Derived Demand Elasticities: Marketing Margin Methods versus an Inverse Demand Model for Choice Beef

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Three methods of calculating the derived elasticity of demand for Choice slaughter beef are used: (a) a traditional marketing margin approach, (b) a modified marketing margin approach, and (c) an econometric, inverse demand model approach. The first method is more restrictive than the second but both tend to overestimate beef price flexibility and revenue changes. The econometric model, though an incomplete demand system, yields demand elasticities that are more consistent with marketing flexibility but are less pronounced than estimates of a complete system. An example using a two-year revenue forecast compares slaughter revenue adjustments based on the first margin method with those based on structural demand models.

Key words: derived demand, marketing margins, price elasticities.

Estimates of derived (farm-level) elasticities of demand for Choice beef obtained from an econometric demand model are compared with those estimated by two marketing margin methods. The econometric model is an incomplete demand system consisting of inverse demand equations at the farm and retail levels. The first margin method is based on the traditional approach which assumes that the margin consists of constant absolute and fixed percentage components (Waugh; George and King), while the second method is a modified approach that approximates relative farm-retail price spreads (Gardner; Heien; Wohlgenant and Mullen).

Estimating derived demand elasticities using linear constant absolute and fixed percentage margins (the traditional procedure) entails multiplying retail price elasticities of demand by the elasticities of price transmission between retail and farm prices (Waugh; George and King). Gardner and Wohlgenant indicate that this method is too restrictive. Such margin relationships imply that the constant absolute and fixed percentage components are

invariant with respect to marketing volume and that the marketing technology assumes fixed proportions between farm outputs and marketing services.

At the other end of the spectrum, farm demand elasticities can be estimated from econometric models of farm prices (inverse demand) with supplies assumed fixed. The inversion of the price flexibility coefficients serves as a lower bound to the elasticities of demand (Houck). Depending upon the maintained hypotheses, elasticity estimates from econometric models may be less restrictive since fixed proportions are not assumed; however, elasticity coefficients calculated from different econometric models usually vary due to different sample periods, systems specifications, a priori constraints, and statistical methods employed (Arzac and Wilkinson; Freebairn and Rausser; Brester and Marsh; Wohlgenant).

The modified margin approach essentially changes the traditional procedure by adding marketing quantities and marketing costs as arguments in a margin equation. Thus, margin behavior is not merely restricted to a markup pricing relationship but reflects relative shifts in retail demand and farm supply (Wohlgenant and Mullen). Since quantities marketed enter the margin equation, a modified formula is used to calculate farm demand elasticities (Hil-

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dreth and Jarrett), but the results are highly conditional upon the nature of retail elasticity of supply. Thus, the modified demand elasticity estimate may be bounded within the estimates of the traditional procedure and the econometric model.

The importance of these beef elasticity estimates relates to model simplification and extensions of margin analysis. Researchers often design econometric beef models based on incomplete demand systems that are considerably less restrictive and less costly to estimate than complete demand systems (see Deaton and Muellbauer for discussion of complete systems). Costs involving model specification, computer time, and statistical methods employed are usually minimized (compared to large integrated models) due to limited scope and purposes of the research. Conceptually, complete systems with numerous theoretical restrictions account for more explicit interaction among disaggregated commodities; thus, the elasticity estimates may more nearly approximate true market behavior. The question becomes how much information is sacrificed when elasticity coefficients are estimated from a more simplified econometric structure and whether they offer any improvement over elasticity coefficients estimated from margin models, particularly relative price spreads which are considered to be a superior margin specification (Wohlgenant and Mullen).

Model Procedures

The three methods used to calculate the elasticity of demand for Choice slaughter beef are: (*a*) the traditional marketing margin approach, (*b*) a modified marketing margin approach, and (*c*) an econometric (incomplete demand) model of farm and retail prices of beef. Quarterly data are used. Retail beef price is necessarily included in the econometric model in order to provide a retail price elasticity of demand used in the calculations of methods (*a*) and (*b*).

Traditional Margins

Traditional marketing margins consist of a relatively simple version of processor markup behavior in prices (George and King). Basically, margins are hypothesized to consist of either linear constant absolute components, linear fixed percentage components, or both. With

seasonal (quarterly) data as the unit of observation, the beef price spread can be described as:

$$(1) \qquad M_b = \beta_0 + \sum_{i=2}^{4} \pi_i D_i + \alpha_0 P_r,$$

where M_b is the beef marketing margin [farm-retail price spread for Choice beef, cents per pound (lb.)]; D_i are the quarterly binary variables to account for seasonality in the margin due to likely seasonal farm and retail price components (i = quarters 2, 3, and 4); β_0 is a constant absolute margin; and α_0 is a fixed percentage margin of retail price (P_r, retail price of Choice beef, cents per lb.). The derived demand elasticity is given as the retail elasticity of demand multiplied by the elasticity of price transmission. The latter can be calculated from equation (1) since $M_b = P_r - P_f$, where P_f is the price of Choice slaughter steers, 900–1,100 lbs., Omaha (cents per lb.). Because of different measurement units between farm and retail prices, P_f implicitly reflects the farm-retail conversion of liveweight to retail weight [U.S. Department of Agriculture (USDA)]. The elasticity calculations are shown in the following:

$$(2) \qquad E_D^f = E_D^r \left(\frac{\partial P_r}{\partial P_f} \cdot \frac{P_f}{P_r} \right)$$

or

$$(3) \qquad E_D^f = E_D^r \left(\frac{P_f}{(1 - \alpha_0) P_r} \right),$$

where E_D^f is the slaughter (derived) elasticity of demand for Choice steers, E_D^r is the retail elasticity of demand for Choice beef, and the expression in either parentheses is the elasticity of price transmission (George and King, pp. 60–61). Equation (3) is equivalent to the derived demand elasticity formula given by Tomek and Robinson (p. 61):

$$(4) \qquad E_D^f = E_D^r \left[1 - \frac{\beta_0}{(1 - \alpha_0) P_r} \right],$$

where β_0 and α_0 have the same meaning as defined in equation (1). As long as $\beta_0 > 0$ then E_D^f will always be less than E_D^r, but for $\beta_0 = 0$ and $\alpha_0 \neq 0$ the primary and derived demand elasticities will be equal. The main criticisms of equations (3) and (4) are that β_0 and α_0 are invariant with respect to marketing volume (Tomek and Robinson) and that the derived

demand elasticity is based on fixed proportions between marketing inputs and farm output. This may underestimate the true elasticity of demand (Gardner; Wohlgenant).

Modified Margins

Since the linear beef margin of equation (1) ignores relative changes in slaughter supply and marketing costs, such variables can be added to give:

$$(5) \qquad M_b^* = a_0 + \sum_{i=2}^{4} \pi_i D_i + a_1 P_r$$
$$+ a_2 Q_F^S + a_3 Q_{NF}^S + a_4 W,$$

where M_b^* is the same definition as M_b but is specific to a different margin equation; Q_F^S is quantity produced of fed beef, million (mill.) lbs.; Q_{NF}^S is quantity produced of nonfed beef, mill. lbs.; and W is wages in the food manufacturing industry, dollars per hour. Equation (5) allows for simultaneous changes in retail demand, farm supply, and marketing costs. Theoretically, if equation (5) is a more robust specification of margin behavior, the derived elasticity of demand in equation (4) is too restrictive. Hildreth and Jarrett (pp. 108–10) indicate that when processing quantities appear in the margin equation, the derived demand elasticity formula should be modified in the following manner:

$$(6) \qquad E_D^f = \frac{E_D' \cdot E_{PT}'}{1 - (E_D'/E_S')},$$

where E_{PT}' is the elasticity of price transmission between retail beef price and slaughter steer price [based on equation (5)] and E_S' is the retail price elasticity of supply. Including the retail elasticity of supply allows for the influence of retail price on output quantity in the marketing system. Theoretically, a change in retail price not only changes quantity demanded but also processing quantities supplied, which affects the derived demand of the basic input, in this case, live cattle. As can be seen in equation (6), the larger (smaller) is E_S', the larger (smaller) is E_D'. Conceptually speaking, equation (6) is a more flexible method to calculate farm elasticity of demand, but whether the elasticity coefficient differs significantly from the traditional procedure of equation (4) depends upon E_{PT}' and E_S'. E_S' can be calculated from an econometric derived price equation which is a func-

tion of farm output, retail price, and marketing costs (Hildreth and Jarrett) or by an econometric retail supply function where retail supply is a function of retail price, wholesale or farm price, and marketing costs. The two specifications may not yield identical supply elasticities.

Econometric Model

Often farm level and retail level demands for red meats are specified as price dependent functions (inverse demands). Quantities supplied are usually assumed fixed due to biological production lags (Dahlgran; Wohlgenant), particularly for demands based on monthly or quarterly data. Under the assumption of fixed supplies on a quarterly basis, the beef model consists of inverse retail and slaughter market demands specified as:[1]

$$(7) \qquad P_r = f_1(\bar{D}, Q_F^S, Q_{NF}^S, Q_{IM}^S, Q_{PK}^S, Q_{PLT}^S, Y)$$
$$\text{(retail price)}$$

and

$$(8) \qquad P_f = f_2(\bar{D}, Q_F^S, Q_{NF}^S, Q_{IM}^S, Q_{PK}^S, Q_{PLT}^S,$$
$$BPV, M_b).$$
$$\text{(slaughter price)}$$

The variable $\bar{D}$ represents the quarterly binary variables of equations (1) and (5); Q_{IM}^S is quantity imported of beef and veal, mill. lbs.; Q_{PK}^S is quantity produced of pork, mill. lbs.; Q_{PLT}^S is quantity produced of poultry (chicken and turkey), mill. lbs.; Y is per capita disposable income; BPV is slaughter (hide and offal) by-product value of Choice steers, dollars per cwt.; and M_b is the farm-retail marketing cost, cents per lb. Market clearing (quantity supplied = quantity demanded) conditions are assumed in the fed beef market. The nonfed market also assumes equilibrium conditions by including both the domestic and import markets, the latter consisting of lower quality processed beef where quantity of beef imports demanded by the U.S. equals exports supplied to the U.S.:

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[1] The carcass or wholesale level of the market is not treated in this study due to the focus on the slaughter market and its relationship to the retail market, particularly for the marketing margin methods of calculating elasticity of demand. Omission of the carcass trade certainly does not deemphasize its importance. But if it were included in the model, carcass price as the dependent variable would have a similar specification as slaughter price except that farm byproduct value would be replaced by carcass byproduct value and the margin variable would be a carcass-to-retail marketing cost.

(9) $Q_F^S = Q_F^D$
                     (fed market clearing)

and

(10) $Q_{NF}^S + Q_{IM}^S = Q_{NF}^D + Q_{IM}^D.$
                 (nonfed market clearing)

The economic theory underlying equation (7) is that Choice retail price depends upon exogenous fed and nonfed beef quantities, beef imports, substitute meat quantities, and an income shifter. The economic theory underlying equation (8) is that Choice steer price depends upon exogenous fed and nonfed beef quantities, beef imports, substitute meat quantities, a joint product such as steer byproduct value, and a marketing margin shifter of derived demand (Tomek and Robinson). Note the full marketing margin (M_b) is specified instead of the wage variable given in equation (5) in order to account for all relevant marketing costs over time, space, and form that affect slaughter price. The link between the two market levels is given by the identity:

(11) $P_f = P_r - M_b.$

From equation (7) the Choice slaughter price elasticity of demand is given as:

(12) $E_D^f \geq \left(\dfrac{\partial P_f}{\partial Q_F^S} \dfrac{Q_F^S}{P_f} \right)^{-1},$

with the price flexibility of demand given in parentheses and its inverse serving as the lower bound to E_D^f (Houck). The method of equation (12) is intuitively appealing since elasticities are based on market data that convey information about aggregate firm behavior. According to Wohlgenant, this method may preclude the restriction of fixed input proportions and yield higher farm elasticities of demand than the traditional method. However, his empirical evidence is based on a complete demand system with restrictions of constant returns to scale and symmetry conditions between retail supplies and farm demands (p. 243).[2]

Data

The observations on the model variables are based on 1975–87 quarterly data. The selection of this sample represents a period when the structure of beef demand has remained relatively constant. Moschini and Meilke indicate that the mid-1970s represent a period of structural change or shift to a new demand regime for beef. Dahlgran's work shows a structural change in the mid-1970s and indicates the demand structure then restabilized in the 1980s. Eales and Unnevehr also found structural changes in beef demand after 1974, much of the explanation due to preference shifts and growth in demand for convenience products of competitive meats.

All price, income, byproduct, wage, and margin variables are deflated by the Consumer Price Index (CPI) (1967 = 100), and the quantity variables in the retail price and margin equations are given on a per capita basis. The beef margin variable is the USDA definition of retail price minus net farm value (adjusted for byproduct allowance). The price, quantity, byproduct, and margin variables were obtained from USDA "Livestock and Meat Situation Reports," "Livestock and Poultry Situation and Outlook Reports," and "Poultry and Egg Situation Reports," and the income, CPI, and wage variables were obtained from issues of the "Economic Report of the President" and from the U.S. Department of Labor's *Monthly Labor Review.*

Statistical Considerations

The structural inverse demand and marketing margin equations are assumed to be dynamic, reflecting market lags due to buyer-seller expectations and biological and institutional factors that impede instantaneous adjustments. Specifying the marketing margin equations as dynamic permits all elasticity coefficients to reflect time adjustments, thus facilitating elasticity comparisons among the different methods. The dynamics are assumed to reflect a partial adjustment process as demonstrated in a geometric distributed lag. Thus, an equation

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[2] Since the current model is an incomplete demand system (i.e., interrelated demands of other foods are not modeled), it is therefore absent the symmetry restrictions found in complete demand systems. It is also absent the restrictions of constant returns to scale in marketing incorporated by Wohlgenant in a reduced-form demand analysis (p. 244). Wohlgenant tested these restrictions and found the results to be compatible with 1956–83 annual market data; however, the restrictions were applied to an aggregate pro-

duction function involving several commodities. The question is whether the restriction holds for beef in the more recent period of the 1980s since there have been economies of scale and excess capacity in meat packing (Purcell). Thus, an important test of the econometric model is to see whether a less restrictive nonsystem's approach will yield conclusions similar to those of Wohlgenant.

in the beef model may be characterized by the following:

(13) $Y_{1t} = \beta_0 + \sum_{i=2}^{4} \pi_i D_i + \beta_1 Z_{1t} + \beta_2 Z_{2t} + \beta_3 \hat{Y}_{2t}$

$\quad\quad + \lambda Y_{1t-1} + U_t, \quad\quad 0 < \lambda < 1,$

where Y_{1t} is a dependent variable, D_i are seasonal coefficients, Z_{1t} and Z_{2t} are exogenous variables, $\hat{Y}_{2t}$ is a jointly endogenous variable estimated as an instrument variable, and Y_{1t-1} is the first-order difference equation variable.[3] U_t is a disturbance term with mean zero ($EU_t = 0$ for all t) and constant variance ($EU_t U_{t-s} = \sigma^2$ for $t = s$) but may display an autoregressive (AR) process, ($EU_t U_{t-s}) \neq 0$ for $t \neq s$). The simplest disturbance process is the AR(1), i.e., $U_t = \rho U_{t-1} + \epsilon_t$, where ϵ_t is white noise. The disturbance term is then correlated with Y_{1t-1}, which yields inconsistent estimates of all parameters in the mean of the regression (Johnston, p. 363). To obtain consistent parameter estimates, the stochastic difference equation of (13) is estimated as a nonstochastic difference equation (i.e., lagged expected value of the dependent variable) with an autoregressive error, the virtue being that the parameters of the error structure are asymptotically uncorrelated with the remaining parameters of the model (for details of the justification and procedure see Rucker, Burt, and LaFrance, pp. 133–35).

In equation (13) the long-run effects of Z_{1t} and Z_{2t} on Y_{1t} are based on their inclusion in the difference equation. Theoretically, a shock in Z_{1t} produces an infinite geometric distributed lag response in Y_{1t}, but for all practical purposes the effects dissipate in some finite

period depending upon the absolute value of λ. Since Y_{1t} and Y_{1t-1} differ insignificantly in the long run, the long-run expression for equation (13) becomes (Kmenta):

(14) $\quad Y_{1t} = \dfrac{\beta_0}{1 - \lambda} + \sum_{i=2}^{4} \dfrac{\pi_i}{1 - \lambda} D_i + \dfrac{\beta_1}{1 - \lambda} Z_{1t}$

$\quad\quad + \dfrac{\beta_2}{1 - \lambda} Z_{2t} + \dfrac{\beta_3}{1 - \lambda} \hat{Y}_{2t} + U_t.$

Thus, the long-run elasticity of Y_{1t} with respect to Z_{1t} evaluated at the mean values of the variables is:

(15) $\quad E_D^{LR} = \dfrac{\partial Y_{1t}}{\partial Z_{1t}} \cdot \dfrac{\bar{Z}_{1t}}{\bar{Y}_{1t}} = \dfrac{\beta_1}{1 - \lambda} \cdot \dfrac{\bar{Z}_{1t}}{\bar{Y}_{1t}}.$

Empirical Results

Tables 1 and 2 present the statistical results of the two margin equations and the econometric price level equations, respectively. The results indicate that each empirical equation contains contemporaneous exogenous variables with a stable geometric lag process since $|\lambda|$ is less than unity. It should be noted that alternative dynamic structures were also tested by increasing the order of distributed lags on both the difference equation terms (lagged dependent variables) and independent variables as well as the error terms. Based upon the criteria of adjusted R^2, standard error of estimate, and asymptotic t-ratios, all alternative models were inferior to the selected model. Table 3 gives the estimated derived demand elasticities specific to the three estimation methods with the coefficients compared to those estimated by Wohlgenant (annual 1956–83 data), Wohlgenant and Mullen (annual 1959–83 data), and George and King (annual and quarterly 1946–68 data).[4]

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[3] The right-hand-side marketing margin variable in equation (8) contains endogenous retail price and slaughter price as components. Likewise equations (1) and (5) contain endogenous retail price as a regressor. Therefore, their predicted values (noted as $\hat{M}_b$ and $\hat{P}_r$ in the empirical model) were used as instrumental variables from OLS regressions of M_b and P_r on all exogenous variables contained in equations (1), (5), (7), and (8). Furthermore, it should be noted that calculation of the standard errors specific to $\hat{P}_r$ and $\hat{M}_b$ are not exact according to statistical theory. In the nonlinear algorithm, the residual variance, σ^2, was estimated by using the sum of squared residuals based on replacing P_r and M_b with $\hat{P}_r$ and $\hat{M}_b$, respectively. According to Kmenta (pp. 683–84), the theoretically correct way to estimate σ^2 is for the sum of squared residuals to be based on the two-stage least squares parameters involving the actual right-hand-side endogenous variables (P_r and M_b in the current model). Nevertheless, the significance of retail prices in the margin equations, though the σ^2s are calculated as such, is consistent with retail price significance found in the margin models of Wohlgenant and Mullen. The margin variable in the steer price equation is only significant at the 85% probability level.

[4] These works were selected for comparison since they are particularly relevant to the procedures of this study and also represent a time period range for the elasticity estimates. Note that the first two studies, respectively, using 1956–83 and 1959–83 data incorporate periods of structural change, particularly periods of both growing and declining trends in beef demand. The third study using 1946–68 data may also involve some structural aspects but, overall, represents a strong growth period in beef demand. These factors can account for some elasticity differences since consumer utility preferences and the nature of consumer responses to income and relative prices will have changed.

Table 1. Regression Results of the Traditional and Modified Beef Marking Margin Equations

Dependent Variable	Variables/Parameters							Statistics		
	Constant	$\hat{P}_r$	Q_F^S	Q_{NF}^S	W	Dep-1	ρ	$\bar{R}^2$	S_y	DW
M_b	5.233 (2.185)	.085 (3.206)				.666 (5.589)	NA	.614	1.912	1.674
M_b^*	6.940 (1.625)	.147 (3.983)	.0097 (3.211)	.0032 (2.504)	−9.171 (−2.570)	.619 (5.792)	NA	.678	1.747	1.911

Notes: The asymptotic t-ratios are given in parentheses below the estimated coefficients. M_b is the traditional beef marketing margin, M_b^* is the modified beef marketing margin, $\hat{P}_r$ is the predicted value (instrument variable) of Choice retail beef price, Q_F^S is quantity produced of fed beef, Q_{NF}^S is the quantity produced of nonfed beef, W is wages in food manufacturing, and Dep-1 is the lagged dependent variable. Except for the constant in M_b^*, all coefficients are significant at the 95% probability level. $\bar{R}^2$ is the adjusted R-squared, S_y is the standard error of estimate, and DW is the Durbin-Watson statistic. The parameter ρ is the first-order autocorrelation coefficient of the error term but was not reported due to statistical insignificance. For the M_b equation the second-, third-, and fourth-quarter binary variable coefficients and asymptotic t-ratios (in parentheses) are, respectively: −2.698 (−2.508), .723 (.774), and −1.063 (−.973). For the M_b^* equation the respective coefficients and asymptotic t-ratios are: −2.124 (−2.149), .492 (.558), and −.542 (−.540).

Margin Equations

The traditional marketing margin equation (M_b, table 1) is shown to have constant absolute and fixed percentage coefficients that are statistically significant from zero (at $\alpha = .05$). The adjusted R^2 is not particularly high at .61 but within the ranges reported by Wohlgenant and Mullen, and the standard error of estimate (S_y) is 5.5% of the mean of the dependent variable. If one assumes price spreads in the beef market are exclusively characterized by fixed margin coefficients, then the margin equation can be integrated into the Tomek-Robinson formula of equation (4). Following the procedure of equation (14), the long-run beef margin equation is derived, consisting of constant absolute and fixed percentage coefficients along with seasonality:

$$(16) \quad M_b = 15.668 + .254\hat{P}_r - 8.078D2 + 2.165D3 - 3.183D4,$$

where $\hat{P}_r$ is the instrument variable for P_r since it is of an endogenous nature. $D2$, $D3$, and $D4$ are the respective binary variables for the second, third, and fourth quarters. Using equation (4) the calculated fed slaughter demand elasticity is −.534, which is slightly higher than the Wohlgenant (W) fixed proportions estimate of −.50 and considerably higher than the George and King (GK) fixed proportions estimate of −.42 (table 3).

The modified margin equation (M_b^*, table 1) appears to be a better fit with an adjusted R^2

Table 2. Regression Results of the Inverse Demand (Price) Equations for Choice Retail and Slaughter Beef

Dependent Variable	Variables								
	Constant	Q_F^S	Q_{NF}^S	Q_{PK}^S	Q_{PLT}^S	Q_{IM}^S	Y	BPV	$\hat{M}_b$
P_r	66.679 (2.939)	−.015 (−3.414)	−.013 (−3.870)	−.003 (−.666)	−.020 (−5.221)	.073 (3.962)	.004 (1.138)		
	Dep-1 = .766 (9.258); ρ = .652 (6.149); $\bar{R}^2$ = .935; S_y = 2.743; DW = 1.744								
P_f	59.978 (9.785)	−.006 (−6.609)	−.005 (−5.432)	−.0006 (−.882)	−.003 (−6.198)	.007 (2.399)		1.883 (2.865)	−.174 (−1.536)
	Dep-1 = .278 (2.673); ρ = .468 (3.787); $\bar{R}^2$ = .946; S_y = .985; DW = 1.859								

Notes: The asymptotic t-ratios are in parentheses. P_r is Choice retail beef price, P_f is Choice steer slaughter price, Q_F^S is quantity produced of fed beef, Q_{NF}^S is quantity produced of nonfed beef, Q_{PK}^S is quantity produced of pork, Q_{PLT}^S is quantity produced of poultry, Q_{IM}^S is quantity of beef and veal imports, Y is per capita disposable income, BPV is slaughter (hide and offal) byproduct value, $\hat{M}_b$ is the predicted value (instrument variable) of the beef marketing margin, and Dep-1 is the lagged dependent variable. Except for Q_{PK}, Y, and $\hat{M}_b$, all coefficients are significant at the 95% probability level. $\bar{R}^2$ is the adjusted R-squared, S_y is the standard error of estimate, DW is the Durbin-Watson statistic, and ρ is the first-order autocorrelation coefficient of the error term. For the P_r equation the second-, third-, and fourth-quarter binary variable coefficients and asymptotic t-ratios (in parentheses) are, respectively: 3.688 (2.584), 2.476 (1.474), and 2.086 (1.219). For the P_f equation the respective coefficients and asymptotic t-ratios are: .960 (1.936), 1.137 (1.853), and .936 (1.395).

Table 3. Elasticity of Demand Estimates for Choice Beef Using Marketing Margin and Econometric Methods

Elasticity Level	Retail Demand Elasticity	Traditional Margin	Modified Margin	Econometric Estimate
E_D^r	−.711	—	—	—
(W)	−.780	—	—	—
(GK)	−.640	—	—	—
E_D^r	—	−.534	−.540	−.655
(W)	—	−.500	−.460	−.760
(GK)	—	−.420	—	—

Notes: All demand elasticities are evaluated at the mean values of the variables. The first row of E_D^r and of E_D^r refers to the results of the current study, (W) refers to the results of Wohlgenant's estimates, and (GK) refers to the results of the George and King estimates. The exception is the modified margin elasticity of −.46 labeled under (W) which is a result of the Wohlgenant and Mullen study.

of .68, and the S_y is 5% of the mean of the dependent variable. The coefficients of retail price, fed and nonfed beef quantities, and wages are significant at the 95% probability level. The dynamics are confirmed by the statistical significance of the difference equation coefficient (λ). The positive signs on beef quantities are consistent with those of Wohlgenant and Mullen while Buse and Brandow's margin analysis showed a negative sign for annual data but a positive sign for quarterly data. The negative sign on wages is, however, inconsistent with economic theory. The primary problem may be multicollinearity between real wages and real retail price which demonstrated strong positive correlation within the sample period.

Using the results of the modified margin equation (M_b^*) and incorporating them into the modified formula of equation (6), the long-run slaughter demand elasticity can be derived. The elasticity of price transmission (E_{PT}') solved from the long-run equation is .839 (i.e., a 10% increase in slaughter price increases retail price 8.4%).[5] Following the Hildreth and Jarrett pro-

cedure where the derived demand for farm output is expressed in price-dependent form, the retail supply elasticity (E_S^r) is estimated at 6.85.[6] The coefficient appears high but Wohlgenant and Mullen used a value of 9.4 in their estimate based on a similar procedure. With a retail price elasticity of demand for Choice beef estimated at −.711 (discussion in following section), the modified slaughter demand elasticity is −.540. This is somewhat higher than the −.46 estimate reported by Wohlgenant and Mullen.

From the above it appears that, even with more flexibility in explaining the beef marketing margin, the slaughter demand elasticity is not different from the estimate of the traditional procedure. Two reasons may account for this: (*a*) though quantities appear in the margin equation, the beef price spread is still some fixed proportion of retail price and (*b*) specification of beef supplies in the margin equation implies that retail price has a feedback effect on supply (Hildreth and Jarrett). Consequently, the derived demand elasticity estimate is sensitive to the value of the retail supply elasticity; the greater its elasticity the higher the derived demand elasticity. For example, if a constant-returns-to-scale production function in marketing is assumed, the implied supply curve of marketing inputs is perfectly elastic (Muth; Wohlgenant). Hence, the slaughter demand elasticity based on this assumption would be $E_D^r \times E_{PT}'$ or almost −.60.

Econometric Estimates

The regression results of the retail and slaughter price equations are shown in table 2. The signs of the coefficients appear consistent with theoretical reasoning, i.e., negative effects of fed beef, nonfed beef, and substitute quantities on retail and slaughter prices, negative effects

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[5] In the modified margin equation M_b^* equals $P_r − P_f$. The elasticity of price transmission, .839, is based on solving for P_r in terms of P_f and forming the long-run relationship. The respective solved long-run price transmission equation and price transmission formula are:

$$P_r = 21.354 + 3.076 P_f$$

and

$$E_{PT}' = \frac{\partial P_r}{\partial P_f} \cdot \frac{\bar{P}_f}{\bar{P}_r},$$

where $\bar{P}_f = 23.102$ and $\bar{P}_r = 84.601$ are the mean values of slaughter and retail prices.

[6] This procedure says that P_f is regressed on retail price ($\hat{P}_r$), quantities supplied (Q_F^S and Q_{NF}^S), and wages (W). For the beef model, the solved long-run equation is (seasonality included):

$$P_f = −9.335 + .368 D2 + .563 D3 + .306 D4$$
$$+ .363 \hat{P}_r − .0025 Q_F^S − .0012 Q_{NF}^S + .249 W.$$

Solving for Q_F^S in terms of $\hat{P}_r$ and applying the retail elasticity of supply formula at the sample means of the variables gives:

$$\frac{\partial Q_F^S}{\partial P_r} \cdot \frac{\bar{P}_r}{\bar{Q}_F^S} = (146.37) \left(\frac{84.601}{1,819.2} \right) = 6.85.$$

The procedure assumes a fixed relationship between farm quantities and retail output.

of the marketing margin on slaughter price, and positive effects of income and byproduct value on retail and slaughter prices, respectively. The exception is the positive coefficient sign on quantity of beef imports. The import relationship with beef prices probably reflects the countercyclical nature of the 1979 meat import law, i.e., U.S. beef imports increase when domestic prices are higher (Roberts and Martin).

Since $|\lambda|$ is less than unity, the long-run inverse demand equations are stable with finite price flexibility estimates. The long-run retail price flexibility of demand with respect to fed beef production (Q_f^S) is calculated at -1.41 and for slaughter price it is calculated at -1.53 (not shown). Therefore, the resulting long-run retail and slaughter price elasticities of demand are $-.71$ and $-.66$, respectively (table 3). The retail estimate falls in between the Wohlgenant and George and King estimates of $-.78$ and $-.64$, respectively. In another study not shown, Moschini and Meilke (using quarterly 1967–87 data) derive the retail beef elasticity of demand at -1.05 after adjusting for structural change in the market. The farm elasticity estimate of $-.66$ is not quite as high as the econometric farm estimate of $-.76$ reported by Wohlgenant (note that comparisons among these elasticities require careful interpretation due to different sample periods and data units of observations employed).

On a comparative basis the econometric slaughter demand elasticity of $-.66$ is about 22% larger than the traditional and modified marketing margin estimates of $-.534$ and $-.54$, respectively. However if the Muth conditions of an infinite supply elasticity of marketing inputs is assumed, then the retail supply elasticity becomes very large and the modified margin elasticity becomes quite close to the econometric estimate. Overall, the econometric estimate may be more market representative of the true beef price flexibility because (a) the reduced-form equations yield empirical results consistent with price discovery and aggregate behavior in price determination by taking into account information relevant to buyer-seller transactions and (b) the long-term distributed lag effects on slaughter price, given a permanent change in fed beef production, are not constrained by rigid margin behavior or fixed input substitution. Based on the above analysis, the margin methods would tend to underestimate the derived beef elasticity of demand and, hence, overestimate the degree of price flexibility for slaughter cattle.

Implications

The results of the study indicate that the econometric elasticity of demand for Choice beef, based on an incomplete demand model, is somewhat larger compared to those estimated by traditional and modified marketing margin procedures. If red meat processing were characterized by constant returns to scale, then the elasticity estimates of the modified margin and econometric procedures would differ very little. The difference, as it stands, is not nearly as pronounced compared to using an econometric model based on a complete demand system. For example, the incomplete demand model of this study showed the derived beef elasticity estimate to be about 22% higher than the marketing margin estimate; the more restrictive complete demand system of the Wohlgenant study indicated the derived beef elasticity was about 52% higher than the margin estimate.

The beef packing and processing industries have adopted certain technologies such as boxed beef, hot fat carcass trimming, and packer trimmed retail cuts in order to reduce costs and improve output quality. Retailers have improved upon packaging technology and product shelf life. Because of these functions, there is a certain degree of technical substitution between marketing services and beef quantities. Therefore, if researchers estimate incomplete dynamic models, the coefficients reflect some (but not all) of these substitutions, permitting farm-level demand elasticities to be more consistent with actual marketing behavior. This method offers some improvement over the margin procedures, but researchers would have to weigh the benefits and costs relative to the purposes of the research. The sacrifice is that the absolute values of the coefficients may be smaller than those estimated in complete systems since they do not fully reflect behavioral feedback from numerous competitive products, including their input substitutions.

The difference in the elasticity methods can be demonstrated by an example of revenue adjustments (or projections) resulting from growth in fed beef production. Assume that fed beef production is projected to increase by

8% over a two-year period. Furthermore, assume there is no expected change in retail demand, that the average dressed weight of fed cattle (ADW) is constant at 675 pounds, and that the average liveweight of fed cattle slaughter (ALW) is constant at 1,050 pounds. Let Choice steer price equal 75¢ per pound and the current annual rate of fed beef production equal 17.8 billion (bill.) lbs., carcass weight (USDA). Under the traditional margin method, with a farm price flexibility of −1.87 (i.e., the inverse of −.534), slaughter price would decrease by 14.96% and revenue would be $19.073 billion (19.224 bill. lbs. new production ÷ 675 lbs. ADW × 1,050 lbs. ALW, or 29.904 bill. lbs. × 63.78¢ per lb. new price). Using the incomplete demand model, with a farm price flexibility of −1.53, slaughter price would decrease by 12.24% and revenue would be $19.683 billion (29.904 bill. lbs. × 65.82¢ per lb. new price), while using the Wohlgenant farm price flexibility of −1.32, slaughter price would decrease by 10.56% and revenue would be $20.06 billion (29.904 bill. lbs. × 67.08¢ per lb. new price). The difference is that the traditional method overestimates the revenue decline by $610 million compared to the incomplete demand model and overestimates the revenue decline by $987 million compared to a complete demand system.

The results of the study warrant a note of caution. The USDA recently (in 1990) revised the beef data series on retail, wholesale, and farm values and the related marketing spreads. These revisions were necessary to reflect changes in data and beef industry practices, i.e., increased marketings of boxed subprimal products, closely trimmed wholesale cuts with less bone-in, higher lean percentages in ground beef, etc. Such changes could produce different empirical results for estimated demand elasticity behavior. In particular, data adjusted for up-to-date processing services and merchandising practices may alter the difference between elasticities estimated by marketing margin versus structural demand methods.

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