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1. **Northeastern
Agricultural
Economics Council**



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PROCEEDINGS ISSUE
VOLUME VIII, NUMBER 2
OCTOBER, 1979

IMPACT ON LIVESTOCK PRODUCERS OF U.S. POLICIES
AFFECTING FEED SUPPLIES

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U.S. agricultural policy has been implemented by various means including price supports, production or acreage controls, trade agreements, commodity reserves, food aid, and other programs (Brandow, 1976). These have been advanced to respond to various public policy objectives. Most of these policies have been directed toward food and feed grains, resulting in varying impacts on producers and consumers of these grains.

The U.S. livestock sector is the primary consumer of U.S. low protein feed and high-protein feed supplies (U.S.D.A. Agricultural Statistics). Previous research has not generally focused on the impact (on the various livestock producer groups) of U.S. agricultural policies which are largely directed toward grains.

King (p. 167) has called for an "additive" research approach to individual livestock sectors such that implications may be expanded to address the entire feed-livestock industry. Breimyer and Rhodes concluded that the livestock and poultry sectors would benefit from stabilization of feed supplies and prices.

Previous research related to interrelationships between the feed and livestock sectors include an integrated model by Brandow (1961), a dynamic, long-run model of the feed-livestock sector by Egbert and Ruetlinger, an aggregate model of all agricultural commodities by Evans, and a global predictive model of the grain-oilseeds-livestock economy by Rojko and others. Many other models examine individual commodities.

Reiger, using the global grain-oilseeds-livestock (GOL) model, showed the world livestock sector acting as a secondary world grain reserve. He described the livestock sector as a regulating element, or stabilizer, related to production, consumption, and prices of grain.

Other recent research efforts related to the interrelationship between the feed and livestock sectors include a quarterly model by Arzac and Wilkenson and an analysis of various trade policies on livestock production and prices by Martin and Meilke.

The next section of this paper discusses a simultaneous equation model of the U.S. feed-livestock sector. The following section reports some of the results of the model, and the final section discusses conclusions.

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DESCRIPTION OF THE MODEL

The research reported in this article was designed to develop an integrated, static equilibrium model of the U.S. feed-livestock sector which could be applied for long-term policy analysis. Impact multipliers were derived from the reduced form solution of simultaneous equation model resulting from structural equations describing important aspects of the U.S. feed-livestock sector.

Impacts on various livestock producer groups resulting from public agriculture policies affecting feed supplies were investigated. Feed supplies available to the livestock sector are influenced directly or indirectly by various U.S. agricultural policies and were considered exogenous in the model. Grains may also be used for food and industry use, seed exports, and inventory. Meilke developed an aggregate model of the U.S. feed grain sector showing inelastic price response for food and industry use, and dependence on government or international variables for inventories and exports. In addition government programs affect the quantity of grain planted directly or indirectly through acreage restrictions, price supports, etc. The result is that decisions about the availability of feed supplies to the livestock sector are made outside the livestock sector, and therefore may be considered exogenous in the model.

Feed availability and price directs the quantities of various livestock products which can be produced profitably. Price elasticities and cross-price elasticities for livestock products determine the quantities of livestock products consumed.

Equilibrium relationships are defined to exist when further change in variables is neither encouraged nor discouraged. This position is never expected to occur in reality since new shocks to the systems are introduced continually. Equilibrium positions are of interest, however, from a policy standpoint. An appropriate question of the model may be, "Given say, three to five years for adjustments to take place in the feed-livestock sector, how will changes in the supply of feeds available affect individual livestock prices and quantities, and total receipts for various producer groups?"

During periods of large supply and low prices, livestock producers respond by expanding their production. If feed supplies are tight and prices high, livestock producers reduce their production in response to price relationships. Consumers also play an important role in livestock production adjustments by making selections at the meat or dairy counter in response to prices. These adjustments are included in the model.

The theoretical requirement of equilibrium requires that incentives for the sector to expand or contract production do not exist. This is consistent with zero long-run profits. This also implies that there are no changes in carryover stocks of feed supplies, and that all adjustments in production and consumption have occurred.

Impacts of alternative levels of grain availability on the livestock sector were examined by specifying a structural model of the form

$$\beta Y + \Gamma X = 0$$

where β = matrix of coefficients of endogenous variables,
 Γ = matrix of coefficients of exogenous variables,
 X = column vector of exogenous variables, and

Y = column vector of endogenous variables.

The equations of the model are presented elsewhere (Prindle). The model consists of four blocks of equations representing (1) demand for livestock products, (2) supply of livestock products, (3) feed utilization in livestock production, and (4) market identities. These blocks of equations are discussed below. Together these equations represent interrelationships between individual livestock commodities in production and consumption and between the livestock and feed subsectors. Production and consumption decisions are simultaneously being made in response to price, and are reflected in the equations.

Demand for Livestock Products

Consumer demand for an individual livestock product is generally considered to depend on the price of the product, prices of substitutes, and consumer income. This relationship, at retail, may generally be denoted:

$$E_{ij} = e_{ij} \cdot \xi_{ij}$$

where q_i = quantity demanded of product i
 p_i = price of product i
 p_j = price of substitute products j , and
 Y = consumer income

Studies by Brandow (1961) and George and King have developed elasticities for food products, including livestock products, based on theoretical and empirical consideration. Demand elasticities from the George and King study were adopted for use in this model. The retail demand elasticities were transformed into farm-level price elasticities by applying the following identity:

$$E_{ij} = e_{ij} \cdot \xi_{ij}$$

where E_{ij} = farm level demand elasticity for the i^{th} product
with respect to the farm level price of the j^{th} product,
 e_{ij} = retail level demand elasticity for the i^{th} product
with respect to the retail price of the j^{th} product, and
 ξ_{ij} = elasticity of price transmission.

The farm-level price elasticities were required to be consistent with the theoretical specifications of the model. Elasticities of price transmission were calculated for the period 1961-72 by estimating the following equation:

$$p^{(f)} = a + b p^{(r)}$$

where $p^{(f)}$ = farm-level price for product
 $p^{(r)}$ = retail price for product, and

a,b = regression coefficients.

Based on the above equation, the elasticity of price transmission was calculated as

$$\xi = \frac{1}{b} \cdot \frac{\bar{p}^{(f)}}{\bar{p}^{(r)}}$$

where the bar represents the mean for the variable. Estimated values for elasticities of price transmission are shown in Table 1 for major commodities.

Table 1
Elasticities of Price Transmission for
Selected Livestock Products

Livestock Product	Estimated (1961-72)	George and King 1964-68
Beef	0.6389	0.6469
Pork	0.5417	0.5832
Eggs	0.8966	0.7072
Chicken	0.7391	0.7749
Turkey	0.9861	(a)

(a) Not available

Slope coefficients, b_{ij} , were necessary for use in the linear structural equations and were derived from the farm-level demand elasticities according to the following identity:

$$b_{ij} = \frac{\partial q_i}{\partial p_{ij}} = E_{ij} \cdot \frac{\bar{q}_i}{\bar{p}_j^{(f)}}$$

where \bar{q}_i = average quantity demanded of product i for the base period, and

$\bar{p}_j^{(f)}$ = average farm-level price for the j^{th} product in the base period.

Slope coefficients for demand for total milk were calculated as the sum of the slope coefficients of the direct and cross relations for the

individual dairy products, including fluid milk. Demand equations for livestock products in the structural model were included in the form:

$$Q_i = D_i(P_i, P_j, Y)$$

where Q_i , P_i , and P_j are quantities and price at the farm level.

The period, 1967-71 was selected as the base period, since it was a recent period of relative price stability. The model could be used with alternative base periods, by adjusting demand elasticities to slope coefficients using alternative base period averages. Evidence that demand elasticities and/or elasticities of price transmission differ from those used in the model would encourage further examination of this portion of the model.

Supply Equations for Livestock Products

Equilibrium conditions sought by simultaneous solution of the structural model require that livestock production will be neither encouraged nor discouraged. Equilibrium in the model is maintained by specifying zero long run profits in the structural equations. This is accomplished by equating farm-level price of the livestock product and total production costs, consisting of feed costs plus nonfeed costs. Nonfeed costs include a return for management and labor. Feed costs consist of feed price multiplied by a fixed rate of feeding. High-protein feeds and low-protein feeds are considered separately.

The equilibrium requirement discussed above provided that nonfeed costs be estimated by the equation:

$$NFC = a + bTIME$$

where $NFC = P_i - k_1PHIPR - k_2PLOPR$

and where

NFC = nonfeed costs,

P_i = price of livestock product i ,

$PHIPR$ = price of high-protein feeds,

$PLOPR$ = price of low-protein feeds,

$TIME$ = trend variable with 1960 = 1, 1962 = 2 . . .

k_1, k_2 = rate of feeding constants, and

a, b = regression coefficients

Nonfeed costs are specified to equal the livestock product price minus feed costs in equilibrium. The trend term was retained if it was significant at the .05 level, indicating change in feed efficiency and/or adjustments in the proportion of nonfeed costs in livestock production.

A slightly different treatment was made for milk production and was based on an assumption of supply elasticity equal to 0.25 with respect to milk prices, and -0.1 with respect to feed costs, based on the results

of an earlier study (Hallberg and Fallert).

Identities Related to Livestock Products

The market for each product considered in the model must be cleared to establish equilibrium conditions. Imports of livestock products must be added to domestic production to determine total available supply.

Total beef supply is made up of three parts, fed beef from placements of beef into feedlots, other beef, and beef imports. Total cattle number is considered exogenous in the model to reflect the position of the beef cycle, and equals placements plus other beef.

Total chicken supply consists of broilers and other chickens. The amount of "other chicken" depends on broiler production and egg production as well as feed costs.

Feed Utilization in Livestock Production

Available feed supplies are utilized by livestock at fixed rates in the model. Substitution between high-protein and low-protein feeds is provided by including price terms in each of the feed utilization equations. Therefore when exogenous feed supplies are, say, low, feed prices will be high, feeding margins will be reduced, livestock supplies will decline to an equilibrium position that will clear the market under the required equilibrium conditions. Individual livestock products will adjust in response to own-price and cross price demand elasticities and to differences in feed utilization efficiencies.

The feed utilization equations have the form:

$$QHIPR = b_0 + b_1 PHIPR + b_2 PLOPR + \sum_i k_i Q_i$$

where $QHIPR$ = quantity of high-protein feed available to the livestock sector, (exogenous)

$PHIPR$ = price of high-protein feed

$PLOPR$ = price of low-protein feed

Q_i = quantity of livestock product i , and

k_i = rate of feeding for livestock product i .

The b coefficients in the above equation were assigned coefficients to meet the constraints of the model. A similar equation was used for low-protein feed utilization.

ANALYSIS OF CHANGES IN FEED AVAILABILITY

Reduced form equations were derived from the structural model giving each of the endogenous variables in the model as linear functions of the included exogenous variables. The reduced form of the model may be written as:

$$Y = -\beta^{-1} \Gamma X$$

where the matrices are as identified above. The reduced form coefficients, also known as impact multipliers, measure the net impact on the endogenous variables of a one unit increase in each of the exogenous variables, while maintaining the market relationships specified in the structural equations. The matrix of reduced form coefficients may be denoted as

$$\pi = -\beta^{-1}\Gamma$$

Selected impact multipliers, expressed as elasticities, are shown in Table 2 for one percent increase in availability of both high protein and low-protein feeds. The data in Table 2 indicate that the price and production responses to changes in availability of high-protein feeds are greater than the similar responses to changes in availability of low-protein feeds. This results primarily from different price coefficients in the feed utilization equations. This relationship is further evidenced by comparing price flexibilities for high-protein and low-protein feeds, which indicates that price elasticities for high-protein feeds are more inelastic than those for low-protein feeds.

Table 2

Effect of an Exogenous Change in the Availability of Feed Products on Price and Quantity of Various Commodities

Product	Change in production associated with an one percent increase in availability of		Change in price associated with an one percent increase in availability of	
	Low-Protein Feeds	High-Protein Feeds	Low-Protein Feeds	High-Protein Feeds
	%	%	%	%
Beef	0.17	0.33	-0.80	-1.70
Pork	0.21	0.38	-1.42	-2.86
Chicken	0.25	0.96	-1.03	-3.00
Turkey	1.44	3.97	-1.21	-3.33
Eggs	0.29	0.67	-1.11	-2.54
Milk	0.01	0.02	-0.07	-0.15
Low-protein feeds	(a)	(a)	-3.30	-5.67
High-protein feeds	(a)	(a)	-1.17	-8.46

(a) Data are not appropriate.

The largest price adjustment to changes in low-protein feed supplies was for pork, resulting from relatively inelastic own-price elasticity and high feed utilization ratio. Turkey and chicken prices had the largest response to changes in high-protein feed supplies. Dairy prices had the lowest price response to changes in feed supplies.

The data in Table 2 indicate the largest production adjustment was for turkey. This result was primarily from a high demand elasticity for the product and a relatively favorable feed utilization ratio. Chicken and egg production changes were larger than those for pork or beef. The lowest production adjustment was for dairy products. Although not shown in Table 2, an increase of one percent of low-protein feed availability resulted in a 1.8 percent increase in beef placements, while reducing non-fed beef production by 4.4 percent. Data in Table 2 show the net effect of the change to be 0.17 percent. Placements increased 3.4 percent in response to a one percent increase in high-protein feed availability, and a net effect of 0.33 percent. This indicates that the beef sector is a primary adjuster to changes in feed availability.

The information presented indicates that not all livestock producers share equally in policies affecting the availability of feed supplies. Table 3 summarizes results of the model for a 30 million ton sustained reduction in availability of low-protein feed supplies. This was approximately the amount of change in feed concentrates actually fed to livestock and poultry between the 1973 and 1974 crop years (U.S.D.A.).

Table 3
Effect of a Change in Feed Availability on Gross Income
of Various Livestock and Grain Producer Groups

Producer Group	Change in Gross Income of 30 million ton Decrease in Avail- ability of Low-Protein Feed Supplies (% of initial equilibrium)
Beef	75.7
Pork	121.9
Chicken	114.8
Turkey	89.2
Eggs	114.4
Dairy	100.9
Low-Protein Feed Producers	131.9
High-Protein Feed Producers	122.3

Beef producers were most adversely affected by shortages in supplies of low-protein feeds. Turkey producers also had reduced gross sales, while other livestock producers showed increased gross income compared to the initial equilibrium position. Pork producers had the largest increase in gross income from reductions in feed supplies, according to the analysis, with increases also indicated for chicken and egg producers. These results depended on simultaneous interrelationships between demand elasticities for various products, feeding rates, and nonfeed costs.

Data in Table 3 also show that grain producers realized increases in gross incomes from restrictions in the supply of low-protein feeds. This increased income follows from inelastic demand and higher prices resulting from reduced supplies. Because of the substitutability of high-protein and low-protein feeds in livestock production, both producer groups share from reduced supplies of low-protein feeds.

CONCLUSIONS

The results of the model examined in this paper indicate that public agricultural policies which affect the availability of feed supplies have an important impact on the livestock sector. These impacts are shared differently by the various livestock producer groups, in terms of equilibrium prices and production. Livestock producers have a stake in agricultural policy related to feed availability.

Important distributional effects result from programs affecting feed supplies. The model results indicate that a policy which restricts feed grain availability would be supported by grain producers and producers of pork, chicken, and eggs. This same policy would be opposed by beef and turkey producers.

Policies which affect feed availability have indirect effects on firms supplying inputs for livestock production, and for firms processing, transporting, or distributing livestock products. These policies may also have an effect on regional employment and investment as incentives to produce a particular livestock commodity are added or removed.

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