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Title: Interregional and Interseasonal Competition in the U.S. Beef Industry, 1967--An Integrated Analysis

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Production and marketing are two important activities of the U.S. beef industry. Spatial differences in these activities result due to the existing cost differences in production and marketing of beef. The overall objective of this study is to determine simultaneously interregional and interseasonal equilibrium with respect to beef production and marketing in the U.S., with special emphasis on the Pacific Northwest region.

Market equilibrium was defined as the stage at which demand was exactly equal to supply for each product in each season and in each region. The reactive programming algorithm was used as the computational means. The CDC 3300 computer was used to obtain the results.

The continental U.S. was divided into 12 regions. Fed and nonfed beef were defined as two products available in two seasons

in 1967. Supply estimates were made for each product for each region in each season. Demand equations were defined for each product in each season and in each region. Transfer costs were also estimated.

The equilibrium shipment patterns, and market prices were obtained for each product in each region during each season. It was concluded that, subject to the restrictions imposed on the equilibrium solution, the shipment patterns obtained approximated the actual industry observations fairly well. Comparison of simple average seasonal market prices and computed equilibrium prices showed that computed prices were in reasonable proximity with actual market prices.

Possible reasons behind discrepancies existing between the equilibrium solutions obtained from the model and actual observations were discussed in detail. It was pointed out that the analytical model could be useful provided the supply and demand estimates, coefficients of demand functions, feed and nonfeed costs estimates, and transportation rates were reasonably accurate.

Effects of changes in truck transportation rates, availability of backhauls, and increase in slaughter demand for fed beef in Washington on equilibrium flows of fed and nonfed beef and prices were analyzed.

The study revealed that interregional flows and prices of fed and nonfed beef were very sensitive to truck transportation rates. The effects of backhauls analyzed in this study indicated that Idaho will lose some of its competitive advantage to Montana-Wyoming, and Arizona-New Mexico regions in supplying fed beef to either Oregon or Washington, and nonfed beef to Colorado. Idaho, Montana-Wyoming, and Colorado are expected to meet Washington's increased slaughter demand for fed beef.

# Interregional and Interseasonal Competition in the U.S. Beef Industry, 1967--An Integrated Analysis

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# INTERREGIONAL AND INTERSEASONAL COMPETITION IN THE U.S. BEEF CATTLE INDUSTRY, 1967--AN INTEGRATED ANALYSIS

## I. INTRODUCTION

The beef industry in the U.S.A. has undergone substantial changes in the last two decades. These changes are the result of new developments in production, marketing, and transportation techniques. Further, increasing population, rising per capita disposable income and improved technology have affected demand for meat. As a result, the beef industry is one of the nation's largest and fastest-growing agricultural industries. Cattle and calf production increased from 28.3 billion pounds in 1959 to 36.5 billion pounds in 1968, a 22 percent rise.[1] This rise in production is due to both a rise in the number of cattle slaughtered and an increase in the average live weight of cattle slaughtered.

Whereas the per capita consumption of beef increased from 81.4 pounds per person in 1959 to 109.4 pounds per person in 1968, beef's percentage of total per capita meat consumption increased from 51 percent to 60 percent in the same period.[2] The

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[1]Source: (34, Table 453).

[2]Source: (*ibid.*, Table 520).

beef cattle business is an important source of income to agricultural producers. Cash receipts from sales of cattle, calves, beef and veal increased from $7.8 billion in 1959 to $11.3 billion in 1968.[3] Over one-fourth of the gross agricultural income in the U.S.A. in 1968 was from cattle and calves.[4] Since 1961, the receipts from livestock and livestock products have accounted for more than one-half of the total cash receipts (receipts from livestock and products plus crops) from farm marketings.[5]

The most significant changes in the beef industry include:

> "(1) the changing make up of the cattle industry, primarily the cow herd--more beef, fewer dairy, (2) the growth in feedlot finishing of cattle, and (3) the movement of cattle into feedlots and then to slaughter at younger ages" (26, p. 19).

Increases in the national beef cattle herd and the rise in grain feeding of cattle have resulted in a substantial rise in beef production (26, p. 19). In contrast with rising beef production, veal production declined from 1.0 billion pounds to 0.7 billion pounds (carcass weight equivalent) during 1959-1968.[6] This decline is

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[3]Source: (34, Table 453).

[4]Source: (39, Tables 10, 11).

[5]Source: (34, Table 678).

[6]Source: (34, Table 520).

mainly due to a fall in the national dairy herd and a rise in the demand for feeder cattle (26, p. 19). The number of cattle and calves kept on farms for milk has declined continuously, from 30.7 million head in 1959 to 22.2 million head in 1968.[7] The number of dairy heifer calves kept on farms also has declined considerably in the last decade.[8] The reduction in dairy cow herd in all regions is probably due to (1) rise in demand for beef, (2) increase in the milk production per cow, and (3) greater competition from the imitation milk.

## A. Regional Patterns

Rapid growth in the U.S. beef cattle industry has brought forth changes in regional production and consumption patterns. The South Central, West North Central, and Western regions' share of national cattle feeding have increased substantially in the last 10 years. This change is apparently due to (1) nationwide increase in demand for beef, (2) regional advantages in feed and production costs, and (3) improved livestock management and use of newer and better

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[7] Source: (*ibid.*, Table 450).

[8] Source: (*ibid.*, Table 450).

technology. Also, the demand for feeder cattle is on a rising trend as a result of (1) a rise in livestock prices in the face of relatively stable feed grain and feed concentration prices, and (2) higher spreads or margins between grain fattened cattle and feeders (26, p. 19).

Although the bulk of fed cattle marketings come from the West North Central, the Western and the East North Central regions, the South Central region (which includes the states of Texas and Oklahoma) is fast becoming a major fed cattle supplier. During 1963-68, fed cattle marketings from the South Central region increased by 217 percent, the largest rise among all regions.[9] The South Atlantic region is growing as a calf slaughter area.[10] The Western and East North Central regions have reduced calf slaughter substantially.[11] These changes in regional production and marketing patterns in the beef cattle industry will have an important bearing on the location of slaughter plants, movements of cattle and dressed beef, and distribution of income earned from livestock-related enterprises.

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[9]Source: (37).

[10]Ibid.

[11]Ibid.

B. The Pacific Northwest Region

In the Western region the Pacific Northwest region (henceforth referred to as PNW), comprised of the states of Oregon, Washington, and Idaho, has also experienced changes in traditional production and consumption patterns. A comparison of percent changes in averages of two five year periods in Table 1 shows that changes in beef cattle production in the PNW follow closely the national pattern. However, in some respects the developments (changes) in the PNW are significantly different from the "rest of the West."[12] For example, dairy heifer calves and dairy cows on farms at the beginning of the year have declined faster in the PNW region than the "rest of the West." Increases in cattle and calf production are greater in the "rest of the West" than the PNW. A comparison in percent changes in averages of two three year periods[13] (1963-1965, and 1966-1968) shows that the number of cattle placed on feed and

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[12]Rest of the West includes the states of Montana, Wyoming, New Mexico, Colorado, Arizona, Utah, Nevada, and California.

[13]Since data on cattle placed on feed and cattle marketed are not available for all the Western states during 1959, 1960, 1961 and 1962, data from 1963 to 1968 are compared.

Table 1. Trends in the Beef Cattle Production and Marketing in the PNW, "Rest of the West," and the Nation, 1959-1963, 1964-1968.[a]

| | Percent changes in averages of 1959-1963 and 1964-1968 | | |
|---|---|---|---|
| | PNW[b] | Rest of the West[c] | Nation |
| 1. All cattle and calves on farms; Jan. 1. | 10.1 (+) | 12.1 (+) | 7.6 (+) |
| 2. Dairy cows on farms; Jan. 1. | 17.3 (-) | 7.7 (-) | 16.5 (-) |
| 3. Dairy heifer calves on farms; Jan. 1. | 17.0 (-) | 13.0 (-) | 20.0 (-) |
| 4. Cash receipts from marketing and sales on farm slaughtered meat | 23.0 (+) | 23.2 (+) | 19.1 (+) |
| 5. Commercial cattle slaughter | 24.3 (+) | 23.6 (+) | 23.4 (+) |
| 6. Commercial calves slaughter | 20.0 (-) | 23.9 (-) | 23.9 (-) |
| 7. Cattle and calves production | 13.6 (+) | 19.9 (+) | 14.5 (+) |

[a]Source: (37)

[b]Oregon, Washington, and Idaho

[c]Montana, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, and California.

fed cattle marketings increased more in the PNW than the "rest of the West."[14]

Gross income received by farmers from livestock products varies from year to year in the PNW. In 1968, for example, income from cattle and calves in the PNW comprised 29.7 percent of total income from all agricultural commodities; and was higher than the "rest of the West" and the nation as a whole.[15] Thus, the beef cattle industry is an important income-producing industry in the PNW.

## C. The Problem

Although the PNW as a whole is an exporter of feeder cattle, the states of Oregon and Washington are deficit regions in the fed beef production, as can be seen from Table 2. For example, Table 2 shows that since 1965 Oregon and Washington have been deficit regions, whereas Idaho has been consistently a surplus region. The PNW as a whole is, however, a surplus beef producing region.

Beef producers in the PNW are constantly facing a stiff competition from "the rest of the West" and other regions for the region's markets. Several factors are behind this situation. First,

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[14]Source: (37).

[15]Source: (39).

Table 2. Fed Cattle Production and Consumption, PNW, 1965-1968[a]

| | Production (million lbs)[b] | | | | Consumption (million lbs)[b] | | | | Balance (million lbs)[b] | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1965 | 1966 | 1967 | 1968 | 1965 | 1966 | 1967 | 1968 | 1965 | 1966 | 1967 | 1968 |
| Oregon | 91.0 | 116.2 | 111.3 | 111.3 | 103.5 | 148.2 | 156.9 | 167.4 | 12.5* | 32.0* | 45.6* | 56.1* |
| Washington | 158.7 | 178.3 | 193.7 | 204.2 | 167.8 | 228.4 | 254.9 | 273.2 | 9.1* | 50.1* | 61.2* | 69.0* |
| Idaho | 135.9 | 187.5 | 224.4 | 253.4 | 39.6 | 52.3 | 55.7 | 58.8 | 96.3 | 135.2 | 168.7 | 194.6 |
| PNW | 385.6 | 482.0 | 529.4 | 568.9 | 310.9 | 428.9 | 467.5 | 499.4 | 74.7 | 52.1 | 61.9 | 69.5 |

[a]Sources: (2, 44)

*denotes deficits; other numbers are surpluses.

[b]all figures are in carcass weight.

feed grain and livestock product prices tend to be lowest in the nondeficit production areas. Table 3 shows differences in seasonal prices received by farmers for different types of feedgrains in various regions in 1968. Seasonal prices received by farmers are higher in the PNW than the national average. Also, except for barley, prices are higher in the PNW than the rest of the West. Of course, one of the main reasons such higher prices exist for many of these agricultural products is the PNW's proximity to an export market.

Secondly, the present transportation structure is such that it is more advantageous to transport meat than to ship the feed equivalent to produce it. Thus, the value of 100 pounds of livestock, in terms of feed in the nondeficit regions, is higher than in the Pacific Northwest. Thirdly, with the increasing competition in rail and truck transportation, rapid changes are taking place in transportation rate structure and technology. This is sometimes to the benefit of regions other than the Pacific Northwest. These and other reasons suggest that for beef producers in the Pacific Northwest whose aim is to maximize their incomes, it might be important to analyze the relative advantages or disadvantages the other regions have in the production and marketing of beef cattle.

Table 3. Seasonal Average Prices Received by the U.S. Farmers, 1968.[a]

| Region | Prices received by farmers | | | | |
|---|---|---|---|---|---|
| | Seasonal averages per bushel | | | | Sorghum grain per hundred wt. |
| | Corn | Oats | Barley | Wheat | |
| N. A. | $1.16 | $0.78 | $0.93 | $1.32 | $ - |
| E. N. C. | 1.01 | 0.66 | 0.90 | 1.33 | 1.70 |
| W. N. C. | 1.04 | 0.64 | 0.87 | 1.42 | 1.60 |
| S. A. | 1.15 | 0.78 | 0.92 | 1.43 | 1.90 |
| S. C. | 1.22 | 0.72 | 0.96 | 1.45 | 1.80 |
| P. N. W. | 1.33 | 0.78 | 0.99 | 1.39 | - |
| Rest of West | 1.29 | 0.76 | 1.02 | 1.36 | 2.07 |
| U. S. | 1.04 | 0.60 | 0.93 | 1.39 | 1.74 |

[a]Source: (40)

Movement of beef cattle from one region to another will thus depend upon transportation costs, production costs and prices offered in different markets. It is hypothesized that the states of Oregon and Washington might have to inship fed beef from nearby excess beef producing regions. Also, the PNW might have to export excess supply of nonfed beef to other Western states. Back hauls of both live cattle and meat might affect movements of beef cattle especially if their result is a reduction in transportation costs. Finally, beef cattle and calf movements might change if transportation rate structure, demand situations, and other factors change.

## D. Objectives

The overall objective of this thesis is to determine inter-regional and interseasonal equilibrium with respect to beef cattle production and marketing in the U. S. A., with special emphasis on the PNW region. In doing so the following intermediate objectives will be satisfied:

(1) to estimate supply of and demand for fed and nonfed beef for various specified regions of the U. S.

(2) to obtain the "optimum" volume and trade patterns for the 1967-1968 cattle marketing season such that the net prices per unit of product at any two or more supply points are equal.

(3) to explain the impact of changes in specified conditions in the system on the "optimum" solution.

## E. Scope of This Study

Very few previous studies of the beef industry accounted for seasonal trends in the production and marketing of beef cattle. Such a study could be useful to beef cattle industry decision makers in their decisions on the efficient allocation of resources in the production and marketing of beef cattle.

Already, many people are engaged in the livestock business and are deriving a large proportion of their total incomes from beef cattle. Also, considering the increasing competition among regions, such a study could help policy makers in their decisions on forecasting growth of their region's beef industry. Lastly, such a study could help provide a thorough understanding of the beef industry in the PNW and throughout the U. S.

## F. Organization of the Thesis

In order to accomplish the objectives listed above, the thesis is divided into 10 chapters. Chapter II is concerned with a theoretical framework of the study. The reactive programming technique used as a tool of analysis is described in Chapter III.

Chapter IV deals with the application of reactive programming to the beef industry in the U. S. Chapters V, VI, and VII describe methodology used to estimate supply, demand, and transfer cost data, respectively.

Equilibrium results obtained from the analytical model are discussed in Chapter VIII. The impact of changes in certain specified conditions on the equilibrium results is explained in Chapter IX. In Chapter X, the study is summarized, and conclusions are drawn. Suggestions for further research are also discussed in Chapter X.

## II. THEORETICAL FRAMEWORK

Issues of interregional competition can be viewed in the context of an economic problem. An economic problem is one in which consumers and producers have a choice in allocating their scarce resources among competing ends such that their objective(s) is (are) satisfied. For a consumer the objective might be maximization of utility, whereas the producer's objective might be maximization of profits.

In perfect competition the independent actions of consumers and producers together determine the equilibrium price and quantity in the market. The markets are of two types: (1) in the product market products are bought and sold for final consumption, (2) in the factor market products are bought and sold as inputs for certain production processes.

Discussion on theoretical framework is divided into four sections:[16]

(A) discussion of demand considerations for a factor of production.

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[16] Some of the material presented here is taken from Henderson and Quandt's text book on Micro economic Theory (13). Hopefully, the author's views are not misinterpreted here.

(B) discussion of supply considerations for a factor of production.

(C) equilibrium in single and multiple markets for a single product.

(D) multidimensional equilibrium.

## A. Demand Considerations for a Factor of Production

The quantity demanded of a given factor (input) depends upon prices of the products made from the input, price of the input, prices of substitute or complementary factors used in the production process, and the production function of the firm. Thus,

$dij = f(P, P_j, P_k, \text{ and } \lambda)$. That is, the $i^{th}$ producer's demand for the $j^{th}$ input is a function of the price of the final product made from input j (P), price of the $j^{th}$ input ($P_j$), price of the substitute or complementary factor ($P_k$), and the production function ($\lambda$).

The demand for an input is a derived demand. For example, demand for beef cattle to be placed on feed depends upon prices of fed beef cattle. Similarly, demand for slaughter cattle depends upon demand for meat cuts in the retail market.

A rational producer will demand additional quantities of a factor (input) until the price of the input is exactly equal to the addition to the revenue caused by an additional unit of the factor. If one or more than one input is used, the producer's optimum demand for each factor will be such that the "last unit hired adds as much to costs as it does to revenue" (21, p. 401).

Over a short period of time the demand for an input may change very little. However, in the long run the demand for an input may increase or decrease, depending upon changes in all factors affecting demand for an input except the price of the input. For example, changes in preferences for the final product, consumers incomes, production techniques and development of new substitutes might shift the demand for the factor. If two inputs are good substitutes, an increase in the price of one would be expected to reduce its demand, and increase the demand for the other. If two inputs are complements, the quantity demanded of one input would be expected to vary directly with the variations in the demand for the other. In the case of independent inputs, demand for one would be expected to remain unaffected by the demand for the other.

## B. Supply Considerations for a Factor of Production

On the supply side, the quantity of an input supplied will normally vary with the price of the input. That is, the quantity supplied of an input will increase (decrease) as the price of the input increases (decreases). The quantity supplied will depend upon the price of the input, the price(s) of other inputs(s), and other factors (e.g., weather, storage facilities). Thus, $sij = f(Pj, P_k, \phi)$.

That is, the $i^{th}$ suppliers supply of the $j^{th}$ input is a function of price of the $j^{th}$ input ($Pj$), price(s) of other input(s) ($Pk$), and other factors ($\phi$). Supply of an input will increase or decrease if factors other than the price of the input changes.

## C. Equilibrium in a Single Market for a Single Product

Given the demand and supply functions for a single product in a single market in a single period, the equilibrium price and quantity is reached when demand for the product in the market during the period is exactly equal to the supply of the product in the market during the period. That is, $dij = sij$.

At equilibrium both demanders and suppliers are satisfied, and no incentive is left for further trade. The industry equilibrium is reached when the aggregate demand for the product is exactly equal to the aggregate supply, i.e.,

$$\sum dij = \sum sij$$

## Equilibrium in Multiple Markets for a Single Product

This single product and single market discussion can be extended to multiproduct, multimarket, and multitime period situations. Suppose now that a single product has demand in more than one market. We want to know the equilibrium prices in all markets, the amount (or quantity) supplied and demanded at each location, and the quantity shipped between supply and demand regions. For simplicity, assume that

(1) a single product has a market demand in two regions, $R_1$ and $R_2$;

(2) demand curves $d_1$, $d_2$ and supply curves $s_1$, $s_2$ for this product are given; and

(3) costs of transporting the product from $R_1$ to $R_2$ or vice versa are known.

Figure 1 shows back-to-back demand and supply curves in two regions for a single product.

In the absence of trade between regions $R_1$ and $R_2$, equilibrium prices and quantities are $P_1$, $P_2$ and $Q_1$, $Q_2$, respectively. At $P_1$ and $P_2$ demand and supply for the product are equal in both $R_1$ and $R_2$, and the excess supply functions $ES_1$ and $ES_2$ are at their zero values. From the graph it is obvious that $P_1 > P_2$. The cost of transporting the product from $R_2$ to $R_1$ is $TC_{21}$. As is noticeable, the difference between the two prices is greater than the transportation cost, i.e., $(P_1 - P_2) > TC_{21}$. As a result, the profit-maximizing producer will ship some of the product from $R_2$ to $R_1$. This exchange will

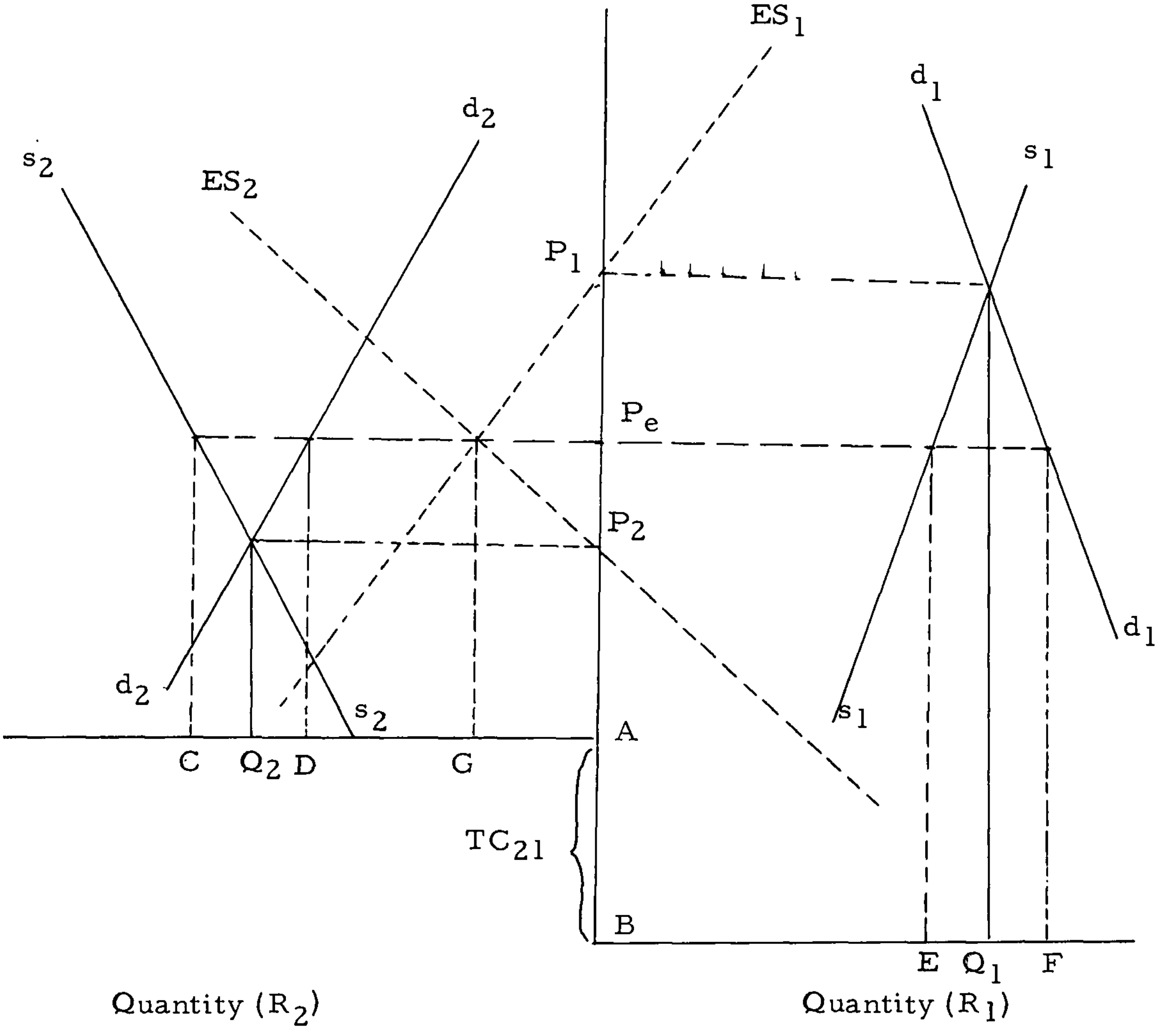


Figure 1. A Hypothetical Determination of Equilibrium Prices and Quantity Flows in a Competitive Market, with Unit Costs of Transportation Given.

disturb the equilibrium prices and quantities in both the markets.

The exchange of the product between $R_2$ and $R_1$ will continue until there is no incentive left for the producers for further trade. The combined market demand and supply functions of $R_1$ and $R_2$ are at equilibrium where excess supply curves $ES_1$ and $ES_2$ intersect. The equilibrium price as a result of trade between $R_1$ and $R_2$ is $BP_e$ in $R_1$ and $AP_e$ in $R_2$. The equilibrium quantity shipped from $R_2$ to $R_1$ is CD (= GA = EF). Had the transportation cost $TC_{21}$ been greater than or equal to the differences between $BP_1$ and $AP_2$, no trade would have taken place.

## D. Multi-dimensional Equilibrium

The above discussion of a single product and two markets can be extended to multiple products, multiple regions and multiple time periods. However, mathematical rather than graphical treatment is convenient for a multidimensional approach. Such a model will be presented mathematically in Chapter IV. The equilibrium in such a case will be reached when demand is exactly equal to supply for each product, during each time period, and for each geographic market. When such an equilibrium is reached there will be no incentive left during any time period and for any geographic market for 1) producers to allocate their products differently in different markets in different seasons, 2) consumers to allocate their resources differently in the consumption of alternative products, and 3) producers and consumers to exchange any more. The industry in question will be at equilibrium when aggregate demand is equal to aggregate supply for each product, during each time period and for each geographic market.

Research techniques such as linear programming, input-output models, simulation, reactive programming, etc., are available to consider multi-dimensional equilibrium problems. Each technique has its own merits and demerits. The application of such techniques also depends upon the researcher's knowledge of the technique and his overall objectives.

No attempt is made in this study to review various studies on interregional competition in which the above-mentioned techniques have been used. This is done mainly to avoid repetition of the subject matter. Excellent references on interregional competition can be easily found in the indexes of economic literature, as well as in the book <u>Interregional Competition Research Methods</u> published by the North Carolina State University (16).

# III. REACTIVE PROGRAMMING - AN ALGORITHM

Reactive programming, a relatively new technique designed by Drs. Tramel and Seale, is a useful technique for studying the problems of interregional competition. An attempt is made in this chapter to describe briefly the reactive programming technique.[17] Chapter III is divided into three parts: (A) discussion of equilibrium conditions and the working of reactive programming technique, (B) merits of reactive programming, and (C) demerits of reactive programming.

## A. Equilibrium Conditions and the Working of Reactive Programming

The reactive programming technique was designed first in 1959 by Seale and Tramel. It was used to obtain solutions to spatial equilibrium problems. Since then the technique has been improved and is made flexible to suit any form of competition and any mathematical forms of demand and supply functions.

### Equilibrium Conditions

Given the transportation cost function, and demand and supply functions for each of the demand (consumption) and supply

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[17] This discussion is solely based upon references 8, 27, 28, 29, 31, and 32 and this author does not wish to take any credit for its originality.

(production) centers, reactive programming essentially obtains equilibrium flows of commodities or goods between different centers. The following restrictions must hold to obtain the equilibrium solution:[18]

(1) no negative shipments.

(2) for a given production center all net prices must be equal for all consuming markets to which products are shipped. Such net prices must be greater than net prices for all consuming centers to which products are not shipped. Net prices are obtained by deducting per unit transportation and production costs from the market prices.

(3) net prices must be greater than or equal to zero for all production and consumption centers between which products flow.

(4) with nonnegative net prices, all available supplies are allocated, but this condition will not necessarily obtain if net prices are zero or negative.

By enforcing the above restrictions and reiterating until no restriction is violated for any producing area, an equilibrium or approximate equilibrium solution is obtained for each of the producing areas.

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[18] These restrictions are expressed in notational form in Chapter IV.

## The Working of Reactive Programming

A desired solution to any spatial equilibrium problem is obtained in the following way: Initially all available (or given) supplies from a production center or supply area are allocated arbitrarily such that all demand regions receive some of the product. With the known demand and supply conditions, a price will be determined for each demand region. Net prices are then obtained by deducting per unit transportation and production costs from the price in the market. On the basis of these net prices, a profit-maximizing producer will reallocate his supplies. The process is continued until the net price for the supplies from the region becomes equal in all markets or the supply from that region is exhausted. An equilibrium is thus reached for one region. In the same manner equilibrium is obtained for all other regions.

Since equilibrium net prices will be different for each region, the profit-maximizing producer will have an opportunity to react to these prices. This will set in motion allocation and reallocation until net prices become equal for all regions. This will be the final equilibrium, since no production or consumption centers will have any incentive left for further trade. Such an equilibrium implies net returns become maximum for each supplying region. It also implies that each production center is at equilibrium with all possible consumption markets. The final solution will show simultaneously:

(1) equilibrium quantities received by each consuming area from each producing area,

(2) equilibrium net prices, and

(3) equilibrium flows of products between regions.

A simple problem given below is taken from Seale and Tramel's discussion on reactive programming (28). It will help to understand the functioning of the reactive programming model. Assume (1) a single product, (2) a single time period, (3) predetermined (fixed) supplies, (4) linear demand relationships with uniform slopes, (5) four demand and three supply regions, each represented by a single point, and (6) transportation costs per unit of commodity are known.

Table 4A depicts transportation costs per unit between various points. Table 4B illustrates the initial situation. Predetermined supplies are shown in the last column. As a starting point supply from each region is allocated arbitrarily such that all four demand regions receive some of the product. Initial total receipts at each receiving point are given in the fifth row. Initial prices and demand relationships are given in the sixth and seventh rows.

Table 4. Application of Reactive Programming: Demand Functions with Uniform Slopes and Fixed Supplies.[a]

Table 4A: Transportation Costs

| Shipping Point | Consumer Center | | | |
|---|---|---|---|---|
| | W | X | Y | Z |
| | (cost per unit) | | | |
| A | 100 | 230 | 180 | 100 |
| B | 90 | 140 | 100 | 175 |
| C | 200 | 140 | 120 | 110 |

Table 4B: Initial Situation

| Shipping Point | Consumer Center | | | | |
|---|---|---|---|---|---|
| | W | X | Y | Z | Supplies |
| | (shipments) | | | | |
| A | 5 | - | - | - | 5 |
| B | 30 | 10 | 20 | - | 60 |
| C | - | - | 15 | 25 | 40 |
| Total Receipts | 35 | 10 | 35 | 25 | 105 |
| Prices | 150 | 180 | 160 | 150 | - |
| Demand | P = 220-2Q | P = 200-2Q | P = 230-2Q | P = 200-2Q | - |

Table 4C: Equilibrium Solution

| Shipping Point | Consumer Center | | | | |
|---|---|---|---|---|---|
| | W | X | Y | Z | Supplies |
| | (shipments) | | | | |
| A | - | - | - | 5 | 5 |
| B | 35 | - | 25 | - | 60 |
| C | - | 10 | 10 | 20 | 40 |
| Receipts | 35 | 10 | 35 | 25 | 105 |
| Prices | 150 | 180 | 160 | 150 | - |

Table 4, cont.

Table 4D: Equilibrium Prices and Net Revenues

| Shipping Point | Consumer Center W | X | Y | Z | Net Revenue |
|---|---|---|---|---|---|
| | (net prices per unit) | | | | |
| A | 45.00 | -50.00 | -20.00 | 50.00 | 250.00 |
| B | 60.00 | 40.00 | 60.00 | -25.00 | 3,600.00 |
| C | -50.00 | 40.00 | 40.00 | 40.00 | 1,600.00 |
| Prices | 150.00 | 180.00 | 160.00 | 150.00 | - |

[a]Source: (28, Table 2)

Table 4C presents equilibrium shipments and market prices. For example, it shows that W and Y centers received shipments from B. Table 4D shows that each shipping center shipped its product to those demand centers where net prices were highest. For example, shipping point C shipped its product to X, Y, and Z, since not only the net prices were highest but they also were equal. If any of the shipping centers ships its product in a way different than the solution, net return to that center will decline. Thus, there is no incentive left for any one to make a further move. This is the equilibrium solution.

## B. Merits of Reactive Programming

Reactive programming is a useful and powerful procedure in solving various types of spatial equilibrium problems. Among the merits of the technique are its flexible procedure and applicability to various types of competition and mathematical forms of demand and supply functions. Specifically, the procedure can be used to handle problems with situations like (a) demand functions with uniform or different slopes, and fixed supplies or supply functions with different slopes, (b) demand and supply functions with or without supply limits, (c) premiums or discounts associated with particular supply points, (d) competing products, (e) problems where raw products are processed with limits on processing capacity, and (f) multiple time periods. These problems are discussed in detail by Seale and Tramel.

Not only does reactive programming determine equilibrium net prices and quantities; it also specifies equilibrium flows. Thus, it can achieve the purpose (finding the least cost routes of supplying fixed quantities) of linear programming.

Savings in computer time due to various short cut methods is another advantage sometimes listed for reactive programming. For example, Tramel and Seale required 15 seconds of IBM 7094 to solve a fixed supply problem consisting of 36 producing areas and 42 markets with demand functions linear in logarithms.

## C. Demerits of Reactive Programming

Among the critics of reactive programming are Judge and Takayama. They criticized reactive programming on the grounds that (1) it does not have restrictions on prices and costs, (2) it may not converge, and (3) a longer computer time is required to arrive at a solution, since reactive programming can obtain exact solutions only after an infinite number of iterations.

## Criticism Answered

Judge and Takayama's criticism is mainly on the calculation procedure for problems wherein supply is determined as a part of the solution. Tramel and Seale answered the criticism as follows:

(1) restrictions on costs (production as well as transportation) are not needed since in any realistic problem costs must be non-negative. This is taken care of in the problem formulation.

(2) any problem sensible from an economic point of view always fulfills conditions necessary for convergence. "Changes in the values of variables within a given subset of restrictions which do not influence the value of variables outside the subset could lead only to convergence of the process" (27, p. 60).

(3) It is true that the reactive programming procedure converges to a solution asymptotically. But shortcuts can be employed to reduce computer time.

Mr. Richard J. Foote, in his discussion on studies of inter-regional competition states that, "reactive programming has more intuitive appeal for me than does linear programming and appears to be a highly useful tool to be added to the econometrician's kit" (8, p. 1039).

However, despite reactive programming's advantages over other techniques, very few researchers have used it in their research work. This implies either that other techniques--especially linear programming satisfy researchers' needs, or that certain tools of analysis are more appropriate for particular types of problems. In this study a reactive programming model is used since it is found most suitable to study the beef cattle industry. The model is applied in the hope of studying simultaneously inter-regional and interseasonal competition in the U.S. beef industry.

# IV. APPLICATION OF REACTIVE PROGRAMMING TO THE BEEF INDUSTRY IN THE U.S.

This section describes the general model and assumptions used to solve the interregional competition problem in the beef cattle industry. The basic model presented by Drs. Tramel and Seale (31) is used extensively except for notational changes required to suit it to the problem under study.

## A. Assumptions[19]

To begin with, assume that

(1) a specific time period (year) is divisible into two seasons. Further, production (t) and marketing (k) seasons for beef cattle are the same; t = k = 1, 2, . . . m

(2) total supplies of r categories of beef cattle are fixed for each production season (t) and are known. Each r category of beef cattle can be converted into any one of the f products demanded at j markets, during k seasons.

(3) $\sum_i r_i^t \lesseqgtr \sum_j f_j^k$, i.e., total supply of the $r^{th}$ category of beef cattle, from i regions during the $t^{th}$ season can be greater than or less than or equal to the equivalent total demand for the $f^{th}$

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[19]This is not the list of all assumptions used in the study. Some assumptions are added at the appropriate time.

product from j regions during the $k^{th}$ season. However, in aggregate, total supply of r categories of beef cattle in i regions during t seasons is not greater than the equivalent total demand for f products in j regions during k seasons. Thus, $\sum_i \sum_t r_i = \sum_j \sum_k f_j$

(4) the unit cost of converting the $r^{th}$ category of beef cattle into the $f^{th}$ product during a season is known for each of the i regions and for each of the t production seasons.

(5) demand for each of the $f^{th}$ products is considered at the initial handler level (in the present study at the feedlot or packer level), rather than at the final consumer level.

(6) a perfectly competitive situation holds for different products, regions, and seasons. Thus, there are no barriers in the movement of cattle from supply regions to demand regions during any season(s). Also, each $r^{th}$ category of beef cattle is homogeneous in all i regions, and demanders in j regions are indifferent to the source of product. Market price is determined at the point where quantity demanded in each region, during each season, for each product is exactly equal to the quantity offered for sale during each season, in each region, and for each product.

(7) demand and supply regions are represented by a single geographical point during each t(=k) seasons and for all types

of beef cattle. The regions are separated by unit costs of transportation between them.

(8) Unit costs of transportation between different regions are given and are held constant, regardless of seasons.

(9) interregional rather than intra-regional beef cattle movements are taken into account.

(10) the analysis holds for the continental U.S. only.

(11) each region has a single demand and supply curve for each product and for each season.

## B. Notation

| | |
|---|---|
| $i = 1, 2, \ldots, m$ | denotes various geographic production or supply regions in the U.S. |
| $j = 1, 2, \ldots, n$ | denotes various geographic demand regions in the U.S. |
| $k = 1, 2, \ldots, m$ | denotes various beef cattle marketing seasons within a specific period. |
| $t = 1, 2, \ldots, m$ | denotes various beef cattle production seasons during a specific period. |
| $f = 1, 2, \ldots, m$ | denotes various beef cattle product forms demanded. |
| $r = 1, 2, \ldots, n$ | denotes various sub categories of beef cattle into which total supply in a given area is divisible. |

## C. Definitions and Equilibrium Conditions

$P^{f}_{j}k$ = Price of the $f^{th}$ beef cattle product, in the $j^{th}$ market during the $k^{th}$ season. This price is a function of total quantity of the $f^{th}$ product demanded in the $j^{th}$ market during the $k^{th}$ season. Thus,

$P^{f}_{j}k = F(x^{f}_{j}k)$

$X^{f}_{j}k$ = Total quantity of the $f^{th}$ product demanded in the $j^{th}$ market during the $k^{th}$ season.

$Q^{r}ijt$ = Total quantity of the $r^{th}$ category of beef cattle produced in the $i^{th}$ region and shipped to the $j^{th}$ market to meet its equivalent demand for the $f^{th}$ product during that season.

$C^{r}it$ = Unit cost of producing and converting the $r^{th}$ category of beef cattle into the $f^{th}$ product, in the $i^{th}$ region during the $t^{th}$ season. The unit cost of production is a function of aggregate fixed quantity of the $r^{th}$ category of beef cattle produced in the $i^{th}$ region during the $t^{th}$ season, for a fixed supply situation. Thus,

$C^{r}it = G(S^{r}it)$

$S^r{it}$ = Aggregate fixed quantity of the $r^{th}$ category of beef cattle produced in the $i^{th}$ region during the $t^{th}$ season, for a fixed supply situation.

$T_i^r jk$ = Unit cost of transporting the $r^{th}$ product from the $i^{th}$ region to j demand regions during k seasons. $T_i^r jk$ is constant, i. e., unit cost of transportation is independent of volume.

$R_i^f jk$ = "net price" for the $f^{th}$ product from the $i^{th}$ region in the $j^{th}$ market during the $k^{th}$ season. Net price is obtained by deducting unit costs of production and transportation from the market price. Thus,

$R^f jk = P_i^f k - C^r{}_{it} - T^r{}_{ijk}$

$\overline{R}_{ik}$ = Weighted average of all $R^f{}_{ijks}$ for i producing areas during k seasons.

$= \sum_i \sum_j \sum_{k=t} R^f_{ijk} \cdot Q^r_{ijt} / \sum_i \sum_j \sum_{k=t} Q^r_{ijt}$

$D_{ijk}$ = Deviation of $R^f_{ijk}$ from $\overline{R}_{ik}$ for i producing areas in j markets during k seasons.

$= R^f_{ijk} - \overline{R}_{ik}$

Equilibrium Conditions

1. $Q^r{}_{ijt} \geqslant 0$ i. e., negative shipments are prohibited

2. $Q^r{}_{ijt} \neq 0 \Rightarrow R^f{}_{ijk} = \bar{R}_{ik} \geqslant 0$

$Q^r{}_{ijt} = 0 \Rightarrow R^f{}_{ijk} \leqslant \bar{R}_{ik}$

i.e., all $R^f{}_{ijk's}$ corresponding to markets where the product is shipped must be nonnegative and equal to each other, and in turn not less than those corresponding to nonactive routes.

3. Condition 2 implies that

$D_{ijk} \leqslant 0$

4. $\bar{R}_{ik} > 0 \Rightarrow \sum_i \sum_j \sum_{t=k} Q^r{}_{ijk} = S^r{}_{it}$

$\bar{R}_{ik} = 0 \Rightarrow \sum_i \sum_j \sum_{t=k} Q^r{}_{ijk} \leqslant S^r{}_{it}$

i.e., all available supply is allocated if $R^f{}_{ijk's}$ are nonnegative but, not necessarily so if they are zero.

As stated earlier in the general discussion on reactive programming, the above conditions will be enforced and reiterated until no condition is violated for any producing area. This will set an equilibrium or approximate equilibrium solution for each of the beef cattle producing regions. At equilibrium the $R^f{}_{ijk's}$ will become equal among all regions, for each of the products, during each of the seasons. Such an equilibrium will mean that there is no incentive left for further trade among different regions, for different products, during different seasons.

# V. SUPPLY DATA DEVELOPMENT

This chapter deals with a general discussion of supply aspects followed by development of supply data in terms of regions, seasons, and products.

## A. Supply Aspects in General

Beef cattle are raised in all states of the union. Among the major beef cattle industry activities are feeding and slaughter. The supply of cattle for feeding and slaughter during a year's period comes from cattle and calves on hand at the beginning of the year, net calf crop, and foreign imports. Figure 2 is a simple flow chart of the fed and nonfed beef cattle industry in the U.S. It shows that net calf crop, consisting of calves born minus death losses, can be used to meet demand for feeding purposes or for slaughter as non-fed beef. Cattle and calves on hand at the beginning of the year go directly for slaughter as nonfed beef or into the feedlots for fattening purposes. Cattle fed in the feedlot for a period of time long enough to gain sufficient weight are marketed to meet slaughter demand for fed beef.

Since different categories of cattle can be used in the production of one or more final products, the supply of some categories

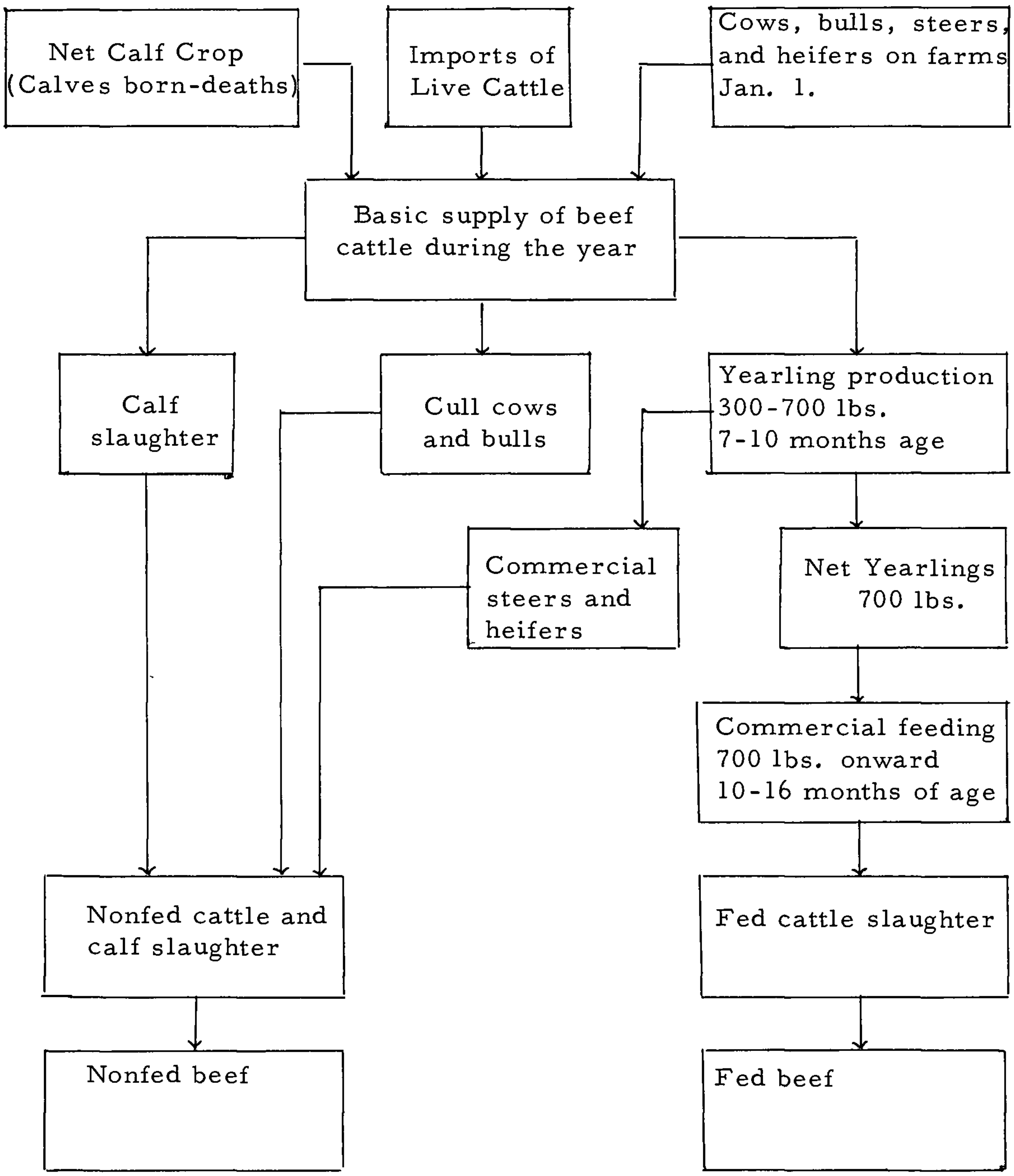


Fig. 2. Flow Chart of Fed and Nonfed Beef Cattle Industry, U.S.

of cattle is inseparable from another. This situation poses difficulty in expressing meaningful supply relationships (functions) within the reactive programming model. Supply function for all categories of cattle can be specified for the continental U.S., as well as for different regions. However, such function would have limited value for purposes of this study, since they consider beef cattle as a whole, rather than different categories into which they could be placed. This difficulty can be overcome by assuming a short-run situation. In the short-run the total supply of cattle, hence, the number of cattle in each category will not vary. Thus the total basic supply of calves and cattle from any one region can be expressed as a series of subcategories, each having a different set of production alternatives with respect to each of the final products.

Beef cattle that are raised in all states of the union can be grouped into regions on the basis of homogeneity with regard to cattle supplied, seasonality, and current and potential position in cattle production. In defining regions, consideration could also be given to shipping distances, size of feed lots, expected commodity movements, and availability of data.

Although beef cattle production and distribution vary from month to month, some consistency exists in the flow of cattle to the market. For example, number of cattle placed on feed is usually high during the July-December period. Although, fed cattle marketings are relatively even for all four quarters, they are somewhat higher during the January-July period. Thus, the supply of various categories of beef cattle can be defined on the basis of consistency existing in their flow to the market. Other factors such as climate, holidays, and any relevant practical considerations could also be taken into account.

The reactive programming model will then determine the equilibrium pattern of marketing predetermined supplies among alternative product forms, geographic demand areas, and seasonal marketing periods.

In the short run the supply side of the model will consist of a series of predetermined quantities in the following form:

$S_{i,r,k} = S'_{i,r,k}$ where i, r, and k are as defined earlier in the model.

In situations where raw products are processed into a final consummable product form, it becomes necessary to select a standard unit of measurement by which numerous supply and demand relationships are formed and compared with each other. For example, information on beef production and marketing is often supplied in different units such as 100 pounds live weight, 100 pounds dressed weight, or number of head. Without a standard unit of measurement, demand relationships among different products will be noncomparable.

To facilitate comparison, a standardization is often achieved by expressing the quantity of each specific final product in terms of its raw product equivalent. This many not be the most accurate standardization procedure, since raw materials are either eliminated or added during the course of production. Nevertheless, it does serve the useful purpose of introducing comparability into the model.

## B. Development of Supply Data in terms of Regions, Seasons, and Products

Having dealt with supply aspects in general, it is now possible to describe the procedure of estimating regional, seasonal, and product supply relationships.

### Regional Demarcation

Since the emphasis in this study is placed more on the PNW, regions are formed in such a manner that they consist of either one or two states in the PNW and the Western region, and a cluster of states for other regions. Availability of data is another factor behind such groupings. The continental U. S. is thus divided into 12 regions. Each region is represented by a single point for demand

and supply purposes, for all products, and during all seasons. These regions are described in Table 5 and are shown in Figure 4.

<u>Supply Seasons</u>

Data on seasonal marketings of different categories of cattle are not available from any of the published sources. The United States Department of Agriculture publishes yearly (and in some cases quarterly) estimates on beef cattle inventories, production, and marketing. Therefore, in order to arrive at some seasonal estimates, a questionnaire was sent to the Statistical Reporting Service offices and extension specialists in each of the 48 states. However, completed questionnaires became available from 16 states only. Many questionnaires were returned blank for want of data. Much of the information obtained were approximations. A wide diversity in estimates was observed in the beef inventory. Estimates on cattle production and disposition were less diverse. Since these estimates obtained from the returned questionnaire were found inadequate to estimate seasonal production and distribution of beef cattle, a relatively simple approach is followed.

Seasonal differences in beef cattle marketing are generally affected by (1) number of working days and holidays in a month, and (2) cattleman's desire to dispose of cattle before income tax

Table 5. Regional Demarcation, and Representative Demand and Supply Points, U.S., 1967.

| Region Number | State(s) | Representative demand and supply point |
|---|---|---|
| 1 | Oregon | Portland |
| 2 | Washington | Spokane |
| 3 | Idaho | Boise |
| 4 | California | Fresno |
| 5 | Montana, Wyoming | Billings |
| 6 | Utah, Nevada | Salt Lake City |
| 7 | Arizona, New Mexico | Phoenix |
| 8 | Colorado | Denver |
| 9 | North Dakota, South Dakota, Nebraska, Kansas | Omaha |
| 10 | Texas, Oklahoma | Fortworth |
| 11 | Minnesota, Iowa, Wisconsin, Missouri, Illinois, Michigan, Indiana, Ohio, Kentucky, Tennessee | Des Moines |
| 12 | Arkansas, Alabama, Connecticut, Deleware, Georgia, Florida, Maine, Louisiana, Mississippi, Maryland, Massachusetts, New Jersey, New York, North Carolina, New Hampshire, Pennsylvania, Rhode Island, South Carolina, Virginia, West Virginia, Vermont | Atlanta |

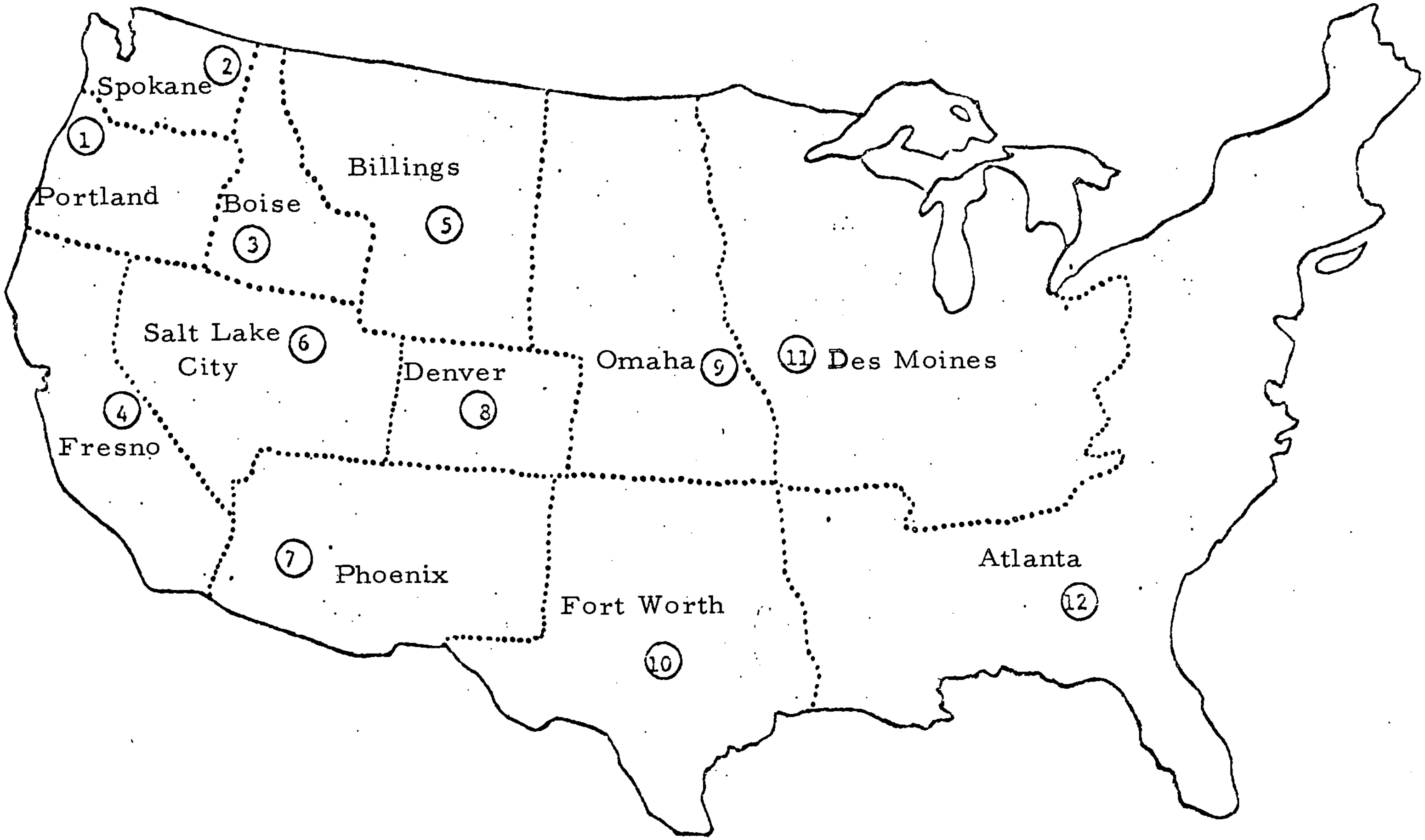


Figure 3. Regional Demarcation of the Continental U.S.A., 1967.

deadline or before the commencement of spring work (23, p. 9). In this study calender year 1967 is divided into two marketing seasons, viz., January-June 1967 and July-December 1967. Such a division may not truly represent seasonal marketing trends in supply of and demand for cattle for slaughter, and feeding. For example, feeder cattle activities are closely associated with grazing seasons, whereas slaughter activities are more in line with consumer demand for meat. It could be possible to introduce more than two seasons in the model; however, two seasons are sufficient to reach the objectives of this study.

Supply of Different Categories of Beef Cattle

It is assumed that the basic supply consisting of various categories of beef cattle comes from the following sources:

(1) Net Calf Crop = (Beef and dairy calves born, 1967) - (death losses, 1967).

(2) Cattle and calves on hand at the beginning of the year. These include:

1. Heifer calves on farm January 1, 1967
2. Other calves on farm January 1, 1967
3. Heifers 1-2 years on farm January 1, 1967
4. Heifers (other) on farm January 1, 1967

5. Steers 1 year and older on farm January 1, 1967

6. Dairy cows on farm January 1, 1967

7. Beef cows on farm January 1, 1967

8. Bulls 1 year and older on farm January 1, 1967

(3) Imports: Beef and dairy cattle, mostly from Canada, and Mexico, are imported either for breeding or for slaughter. The proportion of breeding cattle imported is generally much smaller than the cattle imported for other purposes.[20] Even if "other cattle" imported are assumed to be used for slaughter, their percentage relative to the domestic cattle slaughtered or supplied is meager. For example, in 1967, 0.7 million head of cattle (dairy and other) were imported, as compared with 108.4 million head of cattle and calves on farms, January 1, 1967, and 39.8 million head slaughtered during 1967.[21] Generally, cattle under 700 pounds constitute the bulk of imported cattle.[22] Since 1960, the number of nondairy cattle weighing more than 700 pounds has been highest in 1965 and lowest in 1967.[23] However, their percentage of the total

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[20]Source: (38, Table 215)

[21]Source: (38, Tables 16, 94, 95, and 215).

[22]Source: (ibid., Table 215).

[23]Source: ibid.

cattle imported (including dairy and breeding cattle) has not gone beyond 13 percent.[24]

Cattle imports are likely to increase the actual and potential supply of cattle from some regions. However, due to the negligible percentage of total imports, this study does not attempt to separate imported cattle from domestic supplies of beef cattle and calves for slaughter. Meat imports are also excluded in this study.

This basic supply is divided into two broad categories: fed beef and nonfeed beef. Since at equilibrium the aggregate slaughter demand for fed beef/nonfed beef is exactly equal to aggregate supply of fed beef/nonfed beef, once the aggregate slaughter supply is estimated, aggregate demand at equilibrium is automatically determined. Regional supplies may be in excess of or short of or equal to regional slaughter demands.

Procedures used in estimating regional, and seasonal supplies of fed and nonfed beef are described below.

Total Supply of Fed Beef for Slaughter (TSFB)

It is assumed that cattle marketed each quarter form the supply of fed beef for slaughter. Data on cattle marketings are

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[24]Source: ibid.

published for 32 states only. Although the 16 non reporting states (all from region 12 - Eastern U.S.) are not major beef producing states, it is likely that some fed cattle are marketed from them. It would have been possible to conduct a sample survey on these non-reporting 16 states to arrive at some closer estimate on the number of fed cattle marketed by them. However, time and budgetary constraints prevented the conduct of such a survey. Instead, it is assumed that six percent of the total cattle marketings from the reporting 32 states constitute fed cattle marketings from the non-reporting 16 states.

The percentage chosen is arbitrary, and doubts can be raised about its validity. The following two considerations support its choice.

(1) On the basis of six percent of total fed cattle marketings from the reporting states, cattle marketings from non reporting 16 states comes to 1300.20 thousand head. If the supply of yearlings from non reporting 16 states is considered the estimated number of fed cattle marketings (1300.20 thousand head) from them (non reporting 16 states) is not too high.

(2) Mr. Bob Reirson, Project Leader, Western Livestock Marketing Information Project, pointed out that he used an arbitrary seven percent of fed cattle marketings from the reporting

22 states to arrive at the total marketings for the year (25). For example, according to Reirson's estimates, fed steers and heifers slaughtered commercially in 1967 were 22,255 thousand head. In this study the same figure is estimated to be 22,970.20 thousand head of cattle.[25] The difference in the two figures is not substantial and it exists due to the fact that Mr. Reirson added 7 percent of the reporting 22 states, to arrive at the total fed steers and heifers commercially slaughtered in 1967.[26]

Total supply of fed beef, in 1967 is estimated as follows:

| | | |
|---|---|---|
| 21,670.00 | = | Fed cattle (steers and heifers) marketed by 32 reporting states, 1967[27] |
| + 1,300.20 | = | Six percent of fed cattle marketings from reporting 32 states, 1967[28] |
| 22,970.20 | = | Total supply of fed beef for slaughter from 48 states, 1967.[29] = TSFB |

[25]According to one source, fed cattle marketings from 39 states, in 1967, were 21,920.00 thousand cattle (18, p. 30). This estimation, in fact, support the estimated fed cattle marketings for 48 states.

[26]All figures are in thousand head.

[27]Source: (38, Table 22A).

[28]It constitutes total supply from non reporting 16 states.

[29]TSFB made up 67.82 percent of total commercial cattle slaughter, U.S., 1967.

Regional and Seasonal Supply of Fed Beef (RSFB and SSFB)

Fed cattle marketed from each region are assumed to make up the supply of fed beef for slaughter. For region 12, except for 5 reporting states, supply of fed beef is estimated to be 1,300.20 thousand head.

Seasonal fed beef supplies (SSFB) are equivalent to the number of fed cattle marketed by each region, in each season. In the case of region 12, the estimated number of fed marketings from the non reporting 16 states is divided on the basis of fed cattle marketings from the reporting 5 states of the region.

Estimates on RSFB and SSFB are presented in Columns 2, 3, and 4 in Table 6.

Total Supply of Nonfed Beef for Slaughter (TSNFB)

This study assumes that the supply of nonfed cattle and calves for slaughter consists of cull cows, bulls, and stags, commercial steers and heifers, and calves. For simplicity and estimation purposes, TSNFB is divided into two parts. Thus,

TSNFB = SNFC + SNFV where

TSNFB = total supply of nonfed beef for slaughter,

SNFC = supply of nonfed cattle for slaughter,

SNFV = supply of nonfed calves for slaughter.

Estimation of SNFC

At equilibrium the aggregate demand for each type of cattle is equal to the aggregate supply of each type of cattle. Thus, at equilibrium the aggregate demand for nonfed cattle must be equal to the aggretate supply of nonfed cattle. Commercial heifers and steers, cull cows, bulls, and stags form the supply of nonfed cattle. Supply of nonfed cattle for slaughter is estimated as follows:[30]

SNFC = TCCS - TSFC   where

TCCC = total commercial cattle slaugher, 1967

TSFC = total estimated supply of fed beef, 1967.

| | | |
|---|---|---|
| 33,868.6 | = | TCCS, 1967[31] |
| -22,970.2 | = | TSFC, 1967 |
| 10,898.4 | = | supply of nonfed cattle, 1967.[32] |

After obtaining total supply of nonfed cattle, it is essential to estimate the supply of each category of cattle included in it. Published sources provide information on the different categories of

[30] All figures are in thousand head

[31] Source: (38, Table 94).

[32] SNFC made up approximately 32. 18 percent of total commercial cattle slaughter, 1967.

Table 6. Estimated Fed and Nonfed Beef Supply for Slaughter: Number of head, 12 Regions, 2 Seasons, 1967.

| | Fed Beef | | | Non fed Cattle | | | Non fed Calves | | | Non fed Beef |
|---|---|---|---|---|---|---|---|---|---|---|
| Region | Ja-Je | Jy-Dr | Total[a] 1000 head | Ja-Je[b] | Jy-Dr[c] | Total 1000 head | Ja-Je[d] | Jy-Dr[e] | Total[f] 1000 head | Total |
| 1 | 97 | 84 | 181 | 48.1 | 53.8 | 101.9 | 45.1 | 56.5 | 101.6 | 203.5 |
| 2 | 154 | 161 | 315 | 88.1 | 93.6 | 181.7 | 29.3 | 42.6 | 71.9 | 253.6 |
| 3 | 202 | 163 | 365 | 51.4 | 56.1 | 107.5 | 43.0 | 43.0 | 86.0 | 193.5 |
| 4 | 989 | 1,060 | 2,049 | 491.7 | 489.7 | 981.4 | 114.7 | 104.6 | 219.3 | 1200.7 |
| 5 | 135 | 92 | 227 | 43.0 | 45.2 | 88.2 | 109.8 | 156.8 | 266.6 | 354.8 |
| 6 | 99 | 51 | 150 | 49.3 | 46.6 | 95.9 | 42.2 | 40.2 | 82.4 | 178.3 |
| 7 | 453 | 443 | 896 | 86.9 | 84.8 | 171.7 | 71.0 | 63.0 | 134.0 | 305.7 |
| 8 | 698 | 632 | 1,330 | 261.7 | 239.6 | 501.3 | 81.1 | 59.4 | 140.5 | 641.8 |
| 9 | 2755 | 2,380 | 5,135 | 998.1 | 959.0 | 1957.1 | 526.2 | 371.8 | 898.0 | 2855.1 |
| 10 | 1122 | 946 | 2,068 | 497.0 | 503.0 | 1000.0 | 440.8 | 475.6 | 916.4 | 1916.4 |
| 11 | 4058 | 4,370 | 8,428 | 2158.6 | 2237.7 | 4396.3 | 893.9 | 848.6 | 1742.5 | 6138.8 |
| 12 | 1090.2 | 736 | 1,826.2 | 653.7 | 661.7 | 1315.4 | 608.4 | 651.2 | 1259.6 | 2575.0 |
| Total | 11,852.2 | 11,118.0 | 22,970.2 | 5427.6 | 5470.8 | 10,898.4 | 3005.5 | 2913.3 | 5918.8 | 16,817.2 |

[a]Source: (38, Table 22A)

[b](0.321785) x commercial cattle slaughter (January-June)

[c](0.321785) x commercial cattle slaughter (July-December)

[d](Estimated calf supply for slaughter) x (Percent of total commercial calf slaughter, January-June)

[e](Estimated calf supply for slaughter) x (Percent of total commercial calf slaughter, July-December)

[f](Estimated calf supply) x (0.1445796)

cattle slaughtered under federal inspection.[33] But this does not cover all commercial cattle slaughter. Therefore, cows, bulls, and stags slaughtered commercially are obtained by multiplying commercial cattle slaughter by the percent that each of cows, bulls, and stags is of cattle slaughtered under federal inspection. These estimates are presented in Table 7. It shows that in 1967 9,144.52 thousand head cows were slaughtered commercially; they compsed 27 percent of the total commercial cattle slaughter.

The estimate on the commercial steers and heifers slaughtered is obtained simply by deducting the number of commercial slaughter of cows, bulls, and stags estimated above from the total non fed cattle supply estimate.[34] Thus,

| | |
|---|---|
| 10,898.40 | = Total non fed cattle supply, 1967 |
| - 9,574.65 | = Estimated commercial slaughter of cows, bulls, and stags, 1967 |
| 1,323.75 | = Estimated commercial slaughter of commercial steers and heifers, 1967.[35] |

[33] Source: (38, Table 106).

[34] All figures are in thousand head.

[35] Almost 4 percent of total commercial cattle slaughter.

Table 7. Estimated Commercial Bulls and Stags, and Cows Slaughter: Number of head, U.S., 1967.

| | Percent of Cattle slaughtered under federal inspection, 1967[a] | Total Commercial Cattle slaughter, 1967[b] | Estimated Commercial Cattle slaughter, 1967[c] | |
|---|---|---|---|---|
| | (Percent) | (1000 head) | (1000 head) | |
| Commercial and utility cows | 18.18 | 33,868.6 | 6,157.31 | |
| | | | | 9,144.52 |
| Canner and cutter cows | 8.82 | 33,868.6 | 2,987.21 | |
| Bulls and stags | 1.27 | 33,868.6 | | 430.13 |
| Total | - | - | | 9,574.65 |

[a]Souce: (25)

[b]Source: (38, Table 94)

[c]Obtained by multiplying the percent of cattle slaughtered under federal inspection by the total commercial cattle slaughter.

Regional Supply of Nonfed Cattle (RSNFC)

Since the estimated nonfed cattle supply is found to be approximately 32.18 percent of the total commercial cattle slaughter, the same percentage is assumed to hold for all regions. That is, the regional supply of nonfed cattle is obtained by multiplying the regional commercial cattle slaughter number by 0.321785. Regional estimates are presented in Table 6, Columns 4, 5, and 6.

Seasonal Supply of Nonfed Cattle (SSNFC)

It is assumed that the seasonal supply of nonfed cattle is on the lines of cattle slaughtered commercially during each season. For example, in region 1, 47.2 percent of the total commercial cattle were slaughtered in the first season.[36] Therefore, 47.2 percent of the total nonfed cattle supply from region 1 is assumed to approximate nonfed cattle supply for season I. Season II supply is obtained by deducting season I supply from the total regional supply. Regional and seasonal commercial cattle slaughter percentages are presented in appendix B, and nonfed cattle supply estimates are presented in Columns 4, 5, and 6 in Table 6.

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[36]Source: (38, Table 94).

Supply of Nonfed Calves (SNFV)

In the aggregate, total nonfed calves supplied are equivalent to the number of calves slaughtered commercially during the year. Since 5,918.8 thousand head of calves were slaughtered commercially in 1967, the same number approximates yearly nonfed calf supply.[37] Thus, SNFV = 5,918.8 thousand head.

Regional Nonfed Calf Supply (RSNFV)

In order to obtain the number of nonfed calves supplied for slaughter in 1967, total number of calves available in each region for feeding, slaughter, or other uses is estimated first. The method used in estimating the total regional calf supply is described below, and the estimates are presented in Appendix C.

Net calf crop, 1967 = calves born, 1967 - calf deaths, 1967

Calves on farms, Jan. 1, 1967 = (Heifer calves on farms, Jan. 1) + (other calves on farms, Jan. 1).

Calves on farms, Jan. 1, 1968 = (Heifer calves on farms, Jan. 1) + (other calves on farms, Jan. 1).

Total regional calves available for feeding/slaughter, 1967 = (Net calf crop, 1967) - (Total calves on farms, Jan. 1, 1968) + (calves on farms, Jan. 1, 1967).

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[37] Source: (38, Table 95).

The above method, however, does not provide estimates on actual number of calves supplied for slaughter in 1967, by each region. This is accomplished by calculating the percentage of the total nonfed calves supplied for slaughter relative to the total calves that were available for feeding and slaughter in 1967. Such a percentage is assumed to be common for all regions.

$$\frac{5918.8}{40,938} \times 100 = 14.45796$$

Thus, approximately 14.5 percent of the total estimated calves available for feeding and slaughter are assumed to make up the non-fed calf supply for each region. Estimates on regional calf supply are presented in Columns 7, 8, and 9 in Table 5.

Seasonal Nonfed Calf Supply (SSNFV)

Seasonal supply of calves for slaughter from each region is estimated on the basis of calves slaughtered commercially during each season. Percentages of calves slaughtered in each season are presented in Appendix B. The method used in estimating seasonal calf supply from each region is exactly the same as that used for estimating seasonal supply of nonfed cattle. For example, in Region 1, 44.4 percent of the total commercial calves were slaughtered in season I.[38] Therefore, 44.4 percent of the total nonfed calf supply from region 1 is assumed to approximate its season I nonfed calf supply. Seasonal calf supply estimates for each region are presented in Columns 7, 8, and 9 in Table 6.

Estimates of total nonfed beef supply are presented in Column 11, Table 6. For example, in 1967 Region 1 supplied 101.9 thousand head of nonfed cattle and 101.6 thousand head of calves for commercial slaughter, thus making total nonfed beef supply of 203.5 thousand head.

## C. Regional and Seasonal Supply on a Live weight Basis

Although the supply estimates are obtainable in terms of number of head of cattle or calves, such estimates must be expressed in their live weight equivalents for two important reasons: (1) to facilitate the formation and comparison of different demand estimates, and (2) transportation and other costs which will be used in the present model are generally expressed in relation to the carcass weight or live weight and rarely in relation to the number of head of cattle. Therefore, regional and seasonal supplies of fed and nonfed cattle and calves are expressed in their live weight equivalents. The calculation procedure used is explained below.

[38] Source: (38, Table 95).

<u>Average Live weight, Nonfed Cattle (ALWNFC)</u>

Since the weight of nonfed cattle varies depending upon the type of cattle (e.g., commercial or utility cow, canner and cutter cow, bulls and stags, commercial heifers and steers, etc.); and due to the fact that data on commercial slaughter of these types of cattle are not available for all states of the union, the following method is used to estimate the average live weight of nonfed cattle supplied.

$$ALWNFC = \frac{TDWNFC}{SNFC} \div \text{dressing percentage, where}$$

ALWNFC = Average live weight of nonfed cattle, 1967

TDWNFC = Total dressed weight of nonfed cattle, 1967

SNFC = Supply of nonfed cattle, 1967

Total dressed weight of nonfed cattle is estimated on the basis of information provided by Mr. Reirson about the dressed weight of different categories of cattle, in 1967 (25). Table 8 shows estimated total dressed weight of nonfed cattle slaughtered commercially in 1967. Dressing percentages for cattle, calves, and vealers slaughtered under federal inspection in 1967 were 58.5, and 55.5 respectively.[39] Generally, cows, bulls, and other nonfed cattle yield less carcass weight. Thus, assuming dressing yield for

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[39] Source: (38, Table 148).

Table 8. Estimated Nonfed Cattle slaughter: Total Dressed Weight, U.S., 1967.

| | Estimated Number of cattle 1000 head | Dressed[a] weight pounds | Total[b] (1000 pounds) |
|---|---|---|---|
| Cows | 9,144.52 | 489 | 4,471,670.28 |
| Bulls, stags | 430.13 | 693 | 298,080.09 |
| Commercial steers and heifers | 1,323.75 | 432 | 571,860.00 |
| Total | 10,898.40 | - | 5,341,610.37 |

[a]Source: (25).

[b]Column 2 x column 3.

nonfed cattle to be 55 percent, average live weight of nonfed cattle was calculated as follows:

$$\text{ALWNFC} = \frac{5,341,631.37}{10,898.40} \div 0.55$$

$$= 891.145222$$

In this study the average live weight of nonfed cattle supplied for slaughter is assumed to be approximately 891 pounds for all regions, and for both seasons.

Regional and seasonal nonfed cattle estimates on a live weight basis are obtained by multiplying regional nonfed cattle estimates by their estimated average live weight. These estimates are presented in Columns 5, 6, and 7 in Table 9.

Total Live weight, Nonfed Cattle (TLWNFC)

TLWNFC is obtained simply by adding the regional nonfed cattle supply estimates. Accordingly, TLWNFC in 1967 was 9,712,058.155 pounds or approximately 28.12 percent of total commercial cattle slaughter.[40] TLWNFC also can be obtained by multiplying ALWNFC by TSNFC. Thus

$$\text{TLWNFC} = \text{ALWNFC} \times \text{SNFC}$$

$$= 891.14522 \times 10,898.40$$

$$= 9,712,057.066 \qquad \text{(1000 pounds)}$$

[40] Since ALWNFC is a round figure, TLWNFC x 0.55 is slightly different from 5,341,610.37 thousand pounds dressed weight.

Table 9. Estimated Fed, and Nonfed Beef Supply for Slaughter: Total Live Weight, 12 Regions, 2 Seasons, 1967.

| | Nonfed Calves | | | Nonfed Cattle | | |
|---|---|---|---|---|---|---|
| | Jan. -June[a] | July-Dec.[b] | Total[c] | Jan. -June[d] | July-Dec.[e] | Total[f] |
| Region | | 1000 pounds | | | 1000 pounds | |
| 1 | 10,314.98 | 12,922.32 | 23,237.30 | 42,864.09 | 47,943.61 | 90,807.70 |
| 2 | 6,701.31 | 9,743.20 | 16,444.51 | 78,509.89 | 83,411.20 | 161,921.09 |
| 3 | 9,834.68 | 9,834.69 | 19,669.37 | 45,804.86 | 49,993.25 | 95,798.11 |
| 4 | 26,233.45 | 23,923.44 | 50,156.89 | 438,176.10 | 436,393.82 | 874,569.92 |
| 5 | 25,112.75 | 35,862.30 | 60,975.05 | 38,319.24 | 40,279.77 | 78,599.01 |
| 6 | 9,651.71 | 9,194.29 | 18,846.00 | 43,933.46 | 41,527.37 | 85,460.83 |
| 7 | 16,238.67 | 14,408.95 | 30,647.62 | 77,440.52 | 75,569.11 | 153,009.63 |
| 8 | 18,548.67 | 13,585.59 | 32,134.26 | 233,212.70 | 213,518.40 | 446,731.10 |
| 9 | 120,349.10 | 85,035.71 | 205,384.81 | 889,452.04 | 854,608.27 | 1,744,060.31 |
| 10 | 100,816.95 | 108,776.19 | 209,593.14 | 442,899.17 | 448,246.05 | 891,145.22 |
| 11 | 204,447.06 | 194,086.34 | 398,533.40 | 1,923,626.07 | 1,994,115.66 | 3,917,741.73 |
| 12 | 139,149.35 | 148,938.30 | 288,087.65 | 582,541.63 | 589,670.79 | 1,172,212.42 |
| Total | 687,398.68 | 666,311.32 | 1,353,710.00 | 4,836,779.77 | 4,875,277.30 | 9,712,057.07 |

[a](Estimated number of calf supply for slaughter during Jan. -June) x (228.7136 pounds)

[b](Estimated number of calf supply for slaughter during July-Dec.) x (228.7136)

[c]Column 2+ Column 3

[d](Estimated number of nonfed cattle supply for slaughter during Jan. -June) x (891.14522)

[e](Estimated number of nonfed cattle supply for slaughter during Jy-Dec.) x (891.14522)

[f]Column 5 + Column 6

Table 9, cont.

| | Nonfed Beef | | | Fed Beef | | |
|---|---|---|---|---|---|---|
| | Jan. -June[g] | July-Dec.[h] | Total[i] | Jan. -June[j] | July-Dec.[k] | Total[l] |
| Region | | 1000 pounds | | | 1000 pounds | |
| 1 | 53,179.07 | 60,865.93 | 114,045.00 | 104,835.24 | 90,785.15 | 195,620.39 |
| 2 | 85,211.20 | 93,154.40 | 178,365.60 | 166,439.45 | 174,004.88 | 340,444.33 |
| 3 | 55,639.54 | 59,827.94 | 115,467.48 | 218,316.68 | 176,166.43 | 394,483.11 |
| 4 | 464,409.55 | 460,317.26 | 924,726.81 | 1,068,887.12 | 1,145,622.20 | 2,214,509.32 |
| 5 | 63,431.99 | 76,142.07 | 139,574.06 | 145,904.71 | 99,431.36 | 245,336.07 |
| 6 | 53,585.17 | 50,721.66 | 104,306.83 | 106,996.79 | 55,119.56 | 162,116.35 |
| 7 | 93,679.19 | 89,978.06 | 183,657.25 | 489,591.37 | 478,783.62 | 968,374.99 |
| 8 | 251,761.37 | 227,103.99 | 478,865.36 | 754,381.41 | 683,050.21 | 1,437,431.62 |
| 9 | 1,009,801.14 | 939,643.98 | 1,949,445.12 | 2,977,536.93 | 2,572,246.05 | 5,549,782.98 |
| 10 | 543,716.12 | 557,002.24 | 1,100,738.36 | 1,212,630.28 | 1,022,413.77 | 2,235,044.05 |
| 11 | 2,128,073.13 | 2,188,202.00 | 4,316,275.13 | 4,385,787.60 | 4,722,989.61 | 9,108,777.21 |
| 12 | 721,690.98 | 738,609.09 | 1,460,300.07 | 1,178,261.62 | 795,450.89 | 1,973,712.51 |
| Total | 5,524,178.45 | 5,541,588.62 | 11,065,767.07 | 12,809,569.20 | 12,016,063.72 | 24,825,632.93 |

[g]Column 2 + Column 5

[h]Column 3 + Column 6

[i]Column 4 + Column 7

[j](Estimated number of Fed Cattle supply for slaughter during Jan. -June) x (1080.885654)

[k](Estimated number of Fed Cattle supply for slaughter during July-Dec.) x (1080.775654)

[l]Column 11 + Column 12

Total Live Weight, Nonfed Calves (TLWNFV)

In 1957, total U.S. live weight of commercial slaughter was 1,353,710 thousand pounds.[41] Since at equilibrium the aggregate demand is equal to the aggregate supply, 1,353,710 thousand pounds is assumed to be the total live weight of estimated calves supplied in 1967.

Average Live Weight, Nonfed Calves (ALWNFV)

ALWNFV is obtained by dividing the total live weight of nonfed calves supplied by the total number of nonfed calf supply. Thus,

$$\text{ALWNFV} = \frac{\text{TLWNFV}}{\text{SNFV}}$$

$$= \frac{1,353,710}{5918.8} = 228.714 \text{ pounds}$$

In this study, therefore, the average live weight of a nonfed calf supplied by each region during each season is assumed to be approximately 229 pounds.

Regional and seasonal estimates on nonfed calves supplied are obtained by multiplying estimated regional nonfed calf supply by the average live weight. Regional and seasonal estimates are presented in Columns 2, 3, and 4 of Table 9.

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[41]Source: (38, Table 143).

Total Live Weight, Nonfed Beef (TLWNFBS)

Total live weight of nonfed beef supplied in 1967 is obtained by summing the regional and seasonal totals. Thus, Table 9 shows that in 1967, TLWNFB was 11,065,776.504 thousand pounds.

Total Live Weight, Fed Beef (TLWFB)

Data on live weights of cattle slaughtered commercially are generally available on a monthly basis for all states of the union. However, such data include fed as well as nonfed cattle slaughtered, with no distinction made between the two. Since the total live weight of all cattle slaughtered is obtainable from published sources, total live weight of fed cattle slaughtered commercially can be obtained by deducting total live weight of nonfed cattle from the total live weight of all cattle slaughtered. Thus,

TLWFBS = TLWCCS - TLWNFBS where

TLWFBS = total live weight of fed beef supplied

TLWCCS = total live weight of all commercial cattle slaughtered in 1967.

TLWNFC is as defined before.

TLWFCS = 34,537,690.00[42] - 9,712,057.006
= 24,825,632.934[43]

[42]Source: (38, Table 142)

[43]TLWFCS is approximately 71.88 percent of total commercial cattle slaughtered in 1967. All figures are in 1000 pounds live weight.

Average Live Weight, Fed Beef (ALWFBS)

Average live weight of fed beef supplied is obtained by dividing the estimated total live weight of commercially slaughtered fed cattle by the estimated number of fed cattle supplied during 1967. Thus,

$$\text{ALWFBS} = \frac{\text{TLWFBS}}{\text{TSFB}} \quad \text{where}$$

ALWFBS = Average live weight of fed cattle supplied

TLWFBS and RSFC are as defined earlier.

$$\text{ALWFBS} = \frac{24,825,632.934}{22,970.20}$$

$$= 1080.7756$$

= approximately 1081 pounds[44]

In this study the average live weight of fed beef slaughtered is assumed to be approximately 1081 pounds for all regions and during all seasons. Total live weight of regional commercial fed beef supplied for slaughter is obtained by multiplying the estimated number of fed cattle supplied in each region by the average live weight. Estimates on regional supplies of fed beef for slaughter are preserved on a live weight basis in Table 9.

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[44] According to a report in the Livestock and Meat situation, August 1968, average live weight of choice steers at 7 markets for the year 1967 was 1139 pounds (18, p. 9). Thus, the estimated ALWFBS is not far from the official statements.

# VI. DEMAND DATA DEVELOPMENT

## A. Demand Aspects in General

From the time the live animal leaves the ranch or farm until it is sold as meat to consumers, it passes through distinct marketing channels. To a rancher or a feed lot operator (in many situations both could be combined into one), a fattened animal or nonfed animal or simply cows culled become an end product. An animal sold by a rancher becomes input to a feedlot operator, or a fattened animal marketed becomes an input to a meat packer who slaughters and processes the animal. A retailer is the middleman between final consumer and wholesaler. A retailer generally adds extra services to the product bought from the wholesaler and sells it to the ultimate consumer for final consumption. As is evident from this marketing process, demand at the wholesale and ranch levels is a derived demand.

Beef cattle demanded for commercial slaughter can either be fed or nonfed. Fed beef is primarily used for higher-quality meat cuts, whereas nonfed beef is converted into lower quality cuts; hamburger, stew meat, etc. A decision to slaughter either fed or nonfed beef is dependent on a variety of factors, including expected returns on meat from various classes of beef cattle, expected returns on meat from sheep and lambs, hogs, and poultry, suitability of plant to slaughter various meat animals, slaughter capacity, holidays, and weather conditions.

Once a decision is made to slaughter fed beef (nonfed beef), prices of nonfed beef (fed beef), or other meat animals will have no effect on such a decision. Such a decision could be carried on for a month, or six months or even a year depending upon the factors discussed above. Thus, over a short run period demand for beef at various levels can be treated independent of each other. This implies that it is feasible to define independent demand relationships for different product forms (e.g., fed cattle, feeder cattle, nonfed cattle, etc.) at the wholesale or intermediate demand levels.

Intermediate level demand for fed beef could be in different markets and during different seasons. A market can be defined for a single city or a state, or it can be a cluster of several cities or states. In defining regions, considerations could be given to a multitude of factors, such as orientation toward the adjustment problem, availability of data, shipping distances, homogeneity in production, and expected commodity movements. Marketing seasons could be defined on the basis of marketing trends, climatic conditions, holidays, and any other practical considerations.

A series of functional relationships between prices and quantities demanded for each beef product by various regions, and during different seasons could be incorporated into the model. Such relationships could be of any algebraic form. However, in order to accommodate their use in this model, it will be more practical to express them in linear or linear in log terms. These functions can thus be specified as:

$$P_{f,\ j,\ k} = a - bQ_{f,j,k} \quad \text{or}$$

$$\ln P_{f,\ j,\ k} = \ln a - b \ln Q_{f,\ j,\ k} \quad \text{where}$$

f, j, and k are as defined earlier, b is the elasticity (slope) of the demand function when the function is (not) expressed in logs, and a is a constant term.

Depending upon the availability of sophisticated computers, demand functions for a large number of regions, seasons, and products can be studied simultaneously. One advantage in such a study is the wide coverage of the regions and the data under study. Also, results obtained from such a study will provide a more accurate analysis of the problem. However, for the present study, time and budgetary constraints in obtaining the necessary data and the interest centered on particular aspects of the problem prohibits an extensive analysis of demand situation by regions, seasons, and products.[45]

## B. Development of Demand Data in terms of Regions, Seasons, and Products

### Demand Regions and Seasons

Regional demand demarcation is on the same basis described in Chapter V. In this study, demand and supply regions are assumed to be the same and each region is represented by a single geographical point. Similarly, demand seasons are assumed to be the same as supply seasons for each product, for each region. Thus, $t = k = 2$.

### Slaughter Demand for Beef Cattle

This study considers slaughter demand for beef at the initial or intermediate level rather than at the final consumer level. The

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[45] The computer program used to analyse the beef industry prohibits use of more than 75 demand equations. Thus, the multiplication of numbers of products, demand regions, and seasons cannot exceed 75, i.e., $f \times j \times k = 75$. However, this condition can be removed to accommodate more than 75 demand equations. In the present study, demand equations do not exceed 75, so no need existed to change the program.

decision faced by a rancher in supplying various types of beef cattle is completed once the delivery of the beef animal is made. Also, the decision faced by a meat packing plant in slaughtering various types of cattle is completed once the beef cattle are received for slaughter. The demand relationships used in this study denote the quantity of some type of beef cattle demanded at the initial buyer's level, i.e., meat packing plant, within each demand region at various levels of prices.

There are two different types of products defined in this study; each is discussed below.

Fed Beef. This product form includes all types of beef cattle (mostly steers and heifers) that are fattened and are available for immediate slaughter at the meat packing plant.

Nonfed Beef. This product form is comprised of cows culled from beef and dairy herds, bulls and stags, commercial steers and heifers, and calves. These cattle are assumed not to have gone through a systematic fattening program, and are available for immediate slaughter.

On the basis of twelve regions and two seasons, 2 district demand equations will be obtained for each product.

1(Fed beef) x 2 seasons x 12 regions = 24 Fed cattle demand equations

1(Non fed beef) x 2 seasons x 12 regions = 24 Nonfed cattle demand equations.

Quantification of Products

Having defined the products, it is necessary to quantify the demand for each of them.

Total Slaughter Demand for Fed Beef (TDFB)

In recent years, fed cattle marketings have increased considerably. This is evidenced in the continuous rise in cattle slaughter and the continuous fall in calf slaughter. Calf slaughter as a percentage of total cattle and calf slaughter has declined continuously from 32.5 percent in 1955 to 12 percent in 1969.[46]

Livestock and meat statistics publications do not provide data on cattle slaughtered in terms of fed and nonfed beef. Since fed cattle eventually go for slaughter and in the aggregate demand is equal to supply, the earlier estimate of total supply of fed beef is assumed to equate total demand for fed beef. Thus, approximately 71.88 percent of total commercial cattle slaughter represents total fed beef slaughter demand.

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[46] Source: (35, Table 456).

Regional and Seasonal Slaughter Demand for Fed Beef (RDFB, SDFB)

Average live weight of fed beef for slaughter varies from region to region due to differences in the type of ration fed, feeding period, and slaughter demand in the region. However, data on the average live weight of fed beef slaughtered in different regions are not available. Therefore, it is assumed that the overall (national) percentages of fed cattle slaughter relative to total commercial cattle slaughter, hold for all regions, i.e., $RDFB_i$ = (.718798) x (Commercial cattle slaugher in the region i).

In most cases fed cattle marketed by a region are slaughtered in the same region. However, in a few cases fed cattle are shipped in from outside the region. Since, (1) demand for beef cattle is considered at the meat packing plant level, and (2) total commercial cattle slaughter equals the sum of fed and nonfed cattle slaughter; if demand estimates of non fed cattle are obtained, the other is just the residual. Therefore, regional and seasonal slaughter demand estimates for fed beef can be obtained by deducting the estimated regional slaughter demands for nonfed beef from regional and seasonal total commercial cattle slaughter. Both approaches give the same results. Estimates of regional and seasonal slaughter demand for fed beef are presented in Talbe 10. For example,

Table 10. Estimated Slaughter Demand for Fed and Nonfed Beef: Total Live Weight, 12 Regions, 2 Seasons, 1967.[a]

| Region | Fed Beef | | | Nonfed Cattle | | |
|---|---|---|---|---|---|---|
| | Jan. -June[b] | July-Dec.[c] | Total | Jan. -June[e] | July-Dec.[f] | Total[g] |
| | 1000 pounds | | | 1000 pounds | | |
| 1 | 108,377.53 | 119,653.32 | 228,030.85 | 42,398.47 | 46,809.68 | 89,208.15 |
| 2 | 205,249.98 | 214,960.94 | 420,210.92 | 80,296.02 | 84,095.06 | 164,391.08 |
| 3 | 119,388.08 | 128,615.30 | 248,003.38 | 46,705.92 | 50,315.70 | 97,021.62 |
| 4 | 1,139,643.20 | 1,131,500.66 | 2,271,143.86 | 445,840.80 | 442,655.34 | 888,496.14 |
| 5 | 97,172.19 | 102,349.69 | 199,521.88 | 38,014.81 | 40,040.31 | 78,055.12 |
| 6 | 111,448.96 | 103,151.15 | 214,600.11 | 43,600.04 | 40,353.85 | 83,953.89 |
| 7 | 186,704.26 | 181,581.39 | 368,285.65 | 73,040.74 | 71,036.61 | 144,077.35 |
| 8 | 616,870.54 | 550,895.65 | 1,167,766.19 | 241,326.46 | 215,516.35 | 456,842.81 |
| 9 | 2,382,359.94 | 2,231,617.14 | 4,613,977.08 | 932,005.06 | 873,032.86 | 1,805,037.92 |
| 10 | 988,489.98 | 980,756.44 | 1,969,246.42 | 386,708.02 | 383,682.56 | 770,390.58 |
| 11 | 5,062,610.74 | 5,155,151.71 | 10,217,762.45 | 1,980,548.26 | 2,016,751.29 | 3,997,299.55 |
| 12 | 1,458,006.89 | 1,449,077.25 | 2,907,084.14 | 570,388.11 | 566,894.75 | 1,137,282.86 |
| Total | 12,476,322.28 | 12,349,310.65 | 24,825,632.93 | 4,880,872.72 | 4,831,184.35 | 9,712,057.07 |

[a]Source: (38, Table 142)

[b](Commercial cattle slaughter, January-June) - (Estimated nonfed cattle slaughter, January-June)

[c](Commercial cattle slaughter, July-December) - (Estimated nonfed cattle slaughter, July-December)

[d]Column 2 + Column 3

[e](Commercial cattle slaughter, January-June) x (0.2812017)

[f](Commercial cattle slaughter, July-December) x (0.2812017)

[g]Column 5 + Column 6

Table 10, cont.

| Region | Non Fed Calves | | | Nonfed Beef | | |
|---|---|---|---|---|---|---|
| | Jan. -June[h] | July-Dec.[h] | Total[i] | Jan. -June[j] | July-Dec.[k] | Total[l] |
| | 1000 pounds | | | 1000 pounds | | |
| 1 | 2,473 | 3,570 | 6,043 | 44,871.47 | 50,379.68 | 95,251.15 |
| 2 | 2,501 | 3,552 | 6,053 | 82,797.02 | 87,647.06 | 170,444.08 |
| 3 | 193 | 190 | 383 | 46,898.92 | 50,505.70 | 97,404.62 |
| 4 | 40,158 | 38,481 | 78,639 | 485,998.80 | 481,136.34 | 967,135.14 |
| 5 | 238 | 344 | 582 | 38,252.81 | 40,384.31 | 78,637.12 |
| 6 | 1,501 | 1,422 | 2,923 | 45,101.04 | 41,775.85 | 86,876.89 |
| 7 | 1,685 | 1,489 | 3,174 | 74,725.74 | 72,525.61 | 147,251.35 |
| 8 | 635 | 460 | 1,095 | 241,961.46 | 215,976.35 | 457,937.81 |
| 9 | 4,245 | 2,888 | 7,133 | 936,250.06 | 875,920.86 | 1,812,170.92 |
| 10 | 117,735 | 121,759 | 239,494 | 504,443.02 | 505,441.56 | 1,009,884.58 |
| 11 | 163,174 | 159,414 | 322,588 | 2,143,722.26 | 2,126,165.29 | 4,319,887.55 |
| 12 | 331,083 | 354,520 | 685,603 | 901,471.11 | 921,414.75 | 1,822,885.86 |
| Total | 665,621 | 688,089 | 1,353,710 | 5,546,493.72 | 5,519,273.35 | 11,065,767.07 |

[h]Source (38, Table 143)

[i]Column 8 + Column 9

[j]Column 5 + Column 8

[k]Column 6 + Column 9

[l]Column 7 + Column 10

Table 10 shows that Region 1 (Oregon) had slaughter demand for fed beef in 1967 of 228.0 million pounds. Out of this total slaughter demand for fed beef, 45.5 percent was during season I, and the rest during season II. Region 1's fed beef supply was, however, 195 million pounds. A comparison of Tables, 9 and 10 shows that in 1967, estimated demand for fed beef exceeded estimated supply in Regions 1, 2, 4, 6, 11, and 12.

Total Slaughter Demand for Nonfed Beef (TDNFB)

TDNFB is the sum of slaughter demand for nonfed cattle (DNFC) and nonfed calves (DNFV) for each region, and for each season.

TDNFB = DNFC + DNFV where

TDNFB = Demand for nonfed beef

DNFC = Demand for nonfed cattle

DNFV = Demand for nonfed calves.

Estimates in TDNFB for each region and for the U.S. are presented in Table 10.[47]

[47] Since data on cattle and calf slaughter are available in terms of live weight, it was not necessary to use any conversion formula. Therefore, slaughter demand estimates are expressed in liveweight.

Slaughter Demand for Nonfed Cattle (DNFC)

In the aggregate, estimated supply of nonfed cattle was approximately 28.12 percent of the total commercial cattle slaughter in 1967. Therefore, total slaughter demand for nonfed cattle is estimated to be 971.2 million pounds.

Regional and Seasonal Slaughter Demand for Nonfed Cattle (RDNFC, SDNFC)

Regional and seasonal slaughter demand for nonfed cattle is assumed to be 28.12 percent of total commercial cattle slaughter in each region, during each season. Thus, $RDNFC_{ik} = (.2812) \times (RCCSL)_{ik}$ where

$RDNFC_{ik}$ = Regional demand for nonfed cattle in region i, in season k

$RCCSL_{ik}$ = Regional commercial cattle slaughter in region i in season k.

Estimates of regional and seasonal slaughter demand for nonfed cattle are presented in Table 10. For example, Table 10 shows that Region 1 (Oregon) demand for nonfed cattle in 1967 was 8.9 million pounds. Out of an estimated 8.9 million pounds, approximately 47.6 percent was demanded in season I and the rest during season II. Estimated nonfed cattle supply from region 1 in 1967 was 9.0

million pounds. A comparison of Tables 9 and 10 shows that estimated slaughter demand for nonfed cattle exceeded estimated supply in regions 2, 3, 4, 5, 9, and 11.

## Total, Regional and Seasonal Slaughter Demand for Nonfed Calves

Total slaughter demand for nonfed calves (TDNFV) is assumed to be represented by total commercial calf slaughter. The Livestock and Meat Statistics publications of the U.S.D.A. publish these estimates for all regions, on a monthly basis.

In 1967, TDNFV was approximately 135.4 million live weight pounds. Regional and seasonal calf slaughter estimates are obtained by summation of published monthly calf slaughter estimates. Such estimates are presented in Table 10. For example, Table 10 shows that 49 percent of the total U.S. calf slaughter demand was in Season I and the rest occurred in Season II. Seasonal slaughter demand percentages, of course, vary regionally. For example, in 1967 in Region 8 (Colorado) approximately 58 percent of regional nonfed slaughter demand was in Season I, and the remaining occurred in Season II. A comparison of Tables 9, and 10 indicates that in 1967 estimated nonfed calf supply exceeded demand in Regions 2, 3, 5, 6, 7, 8, 9, and 11.

## C. Quantification of Functional Demand Relationships

The linear demand equations described earlier must now be quantified. Studies and reports on the livestock industry in general and production and consumption of beef in particular appear quite frequently. These studies often throw light on the relationships between the total quantity of beef/meat produced (or consumed) on the national level and the national average retail price, taking into account changes in population, disposable income, and the time period involved. Various reports on the price elasticity of demand for beef show that it (price elasticity) varies from -0.55 to -1.36 (43).

Research efforts in estimating the elasticity of demand for fed and nonfed beef at the farm level are few in number. Langermeir and Thompson estimated the price elasticities of demand for fed and nonfed beef at the retail and the farm level (17). The authors used the two stage least squares method to estimate the statistical relationship embodying simultaneity, and the single-stage least squares method was used to estimate the single-equation relationships (17). The authors took into account seventeen annual (time series) observations beginning from 1947 to 1963 (17). Selected estimates on demand elasticities for fed and nonfed beef at the farm and retail level are presented in Table 11.

According to Table 11, the demand for nonfed beef is more elastic relative to that for fed beef at the farm level. Also, the coefficients of cross elasticity between fed and nonfed beef are positive, indicating that the two are substitutes for each other.

Table 11. Demand Elasticities for Fed and Nonfed Beef at the Farm and Retail Price Level[a]

| Quantity demanded | Retail Price | | Farm Price | |
|---|---|---|---|---|
| | Fed beef | Nonfed beef | Fed beef | Nonfed beef |
| Fed beef | -0.978 | 0.297 | -0.893 | 0.244 |
| Nonfed beef | 1.420 | -1.243 | 1.292 | -1.011 |

[a]Source: (17, Table 3)

In another study, Hayenga and Hacklander analyzed monthly supply and demand relationships for fed cattle and hogs (12). They used five simultaneous equations, each incorporating variables (behavioral) influencing the monthly supply and demand for live cattle and hogs and the monthly change in pork storage. A two stage least squares technique was used to provide estimates of the parameters (12).

Data time period used ranged from April 1963 to June 1968 and the prices used were the U.S.D.A. reported average prices of 900-1100 pound choice steers at Chicago. The quantities were the monthly U.S. commercial slaughter divided by the number of fully utilized slaughter days per month. The price flexibility with respect to beef cattle was found to be -1.1. This would mean that the elasticity of demand with respect to beef cattle at the slaughter (or farm) level was -0.91. This (-0.91) coefficient of price elasticity of demand for fed cattle is similar to the one estimated by Langermeir and Thompson, despite differences in data periods used. It indicates that the elasticity of demand with respect to price of fed cattle at the farm level has changed very little.

Another study on the monthly farm level demand for slaughter cattle shows that values for price flexibilities range from -1.626 to -2.360 (24). Hence, elasticity coefficients ranges from -0.424 to -0.615. In this study data on monthly farm-level demand and prices for slaughter cattle were used for the period 1948 to 1964. With three overidentified equations, the values of price flexibilities were obtained via two-stage least squares (24).

To the best of this author's knowledge, values on price elasticity or price flexibility with respect to nonfed cattle at the farm level are not available except for the values obtained by Langermeir and Thompson. However, one can presume that such values have changed very little over a 10-year period.

In this study coefficients of price elasticity with respect to fed and nonfed beef at the farm (slaughter/wholesale) level for the year

1967 are assumed to be approximated by those obtained by Langermeir and Thompson. Further, these coefficients (-0.983 for fed beef, and -1.011 for nonfed beef) are assumed to be the same for all regions, during all seasons and over the entire range of each demand relationship. In reality these elasticities may differ among regions, but the variations in them are not likely to be substantial. Also, it is unlikely that the interregional shipments will be affected greatly by it alone. The reason is that interregional shipments are influenced simultaneously by demand, supply, costs, and other factors.

The basic form of relationship between quantity demanded as a function of price is assumed to be:

$$Q = a\ P^{-b} \qquad (1)$$

The logarithmic form of the above function then becomes:

$$\ln Q = \ln a - b \ln P \qquad (2)$$

In equation (2), b is the price elasticity of demand. This can be verified by taking the partial derivative of the equation (2) with respect to price, and then solving for b. Equation (2) can be solved further to get the value of P.[48]

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[48]To accommodate equation (1) into computer model, it is necessary to express it in terms of $P = f(Q)$. Thus equation (3) is of the form $P = AQ^{-B}$.

Therefore,

$$\ln P = \frac{1}{b}(\ln a - \ln Q)$$
$$= \frac{1}{b}\ln a - \frac{1}{b}\ln Q$$
$$= A - B\ln Q \qquad (3)$$

$A = \frac{1}{b}\ln a$, and $B = \frac{1}{b}$

In equation (3) values of P, B, and Q are known, and values of A can be estimated by solving the equation in the following way:

$$A = \ln P + B \ln Q$$

Estimated values of A and the final estimated demand functions each for fed beef and nonfed beef are presented in Tables 12 and 13.[49] These two tables show that variations in the A values vary from 18.32 to 22.85, and for nonfed beef from 15.60 to 19.53. Larger values of A are influenced by larger quantities, and higher prices in the region. These A values will have an important role in influencing the market equilibrium prices in the final solution. Market prices for fed and nonfed beef used to calculate demand equations are presented in Appendix A.

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[49]When more than one time period is involved, a market is added for programming purposes for each original market for each time period. Since 12 original regions of demand (also supply) and two seasons are considered in this study, 24 demand equations are estimated.

Table 12. Estimated Slaughter Demand Functions: Fed Beef, 12 Regions, 2 Seasons, 1967.

| Region | Product | Season | Estimated demand function |
|---|---|---|---|
| 1 | Fed Beef | I (January-June) | $18.53\ Q^{-1.12}$ |
| 2 | " | " | $19.21\ Q^{-1.12}$ |
| 3 | " | " | $18.62\ Q^{-1.12}$ |
| 4 | " | " | $21.17\ Q^{-1.12}$ |
| 5 | " | " | $18.32\ Q^{-1.12}$ |
| 6 | " | " | $18.53\ Q^{-1.12}$ |
| 7 | " | " | $19.14\ Q^{-1.12}$ |
| 8 | " | " | $20.42\ Q^{-1.12}$ |
| 9 | " | " | $21.94\ Q^{-1.12}$ |
| 10 | " | " | $20.96\ Q^{-1.12}$ |
| 11 | " | " | $22.77\ Q^{-1.12}$ |
| 12 | " | " | $21.42\ Q^{-1.12}$ |
| 1 | " | II (July-December) | $18.67\ Q^{-1.12}$ |
| 2 | " | " | $19.30\ Q^{-1.12}$ |
| 3 | " | " | $18.73\ Q^{-1.12}$ |
| 4 | " | " | $21.19\ Q^{-1.12}$ |
| 5 | " | " | $18.43\ Q^{-1.12}$ |
| 6 | " | " | $18.47\ Q^{-1.12}$ |
| 7 | " | " | $19.14\ Q^{-1.12}$ |
| 8 | " | " | $20.36\ Q^{-1.12}$ |
| 9 | " | " | $21.92\ Q^{-1.12}$ |
| 10 | " | " | $21.00\ Q^{-1.12}$ |
| 11 | " | " | $22.85\ Q^{-1.12}$ |
| 12 | " | " | $21.48\ Q^{-1.12}$ |

Table 13. Estimated Slaughter Demand Functions: Nonfed Beef, 12 Regions, 2 Seasons, 1967.

| Region | Product | Season | Estimated demand function |
|---|---|---|---|
| 1 | Nonfed Beef | I (January-June) | $15.75\ Q^{-0.99}$ |
| 2 | " | " | $16.35\ Q^{-0.99}$ |
| 3 | " | " | $15.79\ Q^{-0.99}$ |
| 4 | " | " | $18.14\ Q^{-0.99}$ |
| 5 | " | " | $15.60\ Q^{-0.99}$ |
| 6 | " | " | $15.81\ Q^{-0.99}$ |
| 7 | " | " | $16.24\ Q^{-0.99}$ |
| 8 | " | " | $17.50\ Q^{-0.99}$ |
| 9 | " | " | $18.75\ Q^{-0.99}$ |
| 10 | " | " | $18.15\ Q^{-0.99}$ |
| 11 | " | " | $19.53\ Q^{-0.99}$ |
| 12 | " | " | $18.81\ Q^{-0.99}$ |
| 1 | " | II (July-December) | $15.83\ Q^{-0.99}$ |
| 2 | " | " | $16.35\ Q^{-0.99}$ |
| 3 | " | " | $15.83\ Q^{-0.99}$ |
| 4 | " | " | $18.10\ Q^{-0.99}$ |
| 5 | " | " | $15.61\ Q^{-0.99}$ |
| 6 | " | " | $15.69\ Q^{-0.99}$ |
| 7 | " | " | $16.16\ Q^{-0.99}$ |
| 8 | " | " | $17.40\ Q^{-0.99}$ |
| 9 | " | " | $18.63\ Q^{-0.99}$ |
| 10 | " | " | $18.09\ Q^{-0.99}$ |
| 11 | " | " | $19.52\ Q^{-0.99}$ |
| 12 | " | " | $18.75\ Q^{-0.99}$ |

After considering demand and supply aspects, it is now necessary to consider costs involved in converting a raw product into final product[49a] and shipping the final product from one place of supply to one or more places of demand.

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[49a] In this study fed and nonfed beef are the two final products considered demanded at the wholesale level and not at the retail level.

# VII. TRANSFER COST DATA DEVELOPMENT

This chapter deals with estimation of transfer cost data. The term transfer cost is used to mean the sum of transportation costs, and intermediate costs. Transfer cost considerations in general are discussed first, followed by discussions on estimation of transportation costs and intermediate costs.

## A. Transfer Cost Aspects in General

Transfer costs play an important part in giving a realistic picture of interregional shipments and production and price relations. Therefore, to complete the model a transfer cost matrix must be introduced. Each cell in such a matrix will show the total transfer cost of supplying one unit of a product from each producing region during each production season to meet the demand for that unit of product in each market area during each season.

Generally, transportation costs are expressed in units consisting of a car load or a hundred weight. To maintain consistency in units used in the model, transportation costs must be expressed on a hundred weight basis. Since more than one season is used in the study, some artificial method must be used to block the movement of cattle from season II to season I.[50]

[50] Such "blocking" also becomes necessary when certain inputs cannot be used to produce certain types of products.

Once the transfer costs are estimated the reactive programming model will furnish an equilibrium solution for each type of product from each producing area during each season among geographic market areas and seasons. The final solution obtained will be such that no reallocation would result in enhancing the total net revenue for any of the producers. The computer solution will show (1) market prices for each product demanded in each market during each season, (2) net prices associated with each product supplied (shipped) from each producing area during each production season, and (3) equilibrium shipments of each product from each producing area in each season.

## B. Estimation of Transportation Costs

Transportation or shipment costs bear a significant influence over the movement of cattle or dressed beef from the producing region to the place of demand. Thus, it is essential to estimate costs of shipments between two or more points. Beef cattle are transported both by truck and by rail. However, in recent years the importance of cattle shipments by rail has dwindled significantly. A study on the role of railroads in hauling farm products indicates that livestock shipments by rail declined by 80 percent from 1954 to 1969 (3, p. 22). A Utah study shows that in 1956 almost 72 percent of the total beef cattle inspected were transported by truck (10, p. 4).

This trend is evidenced in another study which shows that in 1962 almost 74 percent of the total beef cattle were handled by truck in 12 Western states (5, p. 6). Of the total cattle and calves shipped into the state of California from various states, 88.02, 88.06, and 83.15 percent were transported by truck in the years 1965, 1966, and 1967 respectively (4, p. 14). These reports clearly indicate that trucks play the most vital role in shipping cattle from production centers to consumption centers. Such a rise in transportation of cattle by truck probably has been due to the following factors: (1) flexibility in schedules and better pickup and delivery service at the ranch or feedlot, (2) availability of larger, more powerful and better equipped trucks (20, p. 14), (3) flexibility in adjusting long haul and short haul rates (3, p. 23), and (4) improved highways.

In this study truck transportation costs from the representative point in the supply region to the representative points in the demand regions are considered. These costs can be estimated in terms of weight carried, distance travelled, or time consumed. Different equations have been used by different authors to estimate transportation costs (1, 9, 11).

Truck transportation costs estimated by Havlicek, Rizek, and Judge are used in this study. They used the following equation to arrive at the transportation costs between two or more points (11, p. 6):

$$Cij = bo + b_1\ Dij + b_2\sqrt{Dij} + b_3\ Wij + b_4\ Dij/Tij$$

where Cij = costs ($/100 lbs.) of shipping live cattle by truck from point i to point j

Dij = distance (highway mileage) between i and j

Wij = total live weight of the livestock per shipment from point i to point j

Tij = time required (number of hours) to ship livestock from point i to point j

Dij/Tij = average speed of the haul, and $b_o$, $b_1$, $b_2$, $b_3$, $b_4$ are estimated regression coefficients.

A survey of truckers and the ICC one percent way bill sample statements provided data for estimating the coefficients of the transportation equation. The least squares technique was then used to estimate the parameters (11, p. 6).

There are three reasons for using truck transportation costs estimated by Havlicek, Rizek, and Judge. First the equation simultaneously takes into account distance travelled, weight carried, and average speed of the haul. These variables are important in obtaining realistic transportation costs between various points. Secondly, the transportation cost matrix expresses costs in terms of a hundred weight of live cattle hauled. This unit is consistent with the units used for demand and supply estimation in this study.

Thirdly, the transportation costs estimated are realistic between various shipping point.

These costs, however, do not take into account the effect of backhauls. Shipments of certain agricultural products by truck (private carriers as well as those trucks that haul agricultural products exclusively) are exempt from economic regulation by the ICC (3, p. 24). This gives flexibility to truckers with respect to the route of shipment and the rates charged. Thus, if truckers are assured of backhauls, they would prefer to charge less than go empty (3, p. 24). According to one study, the "truck carriers interviewed indicated that backhauls were available for about one-third of the cases" (9, p. 17). Although backhauls do affect the rates charged between various points, they are not regular, and often are seasonal for some truckers (14, p. 17). Nevertheless, the effect of backhauls can be studied by changing the rate structure.

Truck shipment costs for 1960, obtained by Havlicek, Rizek, and Judge are adjusted according to the demand and supply points used in this study. Since 1960, shipment costs must have changed due to changes in costs for fuel, repairs, and maintenance, driver's wages, insurance, depreciation, and other overhead charges. Some costs have probably gone up, some have fallen, and others have remained stationary in recent years. The exact changes into these factor costs are difficult to estimate without a sample survey of the trucking industry.

Much of the trucking operation is unregulated, and litte data except the 1963 census of transportation are available (42, p. 19). One report in the "Marketing and Transportation Situation," a monthly publication of the ERS, U. S. D. A., however, stated that truck rates for unmanufactured farm products appear to have changed very little over recent years (41, p. 13). Taking these considerations into account, it is assumed that overall changes in truck transportation costs between various shipping points did not change drastically from 1960 to 1967. Truck transportation rates per hundred weight of live cattle hauled are presented in Table 14. For example, Table 14 shows that it costs $0.54 per hundred weight to haul live cattle from Portland to Spokane, and $5.27/hundred weight to haul live cattle from Portland to Atlanta, Georgia.

## C. Intermediate Costs

Intermediate costs include total expenditures incurred in converting the basic supply of cattle into fed or nonfed beef form. Intermediate costs can be divided into two broad groups: (1) feed costs, and (2) non feed costs.

1. Feed Costs. Beef cattle are raised on varying proportions of roughages and concentrate feeds, depending upon the type of cattle production enterprise involved. For example, cattle in the feedlot are more likely to be raised on a higher percentage of

Table 14. Truck Transportation Rates*: Dollars per Hundred Weight (live), Beef cattle, 12 Regions, 1967.[a]

| Origin \ Destination | Portland | Spokane | Boise | Fresno | Billings | Salt Lake City | Phoenix | Denver | Omaha | Fortworth | Des Moines | Atlanta |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Portland | 0 | | | | | | | | | | | |
| 2. Spokane | 0.54 | 0 | | | | | | | | | | |
| 3. Boise | 0.66 | 0.60 | 0 | | | | | | | | | |
| 4. Fresno | 1.24 | 1.71 | 1.19 | 0 | | | | | | | | |
| 5. Billings | 1.36 | 0.84 | 0.93 | 1.49 | 0 | | | | | | | |
| 6. Salt Lake City | 1.27 | 1.14 | 0.57 | 1.35 | 1.02 | 0 | | | | | | |
| 7. Phoenix | 2.28 | 2.45 | 1.74 | 0.98 | 1.60 | 1.08 | 0 | | | | | |
| 8. Denver | 1.69 | 1.47 | 1.11 | 1.79 | 0.97 | 0.97 | 1.38 | 0 | | | | |
| 9. Omaha | 2.37 | 2.33 | 1.72 | 3.06 | 1.23 | 1.57 | 2.25 | 0.96 | 0 | | | |
| 10. Fortworth | 2.62 | 2.37 | 2.03 | 1.84 | 1.92 | 1.60 | 1.35 | 1.03 | 0.86 | 0 | | |
| 11. Des Moines | 2.39 | 1.94 | 1.81 | 3.30 | 1.45 | 1.85 | 2.54 | 1.13 | 0.26 | 1.00 | 0 | |
| 12. Atlanta | 5.27 | 4.66 | 4.39 | 4.74 | 3.62 | 3.61 | 3.42 | 2.59 | 1.76 | 1.55 | 1.58 | 0 |

*It is assumed that truck transportation rates have changed very little in seven years.

[a]Source (11, Table A.3)

concentrate feed than the cattle on the ranch. Ingredients included in the concentrate feeds are barley, wheat, corn, corn silage, milo, oats, beet pulp, molasses, supplement, etc. The proportion of these ingredients and thus the costs involved vary depending upon the type of ration fed, type of animal, the feeding period involved, and the size of business operation.

2. Nonfeed Costs. The nonfeed costs include

1. depreciation
2. taxes, insurance, and interest
3. labor
4. utilities
5. fuel
6. veterinary
7. death loss
8. interest on cattle and feed, and
9. miscellaneous expenses.

Table 15 is reproduced from a feasibility study on the expansion of livestock feeding and meat packing industry in Utah (30, p. 84). It shows differences in nonfeed and feed costs in four states of the Western U.S. It indicates that labor, taxes, insurance and interest, interest on cattle and feed, and depreciation constitute the bulk of the nonfeed costs. Also, it shows that nonfeed costs account for

Table 15. Comparative Costs Per Pound of Gain, Calves, 1968[a]

| Item | Arizona[2] | Colorado[3] | Idaho[4] | Utah[5] |
|---|---|---|---|---|
| | | | Size[1] | |
| Fixed Costs | | | | |
| Depreciation | .62 | .48 | .78 | .69 |
| Taxes, Insurance, Interest | .71 | .72 | .95 | .53 |
| Total Fixed Costs | 1.33 | 1.20 | 1.73 | 1.22 |
| Variable Costs | | | | |
| Labor | 1.78 | 1.95 | .86 | 1.16 |
| Utilities | .26 | - | .07 | .23 |
| Fuel | .15 | .74 | .19 | .20 |
| Repair | .32 | - | .32 | .22 |
| Veterinary | .21 | - | .23 | .10 |
| Other | .15 | 1.61 | - | .01 |
| Death Loss | .42 | - | .94 | .88 |
| Interest on cattle and feed | 1.35 | 2.03 | 1.70 | 1.78 |
| Total non feed variable costs | 4.64 | 6.33 | 4.31 | 4.57 |
| Feed Costs | 14.15 | 17.29 | 16.48 | 12.89 |
| Total Variable Costs | 18.79 | 23.62 | 20.79 | 17.46 |
| Total Costs/lb. gain | 20.12 | 24.82 | 22.52 | 18.68 |

[a]Source: (30, Table 54)

[1]Arizona - 4,000 - 10,000 capacity, Colorado - farm feedlots under 500 capacity, Idaho and Utah include all sizes.

[2]Gum, Russel and John Wildermuth. Profits Feeder calves or Yearling steers, Western Livestock Journal, March, 1969, pp. 12, 13, and 16.

[3]Gee, Kerry. Seasonal feedlots in Colorado, manuscript is unpublished and material to be used for reference only.

[4 and 5]Information obtained from a selected survey conducted by Extension Service, Utah State University, 1969.

almost 30 percent of the total costs in all regions. Variations in nonfeed costs in these four states as well as other states could be due to the scale of operation, scarcity or abundance of resources, feeding period involved, and institutional factors.

In this study nonfeed costs for fed cattle include some but not all of the factors mentioned above. Those factors considered as important and therefore included in the estimation of nonfeed costs for fed cattle are:

(1) cost of interest

(2) cost of labor, and

(3) other nonfeed costs of production. This broad category includes cost of utilities, fuel, repairs, veterinary expenses, death losses, and others.

## Intermediate Costs, Fed Beef

The initial weight of cattle entering the feedlot is assumed to be 700 pounds. A study recently completed at Oregon State University estimated feed and nonfeed costs for beef cattle for 1967.[51] These costs estimated by Bhagia are used in this study (2).

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[51]See Bhagia (2). Future references will be to Bhagia when discussing feed and nonfeed costs. Also, in Chapter IX while discussing truck transportation costs.

Since the average weight of fed cattle supplied is estimated to be 1081 pounds, feed costs are estimated for a gain of 381 pounds, and are presented in Column 3 of Table 16. For example, Column 3 shows that estimated feed costs for 381 pounds of gain varied from minimum of $58.13 in region 1 (Oregon) to maximum of $89.67 in region 4 (California) in 1967. It reflects advantages some regions have with regard to an abundance of feed grains, better techniques, size of business, and availability of cheap labor.

With regard to the nonfeed costs as estimated by Bhagia, two adjustments are made in such estimates.

1. Bhagia has calculated nonfeed costs for a period involved in fattening cattle for additional 425 pounds. In this study these costs are adjusted for 381 pounds.

2. Regions used by Bhagia are different from those in this study; hence, specific regional cost adjustments are made.

Total nonfeed costs for fed cattle are presented in Column 3 of Table 16. For example, Table 16 shows that estimated nonfeed costs were lowest in region 4 in 1967, and highest in region 9. Feedlot operators not only have to incur feed and nonfeed expenditures, but they also have to pay for the cattle to be placed on feed. This cost is taken into account by estimating the prices paid for 700 pound feeder cattle in each region. Such costs are presented in Column 2 of Table 16. Accordingly, the lowest price paid for a 700-pound feeder

Table 16. Estimated Intermediate Costs: Dollars per Hundred Weight (Live) Fed Beef, 12 Regions, 1967.

| Region | Average of choice and good feeder steer prices[a] | Average price paid for feeder steer | Feed Costs[b] | Non feed and Other Costs[b] | Total Cost | Intermediate Costs |
|---|---|---|---|---|---|---|
| | $/100 lbs. | $/700 lbs. | $/381 lbs. | $/381 lbs. | $/1081 lbs. | $/100 lbs. |
| 1 | 24.21 | 169.47 | 58.13 | 28.04* | 255.64 | 23.65 |
| 2 | 24.95 | 174.65 | 66.07 | 28.04* | 268.76 | 24.86 |
| 3 | 25.24 | 176.68 | 76.60 | 23.01 | 276.29 | 25.56 |
| 4 | 24.12 | 168.84 | 89.67 | 13.70 | 272.21 | 25.18 |
| 5 | 24.98 | 174.86 | 62.93 | 21.49 | 259.28 | 23.98 |
| 6 | 24.46 | 171.22 | 75.32 | 19.17 | 265.71 | 24.58 |
| 7 | 24.43 | 171.01 | 66.89 | 25.55 | 263.45 | 24.37 |
| 8 | 25.62 | 179.34 | 73.56 | 16.44 | 269.34 | 24.91 |
| 9 | 25.95 | 181.85 | 64.04 | 30.11 | 275.80 | 25.51 |
| 10 | 24.85 | 173.95 | 64.07 | 15.34 | 253.36 | 24.44 |
| 11 | 26.39 | 184.73 | 61.58 | 27.84 | 274.15 | 25.36 |
| 12 | 24.23 | 169.61 | 78.78 | 22.55 | 270.94 | 25.06 |

[a]Source: (36)

[b]Source: (2)

*Nonfeed costs are assumed to be the same for regions 1 and 2.

steer in 1967 was $169.47 in region 1 (Oregon) and the highest cost paid was $179.34 in region 8 (Colorado). Differences in costs are probably due to differences in regional demand for feeding as well as for slaughter.

Total intermediate costs per hundred weight (live) are presented in Column 7 of Table 16. It indicates substantial differences in costs between regions.

Intermediate Costs, Nonfed Beef

Estimation of feed as well as nonfeed costs for nonfed beef is difficult to quantify since this product includes calves, cull cows, bulls, and commercial heifers and steers. The feeding period and the type of ration fed varies with the type of ranching operation, as well as for each region for each species of cattle. Many times cull cows are regarded as a by product of the beef industry.

Due to the lack of information and difficulty in estimating feed and nonfeed costs for nonfed beef plus the fact that estimated supply of nonfed cattle constitutes 87 percent of the estimated nonfed beef supply, it is assumed that the intermediate costs of nonfed beef are reflected in the simple average of the yearly average prices of commercial, utility, and other cows. This implies that such average prices received in each region covers the cost of production of nonfed beef in the region, and the interregional shipments are possible due to differences in such prices, transportation costs, and prices offered in the market.

Estimated intermediate costs (feed plus nonfeed costs) per hundred weight (live) nonfed beef are shown in Table 17. For example, Table 17 indicates that in 1967 such costs were minimum in region 3 (Idaho) and maximum in region 8 (Colorado).

Even though it is possible to adjust intermediate costs for nonfed beef for each of the seasons, it is assumed that these costs remain constant for both the seasons in 1967. This is done for simplicity purposes. Also, variations in these costs are not likely to be significant so as to affect the equilibrium shipments.

## D. Transfer Costs

Transfer costs which combine truck shipment costs and intermediate costs are presented in matrix form in Tables 18 and 19 for fed and nonfed beef, respectively. Each cell in the matrix shows the total transfer cost of supplying a hundred weight (live) of either fed or nonfed beef from each supplying area during each production season, to meet demand for each of the products in each market area and during each marketing season.

In order to ensure that production in season II is not allocated to fulfill market equilibrium in season I, artificially high

Table 17. Estimated Intermediate Costs:* Dollars per Hundred Weight (live), Nonfed Beef, 12 Regions, 1967.[a]

| Region | Price* $/100 pounds |
|---|---|
| 1 | 15.55 |
| 2 | 16.12 |
| 3 | 15.38 |
| 4 | 16.71 |
| 5 | 16.35 |
| 6 | 16.38 |
| 7 | 15.66 |
| 8 | 17.14 |
| 9 | 16.74 |
| 10 | 16.34 |
| 11 | 15.95 |
| 12 | 16.14 |

*Simple average of yearly average prices of commercial, utility, cutter and canner cows.

[a]Source: (36).

Table 18. Transfer Costs:* Dollars per Hundred Weight (live), Fed Beef, 12 Regions, 1967.

| Destination / Origin | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 23.65 | | 24.19 | 24.31 | 24.89 | 25.01 | 24.92 | 25.93 | 25.34 | 26.02 | 26.27 | 26.04 | 28.92 |
| 2 | 24.86 | 25.40 | | 24.56 | 26.57 | 25.70 | 26.06 | 27.31 | 26.33 | 27.19 | 27.26 | 26.80 | 29.52 |
| 3 | 25.56 | 26.22 | 26.16 | | 26.75 | 26.49 | 26.13 | 27.30 | 26.67 | 27.28 | 27.63 | 27.37 | 29.95 |
| 4 | 25.18 | 26.42 | 26.89 | 26.37 | | 26.67 | 26.53 | 26.16 | 26.97 | 28.24 | 27.02 | 28.48 | 29.92 |
| 5 | 23.98 | 25.34 | 24.82 | 24.91 | 25.47 | | 25.00 | 25.58 | 24.95 | 25.21 | 25.90 | 25.43 | 27.60 |
| 6 | 24.58 | 25.85 | 25.72 | 25.15 | 25.93 | 25.60 | | 25.66 | 25.55 | 26.15 | 26.18 | 26.43 | 28.19 |
| 7 | 24.37 | 26.65 | 26.82 | 25.84 | 25.36 | 25.97 | 25.45 | | 25.75 | 26.62 | 25.72 | 26.91 | 27.79 |
| 8 | 24.91 | 26.60 | 26.38 | 26.02 | 26.70 | 25.88 | 25.88 | 26.29 | | 25.87 | 25.94 | 26.04 | 27.50 |
| 9 | 25.51 | 27.88 | 27.84 | 27.23 | 28.57 | 26.74 | 27.08 | 27.76 | 26.47 | | 26.37 | 25.77 | 27.27 |
| 10 | 23.44 | 26.06 | 25.81 | 25.47 | 25.28 | 25.36 | 25.04 | 25.04 | 24.79 | 24.47 | | 24.44 | 24.99 |
| 11 | 25.36 | 27.75 | 27.30 | 27.17 | 28.66 | 26.81 | 27.21 | 27.90 | 26.49 | 25.62 | 26.36 | | 26.94 |
| 12 | 24.96 | 30.23 | 29.62 | 29.35 | 29.70 | 28.58 | 28.57 | 28.38 | 27.55 | 26.72 | 26.51 | 26.64 | |

*Includes intermediate costs and truck transportation costs.

Table 19. Transfer Costs:* Dollars per Hundred Weight (live) Nonfed Beef, 12 Regions, 1967.

| Destination / Origin | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15.55 | | 16.09 | 16.21 | 16.79 | 16.91 | 16.82 | 17.83 | 17.24 | 17.86 | 18.17 | 17.94 | 20.82 |
| 2 | 16.12 | 16.66 | | 16.72 | 17.78 | 16.96 | 17.28 | 18.39 | 17.59 | 18.45 | 18.54 | 18.06 | 20.84 |
| 3 | 15.38 | 16.04 | 15.98 | | 16.57 | 16.31 | 15.95 | 17.12 | 16.49 | 17.06 | 17.45 | 17.19 | 19.77 |
| 4 | 16.70 | 17.94 | 18.36 | 17.89 | | 18.19 | 18.05 | 17.68 | 18.49 | 19.69 | 18.54 | 20.00 | 21.44 |
| 5 | 16.34 | 17.70 | 17.18 | 17.27 | 17.83 | | 17.36 | 17.94 | 17.31 | 17.57 | 18.26 | 17.79 | 19.76 |
| 6 | 16.37 | 17.64 | 17.53 | 16.94 | 17.72 | 17.39 | | 17.45 | 17.34 | 17.87 | 17.97 | 18.22 | 19.98 |
| 7 | 15.66 | 17.94 | 17.93 | 17.40 | 17.64 | 17.26 | 16.74 | | 17.04 | 17.81 | 17.01 | 18.20 | 19.09 |
| 8 | 17.14 | 18.83 | 18.61 | 18.25 | 18.93 | 18.11 | 18.11 | 18.52 | | 18.01 | 18.17 | 18.27 | 19.73 |
| 9 | 16.74 | 19.05 | 19.07 | 18.42 | 19.73 | 17.97 | 18.24 | 18.89 | 17.61 | | 17.60 | 17.11 | 18.52 |
| 10 | 16.13 | 18.75 | 18.50 | 18.15 | 17.97 | 18.05 | 17.73 | 17.48 | 17.16 | 16.99 | | 17.13 | 17.68 |
| 11 | 16.35 | 18.74 | 18.29 | 18.16 | 19.65 | 17.80 | 18.20 | 18.89 | 17.48 | 16.61 | 17.35 | | |
| 12 | 16.78 | 22.05 | 21.44 | 21.17 | 21.52 | 20.40 | 20.39 | 20.20 | 19.37 | 18.54 | 18.33 | 18.36 | 16.78 |

*Includes intermediate costs and truck transportation costs.

transportation cost ($1000) is used for shipments from season II to season I.

By using reactive programming technique, and estimates on fixed supplies, demand relationships, and transfer costs, it is now possible to obtain equilibrium solution for the U.S. beef cattle industry. In this study CDC 3300 computer is used to obtain the equilibrium solution.

# VII. EMPIRICAL RESULTS

This chapter is divided into three parts:

(A) discussion of equilibrium shipments and net prices in each producing region for fed and nonfed beef,

(B) discussion of equilibrium market prices and quantities obtained from the reactive programming model for fed and nonfed beef,

(C) critical evaluation of the equilibrium results obtained from the model.

## A. Equilibrium Shipments and Net Prices, Fed and Nonfed Beef

Table 20 is based on the output obtained from the computer solution, and shows equilibrium shipments of fed beef from 12 producing regions, for two seasons in 1967.[52] The equilibrium shipments of fed beef are expressed both in million pounds of live weight and in thousand head. Since the average live weight of fed beef is assumed to be 1081 pounds (live) for all regions and during both seasons, it is legitimate to express equilibrium fed beef shipments in number of head. When the computer solution shows that a

[52]Computer solution was obtained in 67 seconds and took 324 iterations.

Table 20. Equilibrium Shipments: Fed Beef, 12 Producing or Supply Regions, 2 Seasons, 1967.

| Producing or Supply region | | Receiving or demand region | Quantity shipped: Million pounds (live weight) | Number of head shipped[a] |
|---|---|---|---|---|
| Season I | 1 | 1 | 104.8 | 96,980 |
| | 2 | 2 | 166.4 | 15,397 |
| | 3 | 1 | 1.3 | 1,178 |
| | 3 | 2 | 11.7 | 10,837 |
| | 3 | 3 | 117.6 | 108,820 |
| | 3 | 3* | 87.5 | 80,942 |
| | 4 | 4 | 1,068.9 | 988,795 |
| | 5 | 2 | 17.0 | 15,708 |
| | 5 | 5 | 90.7 | 83,956 |
| | 5 | 5* | 38.2 | 35,308 |
| | 6 | 6 | 107.0 | 98,979 |
| | 7 | 4 | 85.5 | 79,070 |
| | 7 | 6 | 2.0 | 1,818 |
| | 7 | 7 | 195.3 | 180,633 |
| | 7 | 10 | 206.9 | 191,385 |
| | 8 | 8 | 600.5 | 555,485 |
| | 8 | 8* | 36.6 | 33,911 |
| | 9 | 9 | 2,283.6 | 2,112,471 |
| | 9 | 11 | 362.4 | 335,247 |
| | 9 | 9* | 331.5 | 306,710 |
| | 10 | 10 | 738.2 | 682,864 |
| | 10 | 12 | 174.3 | 161,219 |
| | 10 | 10* | 300.2 | 277,683 |
| | 11 | 11 | 4,385.8 | 4,057,158 |
| | 12 | 12 | 1,178.3 | 1,089,974 |
| Season II | 1 | 1 | 90.8 | 83,982 |
| | 2 | 2 | 174.0 | 160,967 |
| | 3 | 1 | 29.4 | 27,246 |
| | 3 | 3 | 42.3 | 39,108 |
| | 4 | 4 | 1,145.6 | 1,059,780 |
| | 5 | 2 | 37.5 | 34,664 |
| | 5 | 5 | 61.9 | 57,316 |
| | 6 | 6 | 55.1 | 50,989 |
| | 7 | 4 | 29.6 | 27,418 |
| | 7 | 6 | 48.2 | 44,558 |

Table 20, cont.

| Producing or Supply region | Receiving or demand region | Quantity shipped: Million pounds (live weight) | Number of head shipped[a] |
|---|---|---|---|
| 7 | 7 | 195.3 | 180,643 |
| 7 | 10 | 4.8 | 4,426 |
| 8 | 8 | 532.5 | 492,600 |
| 9 | 9 | 1,911.7 | 1,768,442 |
| 9 | 11 | 377.0 | 348,742 |
| 9 | 12 | 283.6 | 262,321 |
| 10 | 10 | 674.5 | 623,945 |
| 10 | 12 | 347.9 | 321,859 |
| 11 | 11 | 4,723.0 | 4,369,093 |
| 12 | 12 | 795.4 | 735,847 |
| Total - | - | 24,252.3 | 22,296,475 |

*denotes carry over from season I to season II

[a]obtained by dividing equilibrium shipment in million pounds live weight by the average liveweight of fed beef slaughtered (1081 lbs.).

region shipped its fed beef to itself it indicates intraregional shipments rather than interregional shipments.[53]

A graphical presentation of equilibrium shipment patterns for fed beef is made in Figure 4. Dark thick arrows indicate shipments in both seasons, and dark thin arrows show shipments in season I only. Shipments in season II only, are shown by dotted arrows. Those regions which carried over excess supplies of fed beef from season I to season II are shown by a dark triangle. Equilibrium shipments of fed beef received by each region (including intra-regional as well as interregional shipments) in both seasons are shown in parentheses.[54] Such information is also given in Tables 20, and 24.

From Table 20 and Figure 4 the following observations about equilibrium shipment patterns of fed beef for 1967 are noticeable:

(1) Almost 98 percent of the total estimated fed beef supply is accounted for in the final equilibrium solution.

(2) Eight regions (regions 1, 2, 4, 6, 10, 11, and 12) received fed beef from other regions besides their own supplies.

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[53]This code is used throughout in Chapters VIII and IX.

[54]This code is also followed for nonfed beef in Chapters VIII and IX.

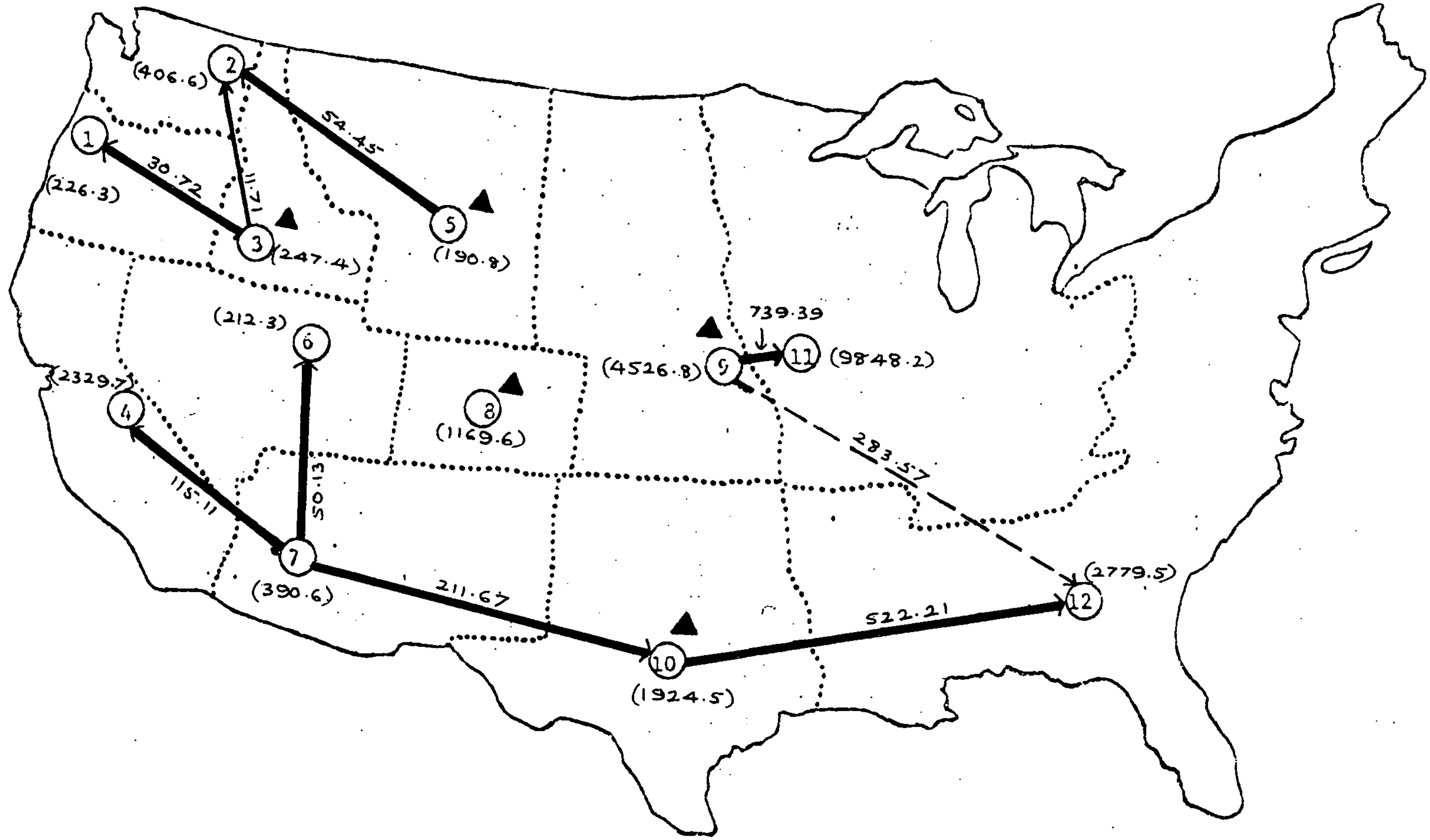


Figure 4. Equilibrium Shipment Patterns: Fed Beef, 12 Regions, 2 Seasons, 1967 (Million Pounds Live Weight).

shipments in season I and II

shipments in season I only

shipments in season II only

carry over from season I to season II

(3) Five regions (regions 3, 5, 7, 9, and 10) shipped fed beef to deficit regions. For example, region 7 shipped 191,385 head of fed beef to region 10 (Texas, Oklahoma), 79,070 head to region 4 (California), 1818 head to region 6 (Nevada, Utah), besides using 180,633 head for regional slaughter. Region 3 shipped 28,424 head of fed beef to region 1 in both seasons together, and 10,837 head to region 2 (Washington) in season I only.

(4) Region 10 (Texas, Oklahoma) emerged as both receiving and exporting region. It received 191,385 head of fed beef in both seasons together from region 7 (Arizona, New Mexico) and shipped 483,078 head of fed beef in both seasons together to region 12. Region 7 (Arizona, New Mexico) shipped fed beef to region 10 (Texas, Oklahoma) since its fed beef could fetch prices higher in region 10 than in the regional market. Also, region 7 was unable to ship fed beef to region 12 due to higher transportation costs involved. Region 10, although an excess beef producing region, received fed beef from region 7 probably on account of lower prices it could offer; thus making it possible to ship regional fed beef to region 12 at higher prices.

(5) Regions 3, 5, 8, 9, and 10 carried over excess fed beef supply from season I to season II.

(6) Region 9 (North Dakota, South Dakota, Nebraska, and Kansas) shipped the largest number of fed beef (946,310 head) in

1967, followed by regions 10, and 7. Also, region 9 alone shipped fed beef to region 12 in season II only. In all other cases, interregional shipments occurred during both seasons, if at all.

(7) Region 7 (Arizona, New Mexico) exported 39 percent of its estimated fed beef supply. This proportion was highest among all exporting regions. Regions 10, 5, 9, and 3 exported 23 percent, 22 percent, 18 percent, and 11 percent, respectively, of their estimated fed beef supplies. Considering seasons, except for region 7, regions 3, 5, 9, and 10 exported more fed beef in season II than in season I. This is not surprising since these four regions carried over their excess supplies from season I to season II.

Region 7 had more interregional outlets (three) for its fed beef than any other exporting region. This is probably due to higher prices its fed beef received, outside the region. The equilibrium solution shows that equilibrium fed beef market price in region 7 was lowest among all other regions ($24.37 per hundred weight). Also, region 7 shipped its fed beef to three regions since its net revenue became maximum.

Equilibrium Net Prices, Fed Beef

Table 21 presents net equilibrium prices, obtained from the computer solution for fed beef in 12 producing regions during two

Table 21. Equilibrium Net Prices: Fed Beef, 12 Producing Regions, 2 Seasons, 1967.

| Producing or supply region | | Season I 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Receiving or demand region (dollars per hundred weight) | | | | | | | | | | | |
| Season I | 1 | 2.57 | 1.97 | 1.25 | 0.47 | 0.31 | 0.53 | -1.56 | -0.43 | -0.51 | -0.55 | -0.27 | -1.65 |
| | 2 | 0.82 | 1.30* | 0.10 | -1.21 | -0.38 | -0.55 | -2.94 | -1.42 | -1.68 | -1.54 | -1.03 | -2.25 |
| | 3 | 0.00 | -0.00 | 0.00* | -1.39 | -1.17 | -0.68 | -2.93 | -1.76 | -1.77 | -1.91 | -1.60 | -2.68 |
| | 4 | -0.20 | -0.73 | -0.81 | 0.18* | -1.35 | -1.08 | -1.79 | -2.06 | -2.73 | -1.30 | -2.71 | -2.65 |
| | 5 | 0.09 | 1.34 | 0.65 | -0.11 | 1.34* | 0.45 | -1.21 | -0.04 | 0.30 | -0.18 | 0.34 | -0.33 |
| | 6 | 0.37 | 0.44 | 0.41 | -0.57 | -0.28 | 0.87* | -1.29 | -0.64 | -0.64 | -0.49 | -0.66 | -0.92 |
| | 7 | -0.43 | -0.66 | -0.28 | 0.00 | 0.65 | 0.00 | 0.00* | -0.84 | -1.11 | 0.00 | -1.14 | -0.52 |
| | 8 | -0.38 | -0.22 | -0.46 | -1.34 | -0.56 | -0.43 | -1.92 | 0.00* | -0.36 | -0.22 | -0.27 | -0.23 |
| | 9 | -1.66 | -1.68 | -1.67 | -3.21 | -1.42 | -1.63 | -3.39 | -1.56 | 0.00* | -0.65 | 0.00 | 0.00 |
| | 10 | 0.16 | 0.35 | 0.09 | 0.08 | -0.04 | 0.41 | -0.42 | 0.44 | 1.21 | 2.28* | 1.33 | 2.28 |
| | 11 | -1.53 | -1.14 | -1.60 | -3.29 | -1.49 | -1.76 | -3.52 | -1.58 | -0.10 | -0.64 | 0.41* | 0.33 |
| | 12 | -4.01 | -3.46 | -3.79 | -4.34 | -3.26 | -3.12 | -4.01 | -2.64 | -1.21 | -0.79 | -0.77 | 2.31* |
| Season II | 1 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 2 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 3 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 4 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 5 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 6 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 7 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 8 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 9 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 10 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 11 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 12 | x | x | x | x | x | x | x | x | x | x | x | x |

Table 21, cont.

| Producing or supply region | | Season II 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Receiving or demand region (dollars per hundred weight) | | | | | | | | | | | |
| Season I | 1 | 2.57 | 1.97 | 1.25 | 0.47 | 0.31 | 0.53 | -1.56 | -0.43 | -0.51 | -0.55 | -0.27 | -1.65 |
| | 2 | 0.82 | 1.29 | 0.10 | -1.21 | -0.38 | -0.55 | -2.94 | -1.42 | -1.68 | -1.54 | -1.03 | -2.25 |
| | 3 | 0.00 | -0.00 | 0.00* | -1.39 | -1.17 | -0.68 | -2.93 | -1.76 | -1.77 | -1.91 | -1.60 | -2.68 |
| | 4 | -0.20 | -0.73 | -0.81 | 0.18 | -1.35 | -1.08 | -1.79 | -2.06 | -2.73 | -1.30 | -2.71 | -2.65 |
| | 5 | 0.88 | 1.34 | 0.65 | -0.11 | 1.34* | 0.45 | -1.21 | -0.04 | 0.30 | 0.18 | 0.34 | -0.33 |
| | 6 | 0.37 | 0.44 | 0.41 | -0.57 | -0.28 | 0.87 | -1.29 | -0.64 | -0.64 | -0.46 | -0.66 | -0.92 |
| | 7 | -0.43 | -0.66 | -0.28 | 0.00 | -0.65 | 0.00 | 0.00 | -0.84 | -1.11 | 0.00 | -1.14 | -0.52 |
| | 8 | -0.38 | -0.22 | -0.46 | -1.34 | -0.56 | -0.43 | -1.92 | 0.00* | -0.36 | -0.22 | -0.27 | -0.23 |
| | 9 | -1.66 | -1.68 | -1.67 | -3.21 | -1.42 | -1.63 | -3.39 | -1.56 | 0.00* | -0.65 | 0.00 | 0.00 |
| | 10 | 0.16 | 0.35 | 0.09 | 0.08 | -0.04 | 0.41 | 0.42 | 0.44 | 1.21 | 2.28* | 1.33 | 2.28 |
| | 11 | -1.53 | -1.14 | -1.61 | -3.30 | -1.49 | -1.76 | -3.53 | -1.58 | -0.11 | -0.64 | 0.41 | 0.33 |
| | 12 | -4.01 | -3.46 | -3.79 | -4.34 | -3.26 | -3.12 | -4.01 | -2.64 | -1.21 | -0.79 | -0.77 | 2.31 |
| Season II | 1 | 2.57* | 1.97 | 1.25 | 0.47 | 0.31 | 0.53 | -1.56 | -0.43 | -0.51 | -0.55 | -0.27 | -1.65 |
| | 2 | 0.82 | 1.30* | 0.10 | -1.21 | -0.38 | -0.55 | -2.94 | -1.42 | -1.68 | -1.54 | -1.03 | -2.25 |
| | 3 | 0.00 | -0.00 | 0.00* | -1.39 | -1.17 | -0.68 | -2.93 | -1.76 | -1.77 | -1.91 | -1.60 | -2.68 |
| | 4 | -0.20 | -0.73 | -0.81 | 0.18* | -1.35 | -1.08 | -1.79 | -2.06 | -2.73 | -1.30 | -2.71 | -2.65 |
| | 5 | 0.88 | 1.34 | 0.65 | -1.11 | 1.34* | 0.45 | -1.21 | -0.04 | 0.30 | -0.18 | 0.34 | -0.33 |
| | 6 | 0.37 | 0.44 | 0.41 | -0.57 | -0.28 | 0.87* | -1.28 | -0.64 | -0.64 | -0.46 | -0.66 | -0.92 |
| | 7 | -0.43 | -0.66 | -0.28 | 0.00 | -0.65 | 0.00 | 0.00* | -0.84 | -1.11 | 0.00 | -1.14 | -0.52 |

Table 21, cont.

| Producing or supply region | Season II: Receiving or demand region (dollars per hundred weight) 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | -0.38 | -0.22 | -0.46 | -1.34 | -0.56 | -0.43 | -1.92 | 0.00* | -0.36 | -0.22 | -0.27 | -0.23 |
| 9 | -1.66 | -1.68 | -1.67 | -3.21 | -1.42 | -1.63 | -3.39 | -1.56 | 0.00* | -0.65 | 0.00 | 0.00 |
| 10 | 0.16 | 0.35 | 0.09 | 0.08 | -0.04 | 0.41 | -0.42 | 0.44 | 1.21 | 2.28* | 1.33 | 2.28 |
| 11 | -1.53 | -1.14 | -1.61 | -3.30 | -1.49 | -1.71 | -3.53 | -1.58 | -0.11 | -0.64 | 0.41* | 0.33 |
| 12 | -4.01 | -3.46 | -3.79 | -4.34 | -3.26 | -3.12 | -4.01 | -2.64 | -1.21 | -0.79 | -0.77 | 2.31* |

*denotes intra regional shipments

___denotes shipping routes used

x denotes artificial blocking of shipments from season II to season I.

seasons in 1967. These net prices are equal to the nearest cents and are expressed in dollars per hundred weight. These net prices are such that each of the individual producing regions shipped its fed beef to the outlets offering highest net prices, and these net prices are equal when fed beef is shipped to more than one outlet.

For example, at equilibrium region 7 (Arizona, New Mexico) shipped fed beef to regions 4, 6, and 10, and net prices are equal in all these regions, for its supply. Similarly, region 3 shipped fed beef to regions 1 and 2 in season I, and net prices are equal in all three of these regions.[55] Shipping routes used are shown by underlining such equal net prices. To remove the confusion between intra regional and interregional shipments an asterisk is used to denote intra regional shipments. For example, since region 1 (Oregon) did not ship fed beef to any other regions, but slaughtered its regional fed beef supply, an asterisk is used.

Blocked shipments are shown by the symbol x. Net price is maximum in region 1 (Oregon) despite no fed beef was shipped from that region under the equilibrium solution.

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[55]One is likely to get confused as to why at equilibrium some regions did not ship to all regions where net prices are shown equal. For example, in Table 23, Region 5 is shown to be at equilibrium with region 8 in season I. However, the net prices are also the same in regions 5 and 8 in season II. The reason is that in the process of calculation the computer has picked up the region(s) that came in first and allocated all available supplies.

Equilibrium Shipments, Nonfed Beef

Similar to fed beef, equilibrium shipments are obtained for nonfed beef. Table 21 is based on the output obtained from the computer solution, and presents equilibrium shipments of nonfed beef for 12 producing regions for two seasons in 1967.[56] The equilibrium shipments are presented in million pounds of live weight.[57]

The equilibrium nonfed beef shipments patterns are presented graphically in Figure 5. Figure 5 shows seasonal shipments, regions carrying over excess nonfed beef supply from season I to season II, and total nonfed beef received (intraregional as well as interregional) by each region in both seasons.

From Table 22 and Figure 5, the following observations about equilibrium shipment patterns of nonfed for 1967 are noticeable:

(1) Almost 99 percent of the total estimated nonfed beef supply is distributed in the final equilibrium solution.

(2) Regions 4, 8, and 12 received nonfed beef from other regions. Region 4 (California) received nonfed beef from the

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[56]The solution was obtained in 24 seconds and 32 iterations.

[57]Since the average live weight per head for nonfed beef for all regions during all seasons are assumed different, equilibrium nonfed beef shipments are not expressed in numbers of head.

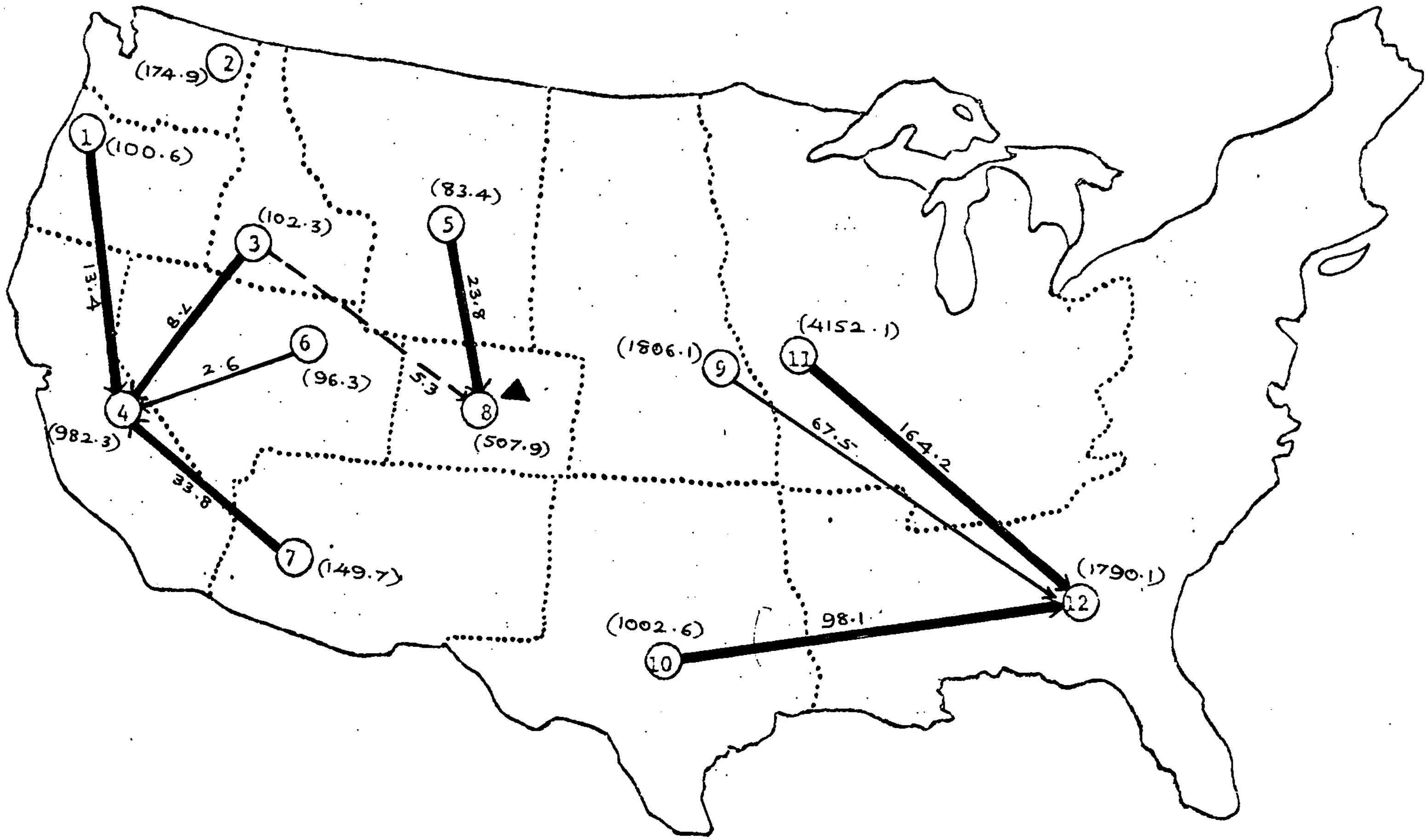


Figure 5. Equilibrium Shipment Patterns: Nonfed Beef, 12 Regions, 2 Seasons, 1967 (Million Pounds Live Weight).

shipments in season I and II

shipments in season I only

shipments in season II only

carry over from season I to season II

greatest number of regions (regions 1, 3, 6, and 7). Region 12 received nonfed beef from regions 9, and 10, and region 8 received from regions 3, and 5. Region 8 alone carried over its excess supply from season I to season II.

(3) In all, eight regions exported nonfed beef to other regions, some in both seasons, while others in either season I or season II, if at all. For example, regions 6 and 9 shipped nonfed beef to regions 4, and 12 respectively in season I only. Also, region 3 shipped nonfed beef to region 8 in season II only.

Among regions that exported nonfed beef in both seasons, region 5 alone exported more in season I than in season II in contrast with other exporting regions that shipped more nonfed beef in season II than in season I. Region 7 (Arizona, New Mexico) shipped 18.4 percent of its estimated nonfed beef supply. This proportion was the largest among all exporting regions.

A comparison of equilibrium shipment patterns of fed and nonfed beef shows that regions 4 (California), and 12 (Eastern U.S.) imported both fed and nonfed beef from other regions in 1967. Regions 3, 5, 9, 10 exported both fed and nonfed beef in 1967. Also, whereas excess fed beef supplies from five producing regions found regional outlets for their fed beef in seven markets, excess supplies of nonfed beef from eight producing regions found regional outlets in three markets only.

Table 22. Equilibrium Shipments: Nonfed Beef, 12 Producing Regions, 2 Seasons, 1967.

| Producing or supply region | | Receiving or demand region | Quantity shipped, million pounds (live weight) |
|---|---|---|---|
| Season I | 1 | 1 | 47.6 |
| | 1 | 4 | 5.5 |
| | 2 | 2 | 85.2 |
| | 3 | 3 | 49.5 |
| | 3 | 4 | 6.1 |
| | 4 | 4 | 464.4 |
| | 5 | 5 | 41.5 |
| | 5 | 8 | 17.8 |
| | 6 | 4 | 2.6 |
| | 6 | 6 | 51.0 |
| | 7 | 4 | 16.7 |
| | 7 | 7 | 76.9 |
| | 8 | 8 | 248.9 |
| | 8 | 8* | 2.8 |
| | 9 | 9 | 942.2 |
| | 9 | 12 | 67.5 |
| | 10 | 10 | 507.3 |
| | 10 | 12 | 36.4 |
| | 11 | 11 | 2.046.8 |
| | 11 | 12 | 81.3 |
| | 12 | 12 | 721.7 |
| Season II | 1 | 1 | 53.0 |
| | 1 | 4 | 7.9 |
| | 2 | 2 | 89.7 |
| | 3 | 3 | 52.8 |
| | 3 | 4 | 1.7 |
| | 3 | 8 | 5.3 |
| | 4 | 4 | 460.3 |
| | 5 | 5 | 41.9 |
| | 5 | 8 | 6.0 |
| | 6 | 6 | 45.3 |
| | 7 | 4 | 17.1 |
| | 7 | 7 | 72.8 |
| | 8 | 8 | 227.1 |
| | 9 | 9 | 863.9 |
| | 10 | 10 | 495.3 |
| | 10 | 12 | 61.7 |
| | 11 | 11 | 2,105.3 |
| | 11 | 12 | 82.9 |
| | 12 | 12 | 738.6 |
| | - | - | 10,948.3 |

*denotes carry over from season I to season II.

Equilibrium Net Prices, Nonfed Beef

Table 23 presents net equilibrium prices obtained from the computer solution for nonfed beef for 12 producing regions during two seasons in 1967. These net prices are such that each of the individual producing regions shipped its nonfed beef to the regional outlets offering highest net price, and they (net prices) are equal when nonfed beef is shipped to more than one outlet. Shipping routes used are shown by underlining such equal net prices. For example, region 1 (Oregon) shipped fed beef to region 4, and net prices are equal in both regions at equilibrium. To remove the confusion between intraregional and interregional shipments of nonfed beef an asterisk is used to denote intra-regional shipments. Blocked shipments are shown by the symbol x.

## B. Equilibrium Market Quantities and Prices, Fed and Nonfed Beef

Columns 2, and 3 in Table 24 present market equilibrium prices and quantities obtained from the model solution for fed beef for 12 slaughter demand or receiving regions during two seasons in 1967.

Market equilibrium price for fed beef was maximum ($27.27 per hundred weight) in region 12 (Eastern U.S.) and minimum ($24.37 per hundred weight) in region 7 (Arizona, New Mexico). Slaughter demand for fed beef was maximum (4748.2 million pounds live weight)

Table 23. Equilibrium Net Prices: Non-fed Beef, 12 Producing Regions, 2 Seasons, 1967

| Producing or supply region | | Season I | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| | | Received or demand region (dollars per hundred weight) | | | | | | | | | | | |
| Season I | 1 | 1.00* | 0.87 | 0.38 | 1.00 | -0.56 | -0.39 | -1.01 | 0.07 | -0.54 | -0.62 | -0.41 | -1.72 |
| | 2 | -0.11 | 0.84* | -0.12 | 0.01 | -0.61 | -0.85 | -1.57 | -0.28 | -1.13 | -0.99 | -0.53 | -1.74 |
| | 3 | 0.51 | 0.98 | 1.21* | 1.21 | 0.04 | 0.48 | -0.30 | 0.82 | 0.26 | 0.10 | 0.34 | -0.67 |
| | 4 | -1.39 | -1.40 | -1.29 | 1.09* | -1.84 | -1.62 | -0.86 | -1.18 | -2.37 | -0.99 | -2.47 | -2.34 |
| | 5 | -1.15 | -0.22 | -0.67 | -0.04 | 0.00* | -0.93 | -1.12 | 0.00 | -0.24 | -0.71 | -0.26 | -0.86 |
| | 6 | -1.09 | -0.57 | -0.34 | 0.06 | -1.04 | 0.06* | -0.63 | -0.03 | -0.55 | -0.42 | -0.69 | -0.88 |
| | 7 | -1.39 | -0.97 | -0.80 | 1.15 | -0.91 | -0.31 | 1.15* | 0.27 | -0.49 | 0.54 | -0.67 | 0.01 |
| | 8 | -2.28 | -1.65 | -1.65 | -1.14 | -1.76 | -1.68 | -1.70 | 0.17* | -0.69 | -0.62 | -0.74 | -0.63 |
| | 9 | -2.50 | -2.11 | -1.82 | -1.94 | -1.62 | -1.81 | -2.07 | -0.30 | 0.58* | -0.05 | 0.42 | 0.58 |
| | 10 | -2.20 | -1.54 | -1.55 | -0.18 | -1.70 | -1.30 | -0.66 | 0.15 | 0.33 | 1.42* | 0.40 | 1.42 |
| | 11 | -2.19 | -1.33 | -1.56 | -1.86 | -1.45 | -1.77 | -2.07 | -0.17 | 0.71 | 0.20 | 1.18* | 1.18 |
| | 12 | -5.50 | -4.48 | -4.57 | -3.73 | -4.05 | -3.96 | -3.38 | -2.06 | -1.22 | -0.78 | -0.83 | 2.32* |
| Season II | 1 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 2 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 3 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 4 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 5 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 6 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 7 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 8 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 9 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 10 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 11 | x | x | x | x | x | x | x | x | x | x | x | x |
| | 12 | x | x | x | x | x | x | x | x | x | x | x | x |

Table 23, cont.

| Producing or supply region | | Season II 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Received or demand region (dollars per hundred weight) | | | | | | | | | | | |
| Season I | 1 | 0.59 | 0.03 | -0.02 | 0.59 | -0.57 | -0.45 | -1.44 | 0.06 | -1.12 | -1.25 | -1.06 | -2.35 |
| | 2 | -0.52 | 0.00 | -0.53 | -0.40 | -0.62 | -0.91 | -2.00 | -0.29 | -1.71 | -1.62 | -1.18 | -2.37 |
| | 3 | 0.10 | 0.14 | 0.81 | 0.81 | 0.03 | 0.42 | -0.73 | 0.81 | 0.32 | -0.53 | -0.31 | -1.30 |
| | 4 | -1.80 | -2.24 | -1.70 | 0.68 | -1.85 | -1.68 | -1.29 | -1.19 | -2.95 | -1.62 | -3.12 | -2.97 |
| | 5 | -1.56 | -1.06 | -1.08 | -0.45 | 0.00 | -0.99 | -1.55 | -0.00 | -0.83 | -1.34 | -0.91 | -1.49 |
| | 6 | -1.50 | -1.41 | -0.75 | -0.34 | -1.05 | 0.00 | -1.06 | -0.04 | -1.13 | -1.05 | -1.34 | -1.51 |
| | 7 | -1.80 | -1.81 | -1.21 | 0.74 | -0.92 | -0.37 | 0.73 | 0.26 | -1.07 | -1.09 | -1.32 | -0.62 |
| | 8 | -2.69 | -2.49 | -2.06 | -1.55 | -1.77 | -1.74 | -2.13 | 0.17* | -1.27 | -1.25 | -1.39 | -1.26 |
| | 9 | -2.91 | -2.95 | -2.23 | -2.35 | -1.63 | -1.87 | -2.50 | -0.31 | 0.00 | -0.68 | -0.23 | -0.05 |
| | 10 | -2.61 | -2.38 | -1.96 | -0.59 | -1.71 | -1.36 | -1.09 | 0.14 | -0.25 | 0.79 | -0.25 | 0.79 |
| | 11 | -2.60 | -2.17 | -1.97 | -2.27 | -1.46 | -1.83 | -2.50 | -0.18 | 0.13 | -0.43 | 0.53 | 0.53 |
| | 12 | -5.91 | -5.32 | -4.98 | -4.14 | -4.06 | -4.02 | -3.80 | -2.07 | -1.80 | -1.41 | -1.48 | 1.69 |
| Season II | 1 | 0.59* | 0.03 | -0.02 | 0.59 | -0.57 | -0.45 | -1.44 | 0.06 | -1.12 | -1.25 | -1.06 | -2.35 |
| | 2 | -0.52 | 0.00* | -0.53 | -0.40 | -0.62 | -0.91 | -2.00 | -0.29 | -1.71 | -1.16 | -1.18 | -2.37 |
| | 3 | 0.10 | 0.14 | 0.81* | 0.81 | 0.03 | 0.42 | -0.73 | 0.81 | 0.32 | -0.53 | -0.31 | -1.30 |
| | 4 | -1.80 | -2.24 | -1.70 | 0.68* | -1.85 | -1.68 | -1.29 | -1.19 | -2.95 | -1.62 | -3.12 | -2.97 |
| | 5 | -1.56 | -1.06 | -1.08 | -0.45 | 0.00* | -0.99 | -1.55 | 0.00 | -0.83 | -1.34 | -0.91 | -1.49 |

Table 23, cont.

| Producing or supply region | | Season II | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| | | Received or demand region (dollars per hundred weight) | | | | | | | | | | | |
| Season II | 6 | -1.50 | -1.41 | -0.75 | -0.34 | -1.05 | 0.00* | -1.06 | -0.04 | -1.13 | -1.05 | -1.34 | -1.51 |
| | 7 | -1.80 | -1.81 | -1.21 | 0.73 | -0.92 | -0.37 | 0.73* | 0.26 | -1.07 | -1.09 | -1.32 | -0.62 |
| | 8 | -2.69 | -2.49 | -2.06 | -1.55 | -1.77 | -1.74 | -2.13 | 0.17* | -1.27 | -1.25 | -1.39 | -1.26 |
| | 9 | -2.91 | -2.95 | -2.23 | -2.35 | -1.63 | -1.87 | -2.50 | -0.31 | 0.00* | -0.68 | -0.23 | -0.05 |
| | 10 | -2.61 | -2.38 | -1.96 | -0.59 | -1.71 | -1.36 | -1.09 | 0.14 | -0.25 | 0.79* | -0.25 | 0.79 |
| | 11 | -2.60 | -2.17 | -1.97 | -2.27 | -1.46 | -1.83 | -2.50 | -0.18 | 0.13 | -0.43 | 0.53* | 0.53 |
| | 12 | -5.91 | -5.32 | -4.98 | -4.14 | -4.06 | -4.02 | -3.80 | -2.07 | -1.80 | -1.41 | -1.48 | 1.69* |

*denotes intrregional shipments

___denotes shipping routes used

xdenotes artificial blocking of shipments from season II to season I in region 11, followed by regions 9 and 12. Slaughter demand for fed beef from regions 9, 11, and 12 comprised 70 percent of total fed beef demand from all regions in season I and 71 percent in season II. Fed beef slaughter demand was thus heavily concentrated in three regions (regions 9, 11, and 12). Apparently, this was related to the size of population and size of the beef cattle industry in those regions.

Columns 3 and 4 of Table 24 show market equilibrium prices and quantities obtained from the model solution for nonfed beef for 12 slaughter demand or receiving regions during two seasons in 1967. Equilibrium market prices for nonfed beef varied from $16.43 per hundred weight in region 6 (Utah, Nevada) in season to $19.10 per hundred weight in region 12 (Eastern U.S.) in season I. In season II equilibrium market prices for nonfed beef varied from $16.12 per hundred weight in region 2 (Washington) to $18.47 in region 12 (Eastern U.S.).

In almost all regions equilibrium market prices for nonfed beef were higher in season I than in season II. Slaughter demand for nonfed beef in regions 9, 11, and 12 comprised 70 percent of total slaughter demand for nonfed beef in season I and 71 percent in season II. It indicates that slaughter demand for both fed and nonfed beef was highly concentrated in three regions (regions 9, 11, and 12).

Table 24. Equilibrium Quantities and Prices: Fed and Nonfed Beef, 12 Receiving or Demand Regions, 2 Seasons, 1967.

| | Fed Beef | | Nonfed Beef | |
|---|---|---|---|---|
| Receiving or demand region | Quantity received million pounds (live weight) | Market price $/hundred weight | Quantity received million pounds (live weight) | Market price $/hundred weight |
| Season I | | | | |
| 1 | 106.1 | 26.22 | 47.6 | 16.55 |
| 2 | 195.1 | 26.16 | 85.2 | 16.96 |
| 3 | 117.6 | 25.56 | 49.5 | 16.59 |
| 4 | 1,154.4 | 25.36 | 495.3 | 17.79 |
| 5 | 90.7 | 25.32 | 41.5 | 16.35 |
| 6 | 109.0 | 25.45 | 51.0 | 16.43 |
| 7 | 195.3 | 24.37 | 76.9 | 16.81 |
| 8 | 600.5 | 24.91 | 266.7 | 17.31 |
| 9 | 2,283.6 | 25.51 | 942.2 | 17.32 |
| 10 | 945.1 | 25.72 | 507.3 | 17.55 |
| 11 | 4,748.2 | 25.77 | 2,046.8 | 17.53 |
| 12 | 1,352.6 | 27.27 | 906.9 | 19.10 |
| Season II | | | | |
| 1 | 120.2 | 26.20 | 53.0 | 16.14 |
| 2 | 211.5 | 26.16 | 89.7 | 16.12 |
| 3 | 129.8 | 25.56 | 52.8 | 16.19 |
| 4 | 1,175.3 | 25.60 | 487.0 | 17.40 |
| 5 | 100.1 | 25.32 | 41.9 | 16.34 |
| 6 | 103.3 | 25.45 | 45.3 | 16.37 |
| 7 | 195.3 | 24.37 | 72.8 | 16.39 |
| 8 | 569.1 | 24.91 | 241.2 | 17.30 |
| 9 | 2,243.2 | 25.51 | 863.9 | 16.74 |
| 10 | 979.4 | 25.72 | 495.3 | 16.92 |
| 11 | 5,100.0 | 25.72 | 2,105.3 | 16.88 |
| 12 | 1,426.9 | 27.27 | 883.2 | 18.47 |
| Total | 24,252.3 | - | 10,948.3 | - |

## C. Critical Evaluation of Equilibrium Shipments and Prices of Fed and Nonfed Beef

The reliability and adequacy of the reactive programming model used in this study cannot be judged without reference to the accuracy of its results. Thus, it is necessary to see if the results obtained closely approximate the real world. In this section, actual observations on movements of fed and nonfed beef are compared with the computer solution. Comparison of equilibrium solution with the actual observations is done on a limited scale, since not many published sources supply information on sources of fed or nonfed beef imported (inshipped) from outside for slaughter. This is then followed by a discussion of possible reasons behind any discrepancy.

(1) Equilibrium shipment patterns for fed beef shows that in 1967 region 1 (Oregon) imported 28,424 head of fed beef (30.7 million pounds live weight) for slaughter, from region 3 (Idaho). Also, region 2 (Washington) imported 15,708 head of fed beef (11.7 million pounds live weight) from region 3 (Idaho), and 50,372 head (54.5 million pounds live weight) from region 5 (Montana, Wyoming) for slaughter. Although accurate information is not available about the origin of fed beef imported into Oregon and Washington, the

following three observations substantiate fed beef shipment patterns obtained from computer solution.

(a) An observer conversant with the beef cattle industry in the Western states will agree that Washington and Oregon import beef from nearby states. Shipments from longer distances are unlikely since it involves increases in shrinkage loss and transportation costs. Such shipments are possible only if prices offered in Washington and Oregon are very high.

(b) The states of California and Utah depend heavily upon nearby states for slaughter of fed and nonfed beef. The state of Nevada is not a major beef producing region, and any of its excess supply can be expected to go to California and Utah. Thus, the major suppliers of fed beef for the states of Oregon and Washington are most likely to be Idaho, Montana, Wyoming, and Colorado.

(c) In the PNW the states of Oregon and Washington produce fed beef less than their needs. For example, in 1967, according to one estimate, the state of Oregon produced 111.3 million pounds (carcass weight) of fed beef, as against 156.3 million pounds of consumption needs, a deficit of 45.6 million pounds (2). Similarly, in 1967, the state of Washington had a deficit of 61.2 million pounds of fed beef (2). On the other hand, the state of Idaho has been consistently an excess fed beef producing region. Thus, in 1967, the state of Idaho had an excess of 168. 7 million pounds of fed beef over its consumption needs (2). Similarly, in 1967, region 5 (Wyoming and Montana) had an excess of 65. 1 million pounds of fed beef over its needs (2).

Since the states of Idaho (region 3), Montana and Wyoming (region 5) produced fed beef on a scale larger than their needs, and the prices offered for fed beef in the states of Oregon (region 1) and Washington (region 2) are relatively high, it is likely that these states (Idaho, Montana, and Wyoming) shipped fed beef to Oregon and Washington. According to the equilibrium computer solution the state of Colorado (region 8), which has beef industry on a large scale is not shown to be an exporter of fed beef to either Oregon or Washington.

(2) The California Livestock Annual Report, published by California Crop and Livestock Reporting Service, shows that in 1967 589,000 cattle and calves were shipped by truck into California, for immediate slaughter (4, 1. 11). The inshipments of cattle and calves for immediate slaughter, according to their states of origin are presented in Table 25. Accordingly, 66 percent of total cattle and calves shipped into California in 1967 for immediate slaughter came from Arizona and New Mexico. Idaho exported 13. 7 percent, and Utah and Nevada together shipped 8. 3 percent of the total cattle

Table 25. Cattle and Calves: Number Shipped into California for Immediate Slaughter, by State of Origin, 1967.[a]

| State(s) | Number of cattle and calves (1000 head) | Percent of total inshipments |
|---|---|---|
| Arizona, New Mexico | 390 | 66.2 |
| Idaho | 81 | 13.7 |
| Utah, Nevada | 49 | 8.3 |
| Oregon | 37 | 6.3 |
| Texas | 17 | 2.9 |
| Colorado | 10 | 1.7 |
| Montana | 3 | 0.5 |
| Nebraska | 2 | 0.4 |
| Total | 589 | 100.0 |

[a]Source: (4, Table 10).

and calves inshipped into California. Shipments from longer distances comprised a very small percentage of the total inshipments.

Equilibrium shipments obtained from the analytical model do not coincide exactly with the actual observations. For example, the model shows that at equilibrium California imported 115.1 million pounds of liveweight (106,488 head) fed beef from Arizona and New Mexico (region 7), and 57.6 million pounds of live weight of nonfed beef from regions 1 (Oregon), 3 (Idaho), 6 (Utah, Nevada), and 7 (Arizona, New Mexico).. The model thus shows that large shipments into California were from region 7 (Arizona, New Mexico), and some from Oregon, Idaho, Utah and Nevada. Again, the equilibrium solution does not show any fed beef exported by Colorado to California.

(3) Some data on feedlot cattle sales from Texas and Oklahoma during 1966-1967 are available to compare with the equilibrium shipments obtained from the reactive programming analysis. Of course, such comparison is valid only to the extent of trends in shipments of beef cattle. A study on the Texas-Oklahoma cattle feeding industry shows that during 1966-1967, 76 percent of cattle sold by Texas feed lots went to packing plants within Texas, while 8.6 percent went to packing plants in Mississippi, Alabama, Georgia, Florida, Arkansas, and Louisiana (all in region 12), and the rest to New Mexico, Colorado, Oklahoma, California and some other states (6, pp. 25-26). On the other hand, during 1966-1967, Oklahoma feed lots sold 18.6 percent to packers within the state, 39.2 percent to Texas, 18.8 percent to Mississippi, Alabama, Georgia, Florida, Arkansas, and Louisiana (all in region 12), very few to California and Colorado, and the remaining mostly to Kansas (6, pp. 25-26). Equilibrium shipments obtained from the analytical model can be compared with the above information by assuming that in 1967

feed lot operators in Oklahoma and Texas shipped their cattle to the same states as they did in 1966-1967.

Equilibrium shipments obtained from the analytical model show that in 1967 region 10 (Texas-Oklahoma) exported 13 percent of its estimated fed beef supply to region 12 (Eastern U.S.). This trend falls in line with the actual shipment trends in 1966-1967 which shows that 18.6 percent of Oklahoma feed lot sales and 8.6 percent of Texas feed lot sales were made to packers in states included in region 12. However, the analytical model does not show fed beef shipments from region 10 to Kansas (included in region 9). Equilibrium fed beef shipments shows that region 7 (Arizona, New Mexico) exported 195,811 head of fed beef (211.7 million pounds live weight) to region 10 (Texas, Oklahoma). However, since no reliable data are available about inshipments of fed or nonfed beef into region 10 for slaughter, region 7's exports to region 10 cannot be verified.

(4) A feasibility study on expansion of the livestock feeding and meat packing industry in Utah points out that in 1964, 37 percent of Utah's cattle and calves for slaughter came from outside that state (30, p. 166). In 1968, however, 44 percent of the cattle and 11 percent of the calves for slaughter came from states such as Idaho, Nevada, Montana, Wyoming, and Colorado (30, p. 167).

The study also points out that Utah packers currently rely more on livestock produced in the nearby states to maintain the level of the kill (30, p. 165).

The equilibrium shipments of fed beef obtained from the analytical model shows that in 1967 Utah-Nevada region imported 46,376 head of fed beef in both seasons from region 7 (Arizona, New Mexico). The model does not show any fed beef shipments from Oregon, Idaho, Washington to region 6 probably because market prices are higher in these regions than in the Utah-Nevada region. Region 7 shipped fed beef to region 6 (Utah-Nevada) since equilibrium market prices in region 6 are higher relative to equilibrium market prices in region 7.

(5) Since no reliable data on inshipments of nonfed cattle and calves for slaughter into various regions are available, it is difficult to verify the reliability of equilibrium results. However, a person acquainted with the U.S. beef cattle industry will agree that the equilibrium shipment patterns obtained from analytical model for non fed beef are on the whole representative of general shipment trends.

(6) Equilibrium market prices for fed and nonfed beef in 1967 are obtained from the computer solution. Comparison of simple averages of seasonal market prices and computed equilibrium

prices in Table 24 shows that computed equilibrium prices are in reasonably close proximity with market prices. For example, Table 26 shows that market equilibrium prices for fed beef are greater than actual prices in seven regions, the maximum excess being 4.77 percent in region 12. Equilibrium market prices are less than actual prices in five regions, the maximum difference being 6 percent in region 7. Differences in the actual fed beef prices and equilibrium model prices vary from 0.15 percent to 6.34 percent.

In the case of nonfed beef, except for regions 11 and 12, equilibrium market prices are less than actual prices. Differences in the actual and model prices for nonfed beef vary from 0.57 percent to 11.01 percent.

## Possible Reasons for Discrepancies Between Analytical Model and Actual Observations

Given the restrictions imposed on the equilibrium solution, the results obtained approximate the actual observations fairly well. The model has perhaps failed to identify smaller interregional shipments of fed and nonfed beef but it has succeeded in identifying more general interregional fed and nonfed beef movements. Similarly, in several regions deviations of actual prices from equilibrium market prices are insignificant. Some of the possible

Table 26. Comparison of Actual Average Prices and Equilibrium Average Market Prices: Fed, and Nonfed Beef, 12 Regions, 1967.

| | Fed Beef | | | Nonfed Beef | | |
|---|---|---|---|---|---|---|
| Producing region | Actual annual average price[a] | Equilibrium Average market price | Computed price as a percent of actual price | Actual annual average price[a] | Equilibrium Average market price | Computed price as a percent of actual price |
| | dollars per hundred weight | | | dollars per hundred weight | | |
| 1 | 26.01 | 26.21 | 100.77 | 17.96 | 16.35 | 91.04 |
| 2 | 25.24 | 26.16 | 103.65 | 17.19 | 16.54 | 96.22 |
| 3 | 25.60 | 25.56 | 99.85 | 17.41 | 16.39 | 94.15 |
| 4 | 26.13 | 25.48 | 97.51 | 18.16 | 17.59 | 96.87 |
| 5 | 24.26 | 25.32 | 104.37 | 17.57 | 16.35 | 93.06 |
| 6 | 25.21 | 25.45 | 100.96 | 18.43 | 16.40 | 88.99 |
| 7 | 26.02 | 24.37 | 93.66 | 17.10 | 16.60 | 97.08 |
| 8 | 25.01 | 24.91 | 99.60 | 19.51 | 17.31 | 88.73 |
| 9 | 25.21 | 25.51 | 101.19 | 17.22 | 17.03 | 98.90 |
| 10 | 25.25 | 25.72 | 101.87 | 17.34 | 17.24 | 99.43 |
| 11 | 24.83 | 25.78 | 103.83 | 17.01 | 17.21 | 101.18 |
| 12 | 26.03 | 27.27 | 104.77 | 18.74 | 18.79 | 100.27 |

[a]Source: (36).

reasons behind discrepancies between the model results and actual results are as follows:

(1) Existence of discrepancies should not be a surprise, since the real world consists of such complex interrelationships that causal relations between all events simply cannot be studied. Many times the researcher has to simplify the process of research at the cost of distorting facts. The main aim, of course, remains to be the discovery of more important relationships. Equilibrium solutions obtained from the model are relative to the restrictions imposed and assumptions made. Therefore, discrepancies of varying degrees between actual observations and computer results are inevitable.

(2) The equilibrium solution for fed and nonfed beef for each producing area is obtained by enforcing restrictions discussed earlier in this chapter, and reiterating until no restrictions are violated by any producing area. An equilibrium solution obtained is such that (1) available supplies of fed and nonfed beef are allocated among the regions offering the maximum net price, and (2) for multiple outlets the net prices are equated. Thus, the equilibrium solution leaves no incentive for any producing region to further allocate their supplies. The equilibrium shipments and market prices for fed and nonfed beef obtained from the analytical model are the most ideal ones.

In reality actions (transactions) of beef industry decision makers are subject to accuracy of information about market prices, goals, possible avenues of actions, financial limitations, and many other factors. Lack of proper information may prompt decision makers to act in ways which lead to results which are less than optimally efficient for the entire beef industry. In the real world, fed and nonfed beef may be shipped to regions where net prices are positive but not necessarily maximum. In some cases the circumstances may force them to ship cattle to these regions where net prices are negative. Thus, the decision maker may not always be making decisions that could lead to maximum net returns. Figure 6 shows how the shipments patterns might look in the absence of ideal solution.

Figure 6 is based on the equilibrium solution obtained from the analytical model, for the fed beef producing region 5 (Montana, Wyoming). It shows regions with positive net equilibrium prices for fed beef in season I in 1967. Equilibrium net prices for region 5's fed beef supply are positive for shipments to regions 1, 2, 3, 6, 9, and 10. The computer equilibrium solution shows that region 5 shipped fed beef to region 2 only, since net prices offered were maximum. However, in the real world, fed beef may be shipped to any one or more of seven regions where net prices are positive.

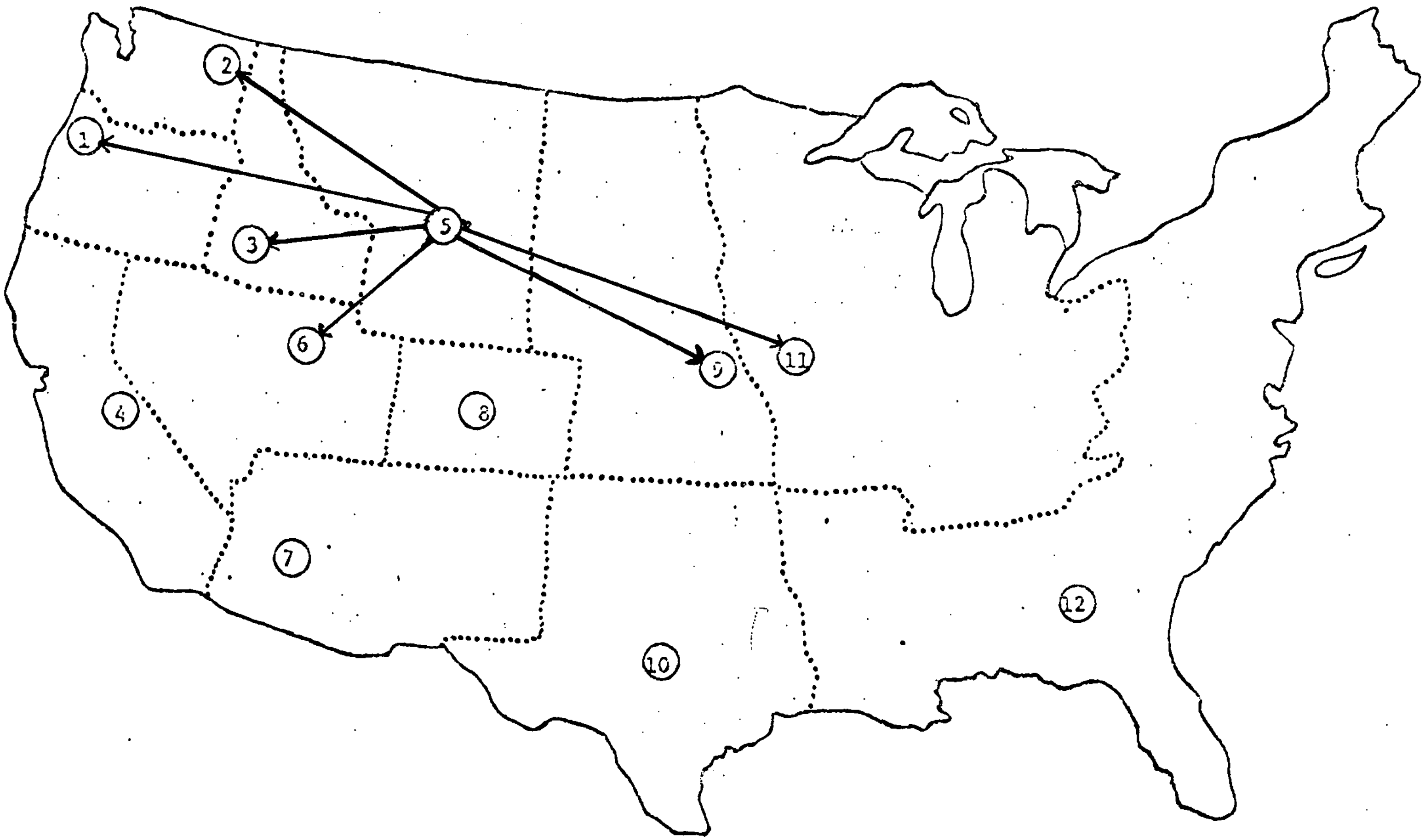


Figure 6. Regions with Positive Net Equilibrium Prices: Fed Beef Supply From Region 5 (Montana, Wyoming) in Season I, in 1967.

Figure 7 shows regions with positive net equilibrium prices, obtained from the computer solution, for producing region 3's (Idaho) nonfed beef supply in season I in 1967. It shows that region 3's nonfed beef may, in reality, be sold to any one or more of nine regions where net prices are positive, but not necessarily maximum.

(3) Two percent of the total estimated fed beef supply and one percent of the estimated nonfed beef supply is not accounted for in the final equilibrium solution. The reason is, one of the conditions of equilibrium solution states that with nonnegative net prices, all available supplies will be allocated, but this condition will not necessarily result if net prices are zero or negative. If all supplies of fed and nonfed beef had been allocated, the equilibrium shipment patterns and market prices perhaps would have been slightly different.

(4) This study takes into account only 12 producing regions and 12 receiving or demand regions. Due to the small number of regions, not all possible shipment patterns that might result in the real world are shown by the analytical model. California, for example, receives cattle and calves for immediate slaughter at least at 14 destinations (4, p. 11). This study considers only one receiving point for California (region 4). If more receiving points (also supply points) had been considered for all regions, the equilibrium solution probably would have been different.

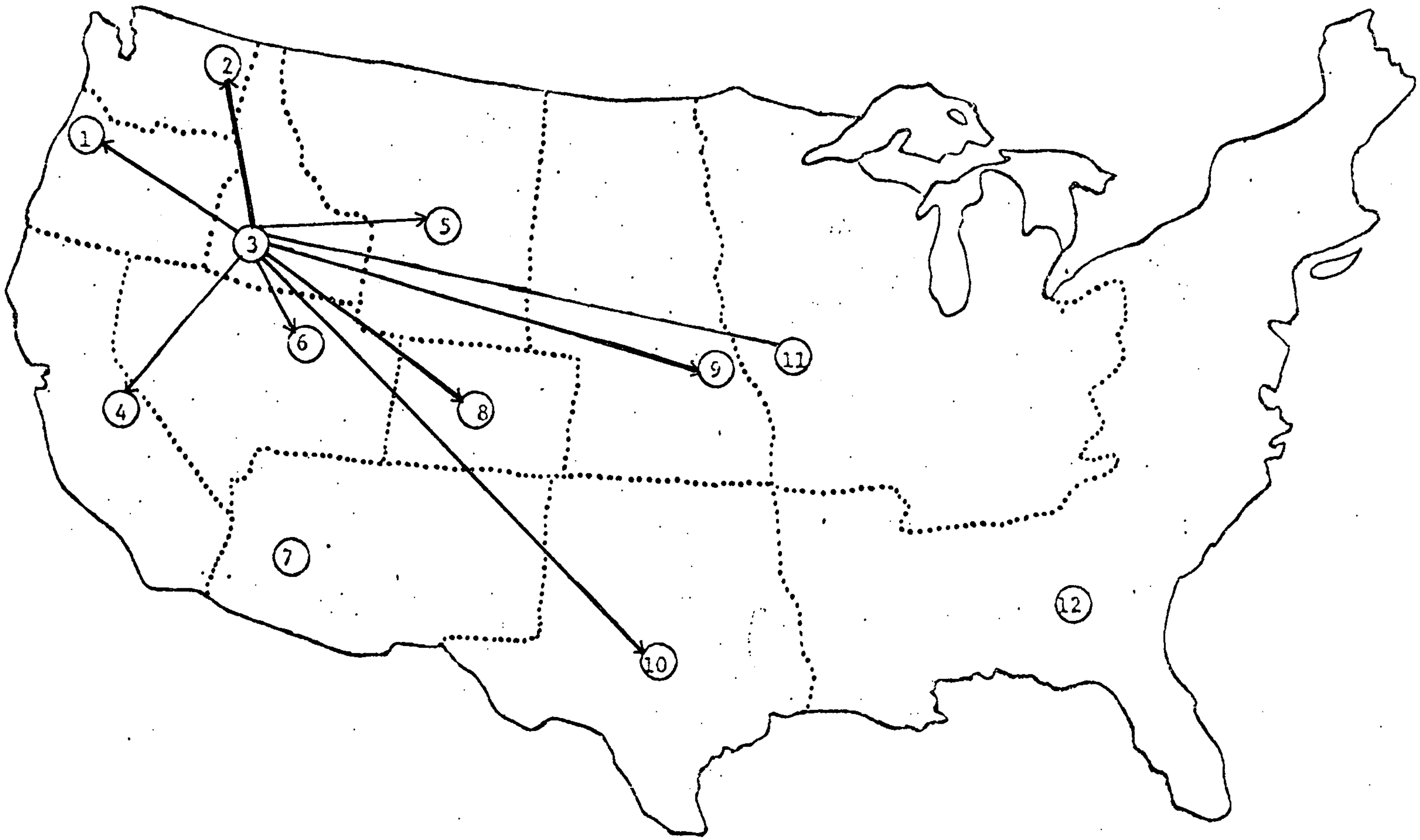


Figure 7. Regions with Positive Net Equilibrium Prices: Nonfed Beef Supply From Region 3 (Idaho) in Season I in 1967.

(5) Beef production and marketing seasons used in this study are based on the calendar year rather than the actual trends. Although fed cattle marketings are quite even from quarter to quarter at the national level, regional differences exist due to differences in feeding programs, seasonality of cattle placed of feed, and length of time on feed (19, p. 7). Seasonality in cow slaughter is related more to culling rates of mostly dairy canner and cutter cows (19, p. 14). With regard to calf slaughter, month-to-month variations are large during the first six months, and these variations decline in the latter part of the year (19, p. 14).

(6) Solutions obtained in this study are subject to the restrictions enforced and data used. For example, assumptions about constant average live weights of fed and nonfed beef during both seasons, and uniform slopes of demand functions for fed and nonfed beef limit the conclusions obtained. The model does not take into account many relevant factors such as prices of substitute products, prices of meat cuts in the retail market, shrinkage loss, means of transportation other than trucks, backhauls, and foreign imports that affect shipment patterns and market prices in the real world. Level of accuracy is another factor affecting the equilibrium solution.

(7) Lack of precise information on actual feed costs, nonfeed costs, market prices, truck shipment rates, and fed and nonfed slaughter

estimates in each region during each season seriously handicap the accuracy of findings in this study.

# IX. IMPACT OF CHANGES IN SPECIFIED CONDITIONS ON THE EQUILIBRIUM SOLUTION

It was noted in Chapter VIII that the equilibrium shipment patterns determined by the model will be affected by changes in the specified conditions. In this chapter an attempt is made to explain the impact of changes in certain conditions specified in model I[58] on the equilibrium shipment patterns. The following three changes are considered separately in three models, each model considering one change at a time:[59]

Model II: Effect of changes in truck transportation rates on the equilibrium shipment patterns for fed and nonfed beef.

Model III: Effect of backhauls on the equilibrium shipment patterns for fed and nonfed beef.

Model IV: Impact of changes in the slaughter demand for fed beef in a specified region on the equilibrium shipment patterns for fed beef.

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[58] Equilibrium shipment patterns discussed in Chapter VIII are referred, henceforth, as model I results.

[59] Unless amended, all other specified conditions of model I, e.g., truck transportation rates, feed costs, nonfeed costs, etc., hold true for the model under consideration.

Equilibrium shipments from various producing regions to various demand regions as determined by the four models are summarized in Table 27 for fed beef and in Table 28 for nonfed beef. Similarly, equilibrium quantities received at various demand regions are presented in Table 29 for fed beef and in Table 30 for nonfed beef. Tables 30 and 31 also present equilibrium market prices under different models for fed and nonfed beef.

For convenience, this chapter is divided into two sections: discussion of changes in the specified conditions and comparison of equilibrium shipments obtained from each model with model I; and comparison of equilibrium shipments obtained from various models.

## Impact of Changes in Truck Transportation Rates on Equilibrium Fed and Nonfed Beef Shipment Patterns

A study recently completed at Oregon State University estimated truck transportation rates for beef cattle for 1967 (2). Bhagia (2) used the following formula to estimate truck transportation rates of live cattle:

$Y = 0.1061 + 0.00191\ X_{ij} + 0.00455\sqrt{X_{ij}}$ where

$Y$ = truck transportation rate in dollars per hundred weight (live)

$X_{ij}$ = mileage between shipping point i to receiving point j.

Table 27. Equilibrium Shipments for Various Models: Fed Beef, 12 Producing Regions, 2 Seasons, 1967.

| Producing or supply region | Receiving or demand region | Quantities shipped: million pounds (live weight) Model I | Model II | Model III | Model IV |
|---|---|---|---|---|---|
| Season I | | | | | |
| 1 | 1 | 104.83 | 104.79 | 104.83 | 104.83 |
| 1 | 1* | --- | 0.05 | --- | --- |
| 2 | 2 | 166.44 | 166.44 | 166.44 | 166.44 |
| 3 | 1 | 1.27 | --- | --- | 0.48 |
| 3 | 2 | 11.71 | 7.57 | --- | 69.74 |
| 3 | 3 | 117.63 | 117.63 | 117.63 | 117.63 |
| 3 | 3* | 87.50 | 93.11 | 93.15 | 31.36 |
| 4 | 4 | 1,068.89 | 1,068.89 | 1,068,89 | 1,068.89 |
| 5 | 2 | 16.98 | 18.88 | 11.81 | 55.85 |
| 5 | 5 | 90.76 | 91.01 | 91.23 | 90.05 |
| 5 | 5* | 38.17 | 36.01 | 42.85 | --- |
| 6 | 6 | 107.00 | 107.00 | 107.00 | 107.00 |
| 7 | 1 | --- | --- | 3.90 | --- |
| 7 | 2 | --- | --- | 20.74 | --- |
| 7 | 4 | 85.47 | 70.34 | 90.39 | 85.46 |
| 7 | 6 | 1.96 | 0.54 | 1.97 | 1.96 |
| 7 | 7 | 195.26 | 195.28 | 195.27 | 195.26 |
| 7 | 10 | 206.89 | --- | 177.32* | 206.90 |
| 7 | 6* | --- | 11.16 | --- | --- |
| 7 | 7* | --- | 195.28 | --- | --- |
| 8 | 8 | 600.48 | 600.47 | 600.48 | 600.48 |
| 8 | 8* | 36.66 | 118.35 | 69.84 | 144.06 |
| 9 | 9 | 2,272.23 | 2,272.23 | 2,283.58 | 2,283.57 |
| 9 | 11 | 362.40 | 311.54 | 362.40 | 362.38 |
| 9 | 9* | 331.55 | 393.75 | 331.56 | 331.59 |
| 10 | 10 | 738.18 | 928.25 | 945.05 | 738.15 |
| 10 | 12 | 174.28 | 150.23 | 174.28 | 174.25 |
| 10 | 10* | 300.17 | 134.15 | 93.30 | 300.23 |
| 11 | 11 | 4,385.79 | 4,385.79 | 4,385.79 | 4,385.79 |
| 12 | 12 | 1,178.26 | 1,178.26 | 1,178.26 | 1,178.26 |
| Season II | | | | | |
| 1 | 1 | 90.78 | 90.78 | 90.78 | 90.78 |
| 2 | 2 | 174.00 | 174.00 | 174.00 | 174.00 |
| 3 | 1 | 29.45 | 27.91 | --- | 28.56 |

Table 27, cont.

| Producing or supply region | Receiving or demand region | Quantities shipped: million pounds (live weight) Model I | Model II | Model III | Model IV |
|---|---|---|---|---|---|
| Season II | | | | | |
| 3 | 2 | --- | --- | --- | 50.19 |
| 3 | 3 | 42.27 | 36.66 | 36.22 | 97.42 |
| 4 | 4 | 1,145.62 | 1,145.62 | 1,145.62 | 1,145.62 |
| 5 | 2 | 37.47 | 35.04 | 41.64 | 0.08 |
| 5 | 5 | 61.96 | 64.39 | 57.78 | 99.35 |
| 6 | 6 | 55.12 | 55.12 | 55.12 | 55.12 |
| 7 | 1 | --- | --- | 32.43 | --- |
| 7 | 4 | 29.64 | 14.13 | 34.63 | 29.64 |
| 7 | 6 | 48.17 | 35.65 | 48.17 | 48.17 |
| 7 | 7 | 195.27 | --- | 195.28 | 195.28 |
| 7 | 10 | 4.78 | --- | 34.45 | 4.84 |
| 8 | 2 | --- | --- | --- | 92.18 |
| 8 | 8 | 532.50 | 450.80 | 499.32 | 425.09 |
| 9 | 9 | 1,911.69 | 1,838.34 | 1,911.67 | 1,911.16 |
| 9 | 11 | 376.99 | 322.36 | 377.11 | 377.13 |
| 9 | 12 | 283.57 | 411.54 | 283.46 | 283.47 |
| 10 | 10 | 674.48 | 827.82 | 674.38 | 674.38 |
| 10 | 12 | 347.93 | 194.59 | 348.04 | 348.03 |
| 11 | 11 | 4,722.99 | 4,722.99 | 4,722.99 | 4,722.99 |
| 12 | 12 | 795.45 | 795.45 | 795.45 | 795.45 |
| Total | | 24,251.24 | 24,000.19 | 24,276.92 | 24,448.64 |

*denotes carry over of excess supply from season I to season II.

Table 28. Equilibrium Shipments for Various Models: Nonfed Beef, 12 Producing Regions, 2 Seasons, 1967

| Producing or supply region | Receiving or demand region | Quantities shipped: Million lbs. live wt. | | |
|---|---|---|---|---|
| | | Model I | Model II | Model III |
| Season I | | | | |
| 1 | 1 | 47.6 | 48.5 | 48.9 |
| 1 | 2 | --- | --- | --- |
| 1 | 4 | 5.5 | 4.6 | 2.8 |
| 2 | 2 | 85.2 | 85.2 | 85.2 |
| 3 | 3 | 49.5 | 50.2 | 48.9 |
| 3 | 4 | 6.1 | 5.4 | 6.7 |
| 4 | 4 | 464.4 | 464.4 | 464.4 |
| 5 | 4 | --- | --- | 12.3 |
| 5 | 5 | 41.5 | 41.5 | 40.7 |
| 5 | 8 | 17.8 | --- | 10.4 |
| 6 | 4 | 2.6 | --- | 3.5 |
| 6 | 6 | 51.0 | 49.7 | 50.1 |
| 6 | 8 | --- | 3.9 | --- |
| 7 | 7 | 76.9 | 77.9 | 76.3 |
| 8 | 8 | 248.9 | 251.8 | 251.8 |
| 8 | 8* | 2.8 | --- | --- |
| 9 | 9 | 942.2 | 949.6 | 941.4 |
| 9 | 12 | 67.5 | 60.2 | 68.4 |
| 10 | 10 | 507.3 | 500.3 | 507.4 |
| 10 | 12 | 36.4 | 43.4 | 36.3 |
| 11 | 11 | 2,046.8 | 2,059.0 | 2,047.6 |
| 11 | 12 | 81.3 | 69.1 | 80.5 |
| 12 | 12 | 721.7 | 721.7 | 721.7 |
| Season II | | | | |
| 1 | 1 | 53.0 | 54.4 | 54.1 |
| 1 | 4 | 7.9 | 6.4 | 6.7 |
| 2 | 2 | 89.7 | 89.7 | 89.7 |
| 3 | 3 | 52.8 | 54,0 | 52,0 |
| 3 | 4 | 1.7 | 2.7 | 7.9 |
| 3 | 8 | 5.3 | 3.1 | --- |
| 4 | 4 | 460.3 | 460.3 | 460.3 |
| 5 | 5 | 41.9 | 41.9 | 41.9 |
| 5 | 8 | 6.0 | --- | 13.9 |
| 6 | 4 | --- | --- | 3.6 |
| 6 | 6 | 45.3 | 45.0 | 45.3 |

Table 28. cont.

| Producing or supply region | Receiving or demand region | Quantities shipped: Million lbs. live wt. Model I | Model II | Model III |
|---|---|---|---|---|
| Season II | | | | |
| 6 | 8 | --- | 5.7 | --- |
| 7 | 4 | 17.1 | 15.7 | 18.1 |
| 7 | 7 | 72.8 | 74.2 | 71.9 |
| 8 | 8 | 277.1 | 277.1 | 277.1 |
| 9 | 9 | 863.9 | 863.9 | 863.9 |
| 10 | 10 | 495.3 | 489.5 | 495.4 |
| 10 | 12 | 61.7 | 67.5 | 61.6 |
| 11 | 11 | 2,105.3 | 2,122.0 | 2,105.1 |
| 11 | 12 | 82.9 | 66.2 | 83.1 |
| 12 | 12 | 738.6 | 738.6 | 738.6 |
| Total | | 10,948.3 | 10,930.1 | 10,964.2 |

*denotes carryover of excess supply from season I to season II.

Table 29. Equilibrium Shipments for Various Models: Fed Beef, 12 Receiving or Demand Regions, 2 Seasons, 1967.

| Receiving or demand region | | Quantities received: million pounds live weight | | | | Equil. market prices: $/100 wt. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Model I | Model II | Model III | Model IV | Model I | Model II | Model III | Model IV |
| Season I | 1 | 106.10 | 104.79 | 108.73 | 105.31 | 26.22 | 26.59 | 25.51 | 26.44 |
| | 2 | 195.13 | 192.89 | 199.00 | 292.03 | 26.16 | 26.50 | 25.59 | 26.38 |
| | 3 | 117.63 | 117.63 | 117.63 | 116.73 | 25.56 | 25.56 | 25.56 | 25.78 |
| | 4 | 1,154.36 | 1,139.23 | 1,159.28 | 1,154.35 | 25.36 | 25.74 | 25.24 | 25.36 |
| | 5 | 90.76 | 91.01 | 91.23 | 90.05 | 25.32 | 25.24 | 25.17 | 25.24 |
| | 6 | 108.96 | 107.54 | 108.96 | 108.96 | 25.45 | 25.83 | 25.45 | 25.45 |
| | 7 | 195.26 | 195.28 | 195.27 | 195.26 | 24.37 | 24.37 | 24.37 | 24.37 |
| | 8 | 600.48 | 600.47 | 600.48 | 600.48 | 24.91 | 24.91 | 24.91 | 24.91 |
| | 9 | 2,283.58 | 2,272.23 | 2,283.58 | 2,283.57 | 25.51 | 25.66 | 25.51 | 25.51 |
| | 10 | 945.07 | 928.25 | 945.05 | 945.05 | 25.72 | 26.24 | 25.72 | 25.72 |
| | 11 | 4,748.19 | 4,697.33 | 4,748.18 | 4,748.17 | 25.77 | 26.09 | 25.77 | 25.77 |
| | 12 | 1,352.54 | 1,328.49 | 1,352.54 | 1,352.51 | 27.27 | 27.82 | 27.27 | 27.27 |
| Season II | 1 | 120.23 | 118.74 | 123.22 | 119.34 | 26.22 | 26.59 | 25.51 | 26.44 |
| | 2 | 211.47 | 209.04 | 215.65 | 316.45 | 26.16 | 26.50 | 25.59 | 26.38 |
| | 3 | 129.77 | 129.77 | 129.77 | 128.78 | 25.56 | 25.56 | 25.56 | 25.78 |
| | 4 | 1,175.26 | 1,159.75 | 1,180.25 | 1,175.26 | 25.36 | 25.74 | 25.24 | 25.36 |
| | 5 | 100.13 | 100.40 | 100.65 | 99.35 | 25.32 | 25.24 | 25.17 | 25.54 |
| | 6 | 103.29 | 101.93 | 103.28 | 103.29 | 25.45 | 25.83 | 25.45 | 25.45 |
| | 7 | 195.27 | 195.28 | 195.28 | 195.28 | 24.37 | 24.37 | 24.37 | 24.37 |
| | 8 | 569.16 | 569.15 | 569.16 | 569.15 | 24.91 | 24.91 | 24.91 | 24.91 |
| | 9 | 2,243.24 | 2,232.09 | 2,243.23 | 2,242.75 | 25.51 | 25.65 | 25.51 | 25.51 |
| | 10 | 979.43 | 961.97 | 979.45 | 979.45 | 25.72 | 26.24 | 25.72 | 25.72 |
| | 11 | 5,099.98 | 5,045.35 | 5,100.10 | 5,100.12 | 25.77 | 26.08 | 25.77 | 25.77 |
| | 12 | 1,426.95 | 1,401.58 | 1,426.95 | 1,426.95 | 27.27 | 27.82 | 27.27 | 27.27 |
| Total | | 24,251.24 | 24,000.19 | 24,276.92 | 24,448.64 | — | — | — | — |

Table 30. Equilibrium Shipments for Various Models: Nonfed Beef, 12 Receiving or Demand Regions, 2 Seasons, 1967.

| Receiving or demand region | | Quantities received: Million pounds live wt. Model I | Model II | Model III | Equilibrium market prices: $/100 wt. Model I | Model II | Model III |
|---|---|---|---|---|---|---|---|
| Season I | 1 | 47.6 | 48.5 | 48.9 | 16.55 | 16.25 | 16.13 |
| | 2 | 85.2 | 85.2 | 86.7 | 16.96 | 16.96 | 16.68 |
| | 3 | 49.5 | 50.2 | 48.9 | 16.59 | 16.36 | 16.79 |
| | 4 | 495.3 | 490.2 | 507.1 | 17.79 | 17.97 | 17.38 |
| | 5 | 41.5 | 41.5 | 40.7 | 16.35 | 16.34 | 16.64 |
| | 6 | 51.0 | 49.7 | 50.1 | 16.43 | 16.87 | 16.72 |
| | 7 | 76.9 | 77.9 | 76.3 | 16.81 | 16.61 | 16.94 |
| | 8 | 266.7 | 255.7 | 262.1 | 17.31 | 18.05 | 17.61 |
| | 9 | 942.2 | 949.6 | 941.4 | 17.32 | 17.19 | 17.34 |
| | 10 | 507.3 | 500.3 | 507.4 | 17.55 | 17.79 | 17.54 |
| | 11 | 2,046.8 | 2,059.0 | 2,047.6 | 17.53 | 17.43 | 17.52 |
| | 12 | 906.9 | 894.3 | 906.8 | 19.10 | 10.37 | 19.10 |
| Season II | 1 | 53.0 | 54.4 | 54.1 | 16.14 | 15.71 | 15.80 |
| | 2 | 89.7 | 89.7 | 88.7 | 16.12 | 16.12 | 16.12 |
| | 3 | 52.8 | 54.0 | 52.0 | 16.19 | 15.83 | 16.45 |
| | 4 | 487.0 | 485.2 | 496.6 | 17.38 | 17.45 | 17.05 |
| | 5 | 41.9 | 41.9 | 41.9 | 16.34 | 16.34 | 16.35 |
| | 6 | 45.3 | 45.0 | 45.3 | 16.37 | 16.51 | 16.38 |
| | 7 | 72.8 | 74.2 | 71.9 | 16.39 | 16.08 | 16.61 |
| | 8 | 241.2 | 235.9 | 241.0 | 17.30 | 17.69 | 17.32 |
| | 9 | 863.9 | 863.9 | 863.9 | 16.74 | 16.74 | 16.74 |
| | 10 | 495.3 | 489.5 | 495.4 | 16.92 | 17.12 | 16.92 |
| | 11 | 2,105.3 | 2,122.0 | 2,105.1 | 16.88 | 16.75 | 16.88 |
| | 12 | 883.2 | 872.3 | 883.3 | 18.47 | 18.70 | 18.47 |
| Total | | 10,948.3 | 10,930.1 | 10,964.2 | — | — | — |

Table 31. Transfer Costs: Dollars per Hundred Weight, Fed Beef, 12 Regions, 1967.[a]

| | | Region | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Region | Origin | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | 23.65 | --- | 24.52 | 24.68 | 25.37 | 25.93 | 25.34 | 26.34 | 26.36 | 27.17 | 27.86 | 27.26 | 29.12 |
| 2 | 24.86 | 25.73 | --- | 25.80 | 27.03 | 26.12 | 26.47 | 27.73 | 27.23 | 27.77 | 28.72 | 27.98 | 29.72 |
| 3 | 25.56 | 26.59 | 26.50 | --- | 27.17 | 26.94 | 26.44 | 27.66 | 27.41 | 28.23 | 28.84 | 28.50 | 30.11 |
| 4 | 25.18 | 26.90 | 27.35 | 26.79 | --- | 27.94 | 26.93 | 26.55 | 27.87 | 28.74 | 28.86 | 29.10 | 29.95 |
| 5 | 23.98 | 26.76 | 25.24 | 25.36 | 26.74 | --- | 25.41 | 26.53 | 26.32 | 25.66 | 27.84 | 26.24 | 27.76 |
| 6 | 24.58 | 26.27 | 26.19 | 25.46 | 26.33 | 26.01 | --- | 26.04 | 25.76 | 26.72 | 27.09 | 27.03 | 28.54 |
| 7 | 24.37 | 27.06 | 27.24 | 26.47 | 25.74 | 26.92 | 25.83 | --- | 26.12 | 27.11 | 26.47 | 27.29 | 28.19 |
| 8 | 24.91 | 27.62 | 27.28 | 26.76 | 27.60 | 27.25 | 26.09 | 26.66 | --- | 26.15 | 27.42 | 26.42 | 27.87 |
| 9 | 25.51 | 29.03 | 28.42 | 28.18 | 29.07 | 27.19 | 27.65 | 28.25 | 26.75 | --- | 26.98 | 25.94 | 27.68 |
| 10 | 23.44 | 27.65 | 27.30 | 26.72 | 27.12 | 27.30 | 26.07 | 25.54 | 25.95 | 24.91 | --- | 25.03 | 25.02 |
| 11 | 23.68 | 27.29 | 27.54 | 26.62 | 27.60 | 25.94 | 26.13 | 26.60 | 25.19 | 24.11 | 25.27 | --- | 25.62 |
| 12 | 24.96 | 30.43 | 29.82 | 29.51 | 29.73 | 28.74 | 28.92 | 28.78 | 27.92 | 27.13 | 26.54 | 26.90 | --- |

[a]Source for truck transportation cost: (2)

Transfer cost matrices for fed and nonfed beef are presented in Tables 31 and 32. These two tables are similar to those used in model I except for the truck transportation rates (see Tables 18 and 19). One noticeable fact is that each cell in the matrices for fed and nonfed beef presented in Tables 31 and 32 shows higher transfer costs than those used in Tables 18 and 19. The main reason is that truck rates between various shipping points estimated according to Bhagia's equation are much higher than those estimated on the basis of equation used by Havelicek, Rizek, and Judge. Bhagia's truck rates are higher despite the fact that his equation considers hauling distance as the only independent variable. Havelicek, Rizek and Judge used distance the load is hauled, load carried, and average speed of the haul as independent variables.

In model I the truck rates estimated for 1960 by Havelicek, Rizek, and Judge are treated as relevant for 1967 under the assumption that these rates remained relatively constant. On the other hand, Bhagia's truck costs are based on minimum loads required by trucking companies and on current tariffs for 1967 (2, p. 84). This suggests that higher truck rates are probably due to substantial increases in all or some trucking costs, such as fuel, repairs and maintenance, drivers' wages, insurance, depreciation, and other overhead charges, during 1960-1967.

Table 32. Transfer Costs: Dollars per Hundred Weight, Nonfed Beef, 12 Regions, 1967.[a]

| | Region | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Region | Origin | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | 15.55 | --- | 16.42 | 16.58 | 17.27 | 17.83 | 17.24 | 18.24 | 18.26 | 19.07 | 19.76 | 19.16 | 21.02 |
| 2 | 16.12 | 16.99 | --- | 17.06 | 18.29 | 17,38 | 17.73 | 18.99 | 18.49 | 19.13 | 19.98 | 19.24 | 20.98 |
| 3 | 15.38 | 16.41 | 16.32 | --- | 16.99 | 16.76 | 16.26 | 17.48 | 17.23 | 18.05 | 18.66 | 18.22 | 19,93 |
| 4 | 16.70 | 18.43 | 18.87 | 18.31 | --- | 19.46 | 18.45 | 18.07 | 19.39 | 20.26 | 20.38 | 20.62 | 21.47 |
| 5 | 16.34 | 19.12 | 17.60 | 17.72 | 19.10 | --- | 17.77 | 18.89 | 18.68 | 18.02 | 20.20 | 18.60 | 20.12 |
| 6 | 16.37 | 18.06 | 17.98 | 17.25 | 18.12 | 17.80 | --- | 17,83 | 17.55 | 18.51 | 18.88 | 18.82 | 20.33 |
| 7 | 15.66 | 18.35 | 18.53 | 17.76 | 17.03 | 18.21 | 17.12 | --- | 17.41 | 18.40 | 17.76 | 18.58 | 19.49 |
| 8 | 17.14 | 19.85 | 19.51 | 18.99 | 19.83 | 19.48 | 18.32 | 18.89 | --- | 18.38 | 19.65 | 18.65 | 20.10 |
| 9 | 16.74 | 20.26 | 19.65 | 19.41 | 20.30 | 18.42 | 18.88 | 19.48 | 18.98 | --- | 18.21 | 17.17 | 18.91 |
| 10 | 16.13 | 20.34 | 19.99 | 19.41 | 19.81 | 19.99 | 18.76 | 18.23 | 18.64 | 17.60 | --- | 17.72 | 17.71 |
| 11 | 16.35 | 19.96 | 20.21 | 19.29 | 20.27 | 18.61 | 18.80 | 19.27 | 17.86 | 16.78 | 17.94 | --- | 18.29 |
| 12 | 16.78 | 22.25 | 21.64 | 21.33 | 21.55 | 20.56 | 20.74 | 20.60 | 19.74 | 18.95 | 18.36 | 18.72 | --- |

[a]Source for truck transportation costs: (2)

Fed Beef. Equilibrium fed beef shipment patterns[60] from model II are shown in Figure 8. In comparison with model I, results from model II are different in the following respects:

(1) Except for region 9 (Midwest), outshipments from all other regions are lower than under model I. Outshipments from regions 7 (Arizona, New Mexico), and 10 (Texas, Oklahoma) are substantially lower. In all, a smaller percentage of total estimated fed beef supply is distributed (96.68 percent). This has resulted in higher market prices in most cases, as can be seen from Column 7, Table 29.

(2) Although region 5 (Wyoming, Montana) exported the largest percentage of its estimated fed beef supply (21.98 percent), region 9 (Midwest) exported the largest quantity in absolute terms (1045.44 million pounds--18.84 percent of its estimated supply). Also, region 9's outshipments of fed beef to region 12 (Eastern U.S.) increased substantially, and region 10's outshipments to region 12 (Eastern U.S.) declined. This is not surprising, since model I shows that region 10 received 211.67 million pounds of fed beef from region 7, in addition to its excess supply. Region 12 being

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[60] Total shipments received by each region (intraregionally or interregionally) are also shown for each region in Figure 9.

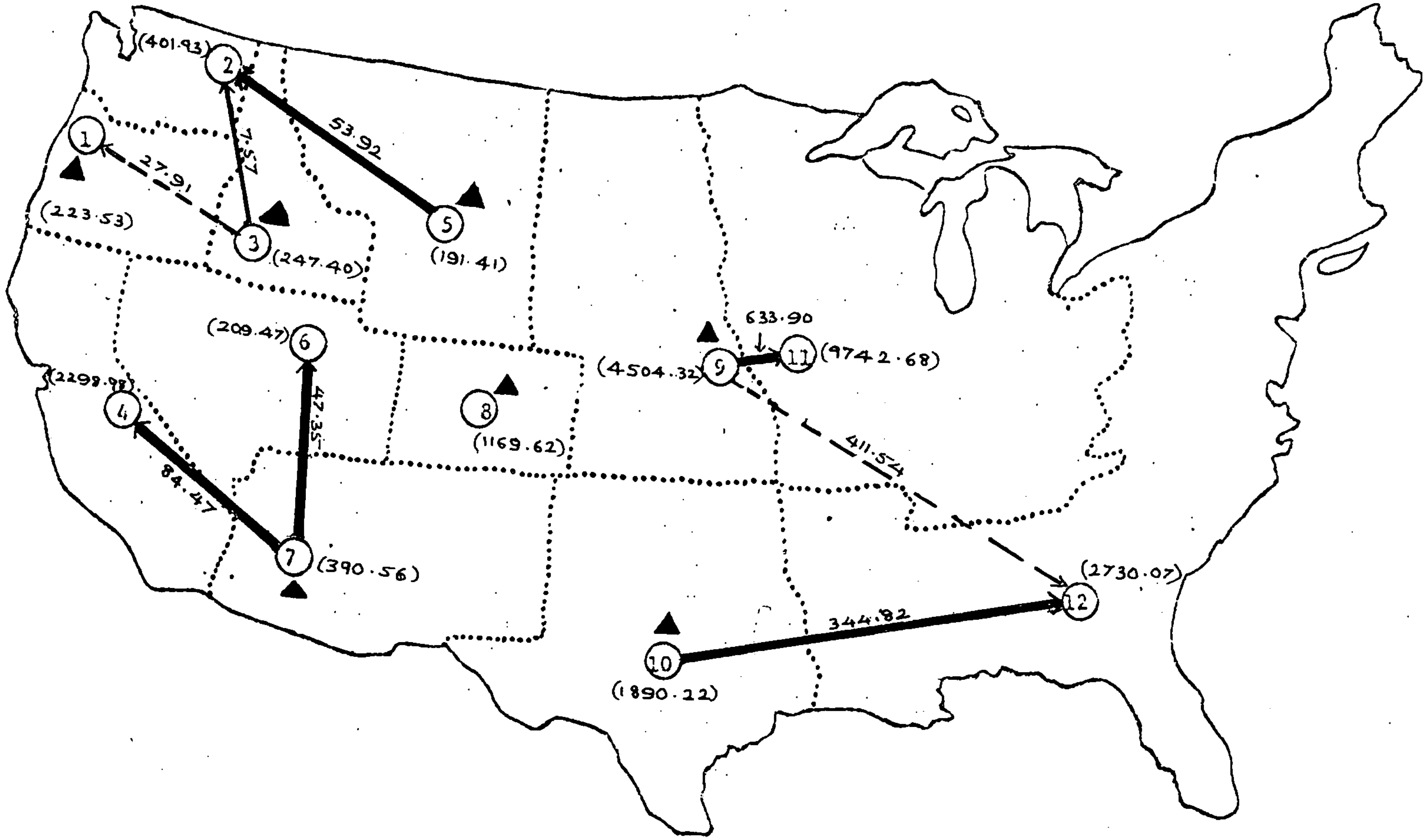



Figure 8. Effect of Changes in Truck Transportation Rates on the Equilibrium Shipments: Fed Beef, 12 Regions, 2 Seasons, 1967. (Million Pounds Live Weight).

shipments in season I and II only — shipments in season II only

shipments in season I only — ▲ carry over from season I to season II a deficit region, model I shows larger shipments from region 10 to region 12. Model II, however, shows no shipments from region 7 to region 10. As a result, region 10's shipments to region 12 are less and region 9's shipments to region 12 are greater under model II than in model I.

(3) Region 7 (Arizona, New Mexico) shipped only 13.61 percent of its estimated fed beef supply under model II with all of its outshipments still going to regions 4 (California), and 6 (Utah, Nevada).

(4) Whereas the number of regions outshipping fed beef declined, the number of regions carrying over surplus fed beef from season I to season II increased in model II. Also, the number of regions shipping fed beef in season II increased.

Nonfed Beef. Equilibrium shipment patterns for nonfed beef from model II are shown in Figure 9. In comparison with model I, results from model II are different in the following respects:

(1) Except for regions 6 (Utah, Nevada), and 10 (Texas, Oklahoma), outshipments from other regions declined. Region 5 (Montana, Wyoming) did not outship nonfed beef. In all, a smaller percentage of the total estimated nonfed beef supply is distributed (98.77 percent). However, general shipment patterns did not show considerable changes (Figure 9).

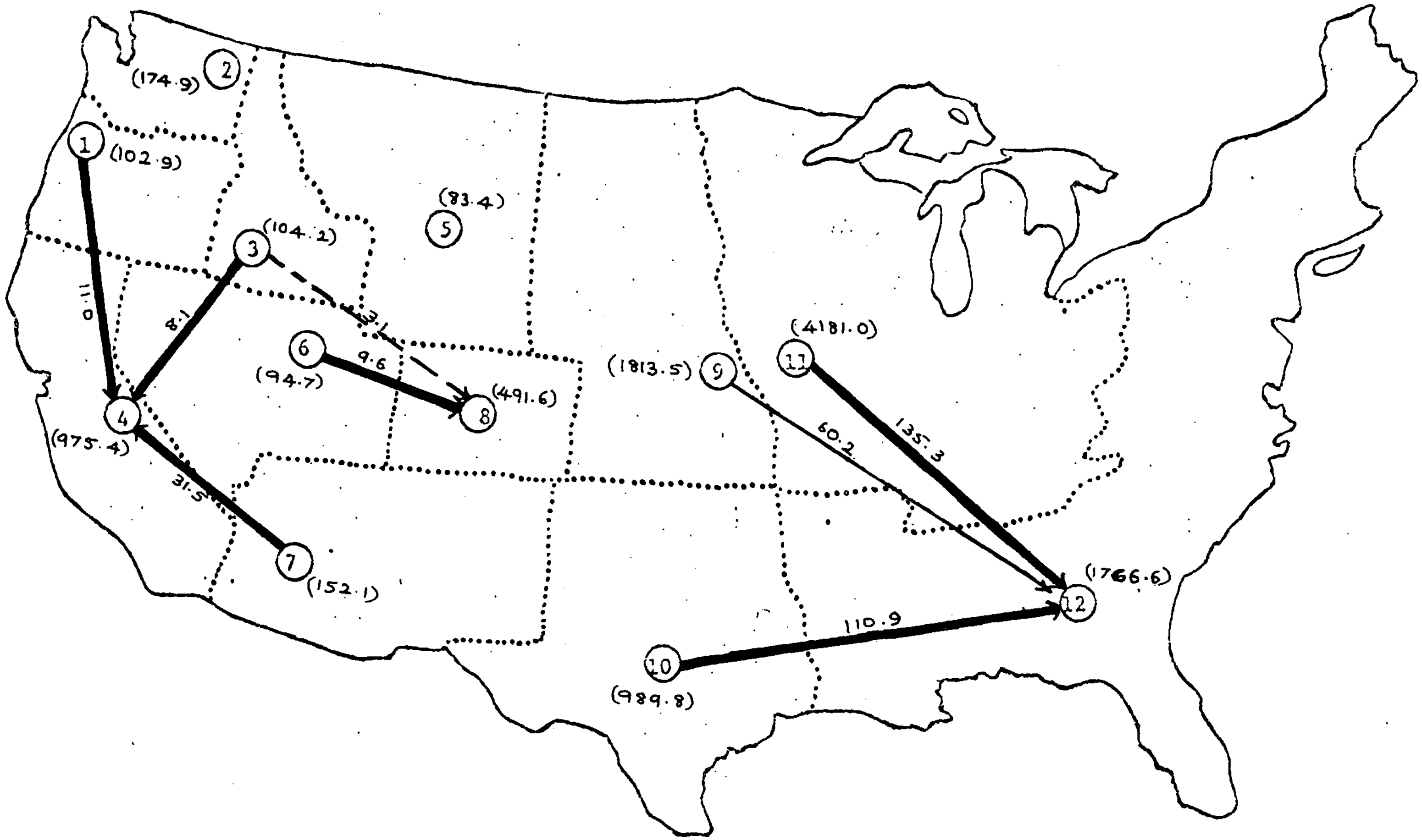



Figure 9. Effect of Changes in Truck Transportation Rates on the Equilibrium Shipments: Nonfed Beef, 12 Regions, 2 Seasons, 1967 (Million Pounds Live Weight).

shipments in season I and II
shipments in season I only
shipments in season II only
carry over from season I to season II

Impact of Backhauls on Equilibrium Fed and Nonfed Beef Shipment Patterns

Although Oregon and Washington inship fed beef to meet their deficits, the Pacific Northwest region as a whole is a surplus feeder cattle producing region. Oregon's stocker and feeder cattle, for example, are shipped to the West North Central states, East North Central States, and Western States (15). California is a deficit region in the production of fed beef. If the truckers carrying live cattle to Oregon, Washington, and California can haul back feeder cattle or lambs and sheep, it could significantly affect the competitive position of one beef producing region over another region. Model III examines the impact of backhauls on the equilibrium shipment patterns.

Assuming that truckers from regions 3, 5, 6, 7, 8, 9, and 10 shipping fed and/or nonfed beef to regions 1 (Oregon), 2 (Washington), and 4 (California) can haul back either feeder cattle or lambs and sheep, truck transportation rates from these seven shipping regions to regions 1, 2, and 4 might be reduced by 50 percent. For example, due to the availability of backhauls, truckers from Denver, Colorado (region 8) are assumed to charge $0.84 per hundred weight (live) to ship cattle to Portland, Oregon (region 1) instead of $1.69 per hundred weight (live), as used in model I. It is also assumed that backhauls are available in both seasons.

Fed Beef. Figure 10 explains fed beef equilibrium shipment patterns from model III. In the following respects equilibrium shipments from model III are different from equilibrium shipments in model I:

(1) A greater percentage of total estimated fed beef supply is distributed (97.79 percent).

(2) Region 7 (Arizona, New Mexico) exported 45.85 percent of its estimated fed beef supply. This proportion was highest among all exporting regions, and was greater by almost 7 percent than shown in model I. Region 7 (Arizona, New Mexico) also exported fed beef to region 1 (Oregon) in both seasons, to region 2 (Washington) in season I, and it had five regional outlets (as compared with 3 regional outlets shown in model I) for its fed beef.

(3) Model III shows that in the event of the backhauls specified here region 7 will compete with regions 3, 5, and 8 in capturing the fed beef market of regions 1 (Oregon) and 2 (Washington). Model I showed region 3 (Idaho) as an exporter of fed beef to regions 1 and 2. However, model III shows no such fed beef shipments from region 3 (Idaho).

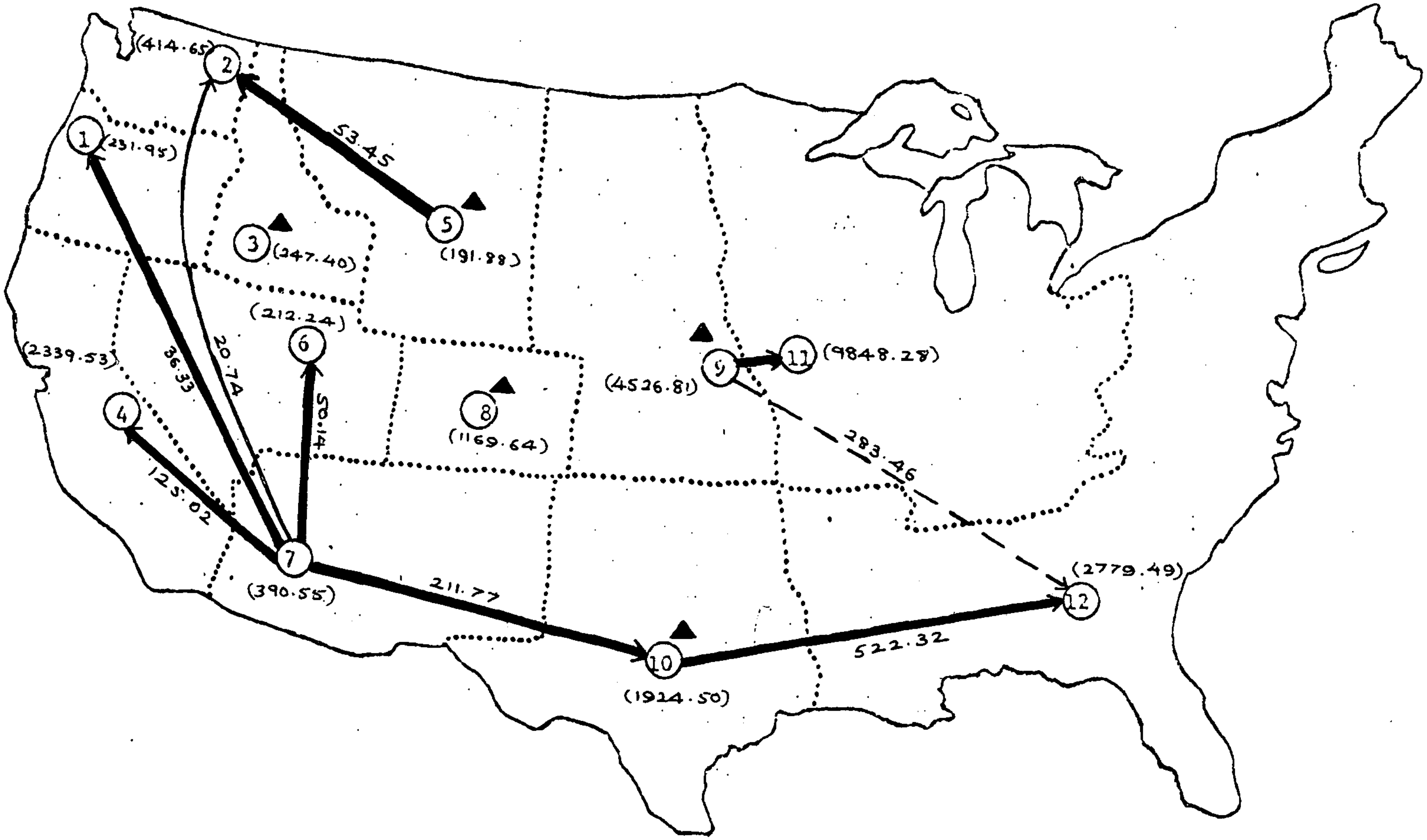
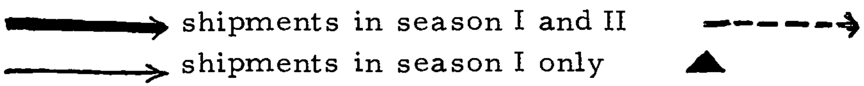



Figure 10. Effect of Backhauls on Equilibrium Shipments: Fed Beef, 12 Regions, 2 Seasons, 1967 (Million Pounds Live Weight).



(4) Equilibrium market prices under model III were higher in regions 1 (Oregon) and 2 (Washington) and lower in regions 4 (California) and 5 (Montana, Wyoming) than were in model I. Prices in other regions remained unchanged.

Nonfed Beef. Figure 11 demonstrates nonfed beef equilibrium shipment patterns from model III. In the following respects equilibrium shipments from model III are different from equilibrium shipments in model I:

(1) Since total outshipments from regions 3, 5, 6, 7, and 9 are greater than in model I, a greater percentage of estimated nonfed beef supply is distributed in model III (99. 1 percent).

(2) Although total outshipments from region 10 (Texas, Oklahoma) and region 1 (Oregon) are lower than in model I, model III shows two regional outlets for nonfed beef from region 1. Region 1 shipped 1.46 million pounds to region 2 (Washington) in season I, and 9.54 million pounds to region 4 (California) in both seasons. Model I did not show shipments from region 1 to region 2.

(3) California inshipped 78.97 million pounds of nonfed beef under model III, as compared with 57.6 million pounds in model I. Also, California received nonfed beef from five regions as compared with four regions in model I. The largest quantity of nonfed beef shipped into California came from region 7 (Arizona, New Mexico).

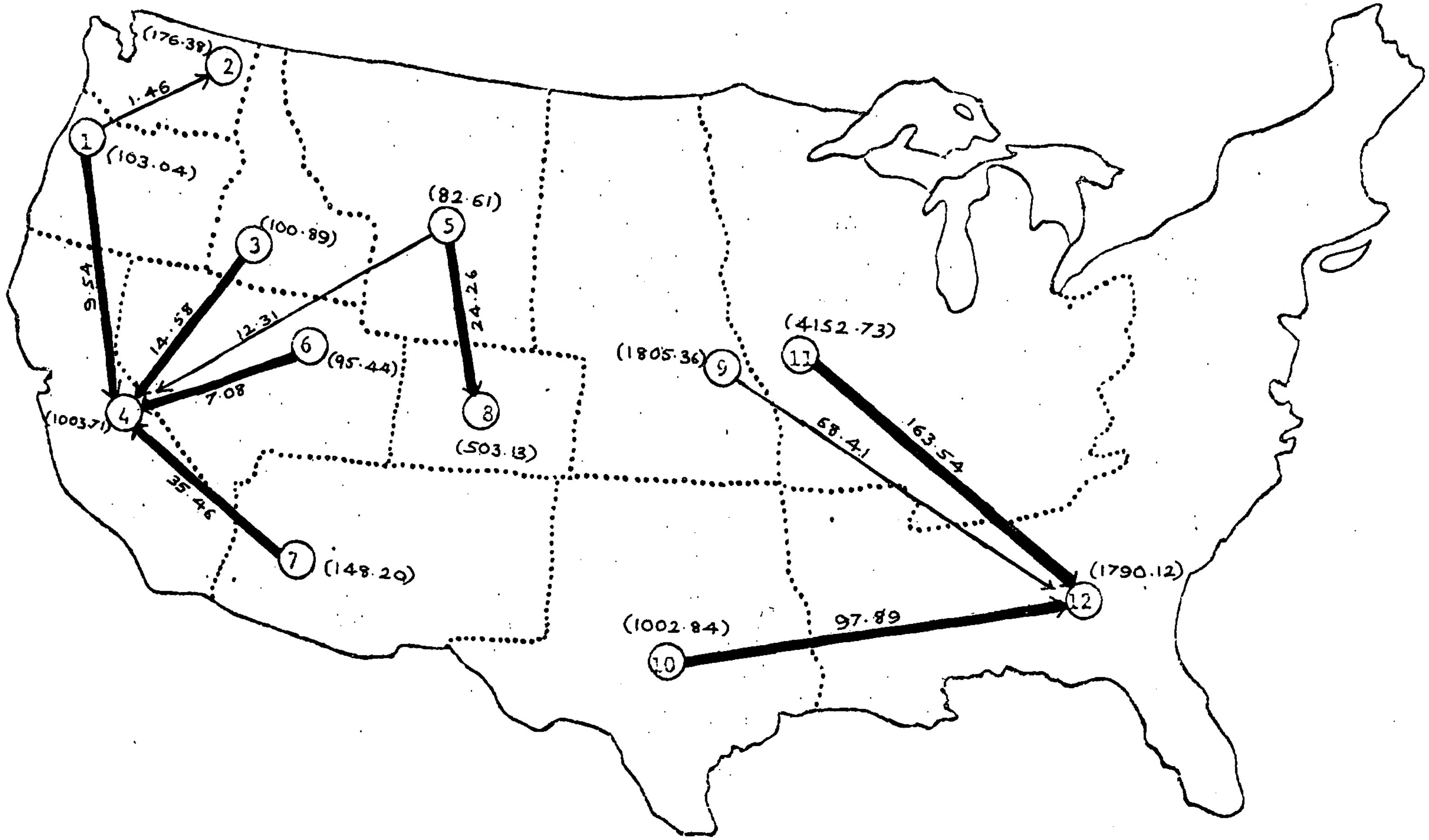



Figure 11. Effect of Backhauls on Equilibrium Shipment Patterns: Nonfed Beef, 12 Regions, (Million Pounds Live Weight).

shipments in season I and II

shipments in season I only

(4) Even though outshipments from region 3 (Idaho) to region 4 (California) almost doubled, its outshipments to region 8 (Colorado) ceased. Model I showed inshipments of nonfed beef into region 8 (Colorado) from regions 3 (Idaho), and 5 (Montana, Wyoming). Model III, however, shows somewhat higher inshipments from region 5 to region 8, no shipments from region 3 to region 8, and no carryover in region 8.

(5) Although in absolute terms region 11 (East North Central U.S.) outshipped the largest quantity of nonfed beef (164.2 million pounds) to region 12 (Eastern U.S.), region 5 (Montana, Wyoming) exported the largest percentage of its estimated nonfed beef supply (26.20 percent).

(6) Equilibrium market prices for nonfed beef in model III are higher in regions 3, 5, 6, 7, 8, and 9 and lower in regions 1, 2, 4, 10, and 11 in comparison with equilibrium market prices for nonfed beef in model I. This discrepancy in equilibrium market prices in the two models is probably due to changes in regional shipments. For example, since outshipments from region 1 (Oregon) are lower in model III than in model I, equilibrium market prices are lower in region 1 under model III than in model I (see Table 30).

Impact of Increased Slaughter Demand for Fed Beef in a Specific Region on Equilibrium Shipment Patterns

It is assumed that slaughter demand for fed beef is increased by 200,000 head (216.2 million pounds live weight) in region 2 (Washington).[61] Figure 12 depicts fed beef equilibrium shipment patterns from model IV. In comparison with model I, results from model IV are different in the following respects:

(1) Due to an increase in outshipments of fed cattle from regions 3, 5, 7, 8, and 10, a greater percentage of total estimated fed beef is distributed (98.48 percent).

(2) Region 3 (Idaho) emerged as the largest exporting region, with 37.76 percent of its estimated fed beef supply shipped to regions 1 and 2 together.

(3) Rise in slaughter demand for fed beef in region 2 was met mainly from region 3 (Idaho), followed by regions 8 (Colorado), and 5 (Montana, Wyoming). Region 8 (Colorado) outshipped 6.41 percent of its estimated fed beef supply to region 2 (Washington).

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[61] In April 1971, a packing plant that can process 130,000 cattle a year on a one-shift basis and 260,000 head per year on a two-shift basis went into operation at Pasco, Washington (22). Therefore, it was arbitrarily decided to consider the effect of an increase in demand by 200,000 slaughter cattle. Since cattle production from nearby states is not going to change suddenly, it is worthwhile to see which regions might supply fed cattle to Washington.

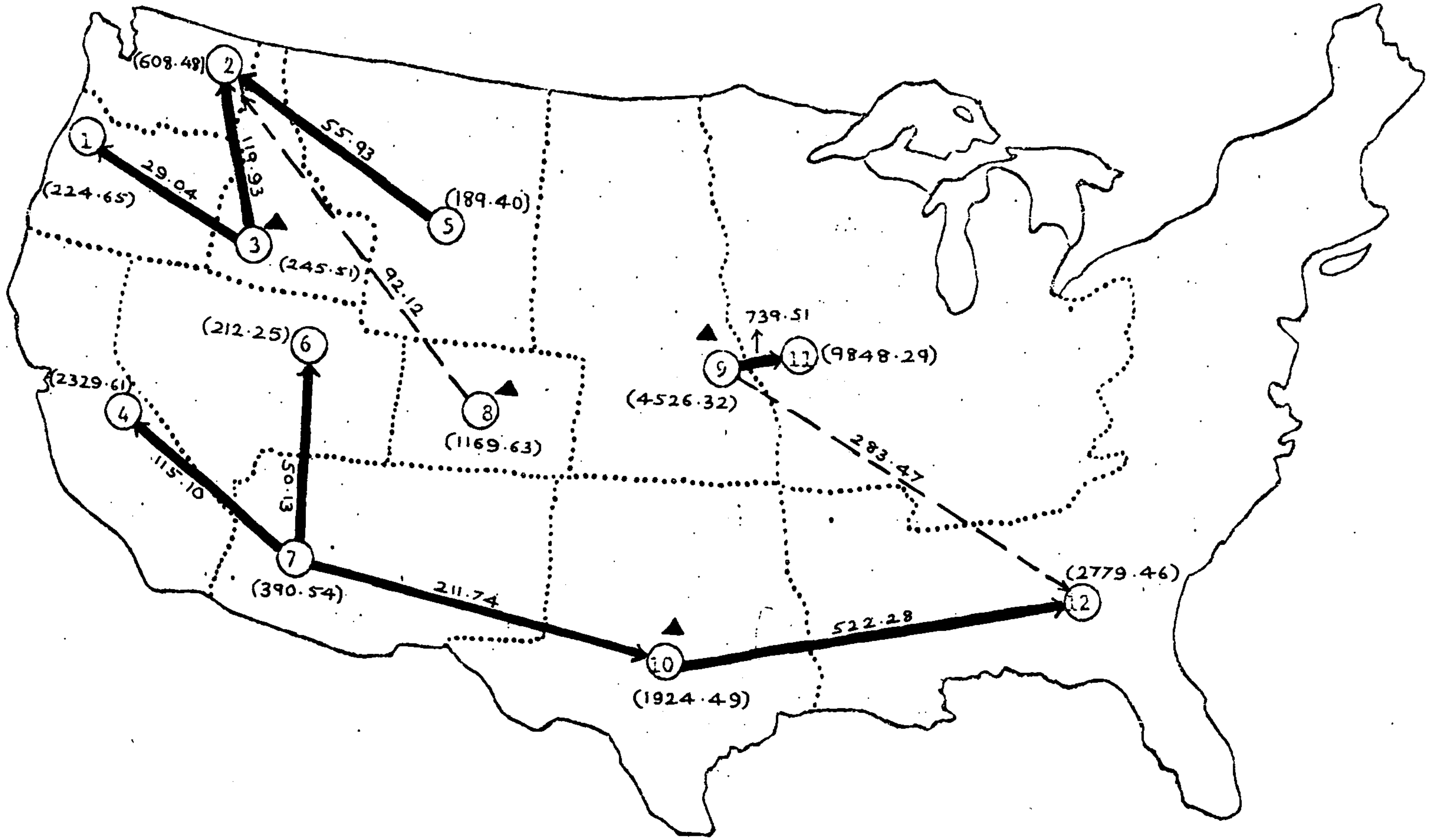


Figure 12. Effect of Increase in Slaughter Demand for Fed Beef on Equilibrium Shipments: Fed Beef, 12 Regions, 2 Seasons, 1967 (Million Pounds Live Weight).

shipments in season I and II
shipments in season I only
shipments in season II only
carryover from season I to season II

(4) The number of regions carrying over excess supplies of fed beef from season I to season II was reduced from five to four.

(5) Equilibrium fed beef market prices in model IV were higher in regions 1 (Oregon), 2 (Washington), 3 (Idaho), and 5 (Montana, Wyoming) than they were in model I (see Table 29). There were no changes in the equilibrium market prices for other regions. Equilibrium market prices were higher in region 2 (Washington), since demand for fed beef slaughter exceeded supply in that region. Equilibrium market prices were higher in regions 3 (Idaho) and 5 (Montana, Wyoming) since these regions exported substantially larger quantities of fed beef to region 2 (Washington), leaving less quantities of fed beef for regional demands.

Comparison of Equilibrium Shipment Patterns Obtained from Models I, II, III, and IV.

After obtaining equilibrium shipment patterns and market prices for fed and nonfed beef from each model, it is now possible to compare them simultaneously, and see if these models closely approximate the real world.

(1) The percentage of fed beef production which is distributed by each model is lowest in model II (96.68) percent) and highest in model IV (98.48 percent). Nonfed beef production which is distributed by each model is lowest in model II (98.77 percent) and

highest in model III (99.1 percent).

(2) Model II shows no shipments of fed beef from region 7 (Arizona, New Mexico) to region 10 (Texas, Oklahoma). Also, the largest number of regions carrying over excess fed beef supplies from season I to season II occurs under model II. These results are mainly due to the fact that truck transportation rates estimated by Bhagia and used in model II are higher than those used in models I, III, and IV. This indicates that truck transportation rates have a substantial impact on the optimum shipment patterns.

(3) Model III shows that due to backhauls, region 7 (Arizona, New Mexico) is able to ship fed beef to region 1 (Oregon) in both seasons, and to region 2 (Washington) in season I. It also shows no fed beef shipments from region 3 (Idaho) to either region 1 (Oregon), or region 2 (Washington). Nonfed beef shipments from region 3 (Idaho) are also affected due to the availability of backhauls. For example, due to backhauls model III shows no nonfed beef shipments from region 3 (Idaho) to region 8 (Colorado), in contrast with such shipments shown in model I. This indicates that under the backhaul pattern posited in this analysis, region 3 (Idaho) might find it more difficult to maintain its share of the fed beef markets in regions 1 (Oregon) and 2 (Washington), and of the nonfed beef market in region 8 (Colorado).

(4) Equilibrium market prices are highest in most of the markets in model II. Changes in equilibrium market prices in certain regions under models III and IV reflect the impact of increases or decreases in supplies or demands of fed and nonfed beef. For example, equilibrium market price in region 2 (Washington), under model IV is much higher, since demand exceeds supply in that region.

Some of the changes in specified conditions considered in this chapter are hypothetical examples and do not necessarily represent the real world. For example, a 50 percent reduction in truck rates due to backhauls may be too high or too low for independent truckers. Similarly, an increase in slaughter demand for fed beef in region 2 (Washington) is probably higher than what might actually occur. Nevertheless, these hypothetical examples help in explaining what might happen if these changes were to take place in varying degrees.

In general, models II, III, and IV suggest that equilibrium shipments from model I will be affected by changes in specified conditions, especially due to changes in truck transportation rates and backhauls. This analysis points out that under the backhaul pattern considered, the competitive position of region 3 (Idaho) in supplying fed and nonfed beef to regions 1 (Oregon), 2 (Washington), and 8 (Colorado) will be greatly affected. Region 7 (Arizona, New Mexico), an excess beef-producing region, will be able to ship more to other regions in the event of backhauls and reduced truck transportation costs considered in this analysis.

Regions 3 (Idaho), 5 (Montana, Wyoming), and 8 (Colorado) will meet Washington's (region 2) increased slaughter demand for fed beef.

Intermediate costs (feed plus nonfeed costs) make up a substantial portion of the total transfer costs. Changes in such costs could affect the equilibrium shipment patterns. However, such changes are not considered in this analysis.

# X. SUMMARY AND CONCLUSIONS

The overall objective of this thesis was aimed at determining simultaneously interregional and interseasonal equilibrium with respect to beef production and marketing in the U.S., with special emphasis on the Pacific Northwest region. This overall objective was further divided into three specific objectives.

In order to achieve the overall objective, the reactive programming algorithm was selected as the computational means. Market equilibrium was defined as the stage at which demand was exactly equal to supply for each product in each season and in each region. At equilibrium there was no incentive for any producers to make any further trades.

The continental U.S.A. was divided into 12 regions. Fed and nonfed beef were defined as two products available in two seasons in 1967. Supply estimates were made for each product for each region in each season. Demand equations were defined for each product in each season and in each region. Transfer costs--including feed and nonfeed costs and truck transportation rates--were also estimated.

With the use of the CDC 3300 computer and the estimates of demand, supply, and transfer costs, equilibrium shipments from each production center to each demand region for each product, equilibrium net prices at each producing center for each product during each season, and equilibrium market prices for each product at each demand region during each season were obtained from the computer solution.

Equilibrium shipment patterns and prices obtained from the analytical model were discussed in detail, and then they were compared with the real situation in 1967. Such comparison was done on a limited scale, especially in the case of fed and nonfed beef shipments, since very little published information was available on the actual inshipments and outshipments of fed and nonfed beef among various regions.

It is concluded that, subject to the restrictions imposed on the equilibrium solution, the results obtained approximated the actual industry situation fairly well. Comparisons of simple average seasonal market prices and computed equilibrium prices showed that computed prices were in reasonably close proximity with actual market prices.

The model failed to identify smaller interregional flows of fed and/or nonfed beef, but it succeeded in recognizing more general interregional beef movements. Possible reasons behind discrepancies existing between the equilibrium solutions obtained from the model and actual observations were also discussed in detail. It was pointed out that the analytical model could be useful provided the supply and demand estimates, coefficients of demand functions, feed and nonfeed costs estimates, and transportation rates and other factors were reasonably accurate.

Effects of changes in truck transportation rates, availability of backhauls, and increase in slaughter demand for fed beef in Washington on equilibrium flows of fed and/or nonfed beef and prices were analyzed. Although these changes were hypothetical examples, they explained possible effects on interregional competition in the beef industry if these changes were to take place in varying degrees. Discussions in Chapters VIII and IX may be used as a summary of results of the study.

## Conclusions and Implications

The study reveals that interregional flows and prices of fed and nonfed beef are very senstitive to truck transportation rates. The effects of backhauls analyzed in this study indicate that region 3 (Idaho) will lose some of its competitive advantage to regions 5 (Montana, Wyoming), and 7 (Arizona, New Mexico) in supplying fed beef to either region 1 (Oregon) or region 2 (Washington), and nonfed beef to region 8 (Colorado).

The Pacific Northwest is not a large beef-producing region as compared with several other regions. Within the Pacific Northwest region, Oregon and Washington are deficit regions in fed beef production relative to consumption (for detail see Table 2). The Pacific Northwest's outshipments of fed and nonfed beef go to three adjoining states. For example, one report points out that, "some 38 percent of the annual volume of slaughter cattle shipped out of state (Oregon) went to California during the 1963-1967 period, with 30 percent going to Washington annually and 28 percent to Idaho" (15, p. 14). Regions surrounding the Pacific Northwest (except California, Utah, and Nevada) are large beef producers, and long distance shipments, especially to the Eastern U.S., are uneconomical due to higher transfer costs involved and stiff competition from other regions.

The beef industry in the Pacific Northwest has opportunities for expansion, especially taking into account the large and growing markets in California, and to some extent in Utah. The Pacific Northwest is a feeder cattle exporting region, and feed costs per hundred weight of gain for fed beef in Oregon, and Washington are quite comparable with other regions. Table 16 shows that in 1967 feeder cattle prices and feed costs per hundred weight of gain were relatively low in Oregon. This places Oregon in a favorable competitive position with other regions. Although nonfeed costs were relatively higher in the Pacific Northwest region in 1967, total intermediate costs in Oregon, Washington, and Idaho were quite comparable with other regions.

Even if it is assumed that nonfeed costs are going to remain high in the Pacific Northwest, the region has opportunities to reduce feed costs and thus become competitive with other regions. One way to accomplish this is to increase regional production of feed grains. Another way is to inship feed grains from other regions at lower costs.

It was pointed out earlier that if truckers are assured of backhauls, they would prefer to charge less than go empty. Closer coordination between feeder cattle industry people in the Pacific Northwest and exporters of fed cattle to the Pacific Northwest is needed. Thus, through proper coordination, trucks bringing fed beef from the Midwest and Southwest into the Pacific Northwest could carry feeder cattle on their return journey. This would be to the benefit of both consumers and the beef industry in the region. As a result of backhauls, truck transpostation costs could be reduced and reflected in lower prices of meat products. Similarly, the supplies of feeder cattle and fed cattle in the regions concerned will be more even and well regulated.

The advantages of backhauls can also be increased if the federal and state authorities will reconsider regulation of truck transportation. For example, in Oregon, trucks once permitted to haul cattle are prohibited from hauling anything other than cattle.[62] It is feasible for truckers to carry cattle on one way and other goods or commodities on the return journey or vice versa.

Oregon, Washington, and California are among the seven largest fruit-growing states in the country (14). Fruits grown in these states are shipped to other western, midwestern, and eastern states on a year-round basis. In this thesis movements of live cattle by trucks are analyzed; hence, such trucks are likely to be unfit to haul fruits to other regions. If the refrigerated trucks carrying carcass beef to Oregon, Washington, and California, are equipped to haul back fruits or beef products, it seems logical (on the basis of effects of backhauls analyzed in this study) to say that consumers as well as fruit growers in the region will benefit, in terms of more trade and lower prices.

The reactive programming algorithm is well adapted to analyses of industrywide, multidimensional (time, space, and form)

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[62] Telephone conversation on June 29, 1971 with Mr. Roy K. Nelson, Administrator, Livestock Division, State Department of Agriculture, Salem, Oregon.

aspects of competition in the beef industry. Such a model can accommodate any form of competition and various mathematical forms of demand and supply functions. Reactive programming potentially can be a valuable tool in thoroughly understanding the U.S. beef industry.

## Suggestions for Future Research

The original plan of this study was to make an integrated analysis of interregional, interseasonal, and interproduct competition in the beef industry. However, due to lack of certain data--especially demand coefficients for feeder cattle--the aspect of interproduct competition was deleted in the empirical work. Nevertheless, the analytical model discussed in the text covers such an idea. In fact, the computer model can be used without any further changes to accommodate multiproduct competition.

Decision makers in the beef industry often face a problem of deciding whether to market the calf or yearling for slaughter, or to keep it on feed as a feeder animal. Total basic supply of beef cattle at the beginning of a year can be expressed as a series of subcategories--e.g., calves, yearlings, and cull cows--each having a different set of production possibilities with respect to fed, nonfed, or feeder cattle. A reactive programming model will determine equilibrium patterns of marketing basic supplies of different categories of beef cattle among fed, nonfed, and feeder cattle, geographic market areas, and marketing seasons.

The accuracy and plausibility of results obtained from such a study will largely depend upon accuracy of data, demand coefficients for fed and nonfed beef and feeder cattle, and transfer costs. Such a study will be an important addition to the spatial analysis of the beef industry done by other researchers. From a methodological point of view, such an integrated approach might provide information superior in its characteristic to individual sector analysis.

Transportation costs are usually measured in distance travelled and total weight carried. It has been lately argued that if all inputs (labor, depreciation, maintenance, fuel, etc.) are measured in consumption per unit of time, it might be more logical to measure the output (miles) in terms of time (33, p. 3). When over-the-road operating costs of a transport unit are obtained by dividing the total costs by total miles, it gives an estimate of cost based on aggregate cost and optimum operation (33, p. 3). If time is used to evaluate the cost of deviating from a given operation, "the cost of traversing the short arc of the deviation is computed in terms of optimum cost without any concern over the applicability of such figures to the specific arc" (33, p. 3). This approach is quite new and has hardly been incorporated in transportation models. The use of such time-oriented transportation costs might lead to a realistic spatial analysis and could lead to more accurate predictions of beef cattle movements and prices.

Since transportation rates greatly affect interregional flows of beef cattle, and trucks haul a large percentage of live cattle and meat, a reliable and comprehensive survey of the rates charged by private, non-regulated truckers is needed. Similarly, there is a need of better data on regional differences in feed and nonfeed costs for various classes of beef cattle.

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# APPENDICES

Appendix A. Market Prices: Fed and Nonfed Beef, 12 Regions, 2 Seasons, 1967.[a]

| Region | | Fed Beef $/hundred weight[b] | Nonfed Beef $/hundred weight[c] |
|---|---|---|---|
| Season I | 1 | 25.63 | 17.77 |
| | 2 | 24.76 | 17.68 |
| | 3 | 25.22 | 17.71 |
| | 4 | 25.81 | 18.42 |
| | 5 | 23.65 | 17.97 |
| | 6 | 24.82 | 18.77 |
| | 7 | 25.64 | 17.56 |
| | 8 | 24.19 | 19.44 |
| | 9 | 24.54 | 17.68 |
| | 10 | 24.59 | 17.89 |
| | 11 | 24.04 | 17.04 |
| | 12 | 25.22 | 19.43 |
| Season II | 1 | 26.38 | 17.16 |
| | 2 | 25.71 | 16.70 |
| | 3 | 25.98 | 17.11 |
| | 4 | 26.44 | 17.90 |
| | 5 | 24.86 | 17.16 |
| | 6 | 25.59 | 18.10 |
| | 7 | 26.40 | 16.64 |
| | 8 | 25.82 | 19.57 |
| | 9 | 25.88 | 16.76 |
| | 10 | 25.90 | 16.79 |
| | 11 | 25.62 | 16.97 |
| | 12 | 26.84 | 18.04 |

[a]Sources: (7, 36)

[b]Choice Steers, 800-1100 pounds

[c]Commercial cows

Appendix B. Commercial Cattle and Calf Slaughter: Percentages, 12 Regions, 2 Seasons, 1967.[a]

| | Commercial cattle slaughter | | | Commercial calf slaughter | | |
|---|---|---|---|---|---|---|
| Region | Jan.-June percent | July-Dec. percent | Total % | Jan.-June percent | July-Dec. percent | Total % |
| 1 | 47.2 | 52.8 | 100 | 44.4 | 55.6 | 100 |
| 2 | 48.5 | 51.5 | 100 | 40.8 | 59.2 | 100 |
| 3 | 47.8 | 52.2 | 100 | 50.0 | 50.0 | 100 |
| 4 | 50.1 | 49.9 | 100 | 52.3 | 47.7 | 100 |
| 5 | 48.8 | 51.2 | 100 | 41.2 | 58.8 | 100 |
| 6 | 51.4 | 48.6 | 100 | 51.2 | 48.8 | 100 |
| 7 | 50.6 | 49.4 | 100 | 53.0 | 47.0 | 100 |
| 8 | 52.2 | 47.8 | 100 | 57.7 | 42.3 | 100 |
| 9 | 51.0 | 49.0 | 100 | 58.6 | 41.4 | 100 |
| 10 | 49.7 | 50.3 | 100 | 48.1 | 51.9 | 100 |
| 11 | 49.1 | 50.9 | 100 | 51.3 | 48.7 | 100 |
| 12 | 49.7 | 50.3 | 100 | 48.3 | 51.7 | 100 |

[a]Sources: (38, Tables 94, 95)

Appendix C: Estimated Calf Supply Available for Feeding and/or Slaughter, 12 Regions, 2 Seasons, 1967.

| Region | Calves born[a] (1000 head) | Calf deaths[b] (1000 head) | Net Calf crop[c] (1000 head) | Heifer calves and other calves on farms[d] Jan 1, 1968 (1000 head) | Heifer calves and other calves on farms[d] Jan 1, 1967 (1000 head) | Total calves available for feeding/ slaughter[e] (1000 head) |
|---|---|---|---|---|---|---|
| 1 | 718 | 32 | 686 | 444 | 61 | 703 |
| 2 | 523 | 28 | 495 | 392 | 394 | 497 |
| 3 | 629 | 32 | 597 | 499 | 497 | 595 |
| 4 | 1,650 | 79 | 1,571 | 1,177 | 1,123 | 1,517 |
| 5 | 2,030 | 114 | 1,916 | 1,352 | 1,280 | 1,844 |
| 6 | 610 | 32 | 578 | 350 | 342 | 570 |
| 7 | 1,001 | 68 | 933 | 644 | 638 | 927 |
| 8 | 985 | 45 | 940 | 871 | 903 | 972 |
| 9 | 6,502 | 299 | 6,203 | 6,627 | 6,635 | 6,211 |
| 10 | 6,737 | 310 | 6,427 | 4,565 | 4,476 | 6,338 |
| 11 | 12,844 | 881 | 11,963 | 10,126 | 10,215 | 12,052 |
| 12 | 9,341 | 586 | 8,755 | 4,394 | 4,351 | 8,712 |
| Totals | 43,570 | 2,506 | 41,064 | 31,315 | 31,315 | 40,938 |

[a] Source: (38, Table 28)
[b] Source: (38, Table 45)
[c] Calves born — calf deaths
[d] Source: (38, Tables 16, 17)
[e] Net calf crop—Heifer calves and other calves on farms, Jan. 1, 1968 + Heifer calves and other calves on farms, Jan. 1, 1967.