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USDA Data Revisions of Choice Beef Prices and Price Spreads: Implications for Estimating Demand Responses

John M. Marsh

Reduced form price equations were estimated to compare market demand responses from two data sources: U.S. Department of Agriculture (USDA) beef price and price spread data per revisions in 1978 and per revisions in 1990. The latest revisions were necessary to account for changing beef industry technology and product consumption in the 1980s. Results indicate the elasticities of retail and derived demands average about 25 and 17% lower, respectively, when using the 1990 revised data. Trends and lag adjustments played an important role. The analyses suggest careful interpretation of demand responses when time series data lag technology conditions in the market.

Key words: elasticities of demand, revised data series, traditional data series.

Introduction

In August of 1990, the U.S. Department of Agriculture (USDA) revised its procedures for calculating Choice beef prices and beef price spreads (White et al.; Duewer and White). This resulted in a monthly data series that was revised back to 1970, permitting comparison with the traditional data series that was last revised in 1978.[1] The observed differences between the two data series range from minor to major; thus, the question becomes whether there are significant implications for econometric demand and price estimation when selecting alternative data sets. To date, demand estimation involving beef prices and price spreads (margins) has been based on the traditional data. However, according to the USDA, such data do not adequately reflect structural changes in the beef market, technological changes in meat processing, or changing retail product consumption of the 1980s (White et al.). The recent USDA revisions are numerous. Therefore, statistical demand functions may reveal different market responses when based on the revised data.

The objective of this article is to analyze the differences between retail, wholesale, and farm (slaughter) beef price flexibilities and demand elasticities using the USDA traditional and revised beef data series. A partial equilibrium econometric model using 1975–89 quarterly data is employed. The model is based on an economic structure that facilitates specification of a reduced form system of market-level prices. The overall results indicate the demand elasticities between the two data series are not identical and that the elasticity coefficients are sensitive to the inclusion of trend in the model dynamics. Though the research here is beef-specific, the general sensitivity of the empirical demand estimates may be meaningful in cases of significant revisions of other commodity data.

Revised Data Series

Changes in calculating beef prices (retail, wholesale, and farm values) and price spreads (wholesale-to-retail and farm-to-wholesale margins) were necessary to accommodate beef

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Table 1. Means, Standard Deviations, and Identities for USDA Traditional and Revised Beef Data

	Data			
	Traditional		Revised	
Variables/Identity	Mean	Std. Dev.	Mean	Std. Dev.
Retail Price	219.10	(39.37)	215.40	(38.73)
(less)				
Wholesale-Retail Margin	83.08	(19.44)	65.68	(17.24)
(equals)				
Wholesale Value	135.98	(22.80)	149.72	(25.10)
(less)				
Farm-Wholesale Margin	8.48	(1.71)	21.47	(28.47)
(plus)				
Farm By-Product Allowance	16.32	(4.02)	15.69	(3.93)
(equals)				
Gross Farm Value	143.83	(26.12)	143.93	(26.29)

Notes: Variables are in nominal terms, cents per pound. Figures in parentheses are the standard deviations (Std. Dev.). Data are based on the 1975 to 1989 sample used in the regression model. "Traditional" data means the USDA numbers that were last revised in 1978, and "Revised" data means the USDA numbers that were last revised in 1990. The identities are as defined by the USDA with the wholesale values and gross farm values given as retail weight equivalents.

industry trends in the late 1970s and the 1980s.[2] Basically, these trends include packers selling more differentiated boxed beef products (fabricated primals and subprimals) and fewer carcasses, retailers selling more closely trimmed, boneless retail cuts and selling more ground beef with higher lean percentages, changes in price discovery and selling methods by marketing firms, and changes in market structure of the feedlot and meat packing industries (Ward).

The specific beef data revisions by the USDA are quite numerous and readers are referred to White et al. and Duewer and White for details of methodologies and procedures employed. What is described in the following is merely a summary analysis of the major changes. They include: (*a*) a new price series has been established for Choice slaughter steers and heifers that consists of a "receipts weighted average" price for five direct live-cattle markets (Texas–Oklahoma Panhandle, Kansas, Colorado, eastern Nebraska, and Iowa–southern Minnesota) that replaced the "eight market average" price of four terminals and four direct markets; (*b*) wholesale beef prices are reported as boxed beef cut-out values rather than carcass values, weighted by trading volume of seven primal wholesale cuts; (*c*) the retail price of Choice beef now reflects the weighted value of more retail cuts (14 cut prices and 50/50 trim value) with more allowance for bone-out table cuts (previously, fewer beef cuts were used, more bone-in was included in the table cuts, and fat was essentially removed from the trimmings in estimating ground beef value); (*d*) conversion factors were changed at the live-to-wholesale and wholesale-to-retail levels to reflect higher dressing percentages and the transition from carcass to boxed beef price reporting (the latter reflecting more fat and bone removal); (*e*) the by-product credits were changed, whereby the former wholesale-to-retail by-product allowance is no longer estimated and a farm-to-wholesale by-product allowance is calculated that not only includes the usual hide and offal value but fat, bone, and kidney values; and (*f*) because of changes in retail, wholesale, and farm values (as well as by-products), the farm-to-wholesale and wholesale-to-retail marketing margins have changed. The former is larger and the latter is smaller, but overall the farm-to-retail margin is narrower in the revised series.

Table 1 shows the means and standard deviations of the variables specific to the traditional and revised data series. The variables are specifically arranged to give market-level identities, so constructed by the USDA. As can be seen, the new retail price averages about 4¢ per pound lower than the old price, the box price averages about 14¢ per pound higher than the carcass price, slaughter values and by-product values show little change, the new wholesale-to-retail margin is about 18¢ per pound lower than its traditional counterpart, and the new farm-to-wholesale margin is about 13¢ per pound larger than the traditional margin. The large margin changes basically result from replacing the carcass price with the higher price of boxed beef in calculating wholesale value. The standard deviations are not significantly different except for the larger variance in the new farm-to-wholesale margin and the slightly higher variance in boxed beef value.

Model Specification

The model approach is to develop a set of price-dependent (or inverse demand) equations that implicitly link the retail, wholesale, and slaughter levels of the beef market. The market-level equations are specified within a dynamic framework since it is assumed quarterly behavior of the dependent variables does not completely adjust to exogenous shocks in the independent variables. These partial adjustments in prices basically are due to biological production lags and expectations of buyers and sellers in the market (Brester and Marsh).

To ultimately derive the price-dependent equations, it is helpful first to specify the conceptual demand and supply relationships underlying the slaughter, wholesale, and retail beef markets. Assuming market-level supplies to be predetermined and competition for inputs and outputs, the conceptual system is given as:[3]

(1) $$Q_d^r = f_1(P_b^r, P_{pk}^r, P_{plt}^r, P_{fsh}^r, Y, \bar{D}) \quad \text{(retail beef demand)},$$

(2) $$Q_d^w = f_2(P_b^r, P_b^w, \bar{D}) \quad \text{(wholesale beef demand)},$$

(3) $$Q_d^f = f_3(P_b^f, P_b^w, Bv, \bar{D}) \quad \text{(farm beef demand)},$$

(4) $$Q_d = Q_s, \text{ with } Q_s \text{ predetermined, all levels} \quad \text{(market-level clearing)},$$

(5) $$M_{w-r} = P_b^r - P_b^w \quad \text{(wholesale margin identity)},$$

and

(6) $$M_{f-w} = P_b^w - P_b^f + Bv \quad \text{(farm margin identity)}.$$

The variable definitions are: Q_d^r is per capita demand of beef and veal at the retail level, Q_d^w is per capita demand of beef and veal at the wholesale level, and Q_d^f is per capita demand of beef and veal at the slaughter level, pounds; P_b^r, P_{pk}^r, P_{plt}^r, and P_{fsh}^r are the respective prices of Choice retail beef, retail pork, retail chicken, and retail fish, cents per pound; Y is per capita disposable income, dollars; M_{w-r} is the wholesale-to-retail marketing spread (margin), and M_{f-w} is the farm-to-wholesale marketing spread (margin), cents per pound; Bv is the farm value of edible and inedible by-products, cents per pound; P_b^w and P_b^f are the respective prices of Choice wholesale beef and Choice slaughter steers, values adjusted to equal one pound of retail cuts, cents per pound; Q_s is per capita supply of beef and veal, pounds; and $\bar{D}$ represents the first through fourth quarterly binary variables for seasonality ($D1$, $D2$, $D3$, and $D4$), with quarter one ($D1$) omitted in the empirical model.

To maintain measurement consistency of quantities and prices between the market levels, wholesale and farm level per capita demands and prices in equations (2) and (3) are defined as retail equivalents. For the demand quantities (which are the same between the two data models), the USDA wholesale equivalent of 1.476 is used for carcasses, 1.142 is used for boxed beef, and a farm equivalent of 2.4 pounds is used for live animals; thus, it takes 1.476 pounds of carcass, 1.142 pounds of boxed beef, and 2.4 pounds of live animal to equal one pound of retail cuts. Wholesale price is stated as the value of wholesale quantity equal to one pound of retail cuts and farm price is the market value to producers equal to one pound of retail cuts. Overall, this procedure permits describing relationships among primary and derived demands, marketing margins, and market-level prices on a single price–quantity graph (Tomek and Robinson, p. 119).

The maintained hypotheses of the demand equations are based on economic theory and margin relationships of primary and derived market-level demands. Per capita retail demand for beef and veal is a function of own retail beef price, competitive retail prices of pork, chicken, and fish, per capita disposable income, and seasonality. Per capita wholesale demand for beef and veal represents intermediate demand by wholesalers and retailers for carcasses and boxed beef. It depends upon prices received for retail output (P_b^r), wholesale prices paid for the carcass and boxed beef inputs (P_b^w), and seasonality. Per capita slaughter demand for beef and veal is the demand by meat packers for cattle and calves in meat packing and processing. This demand is influenced by farm prices paid for cattle inputs (P_b^f), prices received for wholesale outputs (P_b^w), the value of joint products (or by-products) in processing (Bv), and seasonality. It is assumed that retail demand is homogeneous of degree zero in prices and income and that the derived demands are homogeneous of degree zero in input and output prices. Overall, the model specification is consistent with the beef market-level studies of Arzac and Wilkinson; Brester and Marsh; Crom; Freebairn and Rausser; and Wohlgenant.

Equation (4) describes market-level clearing between beef demand and beef supplies for given levels of prices. It should be noted that demand (disappearance) as defined by the USDA also includes beef and veal imports. In the model description above, it is assumed quarterly market supplies are fixed; however, it is recognized that beef supplies (Q_s) may be endogenous through producer marketing adjustments to changes in contemporaneous prices. Even so, given the demand focus of this research, quantity supplied equations for the different market levels are not estimated. Equations (5) and (6) describe the respective wholesale-retail and farm-wholesale marketing margin identities, as defined by the USDA.

With beef quantities assumed fixed, equations (1)–(3) are used to derive the empirical price model. This procedure permits estimating the direct price elasticities of demand by inverting the price flexibility coefficients (Houck). Solving for the beef market prices of equations (1)–(3) yields:

$$P_b^r = g_1(Q_d^r, Q_{pk}^r, Q_{plt}^r, Q_{fsh}^r, Y, \bar{D}) \quad \text{(retail beef price)}, \tag{7}$$

$$P_b^w = g_2(Q_d^w, P_b^r, \bar{D}) \quad \text{(wholesale beef price)}, \tag{8}$$

and

$$P_b^f = g_3(Q_d^f, P_b^w, Bv, \bar{D}) \quad \text{(farm beef price)}, \tag{9}$$

where retail pork, chicken, and fish prices have been replaced by their respective quantities in the retail price equation (7). Q_{pk}^r is per capita demand of pork, Q_{plt}^r is per capita demand of young and mature chicken, and Q_{fsh}^r is per capita supply of fish cold storage holdings, all measured in retail weight pounds. Quarterly per capita demand for fish is not estimated; thus, rather than ignore the effects of fish quantity altogether, cold storage holdings (Q_{fsh}^r) is specified.[4]

Recognizing that quarterly retail, wholesale, and farm values may be jointly dependent, equations (7)–(9) can be written so that the market-level prices are a function of a common set of variables:

$$P_b^j = h^j(Q_d^r, Q_{pk}^r, Q_{plt}^r, Q_{fsh}^r, Y, B_v^*, \bar{D}), \qquad j = 1, 2, \ldots, 6, \tag{10}$$

where $j = 1, 2, 3$ represent P_b^r, P_b^w, and P_b^f of the traditional data series and $j = 4, 5, 6$ represent the same price variables, only of the revised data series. The asterisk (*) indicates that the by-product variable must be appropriately defined in the traditional and revised data series equations. Note that the retail beef and veal quantity variable, Q_d^r, replaces the Q_d^w and Q_d^f variables that would also appear in the beef price functions of equation

(10). This is done since Q_d^w and Q_d^f of equations (8) and (9) are retail equivalents, and therefore are merely conversion factors (multiples) of Q_d^r, as discussed.

Estimation Procedure

Estimation of the model using the traditional and revised data centers on six price-dependent equations implied from equation (10). Since it is hypothesized that market-level prices would only partially adjust to shocks in the right-hand-side variables, the functions are estimated as geometric distributed lags. The difference equations and autoregressive errors are, however, absent the parameter restrictions that result from deriving theoretical partial adjustment and adaptive expectations models by Koyck transformation methods (Johnston, pp. 346–50). The purpose is to permit the data to determine the coefficient values of the difference equations and stochastic errors consistent with the market dynamics underlying the two data series. In essence, the unrestricted slope and difference equation coefficients permit each independent variable to produce its particular partial adjustment effect on price [equations (11) and (12) following].

For purposes of expediting the calculations of market price flexibilities and elasticities of demand, the difference equations are estimated in double log form. An example of a difference equation is written as:

$$(11)\quad \log(P_{jt}) = \log(\beta_{0j}) + \beta_{1j}\log(Q_{d,}^r) + \sum_{i=2}^{6} \beta_{ij}\log(Z_{it}) + \sum_{r=2}^{4} \pi_{rj}D_r + \gamma_j\log(P_{jt-1}) + V_{jt},$$

$$j = 1, 2, \ldots, 6,$$

$$t = 1, 2, \ldots, T,$$

where Z_{it}, includes the other five economic variables listed in equation (10), D_r denotes the seasonal binary variables, and $V_{jt} = \rho V_{jt-1} + \epsilon_{jt}$ denotes first-order autoregressive error terms where the ϵ_{jt}s are independently and identically distributed with mean zero. The V_{jt}s are assumed to be homoskedastic with mean zero and no contemporaneous cross correlation. The time path effect of any Z_{it} on price is given as an infinite geometric process:

$$(12)\quad \frac{\partial\log(P_{jt})}{\partial\log(Z_{i,t-k})} = \beta_{ij}(1 + \gamma_j + \gamma_j^2 + \ldots) \qquad k = 0, 1, 2, \ldots; \; 0 < \gamma_j < 1.0.$$

The long-run price flexibility of demand would be given as:

$$(13)\quad \frac{\partial\log(P_j)}{\partial\log(Q_d^r)} = \frac{\beta_{1j}}{1 - \gamma_j},$$

with its inversion representing the lower bound to the long-run price elasticity of demand (Houck).

Examination of equation (11) indicates there could be a potential problem of joint dependency and also a problem of correlation between the lagged dependent variable and the autoregressive error term (Johnston). Regarding joint dependency, the per capita quantity variables (Q_d^r, Q_{pk}^r, and Q_{plt}^r) may be correlated with the error term, necessitating instrumental variables estimation. However, in the final regressions, the quantity regressors were treated as exogenous due to the results of two tests. First, the Hausman test failed to reject the null hypothesis of no simultaneous equations bias for each quantity variable,[5] and second, each per capita disappearance variable was regressed against the estimated residuals with results showing all adjusted R^2s to be extremely small (less than .05) and all t-ratios were insignificant at the 90% probability level.

To handle the problem of correlation between the difference equation terms and error structures, the dynamic equations were estimated as nonstochastic difference equations (NSDE). The NSDE procedure is based on lagged expectations of the dependent variables and has the effect of divorcing the disturbance process from the mean of the regression; thus, designating the lagged dependent variables as instruments ($\hat{P}_{jt-1}$) (see Burt for an explanation of exogeneity of the regression mean with NSDE; see also Rucker, Burt, and LaFrance, pp. 133–35). Due to these sources of nonlinearity, least squares estimates of the beef model are obtained from a nonlinear least squares algorithm to ensure consistent estimators.

Data

Quarterly data from 1975 through 1989 are utilized. The fourth quarter of 1974 was included to allow for the observation lost in the first order difference equation. The beginning of the sample was selected (at 1975) due to indications of structural change in beef demand during the mid-1970s (Dahlgran; Eales and Unnevehr; Moschini and Meilke). The end of the sample was selected at 1989 since this represented the last complete year the USDA provided estimates of traditional beef prices and price spreads. Thus, the sample design includes all relevant revisions of beef data (i.e., the 1978 and 1990 revisions) specific to Choice prices and price spreads published in the USDA *Livestock and Poultry Situation and Outlook Reports (LPS).* All price, income, margin, and by-product value variables are given in real terms, deflated by the Consumer Price Index (1982–84 = 100).

Data for per capita disappearance of beef and veal and pork were obtained from various issues of the USDA's *LPS* and *Livestock and Meat Statistics.* Per capita disappearance of chicken includes the total of young and mature chicken as reported in various issues of *LPS* and *Livestock and Meat Statistics.* Data for cold storage of fish were obtained from various issues of the U.S. Department of Commerce publication, *Survey of Current Business.* Income, population, and CPI data are reported in various issues of the *Economic Report of the President.*

Empirical Results

Tables 2 and 3 contain the statistical results of the regression model. Note that each reduced form equation is estimated with and without a time trend. The time variable was added due to declines in all real prices during the sample period that were not explained by the independent variables. But trend was also added to test its impact on the elasticities of demand using the traditional and revised data series since technology changes underlie the market price data. According to Maeskiro and Wickers, a level model with a linear time trend (as employed here) would be nearly equivalent to a first difference model with an intercept.[6]

General observations on the reduced form equations reveal certain statistical patterns. All equations are characterized by relatively good fits with the smallest adjusted R^2 being .909 and the largest standard error of estimate being .053. Several variables display strong statistical significance. Specifically, per capita beef and veal disappearance (Q^r_d), by-product value (Bv), trend, and the difference equation terms are statistically significant at the 95% probability level or more. The competitive per capita disappearance variables of pork (Q^r_{pk}) and poultry (Q^r_{plt}) and the per capita stocks of fish (Q^r_{fsh}) generally have negative coefficients, but tend to vary in statistical significance, particularly as trend is included or omitted. Much of the problem relates to correlations between the numerous right-hand-side variables in the equations.

Income (Y) mostly appears in the equations with positive signs, but overall, the coefficients are not highly significant. Another variable often used instead of per capita dis-

Table 2. Regression Results of Beef Retail, Wholesale, and Farm Values Using USDA Traditional Data Series

Independent Variables	Dependent Variables P_b^r NT	P_b^r T	P_b^w NT	P_b^w T	P_b^f NT	P_b^f T
Q_d^r	−.372	−.524	−1.004	−1.314	−1.024	−1.316
	(.097)	(.118)	(.166)	(.202)	(.163)	(.199)
Q_{pk}^r	−.113	−.072	−.228	−.153	−.290	−.227
	(.071)	(.073)	(.116)	(.111)	(.116)	(.118)
Q_{plt}^r	−.261	−.026	−.795	−.413	−.677	−.249
	(.128)	(.160)	(.209)	(.248)	(.208)	(.259)
Q_{fsh}^r	−.047	−.073	.010	−.056	.009	−.033
	(.050)	(.050)	(.080)	(.075)	(.081)	(.080)
Y	−.135	.114	−.107	.487	−.241	.282
	(.224)	(.246)	(.326)	(.354)	(.318)	(.375)
Bv	.159	.123	.258	.171	.351	.282
	(.027)	(.032)	(.043)	(.049)	(.047)	(.053)
Trend		−.005		−.008		−.008
		(.002)		(.003)		(.003)
$D2$	.012	−.004	.071	.053	.066	.044
	(.013)	(.013)	(.025)	(.025)	(.024)	(.024)
$D3$	.010	.017	.022	.036	.015	.027
	(.015)	(.015)	(.028)	(.026)	(.027)	(.026)
$D4$	−.001	.011	.006	.026	.006	.023
	(.012)	(.012)	(.024)	(.023)	(.023)	(.022)
Constant	5.136	3.368	8.818	4.045	10.182	5.989
	(2.175)	(2.276)	(2.968)	(3.090)	(2.779)	(3.189)
Lagged Dep.	.634	.556	.431	.384	.327	.252
	(.098)	(.104)	(.098)	(.099)	(.094)	(.097)
$AR(1)$	.599	.579	.178	.115	.141	.131
	(.103)	(.105)	(.127)	(.128)	(.128)	(.128)
$\bar{R}^2$	.953	.957	.919	.929	.918	.927
Sy	.027	.026	.051	.048	.049	.046
DW	1.733	1.762	1.872	1.898	1.886	1.895

Notes: Q_d^r is per capita disappearance of beef and veal; Q_{pk}^r is per capita disappearance of pork; Q_{plt}^r is per capita disappearance of chicken; Q_{fsh}^r is per capita stocks of fish; Y is real per capita disposable income; Bv is real farm by-product allowance; Trend is a time trend; $D2$, $D3$, and $D4$ are the second, third, and fourth quarter binary variables, respectively; Lagged Dep. is the instrument variable of the lagged dependent variable; $AR(1)$ is the first order autoregressive error; $\bar{R}^2$ is the adjusted multiple R^2; Sy is the standard error of estimate; and DW is the Durbin–Watson statistic. The dependent variables are: P_b^r is real retail price, P_b^w is real wholesale value, and P_b^f is real farm value. The notations NT and T designate no trend and trend, respectively. Asymptotic standard errors are given in parentheses below the coefficients. Regression results are based on double log transformations.

posable income is per capita personal consumption expenditures. The latter variable was substituted for Y in the model; however, the statistical results were quite similar. Much of the problem relates to collinearity between Y and the other regressors (such as trend), but particularly with by-product value. For example, further testing indicated that if Bv is omitted from all equations, income becomes statistically significant at the 95% probability level; however, the regression fits are inferior. The effect of autocorrelation is consistent between the market levels, showing significance in the retail price equations but nonsignificance in the wholesale and farm value equations.[7]

The above statistical results are invariant with respect to alternative model specifications. These specifications include either estimating the reduced form equations as logarithmic first differences (with an intercept) or augmenting the order of distributed lags in the geometric model, i.e., a higher-order rational lag model. The regression fits for these alternatives are inferior, particularly for the latter, as all higher-order terms of the lagged exogenous and dependent variables are statistically insignificant.

Table 3. Regression Results of Beef Retail, Wholesale, and Farm Values Using USDA Revised Data Series

Independent Variables	Dependent Variables					
	P_b^r		P_b^w		P_b^f	
	NT	T	NT	T	NT	T
Q_d^r	−.430	−.597	−1.091	−1.405	−1.117	−1.442
	(.097)	(.114)	(.168)	(.197)	(.163)	(.196)
Q_{pk}^r	−.113	−.066	−.231	−.157	−.292	−.230
	(.070)	(.073)	(.114)	(.113)	(.111)	(.118)
Q_{plt}^r	−.357	−.062	−.924	−.442	−.844	−.287
	(.127)	(.163)	(.206)	(.254)	(.203)	(.265)
Q_{fsh}^r	−.040	−.072	−.006	−.055	.014	−.029
	(.050)	(.050)	(.079)	(.076)	(.079)	(.081)
Y	.029	.253	.077	.616	.055	.516
	(.215)	(.235)	(.313)	(.340)	(.298)	(.356)
Bv	.136	.103	.231	.151	.300	.243
	(.025)	(.029)	(.039)	(.046)	(.042)	(.049)
Trend		−.005		−.009		−.010
		(.002)		(.003)		(.003)
$D2$	.022	.006	.085	.059	.083	.051
	(.014)	(.014)	(.026)	(.025)	(.025)	(.024)
$D3$	.017	.023	.032	.044	.026	.036
	(.016)	(.015)	(.028)	(.026)	(.028)	(.026)
$D4$	−.003	.011	.006	.028	.008	.027
	(.013)	(.014)	(.025)	(.023)	(.024)	(.022)
Constant	3.806	2.382	7.684	3.366	7.910	4.354
	(2.103)	(2.226)	(2.880)	(3.038)	(2.630)	(3.082)
Lagged Dep.	.681	.569	.460	.381	.401	.271
	(.096)	(.106)	(.097)	(.101)	(.092)	(.100)
$AR(1)$	.571	.558	.144	.103	.097	.113
	(.106)	(.107)	(.128)	(.128)	(.128)	(.128)
$\bar{R}^2$	.949	.955	.914	.927	.909	.923
Sy	.029	.027	.053	.048	.051	.047
DW	1.750	1.761	1.872	1.895	1.880	1.894

Note: Refer to footnote of table 2 in its entirety.

Price Elasticities and Flexibilities

The effects of per capita disappearance of beef and veal are statistically significant in all the price equations. Since the values of the difference equation coefficients are statistically significant and less than unity, finite direct price flexibilities and elasticities of demand can be calculated. Table 4 presents the demand response coefficients, with the upper half of the table consisting of the price flexibilities and the lower half consisting of the price elasticities. Asymptotic standard errors are calculated for the long run price flexibilities and are given in parentheses.[8]

The demand response coefficients must be carefully interpreted in the discussions that follow. It should be remembered that the double log inverse demand model is based on an incomplete demand system, not on a complete demand system (involving other related agricultural products) with imposed theoretical restrictions of homogeneity and symmetry (Moschini and Meilke, pp. 274–75; Wohlgenant, pp. 243–46). Also, because beef competes with pork, poultry, and fish in the current demand model, inversion of each price flexibility coefficient only serves as a lower bound to each direct elasticity of demand. But overall, since there is consistency in the specification and estimation of the traditional and revised beef models, any significant changes in the price flexibilities and elasticities of demand would indicate there are certain empirical consequences subsequent to the data revisions.

Upon examining the demand response coefficients, several observations can be made.

Table 4. Market-Level Estimates of Beef Price Flexibilities and Elasticities of Demand Based on USDA Traditional and Revised Data Series

Price Flexibilities	P_b^r Trad.	P_b^r Rev.	P_b^w Trad.	P_b^w Rev.	P_b^f Trad.	P_b^f Rev.
No Trend	−1.016 (.405)	−1.348 (.554)	−1.764 (.497)	−2.020 (.577)	−1.522 (.369)	−1.865 (.472)
Trend	−1.180 (.436)	−1.385 (.498)	−2.133 (.582)	−2.270 (.606)	−1.759 (.412)	−1.978 (.447)
Price Elasticities	(Equations continued)					
No Trend	−.984	−.742	−.567	−.495	−.657	−.536
Trend	−.847	−.722	−.469	−.441	−.569	−.506

Notes: Price flexibilities and price elasticities of demand are based on double log transformations of variables in the regressions. P_b^r represents the retail beef price equation, P_b^w represents the wholesale beef value equation, and P_b^f represents the farm beef value equation. "Trad." indicates the traditional data series and "Rev." indicates the revised data series. "No trend" indicates flexibilities and elasticities are based on equations without trend while "trend" indicates flexibilities and elasticities are based on equations with trend. The lower half of the table gives the direct price elasticities of demand by inverting the price flexibility coefficients. The price flexibilities are obtained by dividing the slope coefficient of Q_d^r by one minus the coefficient of the lagged dependent variable for each equation given in tables 2 and 3. Since prices are the dependent variables in the reduced form model, standard errors are given (in parentheses) for the long run price flexibility coefficients.

They include: (*a*) in general, the calculated price elasticities of demand for the primary and derived market levels tend to be smaller for the model estimated with the revised data compared to estimation with the traditional data; (*b*) including trend in the model dynamics impacts the values of the demand response coefficients in the model using traditional data; and (*c*) differences in the price flexibilities and elasticities of demand between the two data series depend upon whether trend is included or excluded.[9]

Overall, the demand elasticity differences between using the traditional or revised data are apparent when trend is not specified in the traditional model. For example, the retail price elasticity of demand using the traditional data is −.984 while the retail price elasticity using the revised data is −.742. Similarly, at the farm level, the elasticity of derived demand is −.657 for using the traditional data and −.536 for the revised data. Thus, when using the revised data, the primary and derived elasticities of demand are relatively more inelastic. However, when trend is included in the model using the traditional data, the elasticity differentials tend to get smaller. At the retail level, the traditional data yields a demand elasticity of −.847 and the revised data yields a demand elasticity of −.722. The traditional and revised data demand elasticity estimates at the farm level are −.569 and −.506, respectively.[10]

The elasticities of beef demand at the wholesale level display behavior similar to the above responses, although the difference between including and omitting trend is not as pronounced. For example, with trend omitted, the traditional demand elasticity is −.567 and the revised demand elasticity is −.495. With trend included in the model using the traditional data, the elasticity of demand is much closer to that of the revised data (−.469 and −.441, respectively). Thus, when technology is accounted for, buyers of carcasses and boxed beef respond nearly the same to relevant wholesale price changes. Note also that the long run wholesale-level demand elasticities appear smaller than those at the farm level, a result that would not be expected. The wholesale slope coefficients of Q_d^r are larger, but the relatively smaller coefficients of the lagged dependent variables in the farm price equations produce smaller farm price flexibilities in the long run.

The sensitivity of the slope coefficients (to trend) using the traditional data suggests that failure to include some explicit form of time may result in overestimating the price elasticities of demand. Trend does not make as much difference in the response coefficients of the revised model since technology changes are accounted for in the revised data. Overall, the role of trend in the model estimated with traditional data partly reflects technological changes in the industry; i.e., it may be capturing processing and product service changes commensurate with declining real prices, enough to significantly alter the per capita beef disappearance and difference equation coefficients.

Recognizing that sample periods, model specifications, and estimation methods differ, the data series model yields retail demand elasticity estimates higher than those reported in other studies, i.e., in the ranges of the −.60s and −.70s (Dahlgran; Huang and Haidacher; Wohlgenant). However, the current estimates are consistent with those of Moschini and Meilke who used 1967–87 quarterly data. They showed that after correcting for structural change in the mid-1970s, the retail beef price elasticity of demand was −1.05. The farm-level beef elasticities of demand in this study average about −.54 when based on the trend models, which is somewhat higher than the −.42 and −.50 farm demand elasticities reported by George and King, and Wohlgenant, respectively. Their coefficients are based on the assumption of fixed input proportions between farm output and marketing inputs. However, the −.54 farm estimate is considerably less than another farm demand elasticity estimate reported by Wohlgenant (−.76), which is based on variable input proportions. It nevertheless reflects limited variable input proportions because of marketing substitutions implied in reduced form demand models (Wohlgenant).[11]

Conclusions

Government agencies may periodically revise time series data to account for technological, service, and product trends in commodity markets. This article analyzed the implications of estimating market-level beef demand elasticities given recent USDA data revisions of Choice beef prices and price spreads. The revisions were necessary to account for changes in processing technology and beef product characteristics commensurate with structural changes in the beef industry of the 1980s. Overall, the revisions have substantial implications for estimating market responses such as in demand and price behavior.

The econometric results generally show that the elasticities of beef demand at the retail, wholesale, and farm levels are considerably more inelastic when using the revised data series as opposed to using the traditional data series. Specifically, the revised data demand elasticities are 24.5% smaller at the retail level, 12.5% smaller at the wholesale level, and 21.5% smaller at the farm level. Barkema, Drabenstott, and Welch indicate there have been significant changes in the food market structure in terms of consumer demand for new food products and changing farm and processing technologies to meet the new consumer "niches." Beef fits this category. Thus, the results reflect the fact that the revised data more aptly describe the desires and form of retail product consumption, with such preferences also being transmitted to the derived demands. As a consequence, buyers may be actually less sensitive to price changes since the more up-to-date technology of beef processing and consumption are accounted for in market trading.

When trend is included in the dynamics of the model using traditional data, differences in the elasticities of demand become smaller. For beef, this suggests that when using USDA traditional beef price and margin data, omitting some form of time in the econometric procedures could result in biasing the demand elasticities relative to the current technology in the market. Trend may not play the same role in cases of using established data in other commodity markets; however, the foregoing suggests empirical demand measurements may require careful interpretation when based on time series data that lag rapidly changing market technology.

An important qualifier of the research relates to the USDA data revision process. The recently revised data imply that newer beef processing and product technologies were about the same at the beginning and ending of the sample period. However, in reality, changes have been continual over time; for example, boxed beef and packer trimmed subprimals were not as important in the 1970s but increased in prominence over the 1980s. Thus, the model results may reflect more abrupt changes rather than gradual changes between the two data series.

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Notes

[1] In this article the terms "revised" and "traditional" data series are used to differentiate between the USDA's recent 1990 revision of beef prices and price spreads and the previous 1978 revision of beef prices and price spreads, respectively.

[2] The beef price and price spread data referred to in this article are given by the USDA in the specific tables entitled "Beef, Choice Yield Grade 3: Retail, Wholesale, and Farm Values, Spreads, and Farmers' Share." See, for example, table 47, p. 32, of the May 1991 issue of *Livestock and Poultry Situation and Outlook Report* (*LPS*-47).

[3] Fixing the market-level supplies simplifies specification and estimation of the structural model. Quarterly farm, wholesale, and retail beef supplies may not be exogenous and would, therefore, warrant equation specifications. However, their estimation is not a focus of this research. Also, disaggregating beef demand into fed and nonfed components was not undertaken since Select and lower grade (nonfed) beef prices were not part of the revised data.

[4] Annual data for per capita consumption of fish are available, but measurement errors are highly likely if quarterly observations are constructed by interpolation methods.

[5] See Wohlgenant, p. 248, for discussion and application of the Hausman test to potential specification bias in structural equations.

[6] The authors showed that generalized least squares estimators for level and difference models are equal if the level model is correctly specified and has a known disturbance process. This point is emphasized since recent work in beef demand has shown first differences as a desired form of representing dynamic behavior of frequent time-series data (Moschini and Meilke; Wohlgenant).

[7] Though the single equation, nonlinear least squares algorithm does not accommodate the seemingly unrelated regression (SUR) problem, cross-equation correlation of the residuals was nevertheless tested. The results show moderate correlation between the market-level residuals; however, this does not affect the consistency property of the estimators. If GLS could be applied, there would be little gain in efficiency since the independent variables between the price equations are identical (Johnston, p. 338).

[8] The following formula is used to derive the standard errors of the long run price flexibilities:

$$\sigma_\theta^2 = \left[\frac{1}{1-\hat{\beta}}\right]^2 \text{var}(\hat{\beta}) + \left[\frac{\hat{\beta}}{(1-\hat{\lambda})^2}\right]^2 \text{var}(\hat{\lambda}) + 2\,\text{cov}(\hat{\beta}, \hat{\lambda})\left[\frac{1}{1-\hat{\beta}}\right]\left[\frac{\hat{\beta}}{(1-\hat{\lambda})^2}\right],$$

where $\theta = \dfrac{\hat{\beta}}{(1-\hat{\lambda})}$, $\hat{\beta}$ is the slope coefficient of the beef quantity variable, and $\hat{\lambda}$ is the coefficient of the lagged dependent variable. The square root of σ_θ^2 gives the standard error. The function is based on Goldberger's development of asymptotic mean and variance for functions of random variables (pp. 122–25).

[9] The differences between the elasticities of demand for the traditional and revised data are not discussed on the basis of statistical significance. Due to the nature of the nonstochastic difference equations and their inherent nonlinearities, significance tests between relevant slope coefficients would be difficult because of the problems involved in constructing a formal test statistic.

[10] Though not presented here, the equations also were estimated linear in natural units. The regression performances were very similar to those of the double log equations. More importantly, they showed the demand elasticities to display the same relative differences between the traditional and revised data series models for each market level.

[11] The smaller value reflects the fact that the data series models represent an incomplete demand system compared to Wohlgenant's complete demand system. The latter permits more explicit substitution with other related commodities, which is consistent with a "total demand response" concept discussed by Tomek and Robinson (pp. 46–48).

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