Interregional Flow of Slaughter Cattle and of Carcass, Primal, and Retail Beef in the Forty-Eight States

EMER E. BROADBENT AND JAMES D. SULLIVAN

BULLETIN 740

Agricultural Experiment Station
College of Agriculture
University of Illinois at Urbana-Champaign

CONTENTS

AUTHORS

This bulletin was prepared by E. E. Broadbent, professor of livestock marketing, Department of Agricultural Economics, University of Illinois at Urbana-Champaign and J. D. Sullivan, a former graduate student in that department. Dr. Broadbent is currently on an assignment in Africa sponsored by the United Nations Economic Commission for Africa, studying the livestock industry in the northern part of the continent. His headquarters are in Addis Ababa, Ethiopia. Dr. Sullivan is now agricultural economist, livestock group, Marketing Economics Division, Economic Research Service, U.S. Department of Agriculture, Washington, D.C.

URBANA, ILLINOIS JUNE, 1972

PUBLICATIONS IN THE BULLETIN SERIES REPORT THE RESULTS OF INVESTIGATIONS MADE OR SPONSORED BY THE EXPERIMENT STATION.

Interregional Flow of Slaughter Cattle and of Carcass, Primal, and Retail Beef in the Forty-Eight States

EMER E. BROADBENT AND JAMES D. SULLIVAN

THIS STUDY concerns the spatial marketing characteristics of carcasses, primal cuts, and retail cuts of beef in the forty-eight contiguous states. It incorporates cattle slaughtering, centralized processing of primal and retail cuts, and product distribution into an optimum spatial pattern for the U.S. beef industry. This study differs from previous spatial analyses in that it considers together rather than independently four major modes of transportation—truck, iced railroad car, mechanically refrigerated railroad car, and piggyback (truck on freight car); also, the flow of three forms of fresh beef—carcasses, primal cuts, and retail cuts—in addition to that of slaughter cattle. The other primary feature of this study is the construction of a mathematical model to synthesize the total regional cost functions for cattle slaughtering, processing, and the distribution of primal and retail cuts of beef.

OBJECTIVES

The objectives of this study were to estimate the:

1. Deficit or surplus tonnage of beef available in alternate supply and distribution areas of the forty-eight states.
2. Comparative cost advantage for transporting loads of carcasses, primal cuts, and retail cuts between the various supply and consumption areas.
3. Cost economies that might be achieved by using alternate forms of transportation, in order to facilitate the marketing of the principal forms of beef.
4. Most economical form of distribution from surplus to deficit market areas—carcasses, primal cuts, or retail cuts.

PARAMETERS

1. Regional supplies and demands within the forty-eight states for the year 1967 were taken as given.

2. The total demand on a retail-weight basis was equated with the total supply of slaughter cattle by using dressing percentages, primal yields, and retail yield coefficients.

3. Each region was assumed to be a distinct market for the three beef products—carcasses, primal cuts, and retail cuts.

4. All possible combinations of these markets were separated by a transportation cost per unit. The problem was to minimize the total costs of slaughtering, processing, and transportation under the equilbrium restraint that total supply and demand were equal.

An interregional-activity-analysis model was used within the context that the location of economic activity in the beef industry depends on the demand for the final product, the supply of cattle, and the transfer cost among regions. This is designated as Model I.

In Model I-A, the constraints imposed by the assumptions of regional slaughter in the outshipments of cattle and inshipments of retail beef contained in Model I were removed.

A time dimension was introduced in Model II, to estimate the optimum flow that would be likely by 1975. Specific definitions and restrictive assumptions were formulated in order to provide a practical application of the theoretical model.

DEFINITIONS

The products that appear in the model were defined as:

1. *Primary Product.* Slaughter cattle, assumed to be homogeneous in terms of type, grade, and quality.

2. *Primary Intermediate Product.* Beef carcasses, emerging from the slaughtering-plant production process as an output and entering the primal processing activities as an input.

3. *Secondary Intermediate Product.* Primal cuts (chuck, round, loin, and ribs), emerging from the first processing activity as an output and entering the final one as an input.

4. *Final Product.* Retail cuts of beef, desirable and consumable in their current state. No consideration was given to quality, different cuts, or packaging.

Regional supply and demand demarcation. Regions: *1* Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont; *2* New York; *3* Delaware, New Jersey, District of Columbia, Maryland, Pennsylvania; *4* North Carolina, West Virginia, Virginia; *5* Georgia, South Carolina; *6* Florida; *7* Ohio; *8* Kentucky, Tennessee; *9* Mississippi, Alabama; *10* Michigan; *11* Indiana; *12* Illinois; *13* Wisconsin; *14* Minnesota; *15* Iowa; *16* Missouri; *17* Arkansas, Louisiana; *18* North Dakota, South Dakota; *19* Nebraska; *20* Kansas; *21* Oklahoma, Texas; *22* Montana, Wyoming; *23* Colorado; *24* Arizona, New Mexico; *25* Idaho, Nevada, Utah; *26* Washington, Oregon; *27* California. (Figure 1)

ASSUMPTIONS

The following paragraphs draw heavily on the formulation of assumptions as given by Takayama and Judge, pages 349 to 365.* The necessary assumptions as they apply to the U.S. beef-packing industry were:

1. A known, non-negative quantity of slaughter cattle was given for each region.

2. The production activities in each region were assumed to be technologically uniform among regions. The rate at which slaughter cattle were transformed into carcasses was constant for all regions and levels of production. The conversion rates of carcasses into primal and retail cuts were constant between regions and over all levels of processing.

* The references are to items in the bibliography.

3. The final product, in terms of the retail-weight equivalent, was consumed in non-negative quantities in each of the regions. The regional demands were predetermined.

4. Each region had some non-negative capacity for slaughtering cattle, and these capacities were known.

5. In each region a base trading point was selected at which the supply of slaughter cattle, the demand for intermediate and final products, and the slaughtering and processing capacities were assumed to be concentrated.

6. Slaughtering and processing costs per unit of product were known in the time period, t, for each region, and they differed among regions.

7. All possible trading regions were separated by a transportation cost per unit for slaughter cattle and carcasses, as well as for primal and retail cuts of beef. The unit transportation costs were independent of the volume of product flow, and were known for the time period, t.

8. No distinction was made between the regions concerning the methods of slaughtering cattle, the processing of carcasses and of primal and retail cuts, or the consumption of the final product. Thus, slaughtering and processing firms and consumers were considered to be indifferent about the source of supply.

9. No restrictions were imposed on the mode of transportation. Physical facilities to accommodate the four modes of transportation were assumed to exist at the points of origin as well as the destinations of all shipments.

10. Finally, all products were assumed to be traded in competitive markets.

MATHEMATICAL NOTATION

i, j	the regions; i, j = 1, 2, 3, . . .27.
k	the type of beef
	k = 1, carcasses
	k = 2, primal cuts
	k = 3, retail cuts
m	the mode of transportation
	m = 1, truck
	m = 2, iced railroad cars
	m = 3, mechanically refrigerated railroad cars
	m = 4, piggyback, truck on freight car (TOFC).

T^k_{ijm} the unit transport cost for shipment of the kth type of beef between regions i to j by the mth mode of transportation.

X^k_{ijm} the quantity of the kth type of beef shipped between regions i to j by the mth mode of transporation.

c^k_i the unit cost of slaughtering or processing of the kth type of beef in region i.

S^k_i the level of slaughtering or processing of the kth type of beef.

a^k_i the dressing percentage of the live animal, or the yield of beef carcasses into primal cuts, or the yield of primals into retail cuts.

t_{ij} the unit transport cost of the live animal.

l_i the quantity of slaughter cattle produced in region i (the quantity available before inshipments and outshipments) i = l, 2, 3, . . .27.

Z_{ij} the live-animal shipments from regions i to j.

r^k_i the slaughtering capacity or processing capacity in region i.

D^k_i the demand for the kth type of beef in region i.

g^q_i the net availability in region i: q = 1, 2, 3, 4.

MODEL I: THE FORMAL MODEL

Given the assumptions and using the foregoing notation, the problem stated mathematically is:

To maximize

$$F = \sum_{i=1}^{27}\sum_{j=1}^{27}\sum_{k=1}^{3}\sum_{n=1}^{4} T^k_{ijm} X_{ijm} - \sum_{i=1}^{27}\sum_{k=1}^{3} c^k_i S^k_i - \sum_{i=1}^{27}\sum_{j=1}^{27}\sum_{m=1}^{2} t_{ijm} Z_{ijm} \quad (1)$$

subject to

$$g^l_i = \sum_k a^k_i S^k_i - \sum_j \sum_m \sum_k x^k_{ijm} \geq 0 \quad (2)$$

The quantity of the kth beef shipment from ith region must be less than or equal to the kth beef equivalent of the number of cattle slaughtered (j = 1, 2, 3, . . .27; k = 1, 2, 3; m = 1, 2, 3, 4).

$$g_i^2 = \left[l_i - \sum_j (Z_{ijm} - Z_{jim}) \right] - \sum_k S_i^k \geqslant 0 \qquad (3)$$

The level of slaughtering or processing in the ith region must be less than or equal to the number of cattle available for slaughter in the region, plus or minus adjustments for live-animal shipments. (j = 1, 2, 3, . . .27; m = 1, 2; k = 1, 2, 3).

$$g_i^3 = r_i^k - S_i^k \geqslant 0 \qquad (4)$$

The level of slaughtering or processing in the ith region must be less than or equal to the regional slaughtering or processing capacity.

$$g_i^4 = \sum_j \sum_m X_{ijm}^k - D_i^k = 0 \qquad (5)$$

The quantity of the kth type of beef shipped to a region must equal the demand for the kth type of beef in region i (j = 1, 2, 3, . . .27; m = l, 2, 3, 4).

$$X_{ijm}^k,\ S_i^k,\ Z_{ijm}^k \geqslant 0 \qquad (6)$$

All selected variables must be non-negative.

The tableau given in Table 1 shows the programming characteristics of the model specified by Equations 1 through 6.

Input Specifications

The model required the following data input specifications:

1. Regional demarcation.
2. Regional availability of slaughter cattle.
3. Processing capacities and processing costs required to transform cattle into carcasses, primal cuts, and retail cuts.
4. Regional demand for beef at the retail level.
5. Transfer costs for slaughter cattle, carcass beef, primal cuts, and retail cuts of beef.

The forty-eight states were partitioned into twenty-seven regions (Table 2 and Figure 1). This regional demarcation closely followed that used in an earlier spatial analysis of the livestock-meat economy (Judge, Havlicek, and Rizek, 1964).

The regional supply of slaughter cattle was assumed to be concentrated at the regional trading center and predetermined. The regional cattle supply was equal to the total live weight of

commercial cattle available for slaughter in each region during the calendar year 1967. The regional availability of slaughter cattle was assumed to be equal to the live weight of inshipments and the weight added to inshipments, plus the live weight of a decrease in inventory numbers, plus the live-weight production occurring in the region during the calendar year. The supply, so defined, excluded the cattle and calves slaughtered on farms and the calves slaughtered commercially.

It was further assumed that slaughter cattle were homogeneous in terms of type and quality. Shrinkage that occurs in shipping live animals to the slaughter plant was recognized by assuming an average shrinkage loss of 2.5 percent for intraregional and interregional livestock shipments. The allowance for shrinkage was made by adjusting the slaughter coefficient. Thus, the dressing percentage for cattle and the transformation factors of carcasses into primal and retail cuts were equal for all regions.

Measures of capacity consisting of single-shift operations were predetermined and were concentrated at the regional trading points. Regional livestock slaughter was limited only by the slaughter capacities available in the region. Regional capacity per hour in terms of hundredweight units of live animal was converted to an annual figure, based on 7.2 hours per workday for 252 days per year. This method of computing regional slaughter capacity was adopted from the 1964 study by Judge, Havlicek, and Rizek. The procedure was to multiply the hourly rated capacity for each region by the total number of hours worked in the year for the federally inspected plants. The latest obtainable data for rated hourly capacity were for 1964, which was adjusted to represent the study period, 1967, by assuming that state or regional slaughter capacities changed in the same proportion as the percentage of change in the total commercial slaughter between 1964 and 1967. For nonfederally inspected plants, the same approach was used; however, data limitations required hourly rated slaughter capacities to be estimated from slaughter volumes. The estimated regional slaughter capacities are presented in Table 3. Data were not available with which to estimate processing capacities for primal and retail beef cuts.

Cost Components for Slaughtering

The total cost of slaughtering was estimated for 120 animals per hour at on-the-rail slaughtering plants. The annual cost components consisted of the following:

1. Labor.
2. Equipment depreciation.
3. Building depreciation.
4. Personal property tax.
5. Insurance.
6. Interest.
7. Utilities—gas, water, and electricity.
8. Miscellaneous supplies and services—repair and maintenance, office costs, taxes and licenses, telephone costs, and buying and delivery costs.

Department of Labor wage rates were used to represent a realistic evaluation of the regional costs influencing product flow. Among the regions, management salaries were assumed to vary in the same proportion as the wage rates of production workers.

Investment costs were defined as the annual capital costs for land, building improvements, and equipment. In addition, several other cost items such as insurance, taxes, and interest are affected by the size and nature of a firm's investment. Total construction costs as estimated by Logan and King for the Los Angeles area were adjusted to reflect 1967 costs and to show differences among regions (Logan and King, 1962, p. 67).

An index of construction costs as computed by the F.W. Dodge Corporation served as a basis for the adjustment. Regional building costs were determined by multiplying the costs as estimated by Logan and King by the 1967 construction cost indexes (Table 4). Data on required land area were also obtained from the Logan and King study. Land values obtained from Chamber of Commerce offices located in regional trading centers were multiplied by the land area requirements to obtain the total land cost (Table 5). Equipment specifications necessary to perform the slaughtering operation were obtained from published material supplied by the U.S. Department of Agriculture (especially Agricultural Research Service, Marketing Research Report No. 657). The value of equipment was assumed to be equal to its replacement cost, as derived from a list of prices supplied by the Albright-Neil Company, Chicago.

The annual depreciation of various equipmental items was calculated by dividing the balance for depreciation for each item by its estimated, useful life (Table 6). Personal property taxes applicable to land, buildings, improvements, and equipment were estimated. The assessed valuation for tax purposes was assumed to be a percentage of the actual market value of the property.

To estimate the tax costs, a tax rate assumed to equal half the regular rate was applied to the assessed value of depreciable property. The full tax rate was applied to the estimated land-investment costs. Regional tax rates were obtained for each regional trading point from Chamber of Commerce offices. Estimated, 1967 miscellaneous costs of slaughtering were derived by adjusting the 1961 miscellaneous costs given by Logan and King. In estimating the 1967 costs, an increase of 6 percent above the 1961 levels was assumed. The cost of utilities, gas, electricity, and water were established by applying monthly regional rates to the utility requirements derived by Logan and King.

Regional differences in the cost of processing primal and retail beef cuts may exert an influence on the shipments of these products. Centralized beef processing is a relatively recent innovation in the beef-packing industry. Published information about the feasibility of such operations was not obtainable. Because of data limitations, a complete synthesized cost function for the processing of primal and retail beef cuts could not be constructed; therefore, only labor costs were considered. The labor requirements needed to perform the various functions were obtained from the Cryovac Division of W.R. Grace and Company. In estimating the regional, primal-cut processing costs, each processing unit was assumed to have the capacity to process 300 cattle per day. For the analysis, the troublesome problems relating to shelflife and standardization of cuts in the processing of primal cuts into retail cuts were ignored.

The demand for the final product was assumed to be predetermined, as stated before. The level of demand was measured by actual consumption in 1967, as expressed in retail-weight equivalents. The regional demand levels were determined from regional differences in the per-capita consumption of beef and from regional income-consumption relationships. A household food-consumption survey conducted by the USDA in 1965 provided the basic data concerning the differences in regional consumption (Agricultural Research Service, USDA, Reports 1-5, 1968). Estimates were made of income-consumption relationships for each census region from the USDA Household Food Consumption Survey, and these income-consumption response coefficients were used to adjust the 1967 per-capita consumption rates, unweighted by urbanization groups for variations in income among the twenty-seven regions. Total regional consump-

tion was obtained by multiplying the population figure for each region by the corresponding estimate of per capita consumption. The percentage of difference was calculated between the sum of these regional consumption estimates and the actual U.S. commercial cattle slaughter. The total estimate for each region was then adjusted by this percentage, so that the sum of these was equal to the actual, total slaughter figure. The final, regional consumption estimates and regional annual per-capita consumption figures by regions are presented in Table 7.

Transportation Rates

Four sets of transportation rates were required in this analysis. Shipments were assumed to take place between regional trading centers, and costs for intraregional shipments were not considered. Transportation costs for slaughter cattle were available from previous spatial studies of the livestock-meat economy. It was felt that within the scope of this analysis, these cost estimates could not be improved, so already existing data were used. Transportation rates for carcasses, primal cuts, and retail cuts were estimated from rate structures provided by Armour and Company.

Four modes of transportation were considered in shipping these beef products: (1) truck, (2) iced railroad car, (3) mechanically refrigerated railroad car, and (4) piggyback (TOFC). A square-root function was used to estimate the parameters. The direction of shipments was taken into account by fitting separate functions for shipments to the east and the west. The transportation rates used in this analysis are presented in Tables 8 and 9.

The simplex tableau of Table 1 and Equations 1 through 6 represents a highly condensed picture of the beef-packing industry. With a twenty-seven region demarcation, the number of activities in the model came to 2,970. Referring to the simplex tableau of Table 1, the activities were:

729 in X_{ij}^{1} (carcass-flow activities),

27 in S_{i}^{2} (primal-cut processing activities),

729 in X_{ij}^{2} (primal-cut flow activities),

27 in S_{i}^{3} (retail-cut processing activities),

729 in X_{ij}^{3} (retail-cut flow activities),

27 in S_i^1 (cattle-slaughtering activities), and

702 in X_{ij}^o (cattle-flow activities).

Using knowledge of the livestock-meat industry, the size of the problem was reduced by excluding some slaughter-cattle flows that were unlikely to enter the solution. It was assumed that Regions 1, 2, 3, 4, 5, 7, 8, and 9 would not ship live cattle. All flow activities for carcasses, primal cuts, and retail cuts were included in the analysis.

MODEL I RESULTS

Optimum Flow of Slaughter Cattle

The flow of slaughter cattle consistent with the objective of minimizing the costs of slaughtering, processing, and transportation for the beef-packing industry is presented in Table 10 and Figure 2. Regional, excess supplies appear on the right side of the table; regional excess demands, at the bottom. The numbers appearing in the body of the table represent the live-weight, interregional shipments of slaughter cattle. The U_i and V_j values refer to the live-animal price differentials related to the base region. The total, estimated interregional shipments of slaughter cattle are presented directly below the table. Please note that these estimates have meaning only for the regional demarcations used in this analysis; therefore, comparisons of results with previous studies would not be valid.

The main aspects of the interregional movement of slaughter cattle indicated by the analysis were:

1. Approximately 13 percent (4.54 billion pounds) of the total, commercial slaughter-cattle production in the forty-eight states was involved in interregional movements.

2. Region 20 (Kansas) was the dominant surplus region, with an excess supply amounting to 46 percent of its cattle production (1.57 billion pounds).

3. The other, major surplus slaughter-cattle areas, in order of excess supply, were Region 23 (Colorado), Region 24 (Arizona and New Mexico), and Region 16 (Missouri). As a percentage of the total slaughter-cattle production in these regions, this excess represented 25 percent (543 million pounds) in Region 23, 60 percent (515 million pounds) in Region 24, and 21 percent (412 million pounds) in Region 16.

4. Approximately 67 percent (3.04 billion pounds) of all interregional shipments originated in Regions 20, 23, 24, and 16. Minor shipments of slaughter cattle occurred between adjacent regions.

5. The average transportation cost for the interregional movements was $1.03 per hundredweight.

6. Generally, the Corn Belt States shipped slaughter cattle to the deficit areas on the East Coast, while the Western Plains States shipped cattle to the deficit areas on the West Coast.

The surplus and deficit slaughter-cattle supply regions are given in Table 11. The negative numbers appearing in the body of the table represent deficit supply regions; the positive numbers, surplus ones. Region 19 (Nebraska) and Region 21 (Texas and Oklahoma) are represented as deficit supply areas. This appears to be unrealistic; however, the surplus and deficit areas were determined with respect to estimated slaughter capacities within the regions. Excess supply was the residual after the slaughter capacity was fully utilized. Thus, representing Regions 19 and 21 as deficit supply areas implies that excess slaughter capacity existed within these two regions.

Optimum Flow of Carcasses

No interregional flow of beef carcasses was generated by the joint analysis. Admittedly this is unrealistic, but it resulted from data limitations that prevented capacity constraints for processing primal and retail cuts of beef from being included in the model construction. Regional demands for carcass beef do exist. However, final demand in this study was represented for beef in terms of retail cuts. The assumption was that incorporating capacity constraints and regional demands for carcass beef would have induced interregional shipments of this product.

Minimum Shipment of Primal Cuts

The joint analysis produced one interregional shipment of primal cuts. Region 15 (Iowa) shipped 419 million pounds of primals to Region 4 (North Carolina, Virginia, and West Virginia). The mode of transportation was piggyback, and the cost was $1.54 per hundredweight. In the solution, Region 4 not only imported primals, but also received 297 million pounds of slaughter cattle from Region 20 and 452 million pounds of retail beef from Region 19 to satisfy regional demand.

Optimum Flow of Retail Beef

The optimum, interregional flows of retail beef generated by the joint analysis are summarized in Table 12 and Figure 3. The V_j and U_i values may be given the same interpretations as in Table 10. Excess supplies and demands of retail beef cuts are shown at the right and bottom of the table. The interregional flow quantities appear in the body of the table. The important characteristics of the interregional movements were:

1. Approximately 39 percent (5.71 billion pounds) of the total demand for beef (retail equivalent) in the forty-eight states was involved in interregional flows.

2. Of the total interregional retail beef shipments, 49 percent (2.79 billion pounds) originated in Regions 15 and 19 (Iowa and Nebraska).

3. Approximately 70 percent of the total interregional flow of retail beef moved in four deficit areas: Regions 1, 2, 3, and 27 (New England, New York, the Central Atlantic area, and California, respectively). The three deficit areas east of the Mississippi River—Regions 1, 2, and 3 (New England, New York, and the Central Atlantic area, respectively)—accounted for 58 percent of the interregional movements. Regions 1 and 2 accounted for 45 percent of the regional shipments of retail beef.

4. Three of the four alternate modes of transportation were used in the interregional movement of retail beef. Piggyback was the mode used most frequently (75 percent). Trucks (15 percent) and mechanically refrigerated railroad cars (10 percent) accounted for the remaining interregional shipments. Table 13 summarizes the interregional flow by mode of transportation. The average transportation cost was $1.46 per hundredweight.

Surplus and Deficit Regions

The surplus and deficit areas of beef in terms of retail weight are given in Table 14. A similar pattern of surplus and deficit areas was observed for retail beef and for slaughter cattle. In general, deficit retail-beef supply areas were located on the East and West Coasts. Five regions exhibited the characteristic of being surplus slaughter-cattle supply areas and deficit retail-beef areas—Regions 6, 10, 12, 17, and 24. In reality, this outshipment of slaughter cattle and the corresponding inshipment of retail beef probably would not occur.

The model as specified did not allow for more than one working shift. Thus, when regional slaughter capacity was fully utilized, the excess supply of slaughter cattle was created. Region 21 shifted from being a deficit slaughter-cattle supply area to a self-sufficient retail beef region. Two regions, 11 and 13, shifted from deficit slaughter-cattle areas to surplus areas for retail beef.

The optimum levels of regional cattle slaughtering are shown in Table 15. The estimated total amount of cattle slaughtered in the forty-eight states in 1967 was approximately 34.54 billion pounds. Since the estimated U.S. slaughter capacity was 40.35 billion pounds, only 86 percent of the available capacity was being utilized.

Unused Slaughter Capacity

Of the twenty-seven regions in the forty-eight states, eight regions (1, 2, 3, 5, 9, 21, 26, and 27) did not fully utilize existing slaughter capacity. Region 9 utilized 96 percent of the regional slaughter capacity. Two regions (5 and 23) utilized 60 percent or more of the available capacity. Regions 1, 2, and 26 used 39, 41, and 36 percent of their regional slaughter capacity, respectively. In Region 3, only 27 percent of the available capacity was utilized.

Comparison of Programmed Versus Actual Slaughter

A comparison was made of the optimum, regional slaughter quantities with the reported commercial cattle slaughter, revealing that the optimum, regional slaughter quantities as determined by the analysis were generally of the same magnitude as the actual slaughter reported during 1967 (Table 15). However, there were a few notable exceptions. There was a difference between the estimated and actual slaughter for Regions 3, 26, and 27. The reported slaughter exceeded the estimated, optimum slaughter in all three of these regions.

The optimum levels of processing for primal and retail beef cuts consistent with the optimum flow patterns for slaughter cattle and retail cuts of beef are presented in Table 16. Since no reported data existed for the actual levels of regional processing, no comparison of the model results could be made with actual data. Hence, only the levels determined by the model specifications are reported.

The set of price differentials consistent with the optimum flow pattern for slaughter cattle and retail cuts of beef, as derived by the joint analysis, is presented as V_j and U_i values in Tables 10 and 12.

Regional Price Differences

Slaughter cattle. In the slaughter-cattle analysis, Region 20 (Kansas) was chosen as the base region, and the price differentials were computed in relation to that region. The two types of information involved are: (1) the price differentials for the surplus regions, which measure the comparative advantage of each region against the base region; (2) the price differentials for the deficit regions, which provide the delivered price differentials in relation to the base region.

For example, slaughter cattle were estimated to be worth approximately 17 cents per hundred pounds more in Region 16 (Missouri) than in Region 20 (Kansas). This comparative advantage can be explained largely by the proximity of Region 17 to the large, deficit Region 21. Where there was excess supply—Region 22 (Montana and Wyoming), slaughter cattle were estimated to be worth 13 cents per hundred less in Region 22 (Montana and Wyoming) than in Region 20 (Kansas). In deficit Region 21 (Texas and Oklahoma), slaughter-cattle prices were estimated to be approximately $1.13 per hundred higher than in Region 20 (Kansas). (See Table 10.)

Carcasses and primal cuts. Since the results of the analysis produced no interregional flows of carcass beef, no price differentials for this product were calculated. The solution produced no interregional movements because capacity limitations were not placed on the chill-cooler for carcass beef or for primal processing. No price differentials for primal cuts were calculated because only one flow occurred.

Retail cuts. Using Region 20 (Kansas) as the base, the excess-supply region with the greatest comparative advantage was Region 9 (Mississippi and Alabama). This advantage may be attributed to the nearness of Region 9 to Region 5, a deficit one. With Region 20 as the base, other surplus areas in a favorable position were Regions 25, 8, and 11. Regions 18 and 19 were at a disadvantage relative to the base region, Kansas. This came about because of the higher cost of transportation from these two regions, compared to that from Region 20.

Of the deficit areas, Regions 1, 2, 6, and 27 had the highest relative prices; Region 12, the lowest. The estimated price differentials suggested that retail beef prices were highest on the East and West Coasts, and lowest in the Midwestern States. (See Table 12.)

Rents

A byproduct of the spatial analysis was the information about rents for additional slaughter-cattle capacity that were consistent with the optimum interregional flow of products. Such rents, which accrued only to those regions in which the entire capacity was utilized, gave an indication of the relative profitability of increasing the slaughtering capacity within a region. These rents were a result of the geographic advantages in relation to the available supply of slaughter cattle, the available slaughter capacity, and the location of the deficit regions in terms of retail cuts of beef. The regions to which slaughtering rents accrued and the cost in dollars per hundredweight are presented in Table 17.

In the analysis, nineteen of the twenty-seven regions utilized existing slaughter capacity. The total regional slaughter capacity was utilized in seven of the nineteen regions by inshipments of slaughter cattle. Since transportation costs were incurred in shipping the cattle, the rents for these regions were low in relation to the remaining regions. The seven regions were 4, 7, 8, 11, 13, 19, and 25. The remaining twelve regions in which rents accrued were 6, 10, 12, 14, 15, 16, 17, 18, 20, 22, 23, and 24. Of these twelve, Regions 24 and 22 had the highest rents—$1.38 and $1.16 per hundred pounds, respectively.

MODEL I ANALYSIS

1. The East and West Coasts were deficit supply areas for both slaughter cattle and retail beef, while the Corn Belt and Plains States were the major excess supply areas for slaughter cattle and retail cuts of beef.

2. The major mode of transportation in the interregional shipments of retail cuts of beef was piggyback, accounting for three-fourths of the total flow.

3. Five of the six shipments of retail beef via truck transport were to bordering regions, and all shipments were in an eastward

direction. The one remaining shipment was also eastward, but this load was shipped from Region 20 (Kansas) to Region 10 (Michigan). No directional preference for shipments was shown between piggyback and mechanically refrigerated railroad cars.

4. The interregional shipments of slaughter cattle, primal cuts, and retail cuts plus the absence of interregional carcass flows provided the economic implication that potential cost reductions might exist in processing and distribution.

MODEL I-A: REMOVING THE CONSTRAINTS IMPOSED ON REGIONAL SLAUGHTER

Since there has been a trend toward locating new slaughtering facilities in the major slaughter-cattle production areas, an alternate analysis (Model I-A) was performed. This model corresponds to Model I in basic specifications, the difference being the relaxation of the two constraints imposed on regional slaughtering capacities. Model I-A eliminated the outshipment of slaughter cattle as well as the inshipment of retail beef observed in Model I. In Model I-A, slaughtering plants were assumed to operate more than one shift a day, making invalid the estimated slaughter capacities used in Model I.

MODEL I-A RESULTS

Since the capacity constraints were relaxed for slaughtering, there were no interregional flows of slaughter cattle. Likewise, there were no interregional flows of carcasses. The same flow of primal cuts occurred as in Model I. Region 15 shipped 611 million pounds of primal cuts to Region 4.

The retail beef flow consistent with the objective of minimizing the costs of transportation, slaughtering, and processing for the beef industry is presented in Table 18 and Figure 4. A comparison of the interregional movement of retail cuts of beef with the results of Model I showed the following:

1. The total interregional movement of beef (retail-weight equivalent) was 6.65 billion pounds, an increased flow of 940 million pounds above the estimated flow in Model I.

2. Region 4 was no longer involved in the interregional movement of retail cuts. In Model I, Region 4 was a deficit area.

3. Regions 8 and 9 changed from ones of excess supply to deficit areas. This was consistent with the results of Model I in that Regions 8 and 9 were excess-supply areas only because they received inshipments of slaughter cattle.

4. Region 24 became one of excess supply. In Model I, it was the opposite.

5. The major excess-supply areas were Regions 19 (Nebraska), 20 (Kansas), and 15 (Iowa). These three accounted for approximately 60 percent of the total interregional movement.

6. The relative importance of the alternate modes of transportation remained about the same. Piggyback transport accounted for 76 percent of the shipments; mechanically refrigerated railroad cars and trucks, 15 and 9 percent, respectively.

COMPARING RESULTS, MODELS I AND I-A

1. The total interregional movement of beef (retail-weight basis) increased by approximately 12 percent.

2. The three major surplus-supply regions accounted for approximately 60 percent of the total interregional flow.

3. Some regions exchanged positions, in terms of being surplus- or deficit-supply regions. The unrealistic shipments that occurred in Model I were eliminated.

4. By extending the analysis performed in Model I, the regional slaughter capacities were eliminated in Model I-A. As expected, there were no interregional flows of slaughter cattle. The flow pattern for the other products generally remained the same, as did the modes of transportation.

5. The optimum levels of cattle slaughtering for Models I and I-A and the commercial slaughter figures reported by the USDA for 1967 are shown in Table 19. The level of slaughtering changed in all but three of the regions—1, 2, and 3. Table 19 shows that the solution levels for slaughtering given for Model I are closer to the USDA's slaughter figures than the results of Model I-A.

Price differentials consistent with the optimum, interregional flow of retail beef are presented in Table 18. Region 11 was the one of excess supply with the greatest comparative advantage. Other surplus ones having a favorable advantage were Regions 22 and 24. This can be attributed to the proximity of the large deficit area, Region 27. Regions 14, 18, 19, and 23 were at a disadvantage relative to Region 27.

Of the deficit areas, Regions 6, 2, and 3 had the highest relative prices. The estimated price differentials suggest that retail beef prices are the highest in Regions 6 (Florida) and 2 (New York).

MODEL II: ESTIMATES FOR 1975 OPTIMUM FLOW

Model II corresponds to Model I in basic mathematical specifications; the main difference was the time period investigated. The purpose of Model II was to determine what the optimum flow of slaughter cattle and of carcasses, primal cuts, and retail cuts of beef might be under the conditions likely to prevail by 1975.

The slaughter-cattle flow quantities consistent with the objective of minimizing the combined costs of slaughtering, processing, and transportation for the beef-packing industry are presented in Table 20 and Figure 5. The important characteristics of the interregional slaughter-cattle shipments, as obtained in the analysis, are listed below.

Interregional Shipment of Slaughter Cattle

1. The total, interregional shipment of slaughter cattle is projected to be 7.52 billion pounds. This represents approximately 21 percent of the slaughter-cattle production estimated for 1975 in the forty-eight states.
2. The important surplus areas would be Regions 12, 14, 15, and 20. These four would account for approximately 65 percent of the total interregional movement of slaughter cattle.
3. The total transportation bill would be $80,447,570, an average of $1.07 per hundredweight.
4. In general, the Great Plains and Western Corn Belt States would ship cattle east and south, while Region 23 would ship cattle to California. Region 21 would import cattle for slaughter because of the large slaughter capacity available there in relation to that of surrounding regions.

The differences between Models I and II would produce an increase in slaughter-cattle shipments and in transfer activities between regions. Slaughter-cattle production in 1975 was assumed to be higher than in 1967, so the potential would be greater for a larger interregional flow of slaughter cattle.

In terms of the number of transfer activities between regions, there would be an increase from twenty under Model I to twenty-five under Model II.

Movement of Carcasses and of Primal Cuts

Model II produced no interregional shipments of carcasses or primal cuts. The reason is not a fault of the model itself. More accurate regional cost data for the processing of primal cuts and limitations expressed in terms of carcass chill-cooler capacity may have had a substantial influence on the interregional flow of these beef products.

Flow of Retail Cuts

The optimum transfer activities for retail beef are given in Table 21 and Figure 6. The main aspects of this interregional movement are:

1. The total amount of retail beef entering interregional trade is 5.97 billion pounds. This represents approximately 38 percent of the estimated, total beef consumption in the forty-eight states for 1975.
2. Fourteen surplus regions ship retail beef to thirteen deficit-consumption regions. Approximately 25 percent of this surplus comes from Region 15, with 23 percent from Region 19.
3. Deficit Regions 1, 2, and 3 receive 3.7 billion pounds. This represents approximately 62 percent of the interregional shipments of retail beef. The major sources of supply for these areas are Regions 15 and 19, which account for 71 percent of the excess demand for the three regions (1, 2, and 3).
4. Deficit Region 27 imports 14 percent of the excess supply of retail beef. The major sources of supply for this particular region are Regions 21, 23, 24, and 25.
5. The transportation bill totals $85,382,173, an average of $1.43 per hundredweight.
6. All four of the alternate modes of transportation are employed in Model II. As in Model I, piggyback transportation is used the most, some 74 percent. Shipments of retail beef by truck account for 19 percent of the total. Six percent of the remaining shipments are made by mechanically refrigerated railroad cars, and 1 percent via iced railroad cars. Eight of the nine truck shipments are eastward. The exception is Region 18 (North Dakota and South Dakota), which ships to Region 22

(Montana and Wyoming). All truck shipments are to bordering regions. The single, mechanically refrigerated railroad car shipment is westward, while the only iced railroad car shipment is eastward. (See Table 22.)

The estimated surplus- and deficit-supply areas for slaughter cattle and retail cuts of beef in 1975 are presented in Table 23. The negative numbers appearing in the body of the table refer to deficit-supply areas, while the positive ones indicate areas of surplus supply. Region 1 was self-sufficient in terms of slaughter cattle; Region 26, in terms of retail cuts of beef. In actual practice there would be little or no exporting of slaughter cattle and importing of retail beef, as observed in four of the twenty-seven regions—2, 4, 12, and 22. (See Table 23.) A similar situation was observed in Model I. This could be corrected by increasing the estimated slaughter capacities in these particular regions. That was not considered as part of this study, and therefore was not attempted.

COMPARISON OF RESULTS, MODEL II VERSUS MODEL I

1. The total amount of retail beef entering interregional trade increased by approximately 1 percent. This is consistent with the expectation that the population will become further concentrated in the large, metropolitan areas; thus, a greater potential for interregional shipments.

2. Regions 15 and 19 were the major excess-supply areas again. These two accounted for 49 percent of the total interregional movement in Model I, and 47 percent in Model II.

3. Deficit Regions 1, 2, and 3 received 58 percent of the interregional shipments in Model I, and 71 percent in Model II.

4. In general, the flow pattern from surplus to deficit regions remained the same. However, the magnitude of the shipments increased, which was expected.

Estimated Regional Cattle Slaughtering and Excess Capacity

The optimum levels of regional cattle slaughtering and utilized capacity are presented in Table 24. The total amount of excess capacity was 181 million pounds (less than 5 percent). Only three regions—1, 3, and 26—did not fully utilize their existing capacity. In Region 1, only 35 percent of the regional slaughter capacity was used. The other two, Regions 3 and 26,

utilized more than 80 percent and 90 percent of their regional slaughtering capacity, respectively.

Regional Processing of Primal and Retail Cuts

The estimated, optimum levels of processing for primal and retail cuts of beef are presented in Table 25. Since no capacity limitations were incorporated into the model for these particular activities, very little can be said about the levels shown in the solution. No comparison could be made between those levels and the actual ones because no data existed concerning an estimate of the actual regional processing of these beef products.

The set of regional price differentials consistent with the optimum flow of slaughter cattle and retail beef are given in Tables 20 and 21. They are presented as the V_j and U_i values in the last row and column of these tables. Regional rents are presented in Table 24.

Region 20 was chosen as the base region, and the price differentials in Table 20 were computed relative to this region. Region 2 had the greatest comparative advantage in relation to Region 20. This may be the result of the large consumption demand for beef in Region 2 and its proximity to Region 3, where excess slaughter capacity existed. The smallest comparative advantage was in Region 18.

Of the deficit-supply regions, the prices for live cattle were estimated to be $1.97 per hundredweight higher in Region 3 than in Region 20. The delivered price differential in Region 13 was only 55 cents per hundred pounds higher than in Region 20. (See Table 20.)

The comparison of the price differentials generated by Models I and II suggests that the pattern of comparative advantage of the important, surplus-slaughter-cattle regions remained almost the same between the two periods of analysis. Comparing the price differentials for the deficit regions also suggests that the pattern of delivered prices is likely to be repeated to a large extent in 1975. However, one exception can be noted. Region 3 replaced Region 2 in the results of the Model II analysis as the area exhibiting the greatest delivered-price differential. No price differentials were calculated for carcass or primal cuts of beef because no interregional flows were generated in the solution.

Measured against Region 20 (the base region), Region 11 had the greatest comparative advantage for shipping retail beef east, while Region 24 had the comparative advantage for supplying

the West Coast (Table 20). Interpreting the price differentials in the usual sense for the deficit-supply areas, the results indicate that the highest delivered prices were in the regions along the East and West Coasts of the United States; the lowest delivered prices, in Region 5. The general pattern of comparative advantage and price differentials was the same in Models I and II.

Three regions did not use their entire regional slaughter capacity. Those with excess capacity earned no rent. The marginal returns or rents of an additional unit (hundredweight) of slaughter capacity are presented in Table 24. Ten regions earned a rent of a dollar or more per hundredweight, while seven regions earned rents of 50 cents to a dollar. Seven other regions earned rents of less than 50 cents per hundredweight. The highest rent was in Region 22; the lowest, in Region 21.

Given the regional production and consumption patterns and the transportation rate structure specified for this model, the rents generated by the model suggest that additional slaughtering facilities would be more profitable in the Western Corn Belt and the Northern Plains States (Table 24).

SUMMARY

The spatial characteristics of slaughter cattle and of carcass, primal cuts, and retail beef in the meat-packing industry of the forty-eight states were examined. The consideration of alternate modes of transportation and forms of fresh beef as well as of regional cost functions for cattle slaughtering and the processing of primal and retail cuts of beef distinguish this study from previous spatial analyses.

Within an interregional-activity-analysis format, Model I was designed to determine the optimum levels of regional cattle slaughtering and processing for primal and retail cuts, as well as for the interregional flows of slaughter cattle, carcasses, primal cuts, and retail cuts of beef. The final solution was determined with given regional supplies of slaughter cattle; regional beef demands (retail-weight equivalent); and slaughtering, processing, and transportation costs. The results may deviate from what actually exists in the industry because of oversimplification in the assumptions made for the model.

Data consistent with the model specifications were estimated or synthesized from relevant secondary sources. A limited amount of data were also obtained from private firms in the

beef-packing industry. The time period of the basic analysis was the calendar year of 1967. An extension of the analysis (Model II) was used as an application of secondary data for estimating the 1975 slaughter-cattle supplies, slaughter capacities, and demands for beef.

The analysis delineated twenty-seven demarcations within the forty-eight states (Figure 1). Necessary data for the analysis consisted of estimates of regional slaughter-cattle supplies; regional slaughtering and processing costs; dressing percentages and yield coefficients for primal and retail cuts; regional slaughter capacities; and transportation costs for slaughter cattle, carcasses, primal cuts, and retail cuts of beef.

Assuming a perfect competitive market behavior, the study provides a basis for judging the efficiency of the beef-packing industry in slaughtering, processing, and distributing beef products. As always, the validity of the available data conditions the usefulness of the results.

Given the assumptions and data of the study, the following conclusions were drawn:

1. The major supply areas for slaughter cattle and retail beef are the Corn Belt and Plains States.

2. Consistent with the objective function of minimizing the combined costs of slaughtering, processing, and transportation for the beef-packing industry, retail cuts of beef are the most economical form in which to distribute beef from surplus to deficit areas.

3. Ignoring the problem of transportation availability, the optimum modes of transportation for retail beef are (1) piggyback (TOFC), (2) trucks, and (3) mechanically refrigerated railroad cars.

4. Consistent with the objective of minimizing transportation costs, the least-cost mode of transport was piggyback, followed by trucks and mechanically refrigerated railroad cars, in that order.

5. Considering only the combined costs of slaughtering, processing, and transportation, the logical point for breaking and processing beef carcasses into primal and retail cuts is at the point of slaughter. This study showed that the locations for breaking carcasses should be closer to the areas of surplus beef production than they are now.

6. The beef-packing industry should reduce slaughter capacity in the marginal cattle-producing areas of the East and West Coasts and increase processing capacity in the Southwest, Plains,

and Western Corn Belt States, where it would be possible to keep shrinkage, transportation, and service costs at a minimum.

The East and West Coasts were deficit-supply areas for both slaughter cattle and retail cuts of beef. The major supply areas for these products were the Corn Belt and Plains States. A definite pattern of directional shipment was observed in the interregional movement of slaughter cattle. The Corn Belt States shipped slaughter cattle to the deficit cattle-supply areas in the east; the Western Plains States, to the deficit areas located on the West Coast.

Approximately 13 percent (4.54 billion pounds) of the estimated slaughter-cattle production was involved in interregional shipments. Four excess supply areas—Regions 20 (Kansas), 23 (Colorado), 24 (Arizona and New Mexico), and 16 (Missouri)—accounted for 67 percent of the total interregional shipments of slaughter cattle. The greatest excess supply of cattle originated in Region 20 (Kansas), which exported 46 percent of its estimated cattle slaughter. However, Region 24 (Arizona and New Mexico) exported 60 percent. This implies that the production of slaughter cattle had increased faster than the development of slaughtering facilities in these areas. Accordingly, high slaughter rents (79 cents and $1.38 per hundred) showed up in Regions 20 and 24, respectively.

The analysis used in Model I produced only one interregional flow of primal cuts. There would be no interregional shipments of carcasses. One shipment of primal cuts that originated in Region 15 (Iowa) was shipped to Region 4 (North Carolina, Virginia, and West Virginia). Approximately 39 percent of the estimated demand for beef (retail equivalent) in the forty-eight states was involved in interregional shipments. Approximately 45 percent of total interregional flow was transported to Regions 2 and 3 (New York and the Central Atlantic area). Another 25 percent of the total movement was shipped to Regions 1 and 27 (New England and California).

Only three of the four alternate modes of transportation would be involved in interregional shipments of retail beef. The most important mode of transportation was piggyback, approximately 75 percent of the total. Trucks would transport 15 percent, and mechanically refrigerated railroad cars would haul 10 percent. With one exception, all truck shipments would be short hauls to adjacent regions. There was no directional priority between piggyback shipments and those by mechanically refrigerated railroad cars.

By comparing USDA reports of actual slaughtering with the figures suggested by the model, only Regions 3 (the Central Atlantic area), 26 (Oregon and Washington), and 27 (California) showed higher slaughter totals than those estimated in the analysis.

The extension of the analysis (Model I-A, which relaxed the slaughter capacity) eliminated the interregional shipment of slaughter cattle and carcasses; increased the level of slaughtering within all regions except 1, 2, and 3; increased the movement of retail beef cuts by 14 percent (9.4 billion pounds); and caused some regions with excess slaughter capacity to change from areas of surplus to ones of deficit supply. The modes of transportation remained substantially the same as for Model I. The optimum regional flow and price differentials were shown in Table 18 and Figure 4.

The approximation for 1975 conditions indicated that 38 percent of the total U.S. demand for beef would be involved in interregional shipments. New England, New York, the Central Atlantic area, and California would absorb 52 percent of all retail shipments. Under 1975 simulated conditions, slaughter capacity in all but three regions would be fully utilized. The highest slaughter rents would be earned in the Western Corn Belt and Northern Plains States, implying that additional slaughtering facilities would be most profitable in these areas.

ADDITIONAL RESEARCH

This analysis incorporates the centralized processing of primal and retail cuts of beef and the resulting interregional flows into a framework of the American beef-packing industry. Although the results obtained were largely conditioned by the data available, the interregional activity analysis model represents a useful economic tool for analyzing actual industry problems, particularly ones such as whether the industry should move toward centralized processing as the major method of handling and distributing its product. The data problems encountered with this particular analysis suggest further areas for research.

Preliminary research should consider the following:

1. Studying meat preservation, spoilage, shrinkage, and moisture loss in packaged beef, to gain a better understanding of these factors in the handling losses for primal, subprimal, and carcass beef.

2. Examining economies of scale, to determine the most efficient size for processing units that handle primal and retail cuts. This type of research would provide needed cost coefficients to include in the objective function.

3. Obtaining more precise estimates of the regional demand for carcass, primal, and retail beef on an annual or quarterly basis. Such data would lend more realism to the results.

4. Determining realistic production levels of regional cattle-slaughtering and beef-processing activities.

If data measurements with greater precision can be attained, more useful results could be achieved. Skillful research should succeed in making activity analysis a useful tool for predicting and analyzing structural changes in the beef-packing industry. This analysis has indicated that the methodological problems can be solved and the computational tasks performed.

BIBLIOGRAPHY

Anthony, W. E. Structural changes in the federally inspected livestock slaughter industry, 1950-62. USDA, Econ. Res. Serv., Ag. Econ. Rpt. No. 83, 1966.

Bain, J. S. Industrial organization. John Wiley, New York, 1959.

Baker, C. B. Interpretation of regional spatial models *in* Agricultural supply functions. (E. O. Heady *et al.* ed.) Iowa State Univ. Press, Ames, 1958.

Baumol, W. J. Economic theory and operations analysis. Prentice-Hall, Englewood Cliffs, N.J., 1965.

Bawden, D. L. An evaluation of alternative spatial models. Jour. Farm Econ. 46(5), 1964.

Beckmann, M. J. A continuous model of transportation. Econometrica 20(4), 1952.

Bhagwati, J. The pure theory of international trade: A survey. Econ. Jour. No. 293, 1964.

Brandow, G. E. Interrelations among demands for farm products and implications for control of market supply. Pa. Agr. Exp. Sta. Bul. 680, 1961.

Buchholz, H. E. An interregional analysis of the United States feed-livestock economy. Ph.D. thesis, Dept. Agr. Econ., Univ. Ill., 1965.

Buchholz, H. E., G. G. Judge, and V. I. West. A summary of selected estimated behavior relationships for agricultural products in the United States. Ill. Agr. Exp. Sta. Agr. Econ. Res. Rpt. 57, 1962.

Clifton, E. S. Market power in the meat packing industry, discussion under Market power and the farm problem. Jour. Farm Econ. 42(5), 1960.

Crom, R. J. Simulated interregional models of the livestock-meat economy. USDA, Econ. Res. Serv., Agr. Econ. Rpt. No. 117, 1967.

DeGraff, H. The trouble with the beef business is that packers aren't attuned to change. Nat. Provisioner, Mar. 10, 1962.

Dorfman, R. P., P. A. Samuelson, and R. M. Solov. Linear programming and economic analysis. McGraw-Hill, New York, 1958.

Dunn, E. S. The location of agricultural production. Univ. Florida Press, Gainesville, 1954.

Enke, S. Equilibrium among spatially separated markets: Solution by electric analogue. Econometrica 19(1), 1951.

Fox, K. A. A spatial equilibrium model of the livestock-feed economy in the United States. Econometrica 21(4), 1953.

Fox, K. A., and R. C. Taeuber. Spatial equilibrium models of the livestock-feed economy in the United States. Amer. Econ. Rev. 45(4), 1955.

Greenhut, M. L. Plant location in theory and in practise; the economics of space. Univ. North Carolina Press, Chapel Hill, 1956.

Griffiths, W. O. The trend toward centralized meat packaging *in* Packaging for retail impact with specific application to the dairy meat, candy, and baking industries. Mgt. Bul. No. 70, Amer. Mgt. Assn., Chicago, 1965.

Havlicek, J., R. L. Rizek, and G. G. Judge. Spatial structure of the livestock economy: II. Spatial analyses of flows of slaughter livestock in 1955 and 1960. N. Cent. Reg. Res. Bul. 159 (S. Dak. Agr. Exp. Sta. Bul. 521), 1964.

Heady, E. O. Aggregation and related problems in models for analysis of interregional competition *in* Interregional competition research methods. (R. A. King ed.) Agr. Policy Inst., Sch. Life Sci., N.C. State of the Univ. North Carolina, Raleigh [1963?].

Hertsgaard, T. A., and S. D. Phillippi. Distribution patterns for beef: An economic analysis. N. Dak. Agr. Exp. Sta. Bul. 435, 1961.

Higeland, P. H. Developments in meat processing plants. Food Trade Rev. 32(10), 1962.

Hoover, E. M. The location of economic activity. McGraw-Hill, New York, 1963.

Institute of Food and Agricultural Sciences. Synthetics and substitutes for agricultural commodities. Inst. Food Agr. Sci., Pub. No. 1, Univ. Florida, Gainesville, 1966.

Isard, W. Location and space economy. MIT Press, Cambridge, 1965.

Ives, J. R. The livestock and meat economy of the United States. Amer. Meat Inst., Chicago, 1966.

Judge, G. G., J. Havlicek, and R. L. Rizek. An interregional model: Its formulation and application to the livestock industry. Agr. Econ. Res. 17(1), 1965.

_____ Spatial structure of the livestock economy: I. Spatial analyses of the meat marketing sector in 1955 and 1960. N. Cent. Reg. Res. Bul. 157 (S. Dak. Agr. Exp. Sta. Bul. 520), 1964.

Judge, G. G., and T. D. Wallace. Estimation of spatial price equilibrium models. Jour. Farm Econ. 40(4), 1958.

_____ Spatial price equilibrium analysis of the livestock economy:

1. Methodological development and annual spatial analysis of the beef marketing sector. Okla. Agr. Exp. Sta. Tech. Bul. 78, 1959.

2. Application of spatial analysis to quarterly models and particular problems within the beef marketing system. Okla. Agr. Exp. Sta. Tech. Bul. 79, 1959.
3. Spatial price equilibrium models of the pork marketing system. Okla. Agr. Exp. Sta. Tech. Bul. 81, 1960.

Kelley, P. L., J. H. McCoy, and M. L. Mannal. The competitive position of Kansas in marketing hogs. Kans. Agr. Exp. Sta. Tech. Bul. 118, 1961.

King, G. A., and L. F. Schrader. Regional location of cattle feeding—A spatial equilibrium analysis. Hilgardia 34(10), 1963.

Koopmans, T. C. Optimum utilization of the transportation system. Econometrica 17(Supp.), 1949.

Koopmans, T. C., ed. Activity analysis of production and allocation. John Wiley, New York, 1951.

Ladd, G. W. and H. Kuang. Optimal beef and pork marketings. Jour. Farm Econ. 48(2), 1966.

Leftwich, R. H. The price system and resource allocation. Holt, Rinehart, and Winston, Chicago, 1966.

Lösch, A. The economics of location. Sci. Ed. (paperback), Yale Univ. Press, New Haven, 1967.

Logan, S. H., and G. A. King. Economies of scale in beef slaughter plants. Giannini Foundation Res. Rpt. No. 260, Calif. Agr. Exp. Sta., 1962.

_____ Size and location factors affecting California's beef slaughtering plants. Hilgardia 36(4), 1964.

Maki, W. R., C. Y. Liu, and W. C. Motes. Interregional competition and prospective shifts in the location of livestock slaughter. Iowa Agr. Exp. Sta. Res. Bul. 511, 1962.

Mighell, R. L., and J. D. Black. Interregional competition in agriculture. Harvard Univ. Press, Cambridge, 1951.

National Commission on Food Marketing. Organization and competition in the livestock and meat industry. Tech. Study No. 1, Nat. Comm. Food Mktg., Wash., D.C., 1966.

Pålander, T. Beiträge zur Standortheorie. Almquist and Wiksells boktryckeria-a. b., Uppsala, 1935.

Rizek, R. L., G. G. Judge, and J. Havlicek. Spatial structure of the livestock economy: III. Joint spatial analysis of regional slaughter and the flows and pricing of livestock and meat. N. Cent. Reg. Res. Bul. 163 (S. Dak. Agr. Exp. Sta. Bul. 522), 1965.

Rohdy, D. D. Southeast hog-pork industry: A national market competitor. Southern Coop. Series, Bul. 89, Dept. Ag. Econ., N.C. State Univ., Raleigh, 1964.

Samuelson, P. A. Spatial price equilibrium and linear programming. Amer. Econ. Rev. 42(3), 1952.

Schunpeter, J. A. History of economic analysis. Oxford Univ. Press, New York, 1954.

Seaver, S. K. Spatial research—Measurement for what? Jour. Farm Econ. 46(5), 1964.

Smith, A. An inquiry into the nature and causes of the wealth of nations. Modern Library, New York, 1937.

Stout, T. T., E. R. Bentley, and F. E. Walker. Econometric generalizations of the Ohio hog-pork industry in interregional competition. Ohio Agr. Exp. Sta. Res. Bul. 950, 1963.

Takayama, T., and G. G. Judge. An interregional activity analysis model for the agricultural sector. Jour. Farm Econ. 46(2), 1964.
Volz, M. D., and J. A. Marsden. Centralized processing of fresh meat for retail stores. USDA, Agr. Mktg. Serv., Mktg. Res. Rpt. No. 628, 1963.
Wallace, T. D. The general problem of spatial equilibrium: A methodological isssue *in* Interregional competition research methods. (R. A. King ed.) Agr. Policy Inst., Sch. Life Sci., N.C. State of the Univ. North Carolina, Raleigh [1963?].
Weber, A. Theory of location of industries. Univ. Chicago Press, Chicago, 1928.
Williams, W. F., and J. W. Malone. Interregional competition in fed beef. Okla. Agr. Exp. Sta. Processed Series No. 473, 1964.
Williams, W. F., and T. T. Stout. Economics of livestock-meat industry. MacMillan, New York, 1964.
Wyckoff, J. B. Cattle transportation in Washington. Wash. Agr. Exp. Sta. Bul. 636, 1962.

STATISTICAL SOURCES

Albright-Neil Company, Chicago.
Amalgamated Meat Cutters and Butcher Workmen of North America, Chicago.
American Meat Institute, Chicago. Financial facts about the meat packing industry, 1967. Dept. Mktg., 1968. (Issued annually)
Architectural Record, McGraw-Hill, New York. Building costs—indexes and indicators. 144(6), 1968.
Armour and Company, Chicago.
Chamber of Commerce offices, various regional trading centers.
Colorado State University, Ft. Collins. Western livestock round-up. Coop. Ext. Serv., 1967.
W. R. Grace and Company, Cryovac Division, Chicago.
University of California at Berkeley. Economies of scale in beef slaughtering plants. Giannini Foundation Res. Rpt. No. 260, Calif. Agr. Exp. Sta., 1962.
U.S. Department of Agriculture
Cash receipts from major farm commodities, by states. Agr. Mktg. Serv., Stat. Bul. No. 262, 1968.
Cattle killing—floor systems and layouts. Agr. Res. Serv., Mktg. Res. Rpt. No. 657, 1964.
Food consumption of households in the United States, spring, 1965. Agr. Res. Serv., Rpt. No. 1-5, 1968.
Livestock and meat statistics (Supp. for 1967 to Stat. Bul. 333). Econ. Res. Serv., Stat. Rpt. Serv., Consumer and Mktg. Serv., 1968.
Number of livestock slaughter plants, March 1, 1965. Stat. Rpt. Serv., SRS-8, 1965.
U.S. Department of Labor
Employment and earnings statistics for states and areas, 1937-67. Bur. Labor Stat. Bul. 1307-5, 1968.
Wilson and Company, Chicago.

Table 1. A Two-Region Example of the Programming Tableau

Internal prices and rents	Carcass flows				Primal-cut production		Primal-cut flows				Retail-cut production		Retail-cut flows				Slaughtering carcass products		Cattle flows		Regional constant
	X^1_{11}	X^1_{12}	X^1_{21}	X^1_{22}	S^2_1	S^2_2	X^2_{11}	X^2_{12}	X^2_{21}	X^2_{22}	S^3_1	S^3_2	X^3_{11}	X^3_{12}	X^3_{21}	X^3_{22}	S^1_1	S^1_2	Z_{12}	Z_{21}	
u_1	1	1															$-a^1$				=0
u_2			1	1														$-a^1$			=0
u_3	-1		-1		1																$\leqslant 0$
u_4		-1		-1		1															$\leqslant 0$
u_5					$-a^2$		1	1													=0
u_6						$-a^2$			1	1											=0
u_7							-1		-1		1										$\leqslant 0$
u_8								-1		-1		1									$\leqslant 0$
u_9											a^3		-1	-1							=0
u_{10}												a^3			-1	-1					=0
u_{11}																	1		1	-1	$\leqslant Z_i$
u_{12}																		1	-1	1	$\leqslant Z_i$
u_{13}																	1				$-r^k_i$
u_{14}																		1			$\leqslant r^k_i$
u_{15}													1		1						$=D^k_i$
u_{16}														1		1					$=D^k_i$
Unit costs	T^1_{11}	T^1_{12}	T^1_{21}	T^1_{22}	C^2_1	C^2_2	T^2_{11}	T^2_{12}	T^2_{21}	T^2_{22}	C^3_1	C^3_2	T^3_{11}	T^3_{12}	T^3_{21}	T^3_{22}	C^1_1	C^1_2	t_{12}	t_{21}	

Table 2. Regional Demarcation

Regions	States	Demand and supply points (base points)
1	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont. .	Boston
2	New York	New York City
3	Delaware, New Jersey, the District of Columbia, Maryland, and Pennsylvania . .	Philadelphia
4	North Carolina, West Virginia, and Virginia	Richmond
5	Georgia and South Carolina	Atlanta
6	Florida	Orlando
7	Ohio	Columbus
8	Kentucky and Tennessee	Nashville
9	Mississippi and Alabama	Birmingham
10	Michigan	Detroit
11	Indiana	Indianapolis
12	Illinois	Chicago
13	Wisconsin	Milwaukee
14	Minnesota	Minneapolis-St. Paul
15	Iowa	Des Moines
16	Missouri	Columbia
17	Arkansas and Louisiana	Alexandria
18	North Dakota and South Dakota	Bismarck
19	Nebraska	Lincoln
20	Kansas	Kansas City
21	Oklahoma and Texas	Ft. Worth
22	Montana and Wyoming	Billings
23	Colorado	Denver
24	Arizona and New Mexico	Phoenix
25	Idaho, Nevada, and Utah	Salt Lake City
26	Washington and Oregon	Portland
27	California	Los Angeles

Table 3. Slaughter Capacity, 1967 Estimates, by Live Weight and Region

Region	Capacity, *lb.*	Region	Capacity, *lb.*
1	546,937,400	15	3,401,325,000
2	952,933,700	16	1,139,425,100
3	2,171,876,000	17	313,891,200
4	712,658,600	18	781,589,100
5	853,532,900	19	3,380,608,200
6	388,346,200	20	1,824,963,400
7	1,715,729,300	21	3,471,008,900
8	1,276,913,000	22	318,599,500
9	1,055,930,200	23	1,638,896,700
10	494,064,700	24	344,966,500
11	1,181,486,400	25	504,868,300
12	1,926,664,200	26	1,293,859,500
13	1,406,860,400	27	3,118,823,000
14	1,898,414,000		

Table 4. Construction Cost Indexes, by Region and Base Point, 1967

Region	Base point	Indexes			
		1941 = 100		Los Angeles, 1961 = 100	
		1961	1967	1961	1967
1	Boston	237.5	264.3	86.6	106.9
2	New York City	270.8	311.5	98.7	113.6
3	Philadelphia	265.4	290.4	96.8	105.9
4	Richmond	269.9	293.2	98.4	106.9
5	Atlanta	294.7	337.0	107.4	121.8
6	Orlando	259.1	284.7	94.5	103.8
7	Columbus	266.6	292.7	95.4	111.8
8	Nashville	239.1	268.7	92.5	100.5
9	Birmingham	249.9	273.9	91.9	99.9
10	Detroit	264.7	299.6	96.5	109.2
11	Indianapolis	270.9	301.4	98.7	109.8
12	Chicago	289.9	324.4	105.7	118.3
13	Milwaukee	237.5	264.3	87.5	107.5
14	Minneapolis-St. Paul	267.9	296.1	97.7	108.0
15	Des Moines	271.1	296.3	98.2	103.2
16	Columbia	256.9	291.9	93.7	106.4
17	Alexandria	239.1	268.7	92.5	100.5
18	Bismarck	268.7	294.2	97.1	102.1
19	Lincoln	264.6	294.9	96.5	107.5
20	Kansas City	237.1	262.6	86.4	95.7
21	Fort Worth	244.7	269.0	89.2	98.1
22	Billings	268.7	294.2	93.7	102.1
23	Denver	270.9	301.4	98.8	109.0
24	Phoenix	239.1	268.7	92.5	100.5
25	Salt Lake City	264.6	294.9	96.5	107.5
26	Portland	247.0	280.0	90.1	102.1
27	Los Angeles	274.3	306.7	100.0	111.8

Source: *Architectural Record* 144(6):79, 1968.

Table 5. Cost of the Land Area for Synthesized Beef-Slaughtering Plants, by Region, 1967

[197,530 square feet used for the land area][a]

	120 cattle per hour				
Region	Cost per sq. ft.[b]	Total cost, land area	Region	Cost per sq. ft.[b]	Total cost, land area
1	$.90	$177,777	15	$.40	$ 79,012
2	.90	181,728	16	.35	69,136
3	.75	148,148	17	.32	63,210
4	.46	90,864	18	.23	45,432
5	.44	86,913	19	.25	49,383
6	.35	69,136	20	.30	59,259
7	.70	138,271	21	.40	79,012
8	.32	63,210	22	.25	49,383
9	.32	63,210	23	.40	79,012
10	.75	148,148	24	.32	63,210
11	.70	138,271	25	.30	59,259
12	.80	158,024	26	.50	98,765
13	.50	98,765	27	.85	167,900
14	.50	98,765			

[a] Logan and King, Giannini Foundation Res. Rpt. No. 260, 1962, p. 67.
[b] Obtained from land values supplied by Chamber of Commerce offices located in various regional trading centers.

Table 6. Equipment and Depreciation Costs, 120 Cattle Per Hour, Beef Slaughtering Plant, 1967

Cost of equipment (based on manufacturing prices provided by the Albright-Neil Co. in Chicago, and from USDA Mktg. Res. Rpt. No. 657)	$519,288
Salvage value (derived from estimates given in USDA Mktg. Res. Rpt. No. 657)	35,788
Balance for depreciation (cost of equipment, minus salvage value)	483,500
Total depreciation per year (calculated by dividing the balance for the depreciation of each item by its estimated useful life, as given in USDA Mktg. Res. Rpt. No. 657)	62,800

Table 7. Estimated, Adjusted Regional Beef Demand, Retail Weight, Forty-Eight States, by Region, 1967

Region	Annual consumption per capita, *lb.*	Approximate population	Unadjusted beef consumption, *lb.*	Adjusted beef consumption, *lb.*[a]
1	87.88	11,321,000	994,889,000	805,860,000
2	89.44	18,335,000	1,639,882,000	1,328,305,000
3	86.84	23,647,000	2,053,505,000	1,663,339,000
4	78.52	11,358,000	891,830,000	722,382,000
5	77.48	7,114,000	551,193,000	446,466,000
6	81.64	5,996,000	489,513,000	396,506,000
7	101.92	10,462,000	1,084,633,000	878,552,000
8	78.00	7,079,000	552,162,000	447,251,000
9	73.84	5,888,000	434,770,000	352,164,000
10	102.44	8,584,000	879,345,000	712,269,000
11	101.92	4,999,000	509,498,000	412,693,000
12	103.48	10,894,000	1,127,311,000	913,122,000
13	102.08	4,188,000	427,511,000	346,284,000
14	101.92	3,582,000	365,077,000	295,713,000
15	101.61	2,753,000	279,732,000	226,583,000
16	101.40	4,605,000	466,947,000	378,227,000
17	76.44	5,629,000	430,281,000	348,527,000
18	99.84	1,313,000	131,090,000	106,183,000
19	101.56	1,435,000	145,739,000	118,048,000
20	101.45	2,275,000	230,799,000	186,947,000
21	94.64	13,369,000	1,265,242,000	1,024,856,000
22	95.68	1,016,000	97,211,000	78,751,000
23	97.14	1,975,000	191,852,000	155,400,000
24	94.12	2,638,000	248,289,000	201,114,000
25	95.68	2,165,000	207,147,000	167,789,000
26	99.32	5,088,000	505,340,000	409,326,000
27	100.36	19,163,000	1,923,199,000	1,557,791,000
		TOTAL. . . .	18,123,987,000	14,680,450,000

[a]Adjusted by the percentage of difference between the unadjusted beef consumption, column 4, and total commercial slaughter, Table 19.

Table 8. Estimated Truck-Rail Transport Rates for Slaughter Cattle, Forty-Eight States, by Region, 1967

Base point	Region													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	dollars per hundredweight													
Boston	0													
New York City	.84	0												
Philadelphia	.72	.64	0											
Richmond	1.12	.56	.49	0										
Atlanta	1.50	1.19	1.29	1.37	0									
Orlando	1.58	1.44	1.37	1.46	.79	0								
Columbus	1.50	1.12	1.05	1.06	1.13	1.34	0							
Nashville	1.54	1.45	1.33	1.44	.66	1.41	.79	0						
Birmingham	1.76	1.69	1.55	1.67	.96	1.42	1.30	.94	0					
Detroit	1.46	1.34	1.23	1.16	1.25	1.47	.40	1.12	1.40	0				
Indianapolis	1.86	1.46	1.34	1.17	1.10	1.32	.45	.57	1.20	.67	0			
Chicago	1.94	1.72	1.56	1.27	1.23	1.46	.74	.88	1.27	.65	.48	0		
Milwaukee	2.14	1.76	1.70	1.33	1.29	1.52	.90	1.12	1.33	.82	.66	.28	0	
Minneapolis	1.94	1.88	1.82	1.54	1.47	1.69	1.27	1.28	1.45	1.19	1.03	.70	.57	0
Des Moines	1.90	1.84	1.77	1.47	1.33	1.56	1.09	1.12	1.29	1.04	.85	.59	.61	.52
Columbia	1.88	1.87	1.73	1.38	1.16	1.41	.98	.94	1.12	1.13	.64	.62	.80	.80
Alexandria	1.08	1.77	1.66	1.78	1.32	1.52	1.41	1.40	.39	1.51	1.31	1.38	1.44	1.56
Bismark	2.03	2.03	1.90	1.65	1.57	1.84	1.67	1.39	1.53	1.65	1.46	1.03	.95	.46
Lincoln	1.97	1.91	1.84	1.55	1.42	1.65	1.34	1.22	1.32	1.31	1.02	.81	.84	.67
Kansas City	1.94	1.87	1.80	1.48	1.28	1.50	1.15	1.06	1.16	1.33	.83	.87	.96	.76
Ft. Worth	2.28	2.19	2.09	1.66	1.31	1.44	1.64	1.20	.96	2.31	1.43	1.48	2.00	1.56
Billings	2.22	2.15	2.08	2.09	1.98	2.22	1.80	1.86	1.93	1.80	1.72	1.56	1.54	1.32
Denver	2.24	2.17	2.09	1.87	1.71	1.91	1.85	1.54	1.55	1.90	1.76	1.74	1.75	1.29
Phoenix	2.47	2.39	2.30	2.27	1.98	2.10	2.02	1.88	1.72	2.08	1.91	1.94	1.99	2.10
Salt Lake City	2.32	2.26	2.17	2.16	2.03	2.22	1.88	1.86	1.85	1.88	1.80	1.71	1.72	1.69
Portland	2.76	2.69	2.60	2.60	2.48	2.66	2.34	2.33	2.35	2.34	2.24	2.18	2.14	2.20
Los Angeles	2.75	2.77	2.61	2.60	2.39	2.53	2.34	2.29	2.18	2.34	2.24	2.18	2.19	2.41

(cont'd)

Table 8. (Continued)

Base point	Region												
	15	16	17	18	19	20	21	22	23	24	25	26	27
	dollars per hundredweight												
Boston													
New York City													
Philadelphia													
Richmond													
Atlanta													
Orlando													
Columbus													
Nashville													
Birmingham													
Detroit													
Indianapolis													
Chicago													
Milwaukee													
Minneapolis													
Des Moines	0												
Columbia	.49	0											
Alexandria	1.36	1.19	0										
Bismark	.73	1.06	1.58	0									
Lincoln	.35	.79	1.38	.57	0								
Kansas City	.46	.34	1.23	.98	.46	0							
Ft. Worth	1.32	1.22	.97	1.52	1.25	1.13	0						
Billings	1.48	1.68	1.92	1.23	1.37	1.56	1.64	0					
Denver	1.14	1.19	1.55	1.16	1.02	1.07	1.16	1.05	0				
Phoenix	1.93	1.86	1.72	1.98	1.80	1.73	1.43	1.83	1.30	0			
Salt Lake City	1.56	1.70	1.85	1.51	1.45	1.58	1.57	1.16	1.00	1.23	0		
Portland	2.27	2.41	2.35	2.10	2.14	2.26	2.14	1.55	1.74	2.60	1.45	0	
Los Angeles	2.27	2.41	2.18	2.22	2.14	2.29	1.94	1.78	1.73	1.45	1.39	1.27	0

Source: North-Central Reg. Res. Bul. 159, and estimated function for regions where the base point had changed.

Table 9. Estimated Transportation Costs for Fresh Beef, Forty-Eight States, by Region, 1967

Regions of origin	Regions of destination													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	dollars per hundredweight													
1		.66♦	.78♦	1.04♦	1.44♦	1.63♦	1.22♦	1.50▲	1.53♦	1.19♦	1.35♦	1.39♦	1.46♦	1.64♦
2	.60●		.50●	1.00●	1.28♦	1.47♦	1.31●	1.52●	1.52▲	1.45●	1.52●	1.65●	1.74●	1.57♦
3	.74●	.36●		.84●	1.21♦	1.43♦	1.20●	1.67●	1.69●	1.35●	1.43●	1.56●	1.66●	1.52♦
4	1.08●	.79●	.65●		1.28●	1.59●	1.17●	1.40●	1.47●	1.39●	1.38●	1.60●	1.69●	1.02▲
5	1.50■	1.41●	1.21■	1.06●		1.14●	1.30●	.86●	.66●	1.41▲	1.25●	1.48●	1.58●	1.47♦
6	1.67♦	1.48♦	1.63●	1.39●	.92●		1.76●	1.46●	1.29●	1.51♦	1.53▲	1.60▲	1.55♦	1.70▲
7	1.36●	1.09●	.99●	.96●	1.08●	1.56●		1.09●	1.34●	.74●	.70●	1.03●	1.17●	1.48●
8	1.50♦	1.37■	1.47●	1.18●	.67●	1.24●	.88●		.77●	1.31●	.93●	1.17●	1.29●	1.67●
9	1.55♦	1.40■	1.49●	1.26●	.49●	1.07●	1.12●	.59●		1.54●	1.21●	1.43●	1.54●	1.58▲
10	1.27●	1.23●	1.13●	1.18●	1.31●	1.59■	.55●	1.09●	1.32●		.90●	.90●	1.04●	1.47●
11	1.56●	1.31●	1.21●	1.16●	1.03●	1.55●	.52●	.73●	1.00●	.70●		.73●	.90●	1.36●
12	1.28♦	1.44●	1.35●	1.39●	1.27●	1.50♦	.82●	.96●	1.22●	.70●	.55●		.50●	1.11●
13	1.52■	1.55●	1.45●	1.49●	1.38●	1.69▲	.95●	1.07●	1.33●	.83●	.70●	.36●		.97●
14	1.68♦	1.72▲	1.60■	1.57♦	1.53■	1.89▲	1.36●	1.47●	1.47♦	1.26●	1.15●	.90●	.78●	
15	1.66♦	1.70▲	1.50♦	1.54♦	1.50●	1.64♦	1.27●	1.20●	1.40●	1.16●	1.00●	.79●	.83●	.66●
16	1.63■	1.47♦	1.53▲	1.58●	1.25●	1.48♦	1.06●	.91●	1.14●	1.23●	.82●	.90●	.84●	1.21●
17	1.79▲	1.76●	1.58♦	1.42♦	.99●	1.20●	1.20♦	1.02●	.78●	1.43♦	1.36●	1.46▲	1.52▲	1.55♦
18	2.01♦	1.92♦	1.93●	1.88♦	1.85♦	2.14●	1.57♦	1.62♦	1.87●	1.50♦	1.35♦	1.45●	1.35●	.92●
19	1.88▲	1.71♦	1.72●	1.62♦	1.42♦	1.78♦	1.26♦	1.18♦	1.55●	1.39●	1.19●	1.06●	1.09●	.90●
20	1.72♦	1.62♦	1.55♦	1.52♦	1.27♦	1.71●	1.22●	1.09●	1.28●	1.12●	1.00●	1.02●	1.12●	.96●
21	2.04▲	1.92▲	1.78♦	1.66♦	1.40●	1.47♦	1.44♦	1.26●	1.22●	1.65▲	1.49●	1.34♦	1.41♦	1.36♦
22	1.26▲	1.21▲	2.16▲	2.18♦	2.07▲	2.45▲	1.89♦	1.84♦	2.01▲	1.78♦	1.95▲	1.58♦	1.67▲	1.26♦
23	2.12♦	2.08▲	2.03▲	2.03▲	1.76♦	2.04▲	1.70▲	1.55♦	1.73▲	1.72▲	1.49♦	1.38♦	1.43♦	1.28♦
24	2.46▲	2.35▲	2.35▲	2.33♦	2.00♦	2.18♦	2.07▲	1.99▲	1.94▲	2.10♦	1.97▲	1.92♦	2.04▲	1.87♦
25	2.37▲	2.32▲	2.27▲	2.29▲	2.12♦	2.29▲	1.92♦	2.02♦	1.97♦	1.95♦	1.94▲	3.11▲	1.83▲	1.76▲
26	2.65▲	2.61▲	2.57▲	2.60▲	2.48▲	3.62▲	2.36▲	2.36▲	2.40▲	2.35▲	2.32▲	2.21▲	2.14♦	1.96♦
27	2.66▲	2.60▲	2.56▲	2.50▲	2.24▲	2.32▲	2.25▲	2.20▲	2.16♦	2.35▲	2.25▲	2.23▲	2.23▲	2.19▲

(cont'd)

● Truck.
■ Iced railroad car.
▲ Mechanically refrigerated railroad car.
♦ Piggyback.

Table 9. (Continued)

Regions of origin	Regions of destination												
	15	16	17	18	19	20	21	22	23	24	25	26	27
	dollars per hundredweight												
1	1.62♦	1.55♦	1.64♦	1.74▲	1.70▲	1.68▲	1.74▲	.91▲	1.76▲	1.79▲	1.79▲	1.74▲	1.94▲
2	1.62▲	1.58▲	1.62♦	1.72▲	1.66♦	1.59♦	1.71▲	1.76▲	1.75▲	1.97▲	1.77▲	1.95▲	1.95▲
3	1.49♦	1.54▲	1.56♦	1.71▲	1.57♦	1.62▲	1.69▲	1.76▲	1.74▲	1.77▲	1.79▲	1.95▲	1.97▲
4	1.35♦	1.54▲	1.56▲	1.72▲	1.59♦	1.51♦	1.61▲	1.76▲	1.74▲	1.79▲	1.87▲	1.75▲	1.96▲
5	1.70●	1.46●	1.21●	1.70▲	1.56▲	1.30♦	1.61●	1.91♦	1.70♦	1.88♦	1.76▲	1.79▲	1.97▲
6	1.61♦	1.48♦	1.42●	1.76▲	1.69▲	1.57♦	1.46♦	1.77▲	1.74▲	2.01♦	2.12♦	2.44♦	2.15♦
7	1.48●	1.28●	1.50▲	1.55♦	1.65●	1.37▲	1.45♦	1.80♦	1.56♦	1.91♦	1.82♦	2.10♦	2.08♦
8	1.41●	1.13●	1.24●	1.59♦	1.61●	1.31●	1.47●	1.71▲	1.62▲	1.73▲	1.90♦	2.18♦	2.03♦
9	1.61●	1.35●	.99●	1.69▲	1.34♦	1.41▲	1.38▲	1.73▲	1.58♦	1.71▲	1.86♦	2.22♦	2.00♦
10	1.37●	1.44●	1.43♦	1.49♦	1.59●	1.55●	1.61▲	1.69▲	1.63▲	1.96♦	1.84♦	1.77▲	2.18♦
11	1.21●	1.03●	1.57●	1.75●	1.40●	1.22●	1.75●	1.63▲	1.54▲	1.81♦	1.79♦	2.15♦	2.08♦
12	1.00●	1.11●	1.71●	1.31♦	1.28●	1.24●	1.36♦	1.56♦	1.54▲	1.72▲	1.68▲	2.04♦	2.06♦
13	1.04●	1.05●	1.39♦	1.56●	1.30●	1.34●	1.42♦	1.61▲	1.43♦	1.74▲	1.68▲	1.76▲	2.06♦
14	.87●	1.42●	1.61▲	1.14●	1.11●	1.18●	1.50●	1.68●	1.48▲	1.71▲	1.62♦	1.73▲	1.96▲
15		.79●	1.32♦	1.45●	.74●	.78●	1.42●	1.41♦	1.45●	1.67▲	1.58▲	1.91♦	1.93♦
16	.60●		1.48●	1.39♦	.77●	.86●	1.23●	1.65▲	1.66●	1.69▲	1.67♦	2.02♦	1.90♦
17	1.30♦	1.27●		1.71▲	1.29♦	1.29●	1.01●	1.75▲	1.59♦	1.69▲	1.73▲	1.77▲	1.90♦
18	1.24●	1.38♦	1.85♦		1.37●	1.37●	1.60▲	1.19●	1.17●	1.69▲	1.39♦	1.57♦	1.79♦
19	.56●	.58●	1.25♦	1.34●		.77●	1.24●	1.34♦	1.01♦	1.67▲	1.40♦	1.84♦	1.83♦
20	.60●	.66●	1.25♦	1.22♦	.77●		.99♦	1.41♦	1.10♦	1.62▲	1.61▲	1.93♦	1.84♦
21	1.29●	1.21●	1.02●	1.63▲	1.22●	1.02●		1.68▲	1.26♦	1.42♦	1.60♦	2.06♦	1.67♦
22	1.40♦	1.76▲	2.04♦	.98●	1.32♦	1.40♦	1.83▲		1.17●	1.39♦	1.42●	1.35♦	1.67▲
23	1.24●	1.28♦	1.66♦	1.26●	1.07●	1.15●	1.38●	1.38●		1.29♦	1.25●	1.65▲	1.65▲
24	1.72♦	1.86▲	1.78♦	1.78♦	1.81▲	1.57♦	1.41♦	1.37♦	1.25♦		1.16♦	1.64♦	.92♦
25	1.45♦	1.72♦	1.95♦	1.37♦	1.38♦	1.66▲	1.63♦	1.20●	1.04●	1.11♦		1.48▲	1.22♦
26	2.04♦	2.19♦	2.39▲	1.60♦	1.94♦	2.07♦	2.23▲	1.33♦	1.65♦	1.68♦	1.27●		1.59●
27	2.06♦	2.02♦	2.06♦	1.87♦	1.93♦	1.94♦	1.72♦	1.71♦	1.64♦	.88●	1.32●	1.60●	

● Truck.
■ Iced railroad car.
▲ Mechanically refrigerated railroad car.
♦ Piggyback.

Source: Estimated by fitting a square-root function to samples of data obtained from Armour and Company, Transportation and Distribution Department, Chicago.

Table 10. Optimum, Interregional Flow and Price Differentials of Slaughter Cattle, Forty-Eight States, by Region, 1967, Model I

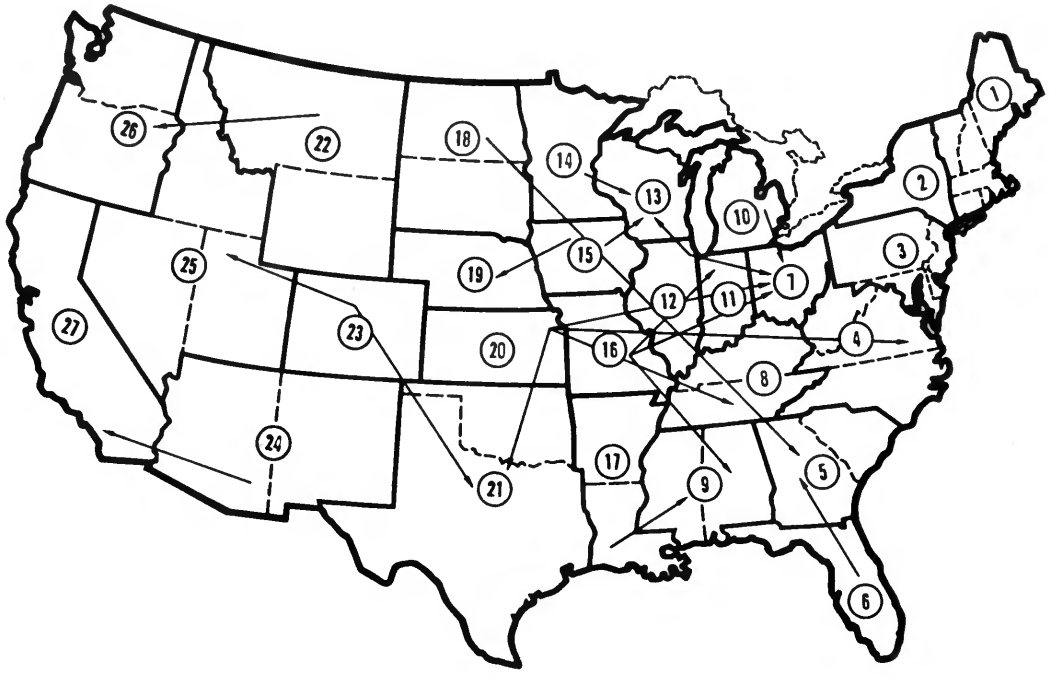
Regions of origin	Regions of destination						
	4	5	7	8	9	11	13
	thousand pounds						
6	...	87,805	...	...	...	...	...
10	...	...	192,014	...	...	...	...
12	...	...	126,797	...	...	...	38,602
14	...	...	...	...	...	...	35,386
15	...	...	...	...	...	...	193,900
16	...	...	217,610	...	45,873	148,159	...
17	...	...	...	...	287,288	...	...
18	...	268,940	...	...	...	...	...
20	296,710	...	222,428	589,372	...	...	...
22	...	...	...	...	...	...	...
23	...	...	...	...	...	...	...
24	...	...	...	...	...	...	...
Excess demand	296,710	356,745	758,849	589,372	333,161	148,159	267,888
V_j (cost/cwt.)	$1.48	$1.50	$1.15	$1.06	$1.29	$ .81	$ .69

(cont'd)

Table 10. (Continued)

Regions of origin	Regions of destination					Excess supply	U_i (cost/cwt.)
	19	21	25	26	27		
	thousand pounds						
6	...	...	...	...	...	87,805	$.71
10	...	...	...	...	...	192,014	.75
12	...	...	...	...	...	165,399	.41
14	...	...	...	...	...	35,386	.12
15	137,317	...	...	...	...	331,217	.08
16	...	...	...	...	...	411,642	.19
17	...	...	...	...	...	287,288	.90
18	...	...	...	...	...	268,990	-.01
20	...	459,334	...	...	...	1,567,844	.00
22	...	...	...	133,007	...	133,007	-.13
23	...	436,294	107,058	...	...	543,352	-.03
24	...	...	...	...	515,063	515,063	.03
Excess demand	137,317	895,628	107,058	133,007	515,063		
V_j (cost/cwt.)	$.43	$1.13	$.97	$1.42	$1.48		

Total shipments: 4.54 billion pounds.



Region			Region			Region			Region			Region		
From	To	Amount, *lb.*	From	To	Amount, *lb.*	From	To	Amount, *lb.*	From	To	Amount, *lb.*	From	To	Amount, *lb.*
20	4	296,710,000	12	7	126,797,000	16	9	45,873,000	14	13	35,386,000	23	21	436,294,000
6	5	87,805,000	16	7	217,610,000	17	9	287,288,000	15	13	193,900,000	23	25	107,058,000
18	5	268,940,000	20	7	222,428,000	16	11	148,159,000	15	19	137,317,000	22	26	133,007,000
10	7	192,014,000	20	8	589,372,000	12	13	38,602,000	20	21	459,334,000	24	27	515,063,000

Optimum, interregional flow of slaughter cattle, Model I, 1967 (see Table 10). **(Figure 2)**

Table 11. Estimated Commercial Slaughter Cattle Production, Reported Commercial Cattle Slaughter, and Estimated Surplus and Deficit Supply Regions, Forty-Eight States, by Region, 1967

Region	Estimated commercial cattle slaughter	Reported commercial cattle slaughter[a]	Surplus (+) or deficit (-) slaughter cattle supply[b]
		pounds	
1	214,063,000	188,945,000	...
2	387,782,000	420,474,000	...
3	586,976,000	1,463,858,000	...
4	415,948,000	410,298,000	- 296,710,000
5	171,844,000	364,082,000	- 356,745,000
6	476,151,000	375,936,000	+ 87,805,000
7	956,881,000	1,262,395,000	- 758,849,000
8	687,541,000	755,358,000	- 589,372,000
9	676,664,000	544,113,000	- 333,161,000
10	686,079,000	718,215,000	+ 192,014,000
11	1,033,327,000	632,549,000	- 148,159,000
12	2,092,063,000	1,501,724,000	+ 165,399,000
13	1,138,973,000	1,305,456,000	- 267,888,000
14	2,055,298,000	2,019,845,000	+ 35,386,000
15	4,807,361,000	4,477,869,000	+ 331,217,000
16	1,953,284,000	1,541,651,000	+ 411,642,000
17	601,179,000	276,661,000	+ 287,288,000
18	1,242,854,000	973,499,000	+ 268,990,000
19	3,632,061,000	3,770,412,000	- 137,317,000
20	3,392,808,000	1,675,104,000	+1,567,844,000
21	1,511,233,000	2,739,637,000	- 895,628,000
22	512,376,000	277,577,000	+ 133,007,000
23	2,182,254,000	1,624,609,000	+ 543,352,000
24	860,030,000	512,363,000	+ 515,063,000
25	430,035,000	643,579,000	- 107,058,000
26	339,215,000	901,841,000	- 133,007,000
27	1,493,410,000	3,159,640,000	- 515,063,000
TOTAL.....	34,537,690,000	34,537,690,000	

[a]Livestock and meat statistics, supplement for 1967 to USDA Stat. Bul. 333, p. 99.
[b]Surplus slaughter cattle supply after regional slaughter capacity was fully utilized.

Table 12. Optimum, Interregional Flow and Price Differentials, Retail Cuts of Beef, Forty-Eight States, 1967, Model I

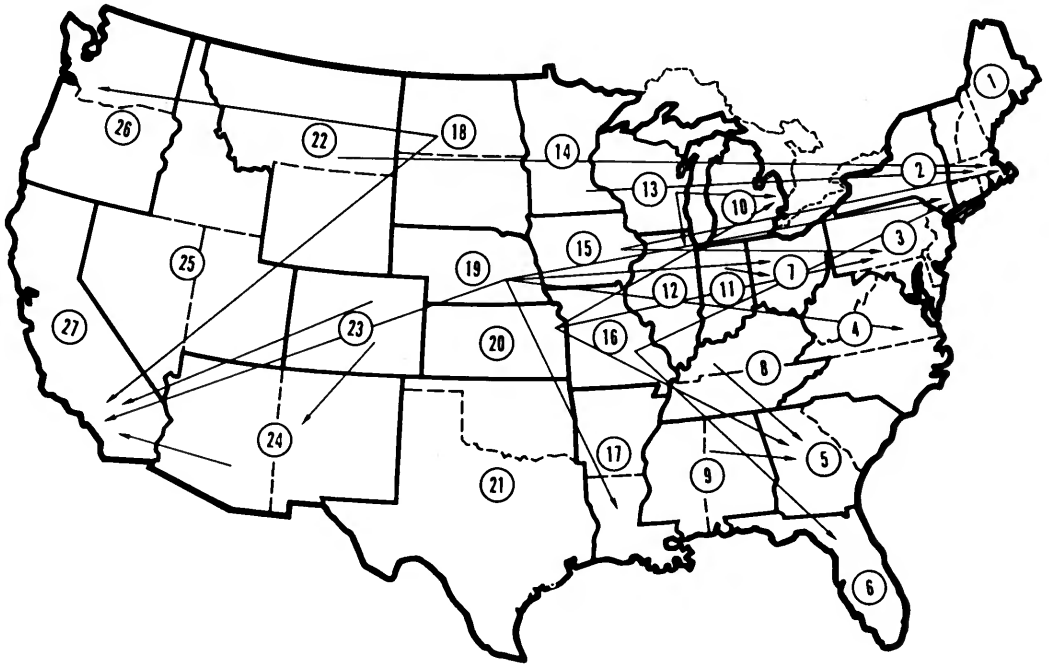
Regions of origin	Regions of destination						
	1	2	3	4	5	6	7
	thousand pounds						
8	...	...	...	...	96,465	...	...
9	...	...	...	...	77,825	...	...
11	...	...	...	...	...	...	90,390
13	...	...	...	...	...	...	...
14	564,376	...	...	...	...	...	...
15	93,424	...	1,212,216	...	...	...	...
16	...	47,066	...	...	...	231,146	...
18	...	...	...	...	...	...	...
19	...	1,116,119	...	45,187	...	...	57,596
20	...	...	201,186	...	47,078	...	...
22	56,910	...	...	...	...	...	...
23	...	...	...	...	...	...	...
25	...	...	...	...	...	...	...
Excess demand	714,710	1,163,185	1,413,402	45,187	221,368	231,146	147,986
V_j (cost/cwt.)	$1.71	$1.56	$1.55	$1.47	$1.27	$1.57	$1.11

(cont'd)

Table 12. (Continued)

Regions of origin	Regions of destination						Excess supply	U_i (cost/cwt.)
	10	12	17	24	26	27		
	thousand pounds							
8	...	...	...	...	...	...	96,465	$.52
9	...	...	...	...	...	...	77,825	.78
11	...	...	...	...	...	...	90,390	.59
13	160,026	92,738	...	...	...	...	252,764	.29
14	...	...	...	...	...	...	564,376	.03
15	...	...	...	...	...	...	1,305,640	.05
16	...	...	...	...	...	...	278,212	.20
18	...	...	...	...	208,251	100,240	308,491	-.11
19	...	...	214,870	...	...	53,198	1,486,971	-.15
20	341,868	...	...	...	...	...	590,132	.00
22	...	...	...	...	...	...	56,910	.45
23	...	...	...	54,225	...	488,226	542,451	.03
25	...	...	...	...	...	60,908	60,906	.46
Excess demand	501,894	92,738	214,870	54,225	208,251	702,572		
V_j (cost/cwt.)	$1.12	$.65	$1.10	$1.32	$1.46	$1.68		

Total shipments: 5.71 billion pounds.



Region From	Region To	Amount, *lb.*	Region From	Region To	Amount, *lb.*	Region From	Region To	Amount, *lb.*	Region From	Region To	Amount, *lb.*	Region From	Region To	Amount, *lb.*
14	1	564,376,000	15	3	1,212,216,000	20	5	47,078,000	20	10	341,868,000	18	27	100,240,000
15	1	93,424,000	20	3	201,186,000	16	6	231,146,000	13	12	92,738,000	19	27	53,198,000
22	1	56,910,000	19	4	45,187,000	11	7	90,390,000	19	17	214,870,000	23	27	488,226,000
16	2	47,066,000	8	5	96,465,000	19	7	57,596,000	23	24	54,225,000	24	27	60,908,000
19	2	1,116,119,000	9	5	77,825,000	13	10	160,026,000	18	26	208,251,000			

Optimum, interregional flow of retail cuts of beef, Model I, 1967 (see Table 12). **(Figure 3)**

Table 13. Optimum, Interregional Shipments of Retail Beef, Forty-Eight States, 1967, by Transportation Mode, Model I

Region		Mode of transportation		
Origin	Destination	Piggyback railroad car	Truck	Mechanically refrigerated railroad car
			pounds	
14	1	564,376,000		
15	1	93,424,000		
22	1			56,910,000
16	2	47,066,000		
19	2	1,116,119,000		
15	3	1,212,216,000		
20	3	201,186,000		
19	4	45,187,000		
8	5		96,465,000	
9	5		77,825,000	
20	5	47,078,000		
16	6	231,146,000		
11	7		90,390,000	
19	7	57,596,000		
13	10		160,026,000	
20	10		341,868,000	
13	12		92,738,000	
19	17	214,870,000		
23	24	54,225,000		
18	26	208,251,000		
18	27	100,240,000		
19	27	53,198,000		
23	27			488,226,000
25	27	60,908,000		
TOTAL		4,307,087,000	859,312,000	545,136,000
PERCENTAGE OF TOTAL, INTERREGIONAL SHIPMENTS		75	15	10

Table 14. Estimated Surplus and Deficit Beef Regions, Forty-Eight States, by Region, Retail-Weight Basis, 1967

Region	Surplus (+) or deficit (-) retail beef supply, *lb.*	Region	Surplus (+) or deficit (-) retail beef supply, *lb.*
1	- 714,710,000	14	+ 564,376,000
2	-1,163,185,000	15	+1,305,640,000
3	-1,413,402,000	16	+ 278,212,000
4	- 45,187,000	17	- 214,870,000
5	- 221,368,000	18	+ 308,491,000
6	- 231,146,000	19	+1,486,971,000
7	- 147,986,000	20	+ 590,132,000
8	+ 96,465,000	22	+ 56,910,000
9	+ 77,825,000	23	+ 542,451,000
10	- 501,894,000	24	- 54,225,000
11	+ 90,390,000	25	+ 60,908,000
12	- 92,738,000	26	- 208,251,000
13	+ 252,764,000	27	- 702,572,000

Note: Region 21 was self-sufficient.

Table 15. Optimum Cattle Slaughter and Excess Capacity, Forty-Eight States, by Region, 1967, Model I

Region	Optimum cattle slaughter (live weight)	Reported commercial cattle slaughter[a]	Excess capacity	Capacity utilized
		pounds		*percent*
1	214,063,000	188,945,000	335,874,000	39
2	387,782,000	420,747,000	565,192,000	41
3	586,976,000	1,463,858,000	1,584,900,000	27
4	712,658,000	410,298,000	...	100
5	528,589,000	364,082,000	324,890,000	62
6	388,346,000	375,936,000	...	100
7	1,715,730,000	1,262,395,000	...	100
8	1,276,913,000	755,358,000	...	100
9	1,009,825,000	544,113,000	46,105,000	96
10	494,065,000	718,215,000	...	100
11	1,181,486,000	632,549,000	...	100
12	1,926,664,000	1,501,724,000	...	100
13	1,406,861,000	1,305,456,000	...	100
14	2,019,912,000	2,019,845,000	...	100
15	4,476,144,000	4,477,869,000	...	100
16	1,541,642,000	1,541,651,000	...	100
17	313,891,000	276,661,000	...	100
18	973,864,000	973,499,000	...	100
19	3,769,378,000	3,770,412,000	...	100
20	1,824,964,000	1,675,104,000	...	100
21	2,406,861,000	2,739,637,000	1,064,142,000	69
22	379,369,000	277,577,000	...	100
23	1,638,902,000	1,624,609,000	...	100
24	344,967,000	512,363,000	...	100
25	537,093,000	643,579,000	...	100
26	472,222,000	901,841,000	821,637,000	36
27	2,008,473,000	3,159,640,000	1,150,894,000	64

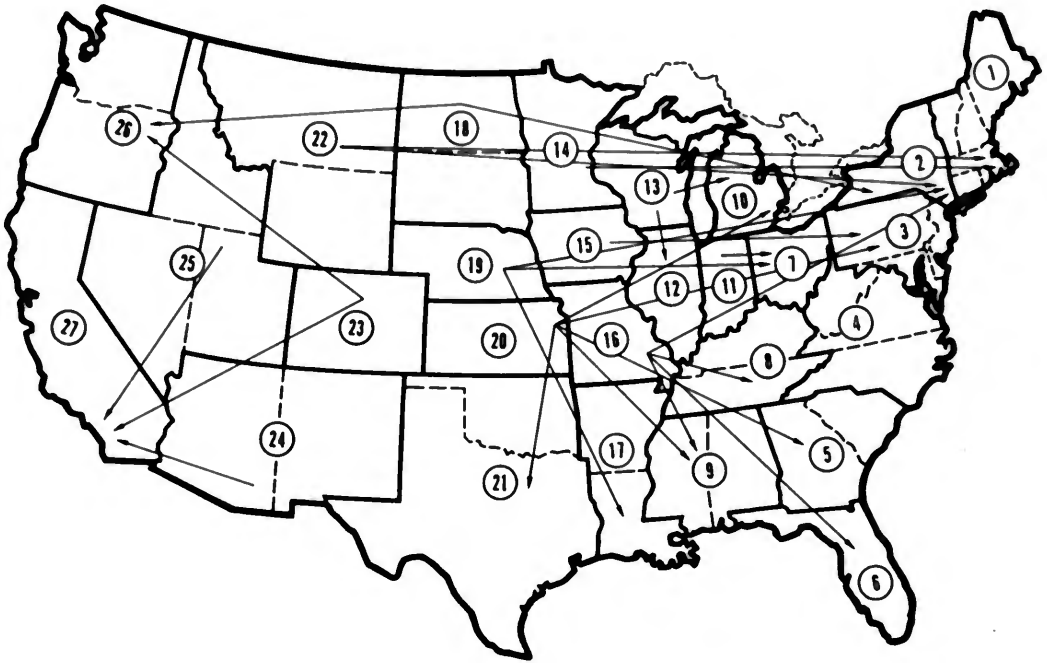
[a]Livestock and meat statistics, supplement for 1967 to USDA Stat. Bul. 333, p. 99.

Table 16. Estimated, Optimum Regional Processing of Primal and Retail Cuts of Beef, Forty-Eight States, by Region, 1967, Model I

Region	Primal cuts	Retail cuts
	pounds	
1	125,227,000	102,185,000
2	226,852,000	185,112,000
3	343,381,000	280,199,000
4	416,905,000	759,187,000
5	309,256,000	252,353,000
6	227,182,000	185,381,000
7	1,003,702,000	819,020,000
8	746,994,000	609,547,000
9	590,747,000	482,050,000
10	289,028,000	235,847,000
11	691,170,000	563,994,000
12	1,127,098,000	919,712,000
13	823,013,000	671,579,000
14	1,181,649,000	964,225,000
15	2,618,544,000	1,717,739,000
16	901,861,000	735,918,000
17	183,626,000	149,839,000
18	569,708,000	464,882,000
19	2,205,085,000	1,799,349,000
20	1,067,604,000	871,164,000
21	1,408,017,000	1,148,942,000
22	186,381,000	152,087,000
23	958,754,000	782,344,000
24	201,805,000	164,673,000
25	314,199,000	256,387,000
26	276,250,000	225,420,000
27	1,174,957,000	258,765,000

Table 17. Rents for Slaughtering, Forty-Eight States, by Region, 1967, Model I

Region	Rent (per cwt.)	Region	Rent (per cwt.)
4	$.08	16	$ .68
6	.90	17	.55
7	.13	18	.87
8	.14	19	.31
10	.54	20	.79
11	.26	22	1.16
12	.66	23	.86
13	.23	24	1.38
14	.70	25	.05
15	.76		



Region From	Region To	Amount, *lb.*	Region From	Region To	Amount, *lb.*	Region From	Region To	Amount, *lb.*	Region From	Region To	Amount, *lb.*	Region From	Region To	Amount, *lb.*
14	1	579,444,000	22	2	4,154,000	11	7	27,302,000	13	10	116,386,000	18	26	258,422,000
22	1	135,268,000	15	3	1,275,146,000	19	7	443,805,000	20	10	303,748,000	23	26	6,464,000
16	2	102,268,000	20	3	138,256,000	16	8	154,493,000	13	12	22,311,000	23	27	741,476,000
18	2	164,608,000	20	5	373,294,000	16	9	2,972,000	19	17	92,542,000	24	27	165,091,000
19	2	892,154,000	16	6	193,758,000	20	9	61,065,000	20	21	381,365,000	25	27	15,322,000

Optimum, interregional flow of retail cuts of beef, Model I-A, 1967 (see Table 18). **(Figure 4)**

Table 18. Optimum, Interregional Flow and Price Differentials, Retail Cuts of Beef, Forty-Eight States, 1967, Model I-A

Regions of origin	Regions of destination							
	1	2	3	5	6	7	8	9
	thousand pounds							
11	...	...	...	...	...	27,302	...	...
13	...	...	...	...	...	...	...	...
14	579,444	...	...	...	...	...	...	...
15	...	...	1,275,146	...	...	...	...	...
16	...	102,268	...	...	193,758	...	154,493	2,972
18	...	164,608	...	...	...	...	...	...
19	...	892,154	...	...	...	443,805	...	...
20	...	...	138,256	373,294	...	...	...	61,065
22	135,268	4,154	...	...	...	...	...	...
23	...	...	...	...	...	...	...	...
24	...	...	...	...	...	...	...	...
25	...	...	...	...	...	...	...	...
Excess demand	714,712	1,163,184	1,413,402	373,294	193,758	471,107	154,493	64,037
V_j (cost/cwt.)	$1.42	$1.61	$1.55	$1.27	$1.62	$1.16	$1.05	$1.28

(cont'd)

Table 18. (Continued)

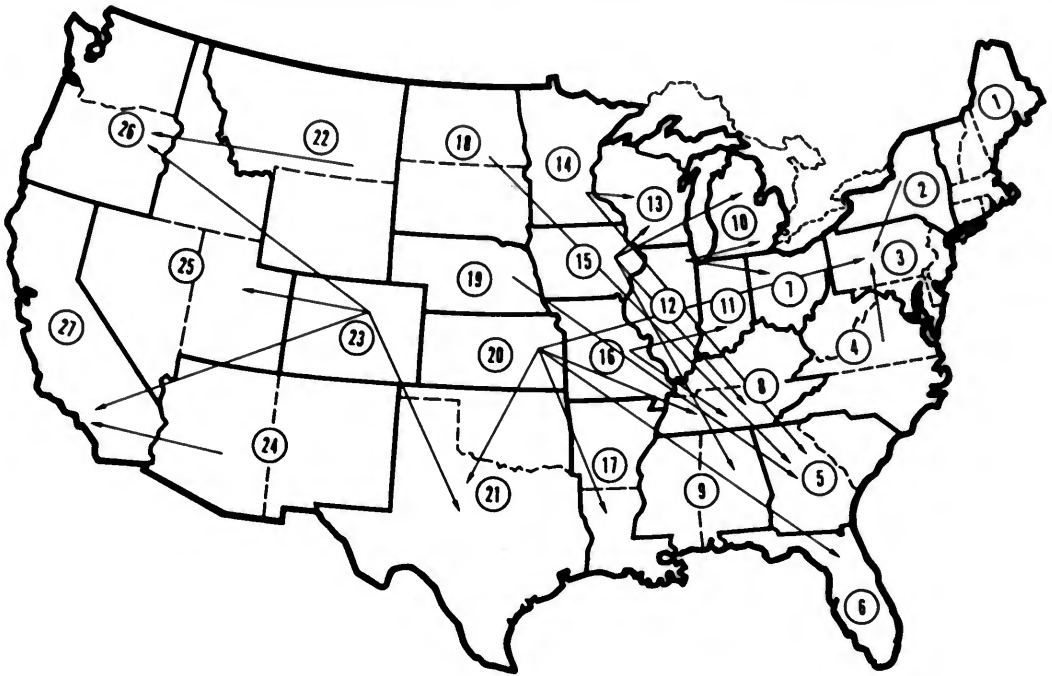
Regions of origin	Regions of destination						Excess supply	U_i (cost/cwt.)
	10	12	17	21	26	27		
	thousand pounds							
11	...	...	...	...	...	...	27,302	$.64
13	116,386	22,311	...	...	...	...	138,697	.29
14	...	...	...	...	...	...	579,444	-.02
15	...	...	...	...	...	...	1,275,146	.05
16	...	...	...	...	...	...	453,491	.14
18	...	...	...	...	258,422	...	423,030	-.31
19	...	...	92,542	...	...	...	1,428,502	-.10
20	303,748	...	...	381,365	...	...	1,257,728	0
22	...	...	...	...	...	...	139,422	.40
23	...	...	...	...	6,464	741,476	747,940	-.39
24	...	...	...	...	...	165,091	165,091	.34
25	...	...	...	...	...	15,322	15,322	.04
Excess demand	420,134	22,311	92,542	381,365	264,886	921,889		
V_j (cost/cwt.)	$1.12	$.65	$1.15	$.99	$1.26	$1.26		

Total shipments: 6.65 billion pounds.

Table 19. Optimum, Regional Levels of Cattle Slaughtering for Models I and I-A and Reported Regional Cattle Slaughter, Forty-Eight States, by Region, 1967

Region	Cattle slaughter, Model I	Cattle slaughter, Model I-A	Reported commercial cattle slaughter[a]
		pounds	
1	214,063,000	214,063,000	188,945,000
2	387,782,000	387,782,000	420,747,000
3	586,976,000	586,976,000	1,463,858,000
4	712,658,000	415,948,000	410,289,000
5	528,589,000	117,844,000	364,082,000
6	388,346,000	476,151,000	375,936,000
7	1,715,730,000	956,881,000	1,262,395,000
8	1,276,913,000	687,541,000	755,358,000
9	1,009,825,000	676,664,000	544,113,000
10	494,065,000	686,079,000	718,215,000
11	1,181,486,000	1,033,327,000	632,549,000
12	1,926,664,000	2,092,063,000	1,501,724,000
13	1,406,861,000	1,138,973,000	1,305,456,000
14	2,019,912,000	2,055,298,000	2,019,845,000
15	4,476,144,000	4,807,361,000	4,477,869,000
16	1,541,642,000	1,953,284,000	1,541,651,000
17	313,891,000	601,179,000	276,661,000
18	973,864,000	1,242,854,000	973,499,000
19	3,769,378,000	3,632,061,000	3,770,412,000
20	1,824,964,000	3,392,808,000	1,675,104,000
21	2,406,867,000	1,511,233,000	2,739,637,000
22	379,369,000	512,376,000	277,577,000
23	1,638,902,000	2,121,485,000	1,624,609,000
24	344,967,000	860,030,000	512,363,000
25	537,093,000	430,035,000	643,579,000
26	472,222,000	339,215,000	901,841,000
27	2,008,473,000	1,493,410,000	3,159,640,000

[a] Livestock and meat statistics, supplement for 1967 to USDA Stat. Bul. 333, p. 99.



Region			Region			Region			Region			Region		
From	To	Amount, *lb.*	From	To	Amount, *lb.*	From	To	Amount, *lb.*	From	To	Amount, *lb.*	From	To	Amount, *lb.*
2	3	306,475,000	19	5	56,000,000	20	8	48,177,000	14	13	782,823,000	23	25	194,000,000
4	3	405,766,000	20	6	311,000,000	15	9	611,000,000	15	13	127,177,000	22	26	434,000,000
20	3	108,766,000	12	7	836,000,000	12	10	378,000,000	20	17	136,000,000	23	26	102,056,000
14	5	387,177,000	15	8	338,223,000	15	10	144,000,000	20	21	665,056,000	23	27	98,000,000
18	5	114,823,000	16	8	368,000,000	16	11	15,000,000	23	21	433,944,000	24	27	117,000,000

Optimum, interregional flow of slaughter cattle, Model II, 1975 (see Table 20). **(Figure 5)**

Table 20. Optimum, Interregional Flow and Price Differentials, Slaughter Cattle, Forty-Eight States, by Region, 1975, Model II

Regions of origin	Regions of destination							
	3	5	6	7	8	9	10	11
	thousand pounds							
2	306,475	...	...	...	...	...	...	...
4	405,766	...	...	...	...	...	...	...
12	...	...	...	836,000	...	...	378,000	...
14	...	387,177	...	...	...	...	...	...
15	...	...	...	...	338,223	611,000	144,000	...
16	...	...	...	...	368,000	...	...	15,000
18	...	114,823	...	...	...	...	...	...
19	...	56,000	...	...	...	...	...	...
20	108,766	...	311,000	...	48,177	...	...	...
22	...	...	...	...	...	...	...	...
23	...	...	...	...	...	...	...	...
24	...	...	...	...	...	...	...	...
Excess demand	821,007	558,000	311,000	836,000	754,400	611,000	522,000	15,000
V_j (cost/cwt.)	$1.97	$1.45	$1.50	$1.07	$1.06	$1.23	$.98	$.76

(cont'd)

Table 20. (Continued)

Regions of origin	Regions of destination						Excess supply	U_i (cost/cwt.)
	13	17	21	25	26	27		
	thousand pounds							
2	...	...	...	...	...	...	306,475	$1.33
4	...	...	...	...	...	...	405,766	1.48
12	...	...	...	...	...	...	1,214,000	.33
14	782,823	...	...	...	...	...	1,170,000	-.02
15	127,177	...	...	...	...	...	1,220,400	-.06
16	...	...	...	...	...	...	383,000	.12
18	...	...	...	...	...	...	114,823	-.12
19	...	...	...	...	...	...	56,000	.03
20	...	136,000	665,056	...	...	...	1,268,999	0
22	...	...	...	...	434,000	...	434,000	.16
23	...	...	433,944	194,000	102,056	98,000	828,000	-.03
24	...	...	...	...	...	117,000	117,000	.29
Excess demand	910,000	136,000	1,099,000	194,000	536,056	215,000		
V_j (cost/cwt.)	$.55	$1.23	$1.13	$.97	$1.71	$1.70		

Total shipments: 7.52 billion pounds.

Table 21. Optimum, Interregional Flow and Price Differentials for Retail Cuts of Beef, Forty-Eight States, 1975, Model II

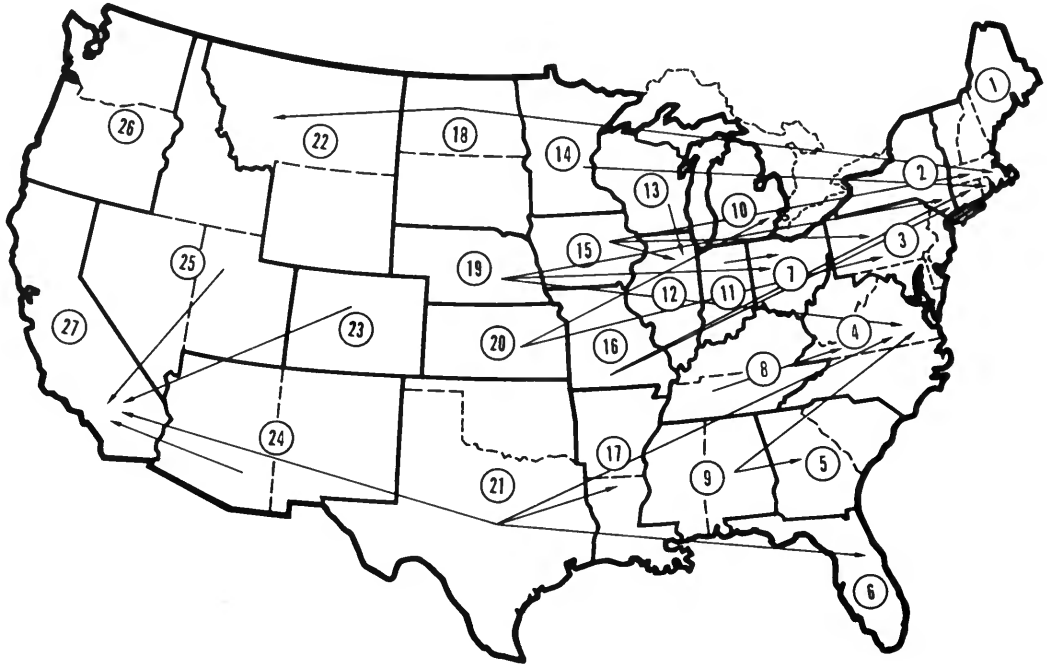
Regions of origin	Regions of destination						
	1	2	3	4	5	6	7
	thousand pounds						
8	...	...	...	147,896	...	...	...
9	...	...	...	173,789	10,196	...	...
11	...	...	...	...	...	...	46,106
13	...	...	...	...	...	...	...
14	378,128	...	...	...	...	...	...
15	149,266	...	1,318,711	...	...	...	...
16	90,677	182,100	....	...	...	...	...
18	210,605	...	...	...	...	...	...
19	...	1,173,492	...	40	...	...	125,345
20	...	...	201,293	...	...	...	...
21	...	...	...	24,822	...	206,527	...
23	...	...	...	...	...	...	...
24	...	...	...	...	...	...	...
25	...	...	...	...	...	...	...
Excess demand	828,676	1,355,592	1,520,004	346,547	10,196	206,527	171,451
V_j (cost/cwt.)	$1.71	$1.55	$1.55	$1.46	$.69	$1.27	$1.10

(cont'd)

Table 21. (Continued)

Regions of origin	Regions of destination					Excess supply	U_i (cost/cwt.)
	10	12	17	22	27		
	thousand pounds						
8	...	...	...	...	...	147,896	$.28
9	...	...	...	...	...	183,985	.20
11	...	...	...	...	...	46,106	.58
13	...	282,048	...	...	...	282,048	.48
14	...	...	...	...	...	378,128	.03
15	...	20,534	...	...	...	1,488,511	.05
16	...	...	...	...	...	272,777	.08
18	...	...	...	6,149	...	216,754	-.30
19	...	...	...	...	...	1,298,877	-.16
20	342,106	...	...	...	...	543,399	0
21	...	...	105,728	...	158,829	495,906	-.20
23	...	...	...	...	328,966	328,966	-.18
24	...	...	...	...	146,405	146,405	.55
25	...	...	...	...	141,024	141,024	.25
Excess demand	342,106	302,582	105,728	6,149	775,224		
V_j (cost/cwt.)	$1.12	$.84	$.82	$.89	$1.47		

Total shipments: 5.97 billion pounds



Region			Region			Region			Region			Region		
From	To	Amount, *lb.*	From	To	Amount, *lb.*	From	To	Amount, *lb.*	From	To	Amount, *lb.*	From	To	Amount, *lb.*
14	1	378,128,000	19	2	1,173,492,000	19	4	40,000	19	7	125,345,000	18	22	6,149,000
15	1	149,266,000	15	3	1,318,711,000	21	4	24,822,000	20	10	342,106,000	21	27	158,829,000
16	1	90,677,000	20	3	201,293,000	9	5	10,196,000	13	12	282,048,000	23	27	328,966,000
18	1	210,605,000	8	4	147,896,000	21	6	206,527,000	15	12	20,534,000	24	27	146,405,000
16	2	182,100,000	9	4	173,789,000	11	7	46,106,000	21	17	105,728,000	25	27	141,024,000

Optimum, interregional flow of retail cuts of beef, Model II, 1975 (see Table 21). **(Figure 6)**

Table 22. Optimum, Interregional Shipments of Retail Beef, Forty-Eight States, by Transportation Mode and Region, 1975, Model II

Regions		Mode of transportation			
Origin	Destination	Piggyback	Truck	Mechanically refrigerated railroad car	Iced railroad car
		thousand pounds			
14	1	378,128			
15	1	149,266			
16	1				90,677
18	1	210,605			
16	2	182,100			
19	2	1,173,492			
15	3	1,318,711			
20	3	201,293			
8	4		147,896		
9	4		173,789		
19	4	40			
21	4	24,822			
9	5		10,196		
21	6	206,527			
11	7		46,106		
19	7	125,345			
20	10		342,106		
13	12		282,048		
15	12		20,534		
21	17		105,728		
18	22		6,149		
21	27	158,829			
23	27			328,966	
24	27	146,405			
25	27	141,024			
TOTAL		4,416,587	1,134,551	328,966	90,677
PERCENTAGE OF TOTAL INTERREGIONAL SHIPMENTS		74	19	6	1

Table 23. Estimated Surplus and Deficit Supply Regions and Quantities for Slaughter Cattle and Retail Cuts of Beef, Forty-Eight States, by Region, 1975, Model II

Region	Surplus (+) or deficit (-) slaughter cattle supply[a]	Surplus (+) or deficit (-) retail beef supply
	pounds	
1	...[b]	- 828,676,000
2	+ 306,475,000	- 1,355,592,000
3	- 821,007,000	- 1,520,004,000
4	+ 405,766,000	- 346,547,000
5	- 558,000,000	- 10,196,000
6	- 311,000,000	- 206,527,000
7	- 836,000,000	- 171,451,000
8	- 754,400,000	+ 147,896,000
9	- 611,000,000	+ 183,995,000
10	- 522,000,000	- 342,106,000
11	- 15,000,000	+ 46,106,000
12	+1,214,000,000	- 302,582,000
13	- 910,000,000	+ 282,048,000
14	+1,170,000,000	+ 378,128,000
15	+1,220,400,000	+1,488,511,000
16	+ 383,000,000	+ 272,777,000
17	- 136,000,000	- 105,728,000
18	+ 114,823,000	+ 216,754,000
19	+ 56,000,000	+1,298,877,000
20	+1,268,999,000	+ 543,399,000
21	- 1,099,000,000	+ 495,906,000
22	+ 434,000,000	- 6,149,000
23	+ 828,000,000	+ 328,966,000
24	+ 117,000,000	+ 146,405,000
25	- 194,000,000	+ 141,024,000
26	- 536,056,000	...[b]
27	- 215,000,000	- 775,224,000

[a]Surplus cattle supply is created after the existing slaughter capacity is fully used.
[b]A self-sufficient region.

Table 24. Estimated, Regional Cattle Slaughter, Excess Capacity, and Rents, Forty-Eight States, by Region, 1975, Model II

Region	Cattle slaughter, *lb.*	Capacity used, *pct.*	Rent per cwt.
1	173,000,000	35	$ ...
2	95,625,000	100	.56
3	1,506,908,000	80	...
4	600,000,000	100	.56
5	750,000,000	100	.28
6	500,000,000	100	.47
7	1,750,000,000	100	.66
8	1,200,000,000	100	.49
9	1,000,000,000	100	.30
10	850,000,000	100	.77
11	1,100,000,000	100	.79
12	1,700,000,000	100	1.28
13	1,500,000,000	100	.91
14	1,600,000,000	100	1.31
15	4,000,000,000	100	1.36
16	1,500,000,000	100	1.27
17	400,000,000	100	.51
18	700,000,000	100	1.30
19	3,300,000,000	100	1.17
20	1,700,000,000	100	1.26
21	3,200,000,000	100	.11
22	200,000,000	100	1.53
23	1,250,000,000	100	1.22
24	900,000,000	100	1.30
25	750,000,000	100	.42
26	1,119,056,000	90	...
27	3,200,000,000	100	.14

Table 25. Estimated, Regional Processing of Primal and Retail Cuts of Beef, Forty-Eight States, by Region, 1975, Model II

Region	Primal-cut processing	Retail-cut processing
	pounds	
1	101,205,000	82,584,000
2	55,941,000	45,648,000
3	817,913,000	667,417,000
4	351,000,000	286,416,000
5	438,750,000	358,020,000
6	292,500,000	238,680,000
7	1,023,750,000	835,380,000
8	702,000,000	472,832,000
9	585,000,000	477,360,000
10	497,250,000	405,760,000
11	643,500,000	525,096,000
12	994,500,000	811,512,000
13	877,500,000	716,040,000
14	936,000,000	763,776,000
15	2,340,000,000	1,909,440,000
16	877,500,000	716,040,000
17	224,000,000	197,710,000
18	409,500,000	334,160,000
19	1,980,500,000	1,595,280,000
20	994,500,000	811,512,000
21	1,872,000,000	1,527,552,000
22	117,000,000	95,472,000
23	731,250,000	596,700,000
24	526,500,000	429,624,000
25	428,750,000	358,020,000
26	654,648,000	534,193,000
27	1,872,000,000	1,527,552,000

4M–6-72–21582