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DEMAND CONSIDERATIONS  
IN ALTERING THE BEEF PRODUCT MIX

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## ABSTRACT

A Demand Model for beef animals by grade is estimated and utilized to view the effects on price of a change in the beef product mix. It is shown that the price differential between beef grades at which greater lean beef would be profitable is not one that consumers would support. Alternatively, it is asserted that the price differential under which more lean beef would be consumed is not one that lean beef producers would find profitable.

## Demand Considerations in Altering the Product Mix of Beef

Inventory holders of beef (in animal or product form) are interested in calculations which optimize the mix of beef demanded by the eventual consumer. They are interested in data on disappearance and price by grade for slaughter animals because these reflect changes in consumer demands for animals of alternative muscle/fat proportions. The discovery of trends (or other systematic changes) in such data leads suppliers to adjust inventory holdings of animals of alternative grades, by altering ration composition, length of feeding period, and/or weight, type or age of input animal.

The purpose of this paper is to examine the effects an altered beef product mix, defined in terms of official USDA beef grades, would have on beef prices as observed in a model of recent consumer behavior. The question addressed directly is: to what extent would a beef product mix containing more lean and less fat beef have been supported by the consumers of that mix in the period 1962-1982. The question addressed indirectly is: to what extent would a beef product mix containing more lean and less fat beef be profitable to producers of that mix.

### Economic Model

The model examined is a set of quarterly demand relations for choice and lean beef animals, hogs (barrows and gilts)

and broilers. Choice beef is defined as steers and heifers grading USDA Choice or above while lean beef is defined as steers and heifers grading USDA Good or below plus cull cows and bulls plus imports (liveweight equivalent) minus additions to storage (liveweight equivalent). Price for choice beef is a quarterly average for Choice steers and heifers at Omaha weighted by pounds sold across months and sexes. Price for lean beef is a quarterly average for Good steers and heifers at Omaha similarly weighted.

All quantities available for consumption are assumed exogenous, that is, decisions to make available a given amount of choice beef and a given amount of lean beef is assumed to have been made, at the latest, in the quarter prior to measurement. Additions to beef (and hog) storage<sup>1</sup> represent the difference between domestic production of lean beef (plus imports) and consumption of lean beef. Its small size relative to total production of beef makes this difference very small.

Additions to stocks and all meat animal prices are assumed jointly endogenous. Expectations of higher prices in the future cause simultaneous increases in today's prices and in the number of pounds of beef (or pork) one is willing to hold in storage. While one may argue that the same may be said for meat on the hoof, the flexibility in holding fattened animals is not great.

It is expected that beef, hog and broiler prices will be affected by the level of real income available for disposal and that strongest effects will occur for choice beef and least for chicken. During periods of recession (as defined officially) it is expected that prices will fall for given available supplies, with the largest decline in price occurring for choice beef and the least for chicken. The behavior of meat demand with respect to income is closely related to the opportunity cost of time. As the value of foregone opportunities rises, relative prices for given quantities of alternative meats and the animals that produce them, change in favor of the meat for which the time commitment in preparation is smallest. However, no attempt is made in this paper to model changes in responsiveness of demand to income over time.

It is expected that the demand for choice and lean beef (as well as that for hogs and broilers) will exhibit sensitivity to the change in official USDA grades which occurred in the first quarter in 1976. The new grades allowed cattle with less intramuscular fat to qualify for the Choice grade and set a maximum age limit on all cattle qualifying for grades Standard and above. A feedlot producer of slaughter ready cattle conceivably could "get by" with more forage in the ration or could market at lighter weights under the new grades. However, Brokken (1980) has shown that under most corn/forage<sup>2</sup> price scenarios, such adjustments would not be made, i. e. corn/forage quantities in rations would remain the same, and

slaughter weight would remain the same as under the old grades. While corn and forage may be thought of as substitutes in cattle rations, in practice they act as complements, their essentially competitive relationship dwarfed by the competition between corn and time on feed.

This is not to deny that in the long run the relationship between the factor prices of corn and forage (and time) determine the relationship between choice and lean beef slaughter prices. This explanation merely helps explain why, after 1976, the relative proportions of steers and heifers grading choice and lean did not change much.<sup>3</sup> Even though the domestic demand for feed corn dropped post-1976, this was a result of an unprecedented drop in all beef production, and perhaps only slightly because of a changing beef mix.

↓  
Confounding the effects of the grade change after 1976, are the severe recession from 1980 through 1982 and possible effects of (research based) admonitions to reduce caloric intake by substituting away from meats (and other foods) high in saturated fats. The extent to which these admonitions have caused changes in perceptions concerning the relationship between diet and health, and thus have altered the way consumers allocate their budgets among meat types is currently inseparable from other causes<sup>4</sup>. Substitution among meats will also vary with changes in labor-leisure opportunities, or with changes in food preparation technology or product definition, or with

Table 1. Definition of variables

- $P_c$  = Quarterly farm price of steers and heifers<sup>1</sup> grading Choice and above deflated by the Consumer Price Index (CPI)<sup>2</sup> measured in \$/cwt.
- $P_g$  = Quarterly farm price of steers & heifers grading Good and below deflated by the CPI, \$/cwt.
- $P_h$  = Quarterly farm price of barrows and gilts, seven markets combined, deflated by CPI, \$/cwt.
- $P_k$  = Quarterly farm price of broilers deflated by CPI, \$/cwt.
- $Q_c$  = Quarterly commercial sales of U.S. steers and heifers grading Choice and above deflated by U.S. population, liveweight pounds/person.
- $Q_g$  = Quarterly commercial sales of U.S. steers and heifers grading Good and below plus beef and dairy cull cows (bulls & stogs) plus imports minus additions to storage, deflated by U.S. population, liveweight pounds/person.
- $Q_h$  = Quarterly Commercial sales of U.S. barrows and gilts deflated by U.S. population liveweight pounds/person.
- $Q_k$  = Quarterly commercial production of young chickens (broilers) minus exports minus additions to stocks, deflated by U.S. population, liveweight pounds/person.
- $Y$  = Yearly per capita disposable income deflated by CPI, measured in thousands of dollars/person/year.
- $R$  = Intercept dummy for recession years. 1973-I to 1975-I; 1980-I to 1980-II; 1981-III to 1982-IV.
- $D$  = Intercept dummy to account for shocks (grade change, "taste" change, technology change) in the period 1976-1982.
- $D_i$  = Intercept dummy for the  $i^{\text{th}}$  quarter.

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<sup>1</sup>Choice and Lean steer and heifer prices are averages, weighted by liveweight sold in each month and each sex at Omaha. Choice price is for USDA Choice beef animals, Lean price is for USDA Good beef animals.

<sup>2</sup>Base year was 1967.



BFSTKS = Quarterly per capita additions to beef stocks (liveweight equivalent) divided by total quarterly beef supplies, measured in pounds/person.

HGSTKS = Quarterly per capita additions to hog stocks (liveweight equivalent) divided by total quarterly hog supplies, measured in pounds/person.

changes in health maintenance oportunities, not to mention changes in relative prices of the meats themselves. All of this is to say that it is hard to define an expectation for the variable D.

### Statistical Model

The statistical model consists of four (CPI deflated) price dependent equations expressed as linear function of per capita consumption quantities for each of the four meat animals, per capita additions to storage for beef and hogs (as a percent of total supplies), real per capita disposable income, a recession dummy, a grade change dummy, and a set of quarterly dummies. All variables are defined in Table 1. The data set on which the statistical model was calculated extended from 1962 I through 1982 IV.

The 2SLS regressions are given in Table 2. Instruments for the jointly endogenous variables, BFSTKS and HGSTKS, were the predetermined variables of the model, the price of corn and hay, and time.

All variables in each equation exhibit expected signs, although the hog and broiler quantity variables were insignificant at the 5% level in the choice and lean equations. The storage variables were significant at the 5% level in all equations except for HGSTKS in the hog price equation.

TABLE 2. PRICE DEPENDENT DEMAND FOR MEAT ANIMALS, 2SLS ESTIMATES, LINEAR FORM.

Equation	Con.	Variables											
		Q <sub>c</sub>	Q <sub>g</sub>	Q <sub>h</sub>	Q <sub>k</sub>	Y	BFSTKS	HGSTKS	D	R	D <sub>2</sub>	D <sub>3</sub>	D <sub>4</sub>
P <sub>c</sub>	17.1 (1.7)	-.940 (7.4)	-.554 (3.2)	-.073 (.4)	-.529 (1.1)	17.67 (5.7)	103.6 (2.0)	154.9 (3.4)	-5.44 (3.5)	-2.96 (2.7)	7.2 (3.8)	3.9 (3.0)	-.56 (.8)
P <sub>g</sub>	20.1 (2.0)	-.866 (6.7)	-.668 (3.9)	-.046 (.2)	-.677 (1.3)	16.74 (5.7)	107.4 (2.0)	163.9 (5.7)	-4.90 (3.5)	-2.43 (2.7)	7.4 (3.8)	4.0 (3.0)	-.68 (.8)
P <sub>h</sub>	57.5 (9.5)	-.239 (3.0)	-.383 (3.6)	-2.09 (17)	-1.01 (3.3)	12.51 (7.0)	215.1 (6.6)	53.4 (1.8)	-4.09 (4.9)	-.96 (1.8)	3.6 (3.0)	-1.4 (1.8)	-.01 (.0)
P <sub>k</sub>	34.3 (7.4)	-.438 (7.3)	-.292 (3.6)	-.523 (5.6)	-1.60 (6.8)	9.18 (6.7)	77.52 (3.1)	56.16 (2.5)	.25 (.4)	-.50 (1.2)	4.1 (4.4)	2.0 (3.1)	-.84 (2.1)

∞

Absolute value of t-statistic given parentheses.

BFSTKS and HGSTKS are jointly endogenous with price variables.

Variable means, 1962-1982.

$$\begin{array}{llllll}
 P_c = 26.25 & P_h = 21.13 & Q_c = 23.68 & Q_h = 21.47 & Y = 2.943 & HGSTKS = -.00046 \\
 P_g = 24.68 & P_k = 13.65 & Q_k = 21.35 & Q_k = 12.93 & BFSTKS = .00016 &
 \end{array}$$

Coefficients associated with the variable D are negative for the choice, lean and hog price equations and insignificant in the broiler price equation. It is surprising that in the period 1976-1982, the price differential between choice and lean beef, as represented by the difference in coefficients on D in the two equations, fell by \$.54. Although the price differential was very stable pre-1976, it did widen to unprecedented levels in the last quarter of 1974 and all of 1975 as very large amounts of cull cows flooded the market. During this period the price differential widened to over \$3.00/cwt, a level far outside its normal range of between \$1.00 and \$2.00/cwt (1967 base). The mean ratio of choice to Good (not lean) beef slaughter after 1976 was greater than that pre-1976 (2.87 vs 2.62) but not significantly so at the 5% level.

The variable R represents those years in which it is commonly accepted that a recession occurred. As expected for given quantities of available supply, choice beef experienced the sharpest decline in price during the recession years and broilers the least.

#### Price Reaction Analysis

To derive the price effects of changes in the beef product mix it is convenient to express total quarterly supplies available for consumption(k) as the sum of choice beef supplies and lean beef supplies, or in changes,

$$(1) \Delta K = \Delta Q_c + \Delta Q_s$$

In deriving price effects it is assumed that  $\Delta k = 0$ , i.e., that additions to lean beef supplies (available for consumption) are exactly offset by changes in choice beef supplies. This need not be so in the short run. For instance, in any one quarter  $Q_s$  can be increased or decreased without any change in  $Q_c$  if more or less cows are culled, or if imports change, or if additions to storage are changed. However, it is unlikely that changes in  $Q_c$  will not affect  $Q_s$ . Changes in  $Q_c$  come about by adjustments in ration composition, or by adjustment in feeder animal characteristics.  $Q_c$  can also change if fewer animals are placed on feed, and fewer animals on feed mean more animals grading Good or below (lean).

Suppose that  $Q_c$  is decreased by 2 lbs/person/quarter and  $Q_s$  is increased by 2 lbs/person/quarter<sup>5</sup>. This change represents 4.4% of mean 1962-1982 quarterly beef supplies, or approximately 1/2 million head of slaughter animals for the 1984 U.S. population. One-half million head of cattle are approximately 6-10% of quarterly placements on feed. In response to such a change in the beef product mix,  $P_c$  increases by \$.77/cwt,  $P_s$  increases by \$.40, widening the price differential by \$.37/cwt.

It may be surprising that lean price increases in response to an increase in available lean supply. In so far as choice

animals are the dominating force in the market, however, the result is plausible.

The historical price differential between choice and lean beef for the years 1962-1982 was very stable and exhibited no trend. Its mean was \$1.58/cwt. with a standard deviation of \$.58. If one excludes the year 1975, when lean supplies rose by more than 6.5 lbs per person per quarter over the average for 1973-1974, and was 3 lbs/person/quarter above the average for 1976-1978, the price differential averages \$1.51/cwt with a standard deviation of \$.39/cwt.

Under our supposition of a 2 lb/person/quarter change in the beef product mix, then, it can be seen that small changes in mix proportions will lead to large (by historical standards) changes in the price differential between choice and lean beef. Such a large positive change in the price differential will provide incentive to feedlot producers to either 1) outbid forage finishers for feeder animals and/or 2) increase the proportion of choice beef produced in the following quarter. Efforts to increase the proportion of lean beef will quickly meet with consumer resistance. The price difference under which more lean beef production would be profitable is not one consumers as modelled here would support.

### Conclusions

In view of the historical levels of the price differential between choice and lean beef, and past consumer behavior, the possibilities for more lean beef entering the market can take place, but only with wider price differentials between the various grades of beef.

In the event of an increased ratio of feedgrain price to roughage price, possibly large initial producer incentives to reallocate resources toward the production of more lean cattle will diminish as increasing choice to lean price ratios act to restore a clearing of the market. Thus the results of this model reinforce the conclusions based solely on costs of production [Brokken] i.e., the incentive to use more roughages as compared to feedgrains in the production of beef are not as they might appear based solely on feed costs.

<sup>1</sup> Additions to stocks for both beef and hogs are defined as a percentage of total production in a quarter. For the period 1962 through 1982, the minimum and maximum values for BFSTKS were -.028 and .026, and for HGSTKS were -.039 and .036.

<sup>2</sup> "Forage" is a term applied to anything from bales of hay or straw to silage to grazed matter, which ranges anywhere from 30% to 70% in TDN and 0 to 25% in crude protein. It is often unpriced in many of its forms and often when it is priced, such a price is based on its TDN and protein content, shadow prices for which are derived from market prices of corn and soybean meal. Rarely is forage as inexpensive as it first appears. A major component of cost when using forage in a fattening ration is the high variability of animal performance relative to that when grain is the main energy source.

<sup>3</sup> Contact author for data.

<sup>4</sup> This is true, in spite of research like that of Chavas, Nyankori and Miller, and Pope, Green and Eales, that state "something" happened in this period.

<sup>5</sup> The source of such changes may be left unspecified, but could arise from increases in corn prices, or from other incentives to produce less grain finished beef.



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