for testing the presence of heteroscedasticity. After obtaining the maximum likelihood estimates of all parameters, the likelihood ratio test can be applied to select an appropriate model among the alternative specifications.

Evidence obtained in the study suggests that the residual variances in household broiler meat expenditures are significantly related to a number of household socioeconomic characteristics. The results show that most of the estimated parameters, marginal effects and elasticity measures are underestimated when homoscedasticity is assumed. More important, the results demonstrate that misleading implications may be derived if heteroscedasticity is ignored. Specifically, under the assumption of homoscedasticity, one would conclude that there is no significant economy of scale associated with household size, and that income has no significant effects on household expenditures for broiler meat. In fact, there is statistical evidence to suggest that this is not the case if the heteroscedastic specification is considered. Furthermore, the differences between the two models are generally more pronounced among those variables that are found to have an impact on the residual variances. This is to be expected because the estimated residual variances are figured in the computation of the results obtained from the models. Based on the evidence presented in this study, it is suggested that homoscedasticity should not be routinely assumed in the empirical application of tobit models. A more prudent practice would be to make some reasonable and realistic assumptions about heteroscedasticity for hypothesis testing as an integral part of the model estimation procedure.

[Received December 1985; final revision received August 1986.]

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