GROUND BEEF: IMPLICATIONS FOR THE SOUTHEASTERN U.S. BEEF INDUSTRY

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Currently the United States consumes an estimated 39 to 45 percent of its beef in the "ground"[1] form [3, 7, 8]. As recently as 1972 the estimated percentage of beef consumed as ground was only 33 [3] and some industry leaders have estimated the proportion by 1985 to be from 50 to 65 percent [5, 8, 11, 12]. This increasing trend in the percentage of beef consumed in the ground form is often attributed to several factors including (1) an increase in the percentage of wives working away from home which results in more "eating out" and less home preparation of "traditional" meat dishes for those meals consumed at home, and (2) the continuing growth of the fast-food restaurants and their popular "hamburger" meals [5, 8, 11, 12].

The demand for ground beef is currently supplied from the following sources: 13 percent from imported deboned beef, 35 percent from the block beef trade (trimmings, ground chuck, "over-aged" block beef, etc.), 11 percent from nonfed steer and heifer slaughter, and 41 percent from boneless manufacturing beef (principally cows and bulls) [5]. During the next few years, however, a 25 to 30 percent reduction is expected in the slaughter of nonfed steers and heifers and of cows and bulls because of the rebuilding phase of the cattle cycle and the accompanying increases in the prices of feeder and breeding classes of cattle [5]. These factors could result in an approximate 15 percent reduction in the total current supply of beef for the "ground beef" trade. The prospects of this reduction in the current supply raises the question of how the current quantity demanded and the expected increases in demand for ground beef can be met.

Several agricultural scientists and industry experts have proposed two basic alternatives for meeting the demand for ground beef. One is to take more beef from the block beef trade (presumably from the relatively less expensive chuck and/or round primals, leaving the loin and rib primals for the block beef trade) [8, 11]. The second proposed alternative is to develop feeding (growing-out) programs that will produce lean beef cattle for slaughter from which the entire[2] deboned carcass could be used for producing ground beef [3, 5, 8].

Though both of the proposed alternative sources of ground beef supply are plausible, the second alternative is of particular significance to the beef industry in the Southeastern United States. If significant markets for steers and heifers suitable only for producing deboned beef for use in the ground beef trade could be developed, the Southeastern United States could conceivably compete favorably with other regions in both the production and slaughter of such animals. The Southeast's presumed advantages would be its long growing season and climate favorable for quality forage production, its relatively large supply of weaned calves, and its current slaughter capacity. The basis of the presumed advantage in production is the belief, held by many beef producers, that high quality forages alone can provide sufficient energy and protein for growing beef cattle, whereas forages alone do not consistently provide sufficient levels of energy for producing "finished" beef cattle. Thus, if slaughter prices of "grown-out" steers and heifers were high enough to offer producers a larger profit than they could obtain from selling their calves and yearlings to traditional "finishing" feedlots, Southeastern beef producers would have an attractive alternative beef production enterprise.

Because of the probably significant impact of this proposed alternative beef production enterprise on the Southeastern beef industry and economy, the feasibility of the development of a market for "hamburger steers" should be carefully evaluated.

In pursuing this evaluation, the authors ignore the question of whether the observed trend over the past few years toward larger percentages of beef being consumed as ground represents a shift in consumers' tastes and

[1]The term "ground beef" in this article includes beef used in hamburger, ground chuck, etc., and beef used in sausage and "processed" meats and "reformed" beef products.

[2]The authors recognize that in using nonfed or "grown-out" beef carcasses the beef packing industry would probably not take the entire carcass for ground beef. Instead, the tender, ribeye, loin strip and top round would probably be diverted to the block beef trade.

preferences or a reaction to lower ground beef prices (in relation to other beef and meat prices). It should be noted, however, that there is some evidence to support the contention that the trend is due, at least in part, to the relatively low prices of ground beef during the last three to four years [see 9]. Also ignored is the obvious alternative of increasing the levels of imported beef to offset, at least partially, the expected decrease in availability of domestic nonfed beef. Though the quantity of beef imported by the U.S. will likely increase, the increases are not expected to be sufficient to replace a significant portion of the decreased supply of domestic nonfed beef [3].

The authors first describe the interdependence in the demand and supply of the various beef submarkets. Then, through an adaptation of a linear programming model to these markets, an estimate is made of the price relationships that must exist in the various beef submarkets for each of the proposed alternatives to become economically feasible. This analysis also provides an indication of the probability of these price relationships developing during the next three to five years.

THE BEEF MARKET

The term "market" is used here in the theoretical sense to mean the equilibrium price and corresponding quantity exchanged—implying the existence of known supply and demand functions. Submarkets, in the same sense, are subsets of markets, i.e., the sum of the quantities exchanged in all of the submarkets equals the quantity exchanged in the market, and the sum of the products of the quantities exchanged and the respective equilibrium price in each submarket divided by the sum of the quantities exchanged in all submarkets yields the equilibrium market price.

On the basis of this theoretical construct, one can represent the structure of the beef market and submarkets with the following functional relationships.

(1) $QDB = QSB$

(2) $QDB = QD_{gb} + QD_{bln} + QD_{brb} + QD_{brn} + QD_{bck} + QD_{ob}$

(3) $QSB = QS_{gb} + QS_{bln} + QS_{brb} + QS_{brn} + QS_{bck} + QS_{ob}$

where

QDB = the quantity demanded for all beef during a specific time period,
QSB = the quantity of all beef supplied during a given time period,
QD, QS = the quantities demanded and supplied, respectively, in each beef submarket, and
subscripts gb, bln, brb, brn, bck, and ob = ground beef, beef loins, beef ribs, beef rounds, beef chucks, and other beef (oxtails, briskets, edible offal, etc.), respectively.

The structure of the demand functions for each beef submarket can be represented in somewhat simplified form as:

(4) $QD_{gb} = f(P_{gb}, P_{prk}, P_{plt}, P_{bln}, P_{brb}, P_{brn}, P_{bcl}, P_{ob}, I, TP)$

(5) $QD_{bln} = f(P_{bln}, P_{prk}, P_{plt}, P_{gb}, P_{brb}, P_{brn}, P_{bck}, P_{ob}, I, TP)$

and

$QD_{brb}, QD_{brn}, QD_{bck}, QD_{ob}, =$ f(similar to equations 4 and 5)

where

P = price of the various meat products, subscripts prk and plt = pork and poultry, respectively,
I = consumer income, and indirectly the relative prices of all other goods and services,
TP = consumer tastes and preferences, and all other variables and subscripts are as defined above.

Further, the structure of the supply functions for each submarket can be represented in simplified form as:

(6) $QS_{gb} = f(P_{gb}, P_{bln}, P_{brb}, P_{brn}, P_{bck}, P_{ob}, P_{ib}, P_{mfb}, P_{bt}, OPC_{gb})$

(7) $QS_{bln} = f(P_{bln}, P_{gb}, P_{brb}, P_{brn}, P_{bck}, P_{ob}, P_{fbc}, OPC_{bln})$

$QS_{brd}, QS_{brn}, QS_{bck}, QS_{ob} =$ f(similar to equations 6 and 7)

where

OPC = other production costs,
subscripts ib, mfb, bt, and fbc = imported deboned beef, domestic manufacturing deboned beef, beef trim, and fed beef carcasses, respectively, and
all other variables and subscripts are as defined above.

Though the structure of the functional relationships for the demand and supply of the various beef products illustrated in equations 1 through 7 may be regarded as somewhat hypothetical,[3] they are very similar to those em-

[3]Equations 1 through 7 represent the beef market and submarkets only in the "pure free market" sense. In actuality no market is completely "free." Of particular significance in the beef market and submarkets are the institutional restrictions on the quantity of beef imports and the natural (technical production) restrictions on the timeliness of producer responses to price changes and the resulting inability to change quickly the quantities supplied to the various beef submarkets.

pirically estimated in other studies [2, 6, 10]. The equations do serve the intended purpose of illustrating the point that there is, theoretically and practically, a high degree of interdependence among the various beef products in the determination of both their supply and demand.

The foregoing model clearly implies that if all other factors remain constant, increases in the equilibrium quantity exchanged of ground beef $[(QD_{gbl} = QS_{gbl}) < (QD_{gb2} = QS_{gb2})]$ necessitate compensating decreases in the equilibrium quantity exchanged of other beef products. Alternatively, increases in the quantity exchanged of ground beef can be provided through increases in the quantities of imported deboned beef and/or domestic manufacturing deboned beef and/or beef trim used in the production of ground beef. Conversely, if the equilibrium quantity exchanged of ground beef is to remain constant given a decrease in the sum of the quantities of imported beef, domestic manufacturing beef and beef trim used in the production of ground beef, beef from the other beef product categories must be used to make up the difference.

The substitutability of sources of ground beef is further complicated by the requirement that ground beef consist of approximately 25 percent fat and 75 percent lean.[4] Thus, the production of ground beef requires that the weighted average of all beef used in its production be approximately 25 percent fat and 75 percent lean.

LINEAR PROGRAMMING BEEF MODEL

To address the question of what will happen when cow, bull, and other nonfed beef slaughter declines by 25 to 30 percent, the authors first examine the proposed alternative of diverting more beef from the block beef trade. To evaluate this proposal one can represent, in a simplified form, the beef market for a given time period by a linear programming model as shown in Figure 1. The model in Figure 1 is assumed to represent the beef market at the processor-wholesaler level. The model allows beef to be sold in six product categories: ground beef, which must be 25 percent fat and 75 percent lean; beef loin, rib, round, and chuck primals, which must be obtained from fed beef carcasses; and beef trim, which can be sold for a minimal salvage price if not used to produce ground beef. Possible sources of meat for ground beef include the loin, rib, round, and chuck primals, beef trim from the fed beef carcasses, imported deboned beef, and domestic manufacturing (deboned) beef.

In representing the current processor-wholesaler beef market, the authors assumed, because of the current consumption levels, that ground beef sales would represent no more than 45 percent of the total beef sales (limited in this model to 1000 lbs. of deboned equivalent beef). Domestic manufacturing and other nonfed beef currently accounts for 52 percent of the total source of ground beef and imported beef accounts for 13 percent. Thus, domestic manufacturing beef was initially limited to 234 lbs. (.52 x .45 x 1,000) and imported beef was limited to 59 lbs. (.13 x .45 x 1,000).

All prices in the objective function represent

FIGURE 1. LINEAR PROGRAMMING MODEL OF CURRENT UNITED STATES PROCESSOR-WHOLESALER LEVEL BEEF MARKET.

		Activities															
Row Number	Row Name	Imported Beef	Domestic MF. Beef	Fed Beef Carcass	Sell Ground Beef	Sell Beef Loins	Sell Beef Ribs	Sell Beef Rounds	Sell Beef Chucks	Sell Beef Trim	Loin to Grn. Beef	Rib to Grn. Beef	Round to Grn. Beef	Chuck to Grn. Beef	Trim to Grn. Beef	Constraint	Units
1	Maximize obj.	-1.052	- .998	- .768	+ .866	+1.310	+1.050	+ .932	+ .750	+ .260	- .064	- .066	- .058	- .060	0.0		$
2	Sell Limit				+1.0	+ .88	+ .84	+ .85	+ .84	+1.0						≤	1,000 lbs.
3	Grn. beef fat lmt.	+ .10	+ .15		- .25						+ .17	+ .15	+ .12	+ .21	+ .55	≤	0
4	Grn. beef product	+1.0	+1.0		-1.0						+ .88	+ .84	+ .85	+ .84	+1.0	≥	0 lbs.
5	Loin product lmt.			+ .172		-1.0					-1.0					≥	0 lbs.
6	Rib product lmt.			+ .096			-1.0					-1.0				≥	0 lbs.
7	Round product lmt.			+ .224				-1.0					-1.0			≥	0 lbs.
8	Chuck product lmt.			+ .268					-1.0					-1.0		≥	0 lbs.
9	Beef trim product			+ .125						-1.0					-1.0	≥	0 lbs.
10	Imported beef lmt.	+1.0														≤	59 lbs.
11	Dom. MF. beef lmt.		+1.0													≤	234 lbs.
Optimal Solution Activity Levels (lbs.)																	
12	Grn. beef price @ $.866 (MFB ≤ 234 lbs.)	59	234	915.2	400.5	157.4	87.9	205.0	245.3	6.9					107.5		
13	(MFB ≤ 164 lbs.)	59	164	1,005.8	307.2	173.0	96.6	225.3	269.6	41.6					84.2		
14	Grn. beef price @ $.926 (MFB ≥ 164 lbs.)	59	164	1,005.8	463.3	173.0	96.6	90.5	269.6	0			134.8		125.7		
15	Grn. beef price @ $.966 (MFB ≤ 164 lbs.)	59	164	1,005.8	689.7	173.0	96.6	90.5	0	0			134.8	269.6	125.7		

[4]The authors recognize that products included in the category "ground beef" vary significantly in the percentage of fat and lean beef used in their production. A 25 percent fat content, however, is an approximate mean and mode of these products.

a 10 consecutive day average (September 11-22, 1978)[5] as reported in the "yellow sheet" [4], with the exception of beef trim which is represented by an estimated salvage price of $0.26 per pound. The costs of diverting the primal cuts—loin, rib, round, and chuck—to ground beef are the estimated deboning costs[6] per pound of bone-in primal. The coefficients representing fat and bone content and the percentage of carcass going to each primal are based on an assumed yield grade 2-3 carcass weighing approximately 600 lbs.

The linear programming formulation of the current beef market shown in Figure 1, though an extreme simplification of the actual market and submarkets, is a realistic representation of the aggregate decisions to be made by the industry. This contention is supported by the optimal solution of the model for which the activity levels are shown in Figure 1, row 12. The optimal solution calls for 40 percent of the beef sold to be ground beef, made up of 58 percent domestic manufacturing beef, 15 percent imported beef, and 27 percent beef trim. These figures differ slightly from the previously mentioned estimates of (1) the percentage that ground beef contributes to total beef sales and (2) the composition of sources of ground beef. The differences, at least in part, are due to the total exclusion of block beef in the composition of ground beef in the model solution. In actual beef market situations, some block beef normally is diverted to ground beef at the retail level (i.e., chuck marketed as "ground beef" and some "over-aged" beef from all primals which is salvaged as ground beef). Though these are legitimate sources of ground beef, they are provided by the retailer and thus are outside the processor-wholesaler market represented by the model.

Beef Diverted from Block Beef Trade

To examine the impact of reducing cow, bull, and other nonfed beef slaughter by 30 percent from current levels, the model was first adjusted by decreasing the availability of domestic manufacturing beef by 30 percent (to 164 lbs.) with all other coefficients remaining constant. The solution to the adjusted model (Figure 1, row 13) calls for ground beef to be reduced to 31 percent of total beef sales (down from 40 percent) with corresponding increases in the sales of other beef products from fed beef carcasses. In an actual market situation one would expect a reduction of this magnitude in the sales of ground beef to be accompanied by an increase in its price. Likewise, the increases in the volume of sales of the other beef products would, *ceteris paribus,* be accompanied by decreases in their market prices.

To further examine the relationship between the prices of ground beef and other beef products in the restricted model, the price of ground beef was increased in increments of $.01 per pound until the optimal solution activity levels changed. The new solution (Figure 1, row 14) is at a ground beef price of $.926 per pound (up from the original $.866 per pound) with the availability of domestic manufacturing beef again restricted to 164 lbs. In this solution, ground beef makes up 46 percent of the volume of total beef sales and is produced from 13 percent imported beef, 35 percent domestic manufacturing beef, 27 percent beef trim from fed beef carcass, and 25 percent from beef rounds converted to ground beef.

Another change in the optimal solution activity levels can be induced by increasing the price of ground beef to $.966 per pound (from $.926). At this price of ground beef, with all other prices remaining constant, the optimal solution (Figure 1, row 15) calls for 69 percent of the volume of beef sold to be ground beef, being composed of 8 percent imported beef, 24 percent domestic manufacturing beef, 18 percent beef trim, 33 percent chuck converted to ground beef, and 17 percent round converted to ground beef.

Reliable estimates of the price elasticities of ground beef and the other beef products at the wholesale level are not available, but price elasticity estimates of ground beef and fed beef products at the retail level have been reported by Freebairn and Rausser and others [6, 10]. Assuming that the estimated retail level price elasticities of −.43 for ground beef and −.83 [from 6] for fed beef products are representative of the elasticities of these products in the current processor-wholesaler markets,[7] one can further assume that each 1 percent reduction of the quantity of ground beef exchanged will be accompanied by a 2.3 percent[8] increase in its price. Thus, a reduction in the volume of

[5]This two-week period was selected when this article was written in September and October 1978. The period was chosen as being representative of the relative prices of the various beef products during the portion of the year 1978 that had then elapsed. Since then the model has been run with prices from other periods, including average annual prices for 1978. The results indicate no changes in the conclusions reported.

[6]The percentage of bone in the primal cuts is assumed to be 16 percent for chuck, 15 percent for round, 16 percent for rib, and 12 percent for loin. Deboning costs are based on the assumption that labor costs $7.50 per hour and overhead costs $5.00/cwt. of bone-in product and the boning rates per man hour of 9 chucks, 14 rounds, 16 ribs, or 10 loins.

[7]Theoretically, one would expect wholesale prices to be somewhat more inelastic than retail prices. Certainly, the retail elasticities should serve as upper bounds on those of the corresponding wholesale markets.

[8]In this case, because substitutes exist and the market is at the wholesale instead of the retail level, this figure must be regarded only as a lower limit on the absolute value of the price flexibility at the wholesale level.

ground beef sales as indicated by the first adjusted solution (Figure 1, row 13) would necessitate an increase in the price of ground beef in relation to the prices of the other beef products. In the second adjusted solution (Figure 1, row 14) the 7 percent increase in the price of ground beef could conceivably result from only a 3 percent decrease in the quantity of ground beef offered for sale (.07 x −.43 = −.03). In the third adjusted solution (Figure 1, row 15), the 11.5 percent price increase for ground beef (from $.866 to $.966) could be induced by a 5 percent decrease in the quantity exchanged of ground beef (.115 x −.43 = −.05).

The adjustments in relative prices and percentages of total volume of beef sales for each beef product as depicted by the linear programming model cannot be expected to simulate actual beef market adjustments to reductions in cow, bull, and other nonfed cattle slaughter. As can be seen by referring to the beef market-submarket structural models in equations 1 through 7, changes in the price of one of the beef products, including the intermediate product domestic manufacturing beef, can result in shifts in both the demand and supply of ground beef and the fed beef products. Thus the LP model results are much simplified approximations of a very complex market situation. The results do, however, accurately illustrate one important point—that is, a ground beef price increase of only 7 percent in relation to the prices of some of the fed beef products (rounds in this model solution) would be sufficient to induce these fed beef primals to be diverted to the ground beef trade. Thus, if the assumed relative price elasticities are reasonably accurate representations of the wholesale markets, a relatively small decrease in the production of ground beef will induce sufficient price increases in ground beef relative to the prices of the fed beef products to cause beef from the block beef trade to be diverted to ground beef.

Although in actual market situations relative prices and volumes are in a continuous process of adjusting toward an equilibrium, it nonetheless seems plausible that if cow, bull, and other nonfed beef are significantly restricted in their availability during the next few years, and imported beef is restricted to current or near current levels, more fed beef primals, principally rounds and chucks, will be diverted to the ground beef trade.

Diverting Cattle to "Grow-Out" Programs

The second alternative is to divert cattle that normally would be finished to a grade of good or choice in a conventional feedlot to a feeding program to produce beef suitable only for the production of ground beef. In the simplified model of the processor-wholesaler beef market the activity of purchasing domestic manufacturing deboned beef, which is 15 percent fat and 85 percent lean, is restricted first to represent the estimated current availability of the product and second to represent its estimated availability after a 30 percent reduction from current levels in the slaughter of cows, bulls, and other nonfed cattle. One indication of the feasibility of diverting cattle from traditional finishing programs to "grow-out" programs can be obtained by determining the maximum price the beef industry could "afford to pay" for additional domestic manufacturing beef to produce more ground beef given the alternative or diverting beef from the block beef trade to produce more ground beef. In the linear programming model, this maximum price is indicated by the shadow price of the limit on domestic manufacturing beef as indicated in the solution where domestic manufacturing beef is restricted to 164 lbs. and ground beef is priced at $.926 per pound (Figure 1, row 14). This approach also necessitates the assumption that domestic manufacturing beef adequately represents the end product of beef produced in a "grow-out" program. The shadow price of domestic manufacturing beef corresponding to the solution activity levels shown in Figure 1, row 14, is $.146 (not shown in Figure 1) which indicates that with the model price of domestic manufacturing beef of $.998, the beef industry could afford to pay no more than $1.144 per pound for additional domestic manufacturing beef. Alternatively it indicates that if additional domestic manufacturing beef could be purchased at a price of $1.14 or less, it would be profitable to do so and to substitute it for the round primals that the solution indicated would be used in the production of ground beef.

This derived relative maximum price that the industry could afford to pay for additional domestic manufacturing beef enables one to determine a maximum carcass and liveweight price for animals that could be used to produce the domestic manufacturing beef. If it is assumed that carcasses from "grown-out" beef cattle will yield 76 percent of their carcass weight as deboned meat, and that deboning costs $.07 per pound of carcass, a carcass price of $.799 per pound [(1.144 x .76) − .07] can be derived. This price compares to a carcass price of $.768 per pound for the fed beef carcasses used in model solution (average price of high-good quality grade carcasses). Conversion to liveweight equivalents shows the derived relative maximum price of the "grown-out" beef animal to be $.44 per pound (assuming a yield of 55 percent). The comparable derived liveweight price of the fed beef used in the model is

$.48 per pound (assuming a yield of 62 percent).

Though this analysis represents an oversimplification of the nature of the price relationship, it does indicate that, at best, producers of "grown-out" cattle could expect to receive only about 92 percent of the price of "high-good" slaughter cattle. Further, if it is assumed that the price of good grade cattle is at 92 percent of the price of choice grade cattle, then the "grown-out" cattle could be expected to bring no more than 85 percent of the price of choice cattle.

To follow through with the implication of these relative prices for beef cattle producers, assume that a 750-lb. feeder animal could be purchased for $.52 per pound. In a traditional feeding program this animal would be expected to gain at least 2.5 lbs. per day and could be expected to reach a slaughter weight of 1,050 lbs. in 120 days and grade high-good to low choice. If interest costs of 10 percent per annum and a selling price of $.48 per pound (high-good quality grade) are assumed, the animal would net $101.00 to pay all feeding, marketing, and death loss costs. The same animal, if put in a "grow-out" program, could be expected to gain only about 1.75 lbs. per day and would reach a slaughter weight of 1,050 lbs. in 171 days at which time it would be sold for $.44 per pound (92 percent of $.48). The animal in the "grow-out" program would net only $53.00 to pay all feeding, marketing, and death loss costs (again assuming interest costs of 10 percent per annum on the purchased animal). If it is further assumed that marketing and death loss costs are the same for both programs, feeding and other costs (such as transportation) in the "grow-out" program in this example would have to be less than half of the feeding costs in the traditional program to make the "grow-out" program an attractive alternative enterprise to producers.

In the case of Southeastern United States producers, one might assume that a ryegrass-wintergrazing operation could be used to produce the "grown-out" cattle. Recent studies, however, show that the cost of the pasture alone for such programs would be between $70 and $90 per head [1].

Despite the oversimplified and approximate nature of this analysis, it shows that the development of "grow-out" programs to furnish a source of relatively lean beef for the ground beef trade is not generally plausible. This is not to say that such programs could not be profitable under certain circumstances. For example, certain types of feeder cattle which might generally be poorly suited to producing good and/or choice grade carcasses in a traditional feeding program might be well suited to a "grow-out" program. These cases, in the opinion of the authors, would be exceptional and certainly not common enough to offer a significant number of beef producers in the Southeastern United States an attractive alternative beef production enterprise.

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