An Econometric Analysis of the Beef-Feed Grain Economy

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The main purpose of this paper is to report the results of a study analyzing the effects of selected economic phenomena on the beef-feed grain economy. In recent years many disruptive events have taken place which have had a profound influence on the cattle industry. Probably the most significant development has been the increase in grain prices associated with rising world demand. Two devaluations of the U.S. dollar, crop failure caused by adverse weather in major grain-producing regions and rising incomes in Europe and Japan have been major determinants of this recent increase in world grain demand.

The feed grain and livestock sectors are both technically and economically interdependent. Thus, attempts to treat the feed grain sector as exogenous (in a study of beef supply and demand relations) could result in structural misspecification. The model presented in the following section is meant to depict current relationships in the beef-feed grain economy.

Economic Model

An economic model of the beef industry (including the grain and foreign sectors) was constructed to investigate economic, technological and institutional impacts on beef production and consumption. The development of this simplified model of the beef-feed grain economy was based on traditional consumer demand, factor demand and supply theories as well as previous research (Ehrich and Usman; Feltner; Foote, Klein and Claugh; Freebairn and Rausser; Hayenga and Hacklander; Hildreth and Jarrett; Langemeier and Thompson; Meilke; Reutlinger; Working). The functional relations specified in the model follows:

1) Supply of Fed Beef
$$Y_1 = f(Y_2/Y_7, Z_2, Z_3, Z_4, Z_{15})$$

2) Farm Price of Fed Beef
$$Y_2 = f(Y_1, Y_4, Z_4)$$

3) Supply of Non-Fed Beef
$$Y_3 = f(Y_4, Y_2/Y_7, Z_1, Z_2, Z_3)$$

4) Farm Price of Non-Fed Beef
$$Y_4 = f(Y_3, Y_2, Y_5, Z_4, Z_{10}, Z_{16})$$

5) U.S. Imports of Beef
$$Y_5 = f(Y_4, Z_5, Z_6)$$

6) Supply of Corn
$$Y_6 = f(Y_7, Z_7, Z_8, Z_{14})$$

7) Farm Price of Corn
$$Y_7 = f(Y_6, Y_2, Z_9, Z_{10})$$

8) Foreign Demand for U.S. Corn
$$Y_8 = f(Y_7, Z_{11}, Z_{12}, Z_{13})$$

The variables are defined in table 1. The data used to estimate the above model were obtained primarily from U.S. Department of Agriculture publications and covered the period 1950-1974. The model is over-identified and two-stage least squares (TSLS) was employed to estimate the economic relationships set forth above.

Empirical Results

The results are presented in table 2. It should be recognized that the t, R^2 and F values presented

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Table 1. Definitions of Variables[a]

Endogenous Variables

Y_1 = quantity of fed beef produced in the U.S. (number of steers slaughtered under federal inspection—grade choice—thousand head).

Y_2 = U.S. farm price of fed beef (average price per 100 pounds of choice slaughter steers at Omaha).

Y_3 = quantity of non-fed beef produced in the U.S. (number of steers slaughtered under federal inspection—grade other—thousand head).

Y_4 = U.S. farm price of non-fed beef (average price per 100 pounds of slaughter steers grade other at Omaha).

Y_5 = U.S. imports of beef from Australia, New Zealand and Argentina (million pounds).

Y_6 = quantity of corn produced in the U.S. (million bushels).

Y_7 = U.S. farm price of corn (dollars per bushel).

Y_8 = U.S. exports of corn (million bushels).

Exogenous Variables

Z_1 = U.S. pasture condition in August (percentage of normal as reported by crop correspondents).

Z_2 = U.S. farm price of fed beef in t-1 (dollars per 100 pounds).

Z_3 = number of cattle and calves on U.S. farms on January 1 (thousand head).

Z_4 = U.S. per capita disposable personal income (dollars).

Z_5 = price of beef in exporting countries (wholesale price of first and second export quality beef carcasses weighing 650-700 pounds at Brisbane, Australia—dollars per 100 pounds).

Z_6 = quantity of beef produced in exporting countries (quantity of beef and veal produced in Australia and Argentina—thousand metric tons).

Z_7 = weather conditions in Corn Belt (pasture condition in Illinois on September 1 expressed as percentage of normal).

Z_8 = technology (index numbers of U.S. farm output per unit of input).

Z_9 = total stock of U.S. corn (carryover stock on October 1—million bushels).

Z_{10} = U.S. farm price of hogs (average price received by farmers—dollars per 100 pounds).

Z_{11} = world market price of corn (price of first quality corn received by farmers at Brescia, Italy—dollars per bushel).

Z_{12} = exchange rate (spot rate between West German mark and U.S. dollar).

Z_{13} = stock of feed grains in Canada, Argentina and Australia (thousand metric tons).

Z_{14} = stock of corn in the U.S. in t-1 (million bushels).

Z_{15} = price received by farmers for roughage (price of all hay-baled-dollars per ton).

Z_{16} = U.S. farm price of broilers (dollars per 100 pounds).

[a] A detailed explanation of the variables used in this study are reported in Shuib.

for the second stage of TSLS are not strictly valid because they are based on estimates instead of actual values of the endogenous variables. In addition, the Durbin-Watson is generally not appropriate for equations which belong to a system of simultaneous equations or to equations that contain lagged values of endogenous variables as an exogenous variable (Kmenta). Thus, these tests serve only as approximations and should be interpreted as such.

Evaluation of Results

The inadequacies of the results, particularly the supply of non-fed beef (Y_3), farm price of non-fed beef (Y_4) and price of corn (Y_7) equations, as measured by consistency of coefficient signs with respect to theoretical expectations, coefficient sizes relative to their standard errors, and R^2 can be traced to problems of data and equation specification. Specifically, for the non-fed beef equation,

Table 2. TSLS estimates, beef-fed grain economy[a]

Equation	Constant	Variables[b]						R^{2d}	DW[e]	F[f]
Supply of Fed Beef		Y_2/Y_7	Z_2	Z_3	Z_{15}					
Y_1	-19206.6	77.749	37.923	0.310	-115.706			0.957	1.23	112.395
		(42.348)[c]	(66.282)	(0.0215)	(66.893)					
Farm Price of Fed Beef		Y_1	Y_4	Z_4						
Y_2	13.664	-0.00128	0.733	0.00556				0.965	2.185	191.216
		(0.00048)	(0.157)	(0.0025)						
Supply of Non-Fed Beef		Y_4	Y_2/Y_7	Z_1	Z_2	Z_3				
Y_3	392.075	-6.025	-0.840	0.218	1.960	-0.00150		0.866	0.853	24.445
		(1.635)	(1.280)	(0.628)	(1.472)	(0.0004)				
Farm Price of Non-Fed Beef		Y_3	Y_2	Y_5	Z_4	Z_{10}	Z_{16}			
Y_4	1.318	-0.0127	0.908	0.00280	-0.00127	0.099	-0.134	0.963	2.625	78.872
		(0.0202)	(0.130)	(0.00313)	(0.00126)	(0.113)	(0.146)			
Imports of Beef		Y_4	Z_5	Z_6						
Y_5	-609.995	17.506	14.266	0.145				0.819	0.792	31.763
		(7.424)	(6.535)	(0.0571)						
Supply of Corn		Y_7	Z_7	Z_8	Z_{14}					
Y_6	-4217.187	434.656	7.595	80.377	-0.452			0.952	2.515	99.473
		(194.351)	(4.492)	(4.264)	(0.165)					
Price of Corn		Y_6	Y_2	Z_9	Z_{10}					
Y_7	0.891	-0.0000779	0.0199	-0.000203	0.0196			0.488	2.173	4.769
		(0.0000724)	(0.0169)	(0.000165)	(0.0162)					
Foreign Demand for Corn		Y_7	Z_{11}	Z_{12}	Z_{13}					
Y_8	4257.994	-556.377	94.098	-826.259	-0.00396			0.904	1.614	46.825
		(112.956)	(114.286)	(110.484)	(0.0145)					

[a] Reduced form equations are presented in Shuib.
[b] For definitions of variables, see table 1.
[c] The numbers in parentheses are standard errors for respective regression coefficients.
[d] R^2 is the coefficient of multiple determination.
[e] DW is the Durbin-Watson test statistic for the presence of autocorrelation in the residuals.
[f] F is the test for significance of regression.

it was not only difficult to determine exactly what best described quantity of non-fed beef but also to measure the price of non-fed beef. In this study, quantity of non-fed beef was represented by number of steers slaughtered under federal inspection of grade "other" and price of non-fed beef was represented by the average price of slaughter steers grade "other" at Omaha. In addition, since government programs were not considered in the price of corn equation, the results may reflect this inadequacy of model specification. Another omission in this latter equation is the demand for corn by poultry (Black).

Empirical consideration of the foreign sector is

difficult. In addition to economic reasons the U.S. also exports grain for political and humanitarian purposes. Additionally, climatic conditions of importing countries may affect the quantity of grains imported. The recent increase in U.S. grain exports has been influenced by these factors. Unfortunately, these influences cannot be included in a statistical model due to the lack of quantitative measurements.

Results are compared with those of previous research to ascertain the magnitude and direction of changes which might have occurred in the industry (table 3). The fact that some of the elasticity estimates reported here are different from those in other studies does not indicate that the results of this study are in error. Since many of the previous studies were conducted nearly a decade ago, differences might be attributed to structural changes in the beef-feed grain industry.

Table 3. Comparisons of estimated elasticities and flexibilities[a]

	Elasticities (Farm)	
Quantity Demanded	Current Study	Previous Studies
Fed beef	-1.776	-0.893[b]
Non-fed beef	-11.49	-1.011[b]
Corn		
Domestic	-4.27	-0.514[c]
Foreign		
U.S. price	-1.51	-1.3[d]
World market price	0.414	
Quantity Supplied		
Non-fed beef	-0.966	-0.924 to -1.23[e]
Imported beef	0.730	1.47[f]
Corn	0.145	0.11[g]

Farm Level Demand by Type of Beef	Flexibilities			
	Quantity	Income	Quantity[b]	Income[b]
Fed beef	-0.563	0.479	-1.724	2.20
Non-fed beef	-0.087	-0.135	-1.522	-1.312

[a]The traditional concepts of elasticities and flexibilities are not strictly valid in simultaneous equations. In an equation where more than one endogenous variable may appear the *ceterus paribus* assumption of the conventional definition of elasticity is violated.

[b]Langemeier and Thompson.

[c]Feltner

[d]Brandow

[e]Reutlinger

[f]Ehrich and Usman

[g]Coyler and Irwin

Implications of Results

Until recently the supply of higher grade beef increased relative to lower grades. This was made possible by the surplus and low price level of feed grains. In addition, demand increased for higher grade beef relative to lower grades as a result of increases in consumer income. For the same reasons, livestock production increased in many of the more developed countries. However, recent factors (previously mentioned) have drastically altered feed grain prices. As a result, changes have occurred in the production of beef. Estimates of the response of quantity of fed beef and non-fed beef supplies with respect to the price of the fed beef-corn price ratio indicates this phenomena. The production of fed beef (Y_1) has a direct relationship with the fed beef-corn price ratio (Y_2/Y_7). The supply response of fed beef to a 1% change in the aforementioned price ratio is 0.14%. On the other hand, a 1% change in the fed beef-corn price ratio brings about a 0.12% change in the production of non-fed beef (Y_3) in the opposite direction.

The elasticities of demand for fed (Y_2) and non-fed beef (Y_4) as presented in table 3 are larger in the current study than those obtained by Langemeier and Thompson. In general, these differences may be attributable to the relatively larger number of substitutes for beef presently than when the Langemeier study was undertaken. For example, synthetic meat and poultry products are becoming more and more competitive with beef products. The sign of the coefficient on price of non-fed beef (Y_4) in the price of fed beef (Y_2) equation is positive denoting substitutability of non-fed beef and fed beef. In addition, the sign of the coefficient on disposable per capita income (Z_4) indicates that fed beef is a normal good as expected. Conversely, in the price of non-fed beef equation per capita disposable income (Z_4) exhibits a negative coefficient sign indicating an inferior good. This too is consistent with previous research as reported in table 3. However, the income elasticities for both fed beef and non-fed beef estimated in this study are less responsive to income changes than estimates previously obtained.

Exports of feed grains from the U.S. are subject to many influences. Of primary importance are the import duties and quotas in foreign countries. The estimate of price elasticity of corn for export (Y_8) indicates that a 1% increase in the price of corn in

the U.S. (Y_7) will decrease export demand by roughly 1.5%. The result of the recent devaluation of the U.S. dollar has made U.S. goods cheaper in terms of foreign currencies (Schuh). The elasticity of foreign demand for U.S. corn with respect to the exchange rate (Z_{12}) is -6.6 – extremely elastic. Thus, as Schuh suggests, it is apparent that an adequate representation of the agricultural sector cannot be obtained without consideration of the exchange rate. The effects of the devaluation may be short-lived but changes in economic conditions in foreign countries may further increase the demand for U.S. grains.

Conclusion

Although the model reported here is simplified with respect to representing the structure of the U.S. beef-feed grain economy, results suggest that the structure of this industry has changed as compared to results of previous research. Results of these earlier efforts should be used with caution in policy analysis and forecasting work. Additional research is required to more adequately obtain relationships now existing in the U.S. beef-feed grain industry. To facilitate this research, there is a need for more accurate and current data, particularly as related to the foreign sector. It is apparent that a thorough analysis of the beef sector can no longer be undertaken without considering both the effects of the feed grain economy and the foreign sector.

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