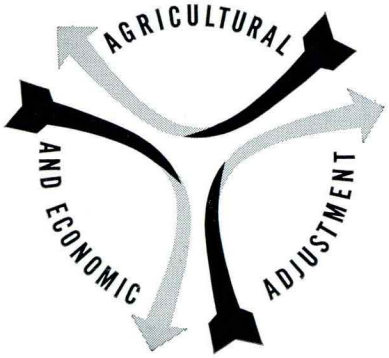

Interregional Competition and Prospective Shifts in the Location of Livestock Slaughter

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CONTENTS

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Future prospects of growth in livestock production and meat consumption impose new patterns of adjustment upon our livestock marketing institutions. Historically, our livestock and meat markets have adjusted to changing patterns of production and consumption by gradually modifying, expanding or relocating existing facilities and by adopting new methods of livestock procurement and distribution.

Sharp changes in these historical patterns of marketing and distribution may occur in future years. These changes involve the entire marketing process. Retailers, for example, are more insistent now than ever before about buying a prescribed quality of product in adequate volume and at the lowest possible price. Wholesalers and packers are seeking means of reducing short-term variability in supplies and prices through programming of procurement and slaughter activities based on improved market outlook information. Producers are adopting new production practices and methods of marketing to increase their income position and to obtain a more precise valuation of their outputs.

The market changes that occur are related to a host of factors affecting, in some way, the entire livestock-meat economy. Each component of the economy, however—slaughtering, processing and distribution—is affected in a different, but not necessarily an unpredictable, manner. Moreover, desirable business adjustments to these changes in livestock and meat marketing are being achieved through the individual efforts of business enterprises in the areas of capital budgeting, long-range planning and the improvement of information on prospective economic conditions.

In this report, factors accounting for changing patterns of livestock production and meat consumption in the United States and its regions are presented in terms of their probable effects on the location of the meat packing and related industries. Finally, these evolving locational patterns are discussed in the framework of interregional competition in the livestock-meat economy.

[1] Projects 1383 and 1409, Iowa Agricultural and Home Economics Experiment Station, Center for Agricultural and Economic Adjustment, cooperating. This report is the second of two reports prepared, in part, under a cooperative agreement with the United States Department of Agriculture.

Interregional Competition in the Livestock-Meat Economy

Interregional competition in livestock production comprehends a whole process of adjustment whereby farm and farm-related businesses attempt to earn a reasonable income from available resources. As the demand for meat changes, for example, meat packers and livestock producers change the volume and quality of the composite meat output in seeking the most profitable organization of production for each business enterprise. When these adjustments occur on a rather broad geographical basis, existing patterns of specialization are modified as business enterprises of all areas attempt to use their resources in the production of those goods and services in which their income advantage is comparatively high. For the purposes of this report, however, interregional competition is conceived more narrowly in terms of the year-to-year changes in the geographical distribution of livestock slaughter and in the principal factors affecting livestock slaughter.

In this report, the regional agricultural economies are conceived as an interrelated system of markets and producing units. Each livestock or meat market is intimately involved in the day-to-day performance of all other livestock and meat markets. Livestock prices at Sioux City, for example, are related to Chicago prices, but Chicago prices are affected by the volume of marketings through the Sioux City and other livestock markets. Price determination among livestock markets is thus a phenomenon of nationwide scope.

Prices at livestock markets also are tied to dressed-meat prices. Even more than the livestock markets, the dressed-meat markets respond to broad national conditions affecting meat production and consumption. Wholesale and retail buyers of meat procure their supplies wherever the prescribed quality and volume of these supplies are obtained most economically. Modern communication and transportation facilities join all buyers and sellers in the hundreds of places where livestock and meat are sold and bought in a vast network of interdependent relationships.

Although all markets are involved in price making, one or more of the larger livestock and dressed-meat markets may serve as focal points

in the pricing process. Superior means of communication and transportation and a well-developed system of market intelligence favor these major markets with comprehensive market news reports that are available also to other points in the market network. These major livestock and dressed-meat markets serve, therefore, as pricing points for livestock producers who generally trade with local livestock markets.

The major market centers, together with regional specialization in livestock production and the existing transportation network, are the principal elements in the organization of data presented in this report. For each of the livestock regions, which includes one or more major livestock and meat markets, the levels of livestock production, meat consumption and marketing costs are estimated. In terms of this report, livestock and meat are shipped from one region to another so as to minimize the total transportation costs, given the existing or projected location of the meat-packing industry. Price-quantity relationships are used to adjust the regional consumption levels to the set of livestock and meat prices based on the most economical pattern of interregional livestock and meat shipments. Thus, all geographical areas and their markets are involved in the mutual determination of interregional commodity flows and the related set of regional livestock and meat prices presented in this report.

Facilitating Adjustments in Meat Production

A secondary objective of this study is to provide an informational basis for a more general understanding of economic adjustments now under way in livestock slaughter and meat production. As the location of the meat-packing industry changes, the related marketing or distribution facilities also change in their location and services. These geographical and functional changes in the distribution of livestock and meat from farm to consumer may have a profound impact on the pattern of regional specialization in livestock production. Many millions of dollars invested in land, buildings and equipment are at stake as a result of shifts in the location of the meat-packing industry.

Private businesses attempt to economize their efforts in plant relocation, for example, through capital budgeting procedures. Decisions to undertake a specified set of capital expenditures in the meat-packing industry depend upon a host of considerations including not only estimates of prospective returns from the proposed investments under existing market conditions, but also estimates of prospective production, processing and distribution costs at alternative packing points. Economical investments in new plants and facilities thus require a degree of market foresight that extends substantially beyond the particular markets and areas in which a meat packer transacts his business. This market foresight requires, moreover, an appreciation of the changing patterns of interregional competition in the livestock-meat economy and the forces which account for the changing regional relationships in production, prices and consumption. A high degree of reliability and precision in the regional market outlook and the economic forecasts that make up the expected market patterns for each business enterprise would serve the best interests of the entire livestock-meat economy insofar as these market forecasts provide a basis for desirable investment decisions in improved marketing and processing facilities.

In the preparation of this report, published research reports dealing with the livestock-meat economy were reviewed and used in deriving an econometric model of the livestock-meat economy for the purpose of generating relevant data covering the period 1960 to 1964. Regional projections of livestock production and meat consumption based on a short-run model of the livestock-meat economy were reconciled, finally, with the economic projections for the United States prepared by various federal offices. The statistical results were deemed adequate for ascertaining the general effects of changing patterns of interregional competition on the regional location of livestock slaughter and the meat industry.

COMPETITIVE RELATIONSHIPS IN THE MEAT INDUSTRIES

The meat industry, which includes both meat packing and prepared meats establishments as defined by the U. S. Bureau of the Census, may be described as both a supply-oriented and a market-oriented industry. Livestock-slaughtering establishments, or meat-packing plants engaged only in livestock slaughter, generally are located in supply areas large enough to satisfy the normal needs of the plants throughout the year. The considerable weight reduction which occurs in the conversion of livestock into carcasses results in transportation economies even under present rate structures. Moreover, livestock procurement costs for plants located in areas of inadequate livestock supplies generally exceed the procurement costs of comparable plants located in the major producing areas. In addition, weight losses of livestock in transit or on hand weaken the competitive position of slaughtering establishments in livestock-deficit areas.

Market-oriented establishments in the meat industry generally engage in processing meat products for a local wholesale or retail market. Frequently these plants produce differentiated products, such as brand-name smoked ham, which compete effectively with the meat products of packing plants located in the producing areas.

Large, integrated meat packing plants typically are located in the major hog producing areas included in the 12 North Central states. These plants account for a major part of the meat production in the United States, particularly the meat shipped into states in which total meat consumption greatly exceeds total meat production.

As demonstrated later in this report, two significant trends are apparent from historical data on the meat industry. First, functional specialization has increased in recent years, thus result-

ing in more plants engaged only in slaughtering operations and typically handling only one species of livestock. Furthermore, supply considerations occupy an increasingly important place among the factors affecting the location of slaughtering plants. Because of the wide geographical distribution of cattle feeding and breeding enterprises and the increasing consumer demand for beef, the meat packing industry is more dispersed now than it was 20 or 30 years ago. Also, as a result of these two trends, the four largest packers account for a decreasing proportion of the total livestock slaughtered.

An expanding national economy, furthermore, has sustained a growing consumer market for the more expensive processed meat products. These products are differentiated in quality and also on a brand-name basis through national and local advertising. The large national packers enjoy considerable advantages in the development of the more expensive and more profitable lines of processed meat products through an established name and large-scale organization which can support both a more effective research and development program and a more adequate advertising budget.

In large measure, the future location of the meat industry is described in terms of the future location of livestock production and of human population. Most slaughtering plants generally will be located in supply areas, while most sausage kitchens and other processing facilities will gravitate toward the population centers.

A map of Standard Metropolitan Statistical Areas, as defined by the U. S. Bureau of Census, serves to illustrate the more favorable localities for the future location of the meat industry (see fig. 1). This map also shows roughly the distribution of human population in the United States. A second map showing the distribution of livestock production serves to delimit further the major centers of processing and slaughtering (fig. 2).

To evaluate the locational effects of the major economic forces—market prices, livestock production, meat consumption, distribution costs and industry organization—certain competitive relationships in the meat industries are first reviewed.

A schematic diagram is used to show the influence of production, consumption and related factors on location decisions in the meat industry (fig. 3). These factors are grouped under four general headings: the structural characteristics of the meat industry, the livestock-feed economy, the consumer markets for meat products and the transportation network.

Economic Structure of the Meat Industries

The economic structure of the meat industries is characterized by the number and size of firms and establishments, the geographical location of these establishments, the rate of entry of new firms into the industry, the degree of vertical integration or specialization and the extent of

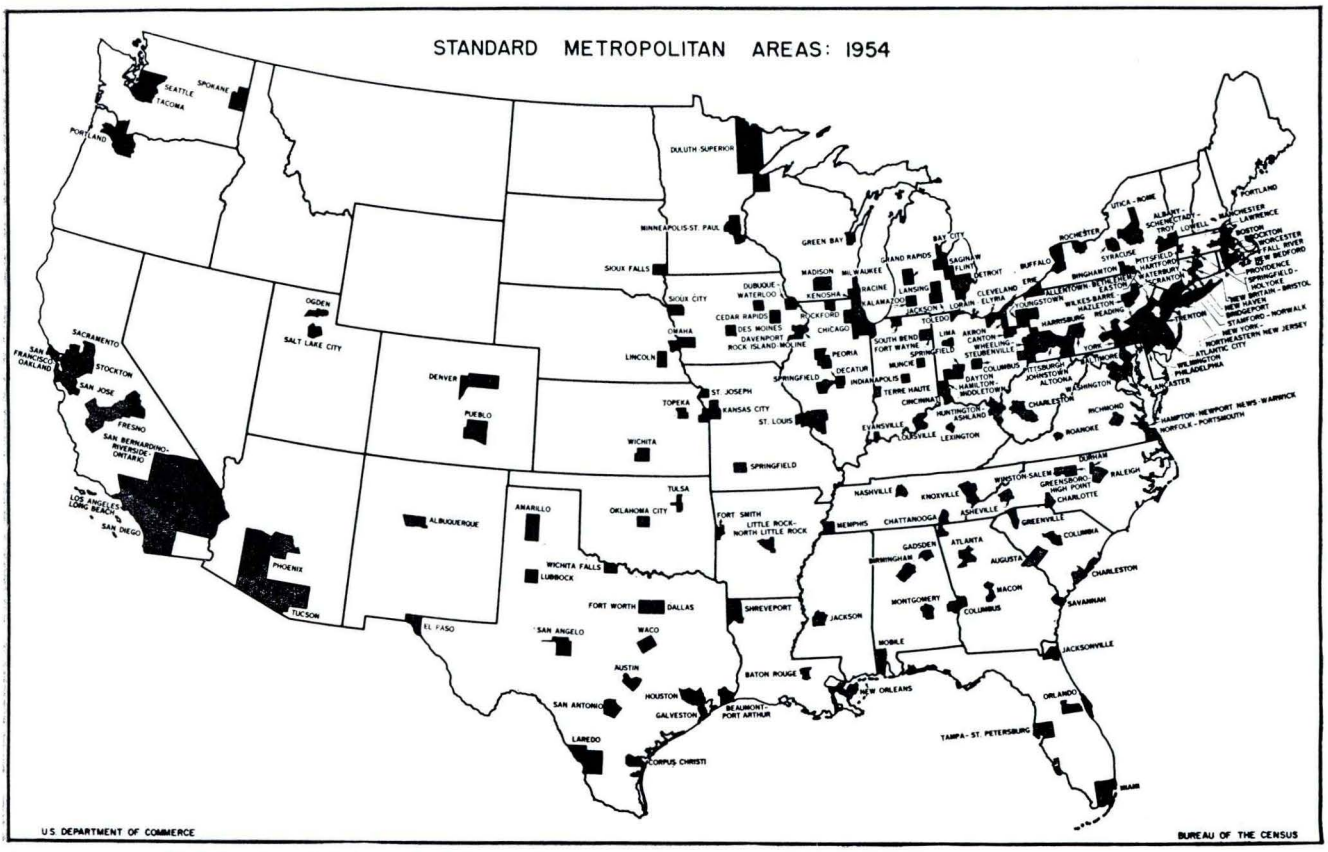

Fig. 1. Geographical location of 172 standard metropolitan areas, 1954.

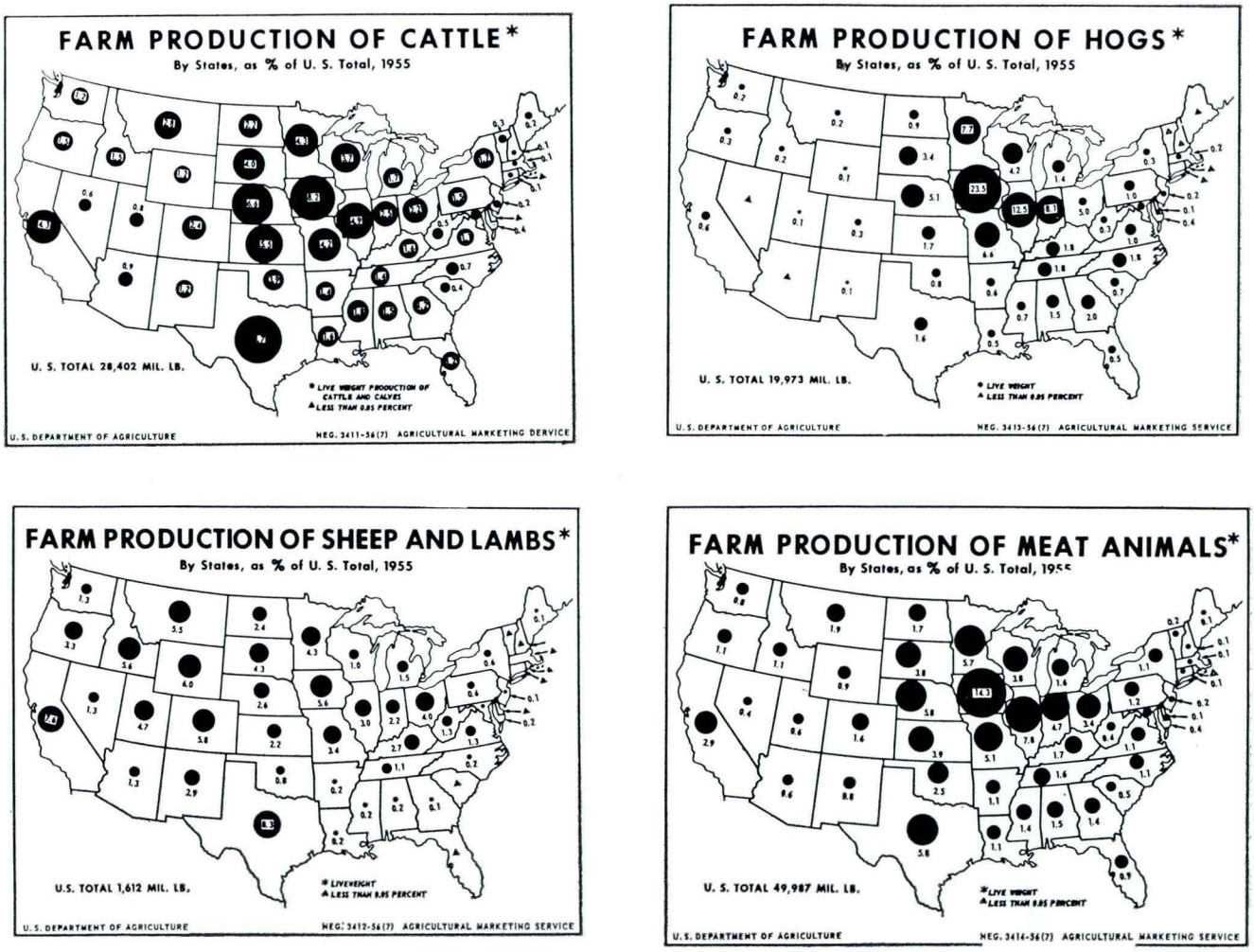

Fig. 2. Percentage distribution of farm production of specified livestock species, by states, 1955.

product differentiation. These structural attributes are believed to account for the behavioral relationships of firms in the industry. Behavioral relationships among firms are extremely difficult to ascertain; hence, the more readily available measures of market conduct and performance are presented.

Determinants of Market Conduct and Performance

Two phases of market conduct are cited by Bain in a recent study of industry organization:[2] (1) the character of interfirm relationships and coordination and (2) the principles and methods which the effective decision-making units observe in arriving at decisions and actions. The market conduct of firms in the meat industries might be classified further with respect to the conduct of (a) livestock slaughterers and meat wholesalers and (b) livestock buyers. On the sales side, the principal considerations include the determination of prices and outputs, sales-promotion and product policy, and improvement of market position.

The volume of meat production is determined by the actions of several million livestock producers. Furthermore, a major part of the output is composed of a bundle of relatively homogeneous products as prescribed by the grades and standards generally used throughout the economy. Hence, prices are established by the over-all market conditions—livestock production and marketings, cold storage holdings, consumer incomes and other demand determinants of broad national influence. A relatively small number of meat buyers, however, accounts for a major part of the meat sales (which thus differentiates the activities of the industry with respect to its output and input markets). For this reason, and also because of product homogeneity, prices are established with a remarkably high degree of precision for any specified quality of product. Though buyers and sellers act independently in setting prices, the net result of their market activities is characterized by a mutually determined set of prices representing the influence of the major demand determinants which essentially are separated by the dimensions of time, space and form.

Product and sales-promotion policies are inher-

[2] This discussion on structural characteristics in the meat industry follows the terminology and general pattern of presentation used by Bain. See: Joe S. Bain. Industrial organization. John Wiley and Sons, Inc., New York. 1959. pp. 266-427.

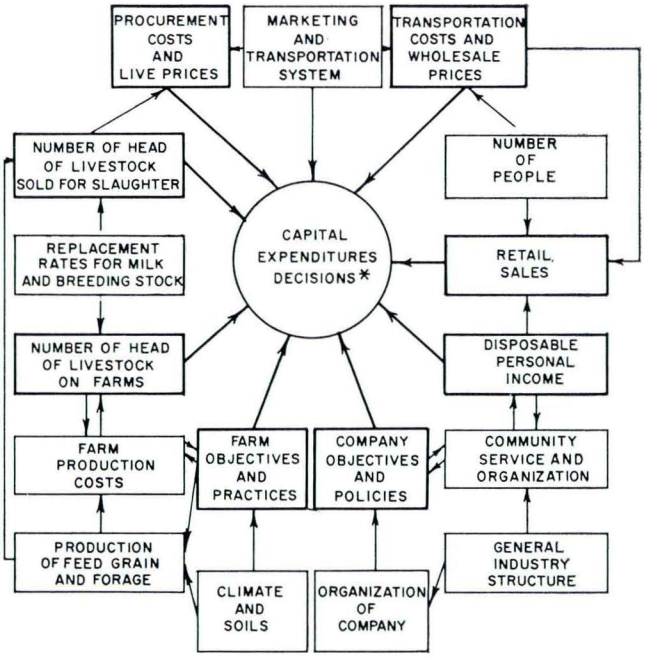

Fig. 3. Decision-making environment affecting capital expenditures and plant location in the meat packing industry.

ently more important among meat processors and national packers than among specialized slaughterers. Market strategy for processed meat products, for example, comprises elements of both product and market development. Thus, the research and development departments of a meat packing company are important elements of the company's over-all programs of market expansion through the design and development of new products which have large potential consumer markets. Because of the possibilities of achieving widespread acceptance of well-conceived new products through a coordinated sales-promotion program, meat processors invest more willingly in an aggressive development program for new products. Sales-promotion activities thus serve as an integral part of a strategy of market penetration and expansion either through new product development or through the changing of consumer preferences with respect to existing products. Sharp breaks from past policies, however, may precipitate more aggressive market strategies among competing firms. Hence, changes in existing product and market relationships may be viewed conservatively by firms that are extremely vulnerable to retaliatory action by competitors.

Finally, the existing firms in the meat industry may desire policies to limit the entry of new firms. Such policies, if effective, would create or protect favorable market shares and profit margins for the industry. In practice, however, entry into the meat industry is quite easy because of the low capital requirements of specialized slaughtering facilities and also because of governmental policy inhibiting market sharing and certain forms of merger and vertical integration.

On the buying side, the meat industry has a considerable degree of flexibility in its profit-making activities. Though the industry as a whole takes care of the entire output of the livestock sector as it comes to market, individual plants have some discretion in programming production and employment.

Lack of coordination between production and employment contributes to short-term fluctuations in profit margins in the meat industry. While production schedules may fluctuate from day to day, employment is fixed for the week. Even weekly fluctuations in meat production induce additional costs because of the undesirable effects of frequent changes in the rates of hiring or firing production workers (which may exceed the costs of less-than-full employment). During periods of less-than-full employment of labor resources, livestock buyers bid aggressively for the limited supplies of livestock, while during periods of heavy farm marketings, the existing labor force is paid overtime to handle the larger-than-expected production schedules. Thus, the cost of livestock may vary sharply from day to day because of short-term variability in livestock marketings. Improvements in short-term market forecasting would reduce some of the price variability, provided the procurement activities of slaughterers were effectively coordinated with the market forecasts and the scheduling of workers in each plant.

Spatial Distribution of the Meat Industries

Earlier, the two major factors accounting for the spatial distribution of the meat industries—human population and livestock production—were cited with reference to locational trends in livestock slaughter and meat processing. In 1954, 48 percent of all meat packing plants and 79 percent of all prepared meats plants were located in the 172 standard metropolitan areas.[3] An even larger percentage of the total employment in the two industries occurred inside these metropolitan areas —79 percent in the meat packing industry and 91 percent in the prepared meats industry (see table 1). Furthermore, less than 10 percent of the total employment in these two industries was located outside cities of 2,500 inhabitants or more.[4]

Generally, the larger-sized meat packing and prepared meats establishments are located in standard metropolitan areas (table 2). Most of the smallest packing plants—those reporting less than 20 employees—are located outside these areas.

Because of geographical diversity in livestock production, a regional breakdown of the livestock-meat economy is used in describing further the size distribution of establishments in the meat

[3] A standard metropolitan area, except in New England, is a whole county or group of contiguous counties which contain a city or cities of 50,000 inhabitants or more.

[4] Because of the greater detail of the published 1954 Census of Manufacturers data, most of the factual information pertaining to the meat packing industry is limited to the 1954 calendar year. Moreover, 1954 is the base year for this study.

Table 1. Distribution of employment in meat packing and prepared meats industries by metropolitan area and city size, 1954.[a]

Urbanization and 1950 population	Employment (percent)	
	Meat packing	Prepared meats
Inside Standard Metropolitan Areas (SMA)		
Incorporated cities:		
500,000 or more	20.8	51.7
100,000-499,000	26.1	21.1
50,000- 99,999	13.1	4.1
10,000- 49,999	6.8	3.6
2,500- 9,999	0.6	0.6
All other places	11.4	9.5
Outside Standard Metropolitan Areas (SMA)		
Cities:		
10,000- 49,000	10.0	3.7
2,500- 9,999	1.9	2.8
All other places	9.2	3.0

[a] U. S. Department of Commerce. Metropolitan area and city size patterns of manufacturing industries, 1954. Area Trend Series, No. 4. June 1959. Detailed figures may not add to 100 percent because of independent rounding.

Table 2. Distribution of meat packing and prepared meats plants, by metropolitan area status and employment size, 1954.[a]

Number of employees per establishment	Meat packing plants			Prepared meat plants		
	Inside SMA	Outside SMA	Total	Inside SMA	Outside SMA	Total
	(number)					
1- 19	546	889	1,435	652	229	881
20- 99	365	261	626	287	45	332
100-499	153	67	220	90	7	97
500-999	35	6	41	3	0	3
1,000 or more	41	4	45	3	0	3
Total	1,140	1,227	2,367	1,035	281	1,316

[a] U. S. Department of Commerce. Metropolitan area and city size patterns of manufacturing industries, 1954. Area Trend Series, No. 4. June 1959.

industries. Though many possible groupings of states exist, the U. S. Census breakdown into the nine major Census regions is used in this study. Four regions, however, are combined into two regions, and Delaware and Maryland are regrouped as part of the first of these two regions. Thus, in this study, the Northeast comprises the six New England states and the three Middle Atlantic states, in addition to Delaware and Maryland. As shown later, this first group of states represents the most important consumer market for the livestock and meat which move in interstate commerce. The second composite region includes the South Atlantic and East South-Central states. This region also comprises a growing consumer market for meat (although livestock shipments into this region may decline in future years). The remaining five regions shown in fig. 4—East North-Central, West North-Central, West South-Central, Mountain and Pacific—correspond with the U. S. Census regions.

The regional distribution of meat packing and prepared meats establishments inside the standard metropolitan area corresponds with the number of these metropolitan areas and the distribution of human population. The Northeast, for example, has the highest concentration of establishments inside the standard metropolitan areas—71 percent and 81 percent, respectively, of the meat packing and prepared meats plants. In the sparsely populated Mountain states, however, only 30 percent of the meat packing plants and 53 percent of the prepared meats plants are inside the standard metropolitan areas. In the Southeast, these two percentages are only 28 and 45, respectively, because of the occurrence of smaller plants and the lesser importance of interstate meat shipments originating from plants located in this region.

The spatial distribution of the meat industry differs also in plant size. Most of the aggregate national output of the two meat industry groups is derived from a small number of large-size establishments. In the meat packing industry in 1954, 3.6 percent of these establishments—those employing 500 workers or more—accounted for 56 percent of the total value added by manufacturing and 73 percent of the total employment in the industry. In the prepared meats industry, establishments with 500 employees or more—which made up less than 1 percent of the establishments—accounted for 14 percent of the total value

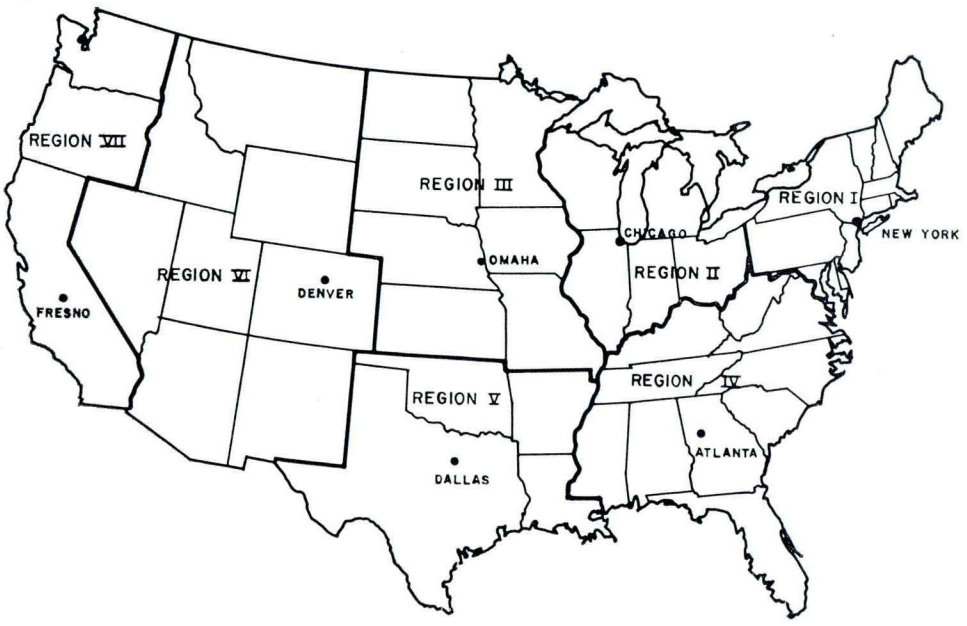

Fig. 4. Livestock regions and major transportation centers in the United States.

added by manufacturing and 13 percent of the total employment in the industry during the same period. The regional distribution of meat packing and prepared meats establishments is shown in tables 3 and 4 according to size and metropolitan status.

The geographical location of meat packing and prepared meats establishments reporting 20 or more employees in 1954 is shown in figs. 5 through 8. In the meat packing industry, establishments reporting less than 100 employees were widely dispersed (fig. 5), while the larger establishments were confined largely to the Corn Belt states and major wholesale centers outside the Corn Belt (fig. 6).

Prepared meats establishments employing 20 or more persons generally were located in the major metropolitan areas. Establishments with 20 to 99 employees were concentrated in the principal regional population centers (fig. 7). Most of the output of this industry, however, originated from the large plants located in the Chicago, New York, Philadelphia, Baltimore, Boston, San Francisco, Los Angeles, Detroit, Milwaukee and St. Paul-Minneapolis metropolitan areas (fig. 8).

Meat packing plants may be differentiated further in terms of federal inspection.[5] Establishments under federal inspection may engage in interstate commerce and are generally large-scale meat slaughtering operations. If nearby consumer markets are large, federally inspected slaughter may locate a considerable distance from the major livestock producing areas. Typically, however, these establishments are supply-oriented with reference to major sources of slaughter livestock (see table 5).

Other wholesale and local slaughtering establishments include the majority of livestock slaughterers. These establishments serve smaller local markets and typically slaughter locally produced livestock. The size of market and supply area, in addition to management experience and financing, are major factors affecting the prospective growth of these firms.

Substantial differences in output occur among establishments under federal inspection and between federally inspected plants and those that are not under federal inspection. As shown in table 6, the average 1954 slaughter per plant under federal inspection in the West North-Central states was several times greater than the average slaughter per plant in any other region. Regional differences among slaughtering establishments not under federal inspection, however, are quite small.

Commercial livestock slaughter under federal inspection made up 70 percent of the total number of cattle and calves slaughtered in 1954, 83 percent of the hogs and 89 percent of the sheep and lambs (table 7). The concentration of federally inspected meat production in each region is di-

[5] The U. S. Department of Agriculture listed 3,217 establishments as of March 1955, while the U. S. Department of Commerce listed only 2,367 in the 1954 Census of Manufacturers. In terms of volume, the Census of manufacturers covered about 90 percent of the commercial meat production in the United States. The census definition excludes meat wholesalers and other establishments which are not engaged in livestock slaughter as a primary part of their business. Many of these establishments, as well as small freezer-processor plants and local retailers, are included in the U. S. Department of Agriculture survey.

Table 3. Regional distribution of meat packing plants of specified size and metropolitan status, 1954.[a]

Region	Number of employees per establishment							
	1 to 19		20 to 99		100 to 499		500 or more	
	Inside SMA	Outside SMA	Inside SMA	Outside SMA	Inside SMA	Outside SMA	Inside SMA	Outside SMA
	(percent)							
Northeast	37	12	28	9	18	5	23	0
East North-Central	30	24	25	15	27	25	27	6
West North-Central	6	12	9	13	10	19	31	50
Southeast	8	18	12	33	14	36	4	19
West South-Central	7	15	8	13	12	4	3	12
Mountain	3	9	4	7	7	6	3	0
Pacific	9	10	14	10	12	5	9	13
Total	100	100	100	100	100	100	100	100

[a] U. S. Department of Commerce. Metropolitan area and city size patterns of manufacturing industries, 1954. Area Trend Series, No. 4. June 1959.

Table 4. Regional distribution of prepared meats plants of specified size and metropolitan status, 1954.[a]

Region	Number of employees per establishment						
	1 to 19		20 to 49		100 to 499		500 or more
	Inside SMA	Outside SMA	Inside SMA	Outside SMA	Inside SMA	Outside SMA	Inside SMA
	(percent)						
Northeast	43	24	38	35	40	31	33
East North-Central	23	17	31	27	36	23	67
West North-Central	5	10	7	6	5	23	0
Southeast	8	27	8	17	4	0	0
West South-Central	6	9	5	6	5	8	0
Mountain	2	5	1	0	1	0	0
Pacific	13	8	10	9	9	15	0
Total	100	100	100	100	100	100	100

[a] U. S. Department of Commerce. Metropolitan area and city size patterns of manufacturing industries, 1954. Area Trend Series, No. 4. June 1959.

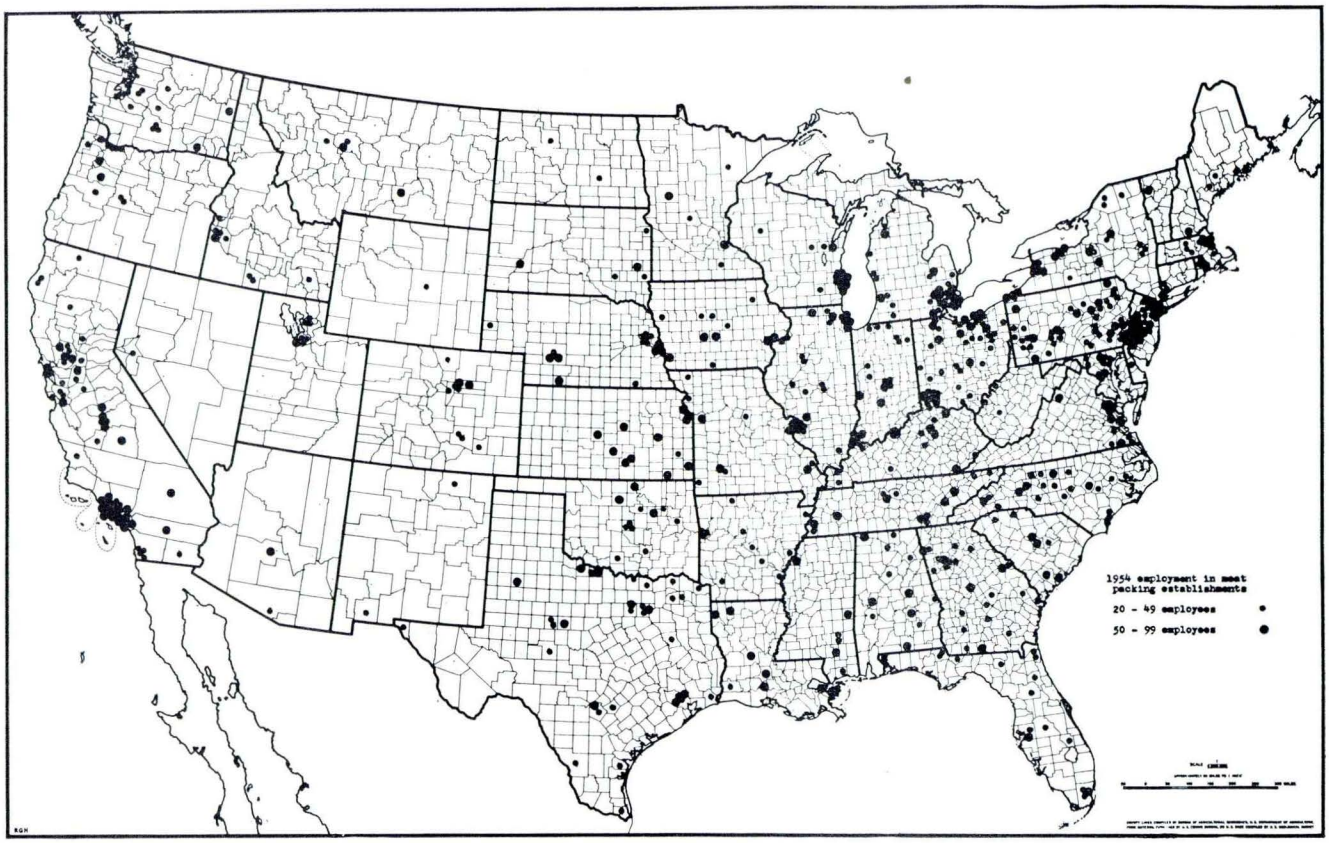

Fig. 5. Geographical distribution of meat packing establishments with 20 to 99 employees in 1954.

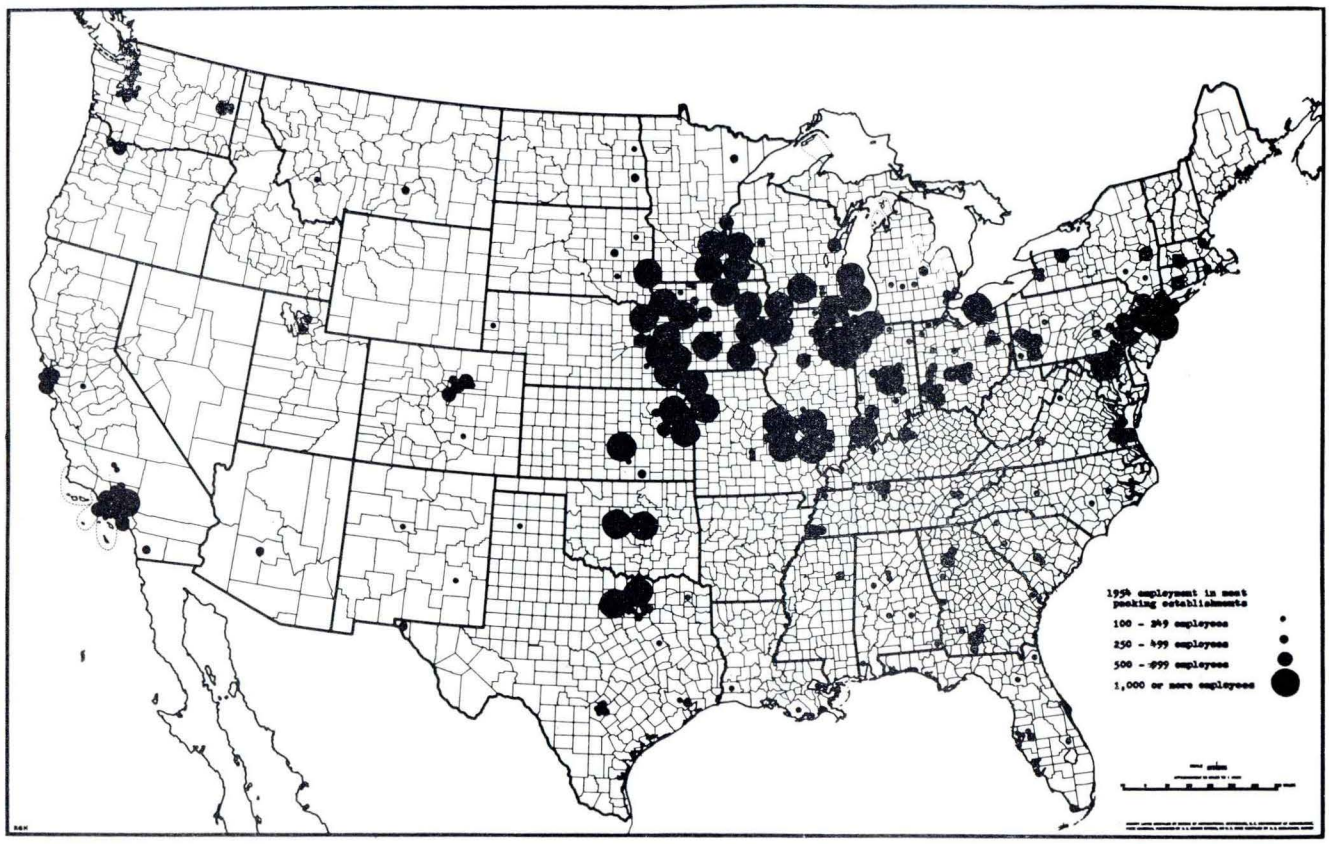

Fig. 6. Geographical distribution of meat packing establishments with 100 employees or more in 1954.

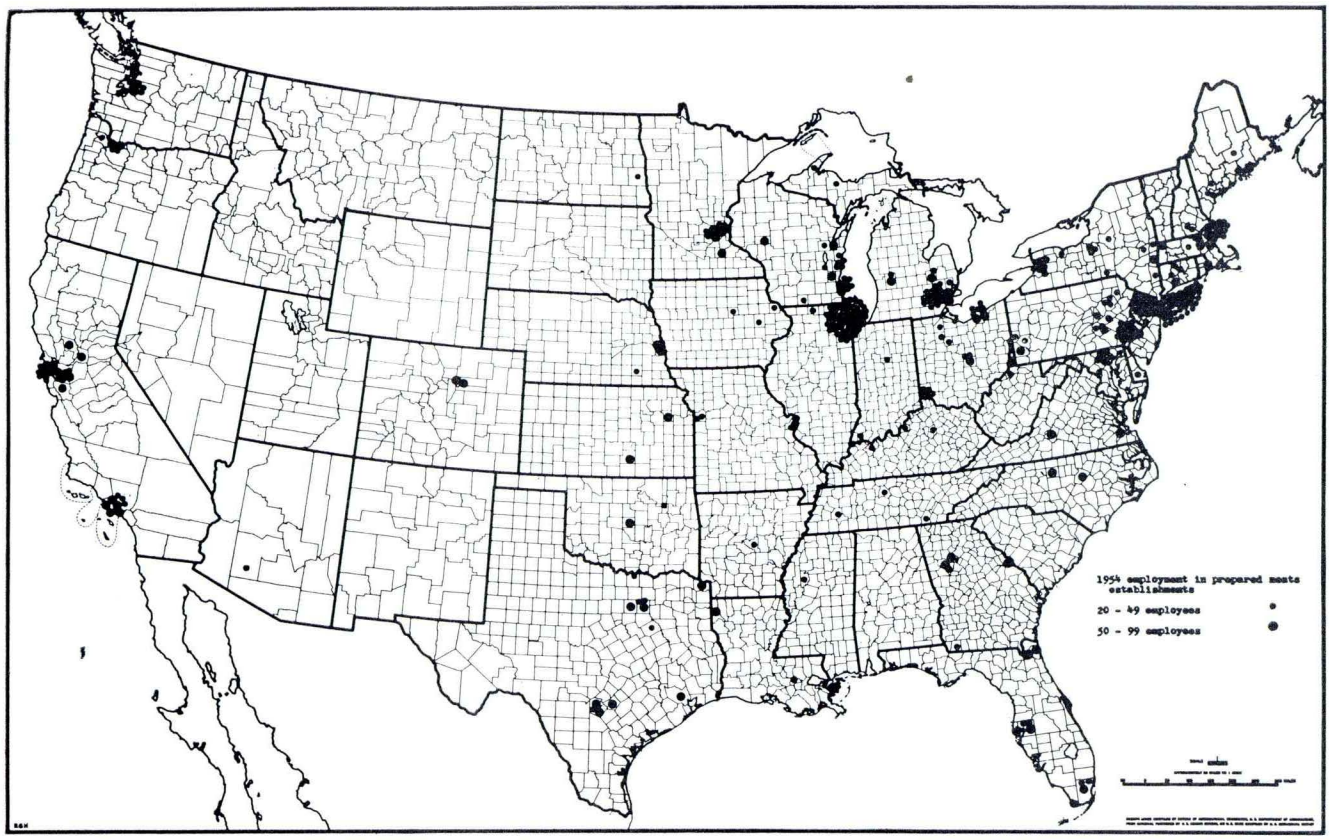

Fig. 7. Geographical distribution of prepared meats establishments with 20 to 99 employees in 1954.

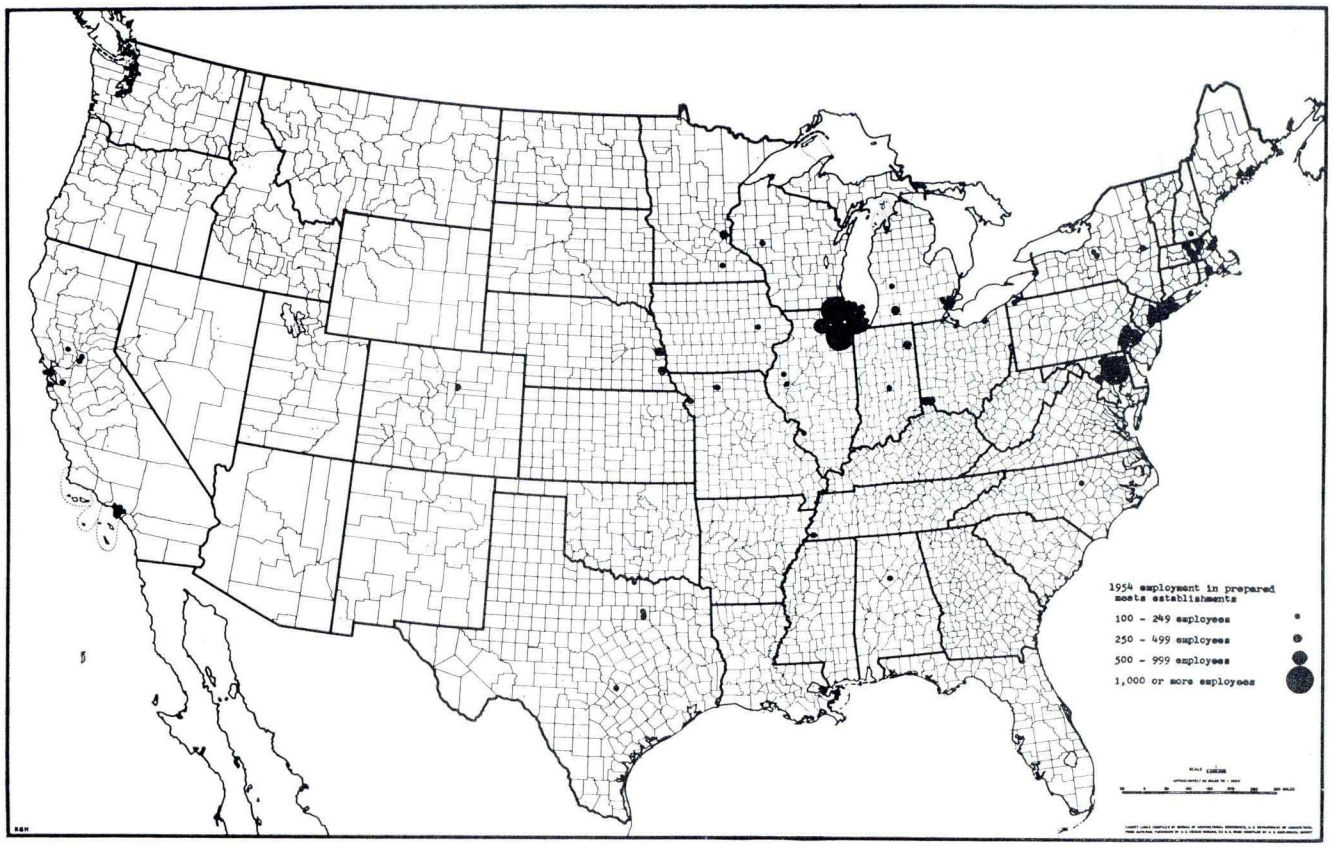

Fig. 8. Geographical distribution of prepared meats establishments with 100 employees or more in 1954.

Table 5. Regional distribution of federally inspected and other livestock slaughtering plants, March 1955.[a]

Region	Federally inspected[b]	Not federally inspected		Total
		Other wholesale[c]	Local[d]	
	(number)			
Northeast	91	168	427	686
East North-Central	96	258	420	774
West North-Central				
Missouri and Kansas	29	38	53	120
Other states[e]	57	31	82	170
South Atlantic[f]	23	127	228	378
South Central[g]	52	186	384	622
Mountain	29	51	105	185
Pacific	78	93	111	282
Total	455	952	1,810	3,217

[a] Includes all plants with an output of 300,000 pounds or more liveweight annually as reported by U. S. Dept. Agr., June 15, 1955.
[b] Includes all plants which slaughter animals under inspection conducted by the Meat Inspection Branch, U. S. Dept. Agr.
[c] Includes principally those plants not under federal inspection and slaughtering over 2 million pounds liveweight annually.
[d] Includes principally those plants not under federal inspection and slaughtering less than 2 million pounds, but more than 300,000 pounds liveweight annually.
[e] Minnesota, Iowa, Nebraska, South Dakota, North Dakota.
[f] Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida.
[g] Kentucky, Tennessee, Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas.

rectly related to the total regional meat production per person. For example, in the West North-Central states, excluding Missouri and Kansas, practically the entire livestock slaughter is under federal inspection. Meat production per person in these states is five to six times the national average.

Slaughtering establishments operating under federal inspection show a rather persistent historical trend toward increasing output per establishment (see table 8). In the period from 1920 to 1939, the number of these establishments declined gradually (from a peak of 347 in 1924 to 284 in 1939). During this period the total meat output of these establishments was quite stable. Hence, the output per establishment increased gradually. World War II, however, disrupted the earlier patterns as shown in fig. 9. During the 5-year period, 1939-44, total federally inspected meat production increased about 54 percent—from 11,608 million pounds to 17,921 million pounds in carcass weight equivalent—while the number of slaughtering establishments conducting slaughter under federal inspection increased from 284 to 481. Total meat production under federal inspection more than kept pace with the increase in total commercial production by increasing the percentage of total production from 75 in 1939 to 78 in 1944. Most of the relative increase in federally inspected slaughter occurred in beef production. In 1959, 527 establishments were conducting slaughter under federal inspection. Total meat production under federal inspection was 21,114 million pounds, or 81 percent of total commercial production.

The association between livestock production, human population and the size distribution of meat packing plants was revealed in a series of three relationships derived from data reported in the 1954 Census of Manufacturers and summarized by the U. S. Department of Commerce.[6] The reported data on the number of establishments in each of three specified size classes were related to (1) farm production of cattle and calves, (2) farm production of hogs and (3) human population. Estimates of each of these variables were obtained for 48 states from U. S. Department of Agriculture and U. S. Department of Commerce publications.[7] The functional relationships and their coefficients are as follows:

$$\hat{Y}_{1i} = \underset{}{5.162} + \underset{(6.584)}{7.040Z_{1i}} - \underset{(4.710)}{0.518Z_{2i}} + \underset{(0.848)}{6.246^{**}Z_{3i}} \qquad R^2 = 0.594 \quad (1.1)$$

$$\hat{Y}_{2i} = \underset{}{0.607} + \underset{(2.825)}{6.020^{*}Z_{1i}} - \underset{(2.021)}{1.299Z_{2i}} + \underset{(0.364)}{3.764^{**}Z_{3i}} \qquad R^2 = 0.750 \quad (1.2)$$

$$\hat{Y}_{3i} = \underset{}{0.444} + \underset{(0.589)}{1.292^{*}Z_{1i}} + \underset{(0.422)}{2.255^{**}Z_{2i}} + \underset{(0.076)}{0.621^{**}Z_{3i}} \qquad R^2 = 0.803 \quad (1.3)$$

where, for the i^{th} state,

Y_1 = number of meat packing establishments with less than 20 employees in 1954;
Y_2 = number of meat packing establishments with 20 to 249 employees in 1954;
Y_3 = number of meat packing establishments with 250 or more employees in 1954;

[6] U. S. Department of Commerce, Bureau of the Census. U. S. Census of Manufacturers, 1954. Vol. 2, Part I. U. S. Govt. Print.Off., Washington, D. C. 1957.

[7] U. S. Department of Agriculture. Agricultural Marketing Service. Livestock and meat statistics. U. S. Dept. Agr. Stat. Bul. 230. 1958.

Table 6. Estimated average number of livestock slaughtered annually per establishment, by species, inspection and region, 1954.[a]

Region	Cattle and calves		Hogs		Sheep and lambs	
	Under federal inspection	Not under federal inspection	Under federal inspection	Not under federal inspection	Under federal inspection	Not under federal inspection
	(1,000 head)					
Northeast	36.9	4.4	131.2	5.9	58.6	1.5
East North-Central	70.6	4.8	309.7	9.2	36.0	3.5
West North-Central						
Missouri and Kansas	86.9	4.1	327.9	5.7	107.9	1.5
Other states	128.2	3.4	718.3	2.0	178.6	0.1
South Atlantic	49.2	3.5	137.1	7.4	——	0.3
South Central	69.8	4.6	103.5	4.4	50.4	0.6
Mountain	43.3	2.5	49.4	3.1	71.9	0.7
Pacific	37.0	5.5	75.3	3.1	41.5	2.6
Total	63.2	4.4	234.2	5.9	64.8	1.8

[a] U. S. Department of Agriculture. Livestock and meat statistics, 1957. U. S. Dept. Agr. Stat. Bul. 230. July 1958.

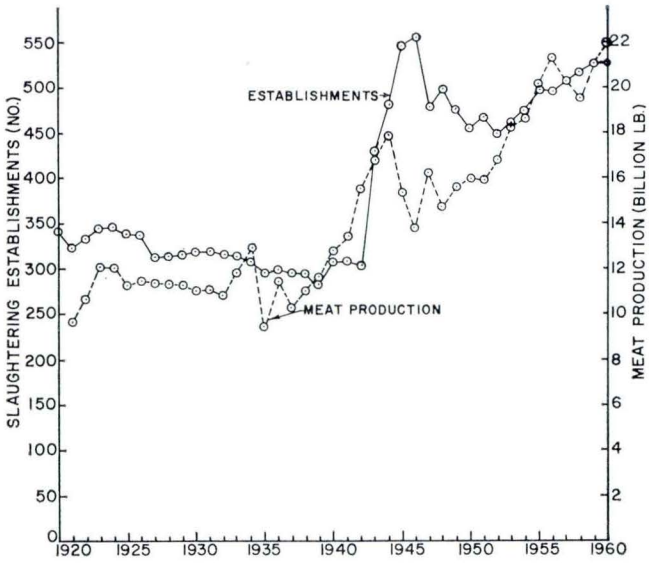

Fig. 9. Total meat production and livestock slaughtering establishments under federal inspection, 1920-59.

Z_1 = farm production of cattle and calves in billions of pounds liveweight in 1954;
Z_2 = farm production of hogs in billions of pounds liveweight in 1954;
Z_3 = human population in millions of persons in 1954.

These data show the decreasing importance of human population, Z_3, and the increasing importance of livestock production in explaining the number of establishments of a specified size class in any of the 48 states for which estimates were available. For the smallest size group, only the population variable is significant at the 1-percent level. (Following customary usage significance at the 1-percent level is indicated by two asterisks, while significance at the 5-percent level is indicated by one asterisk.) An increase of 1 million in state population is associated with an increase of 6.246 establishments in the specified size class. For the largest size group, however, an increase of 1 million in state population is associated with an increase of 0.621 establishment, while an increase of 1 billion pounds of liveweight production of cattle and calves or of hogs, respectively, is associated with an increase of 1.292 and 2.255 establishments. The effect of cattle and calf production, however, is significant only at the 5-percent level.

The statistical relationships in equations 1.1 through 1.3 were used to estimate the number of establishments in each of the three size groups. When the estimated values differed from the reported values for each state by more than 50 percent of the average number of establishments per state in 1954, the states thus identified were listed separately (with the difference between the two values shown in parenthesis) in table 9.

States with major wholesale food centers, or with an early start in meat packing, generally showed a greater-than-expected number of establishments in each of the size classes. Most of the New England and New York retail meat markets,

Table 7. Percentage of total livestock slaughter under federal inspection, by species and region, 1954.[a]

Region	Commercial slaughter under federal inspection		
	Cattle and calves	Hogs	Sheep and lambs
Northeast	53	74	86
East North-Central	66	77	64
West North-Central			
Missouri and Kansas	87	94	99
Other states	95	99	100
South Atlantic	46	51	0
South Central	58	64	94
Mountain	76	72	94
Pacific	72	83	85
Total	70	83	89

[a] U. S. Department of Agriculture. Livestock and meat statistics, 1957. U. S. Dept. Agr. Stat. Bul. 230. July 1958.

Table 9. Difference between reported and predicted number of establishments, by size class and states, 1954.

Number of employees per establishment	Reported greater than predicted number	Reported less than predicted number
1 to 19 employees	Pennsylvania (44) Ohio (58) Indiana (49) Michigan (22) Texas (26) Washington (24) Oregon (28)	New York (38) Minnesota (17) Iowa (20)
20 to 249 employees	Pennsylvania (22) Ohio (20) Georgia (11) California (13)	Massachusetts (11) New York (32) Illinois (9) Iowa (10)
250 or more employees	New Jersey (2.0) Pennsylvania (1.8) Ohio (5.0) Illinois (3.0) Kansas (2.5) Georgia (2.0) Utah (1.7)	New York (4.1) Michigan (3.2) Iowa (1.9) North Carolina (3.2) Alabama (2.6) Louisiana (2.1)

Table 8. Average number of slaughtering establishments operating under federal inspection and average annual slaughter per establishment, by livestock species and 5-year period, 1920-59.[a]

5-year period	Cattle		Calves		Hogs		Sheep and lambs	
	Establishments slaughtering	Head per establishment	Establishments slaughtering	Head per establishment	Establishments slaughtering	Head per establishment	Establishments slaughtering	Head per establishment
1920-24	272	32,049	270	15,925	254	177,926	222	52,598
1925-29	256	36,178	263	18,670	243	185,334	204	64,075
1930-34	248	34,275	252	19,689	232	194,297	207	83,326
1935-39	250	40,008	243	23,731	214	160,401	191	91,551
1940-44	316	37,222	297	19,932	260	217,895	246	83,338
1945-49	433	31,252	329	20,735	285	165,110	219	77,784
1950-54	394	37,690	309	19,880	262	219,814	198	63,427
1955-59	449	41,743	336	19,793	263	240,463	222	61,053

[a] U. S. Department of Agriculture. Livestock and meat statistics, 1957. U. S. Dept. Agr. Stat, Bul, 230, July 1958 (and yearly supplements).

for example, generally are handled by packers located in Pennsylvania, Ohio or the Middle West. Also in these estimates, Iowa appears with less than the expected number of establishments in each size class, which indicates a substantial shipment of livestock to other states for slaughter purposes. Finally, Georgia packing plants would appear to have some locational advantages not available to packing plants in North Carolina, Alabama and Louisiana. More recent data, however, reveal changes from the 1954 patterns in the extent of geographic specialization in livestock slaughter as a result of plant abandonment and relocation during the latter part of the 1950's. These locational changes are discussed later in this report.

Consumer Markets for Meat Products

The growth of population and personal income, the changing patterns of consumer tastes and the competition of other goods and services are the principal economic factors affecting the demand for meat products. Insofar as these changes occur at differential rates within the United States, the geographical location of the meat packing industry will shift to some extent in response to the changing spatial pattern of the consumer markets for meat products. In this section, two facets of the demand for meat products are reviewed briefly: the aggregate growth of population and income, and the interspatial and intertemporal differences in consumer demands.

Aggregate Population and Income Trends

The total national population is foremost among the demand determinants with reference to meat consumption. When the total population and the tastes of this aggregate consumer market are stable, however, income changes are the major source of instability in consumer demand for meat. Consumer tastes are not stable, nor is the composition of the consumer market in terms of household size and total number of households. When analyzing changes in per-capita demand for meat, income effects are confounded with the effects of changing tastes and household composition. In addition, price variability among meat items and meat substitutes contribute to further short-term changes in meat consumption.

Underlying the regional projections of total meat consumption used in this study were studies of prospective aggregate meat consumption in the United States. Recently, Koffsky presented some population projections for 1980 ranging from a low of 225 million to a high of 278 million.[8] These projections, which were prepared by Resources for the Future, present a somewhat wider range than the Census Bureau projections of from 231 million to 273 million. The "medium" projection cited by Koffsky was 244 million persons—an increase of 38 percent from 1959 population. Other projections prepared in the United States Department of Agriculture show a 31-percent increase in population from 1959 to 1975. These projections served as the basis for the estimates shown in table 10.

Projections of per-capita income involve additional uncertainties regarding future economic conditions, including, particularly, over-all economic productivity and growth. In this connection, the projections prepared by Rex Daly in 1957 were used as a basis for developing a set of regional income projections for future years.[9] The Daly projections, however, are adjusted to the population and income levels shown in table 10.

The projected increases in population and per-capita income are related to changes in per-capita consumption in terms of assumed demand elasticities and prices. Koffsky recently presented, with slight modification, the income and price elasticity coefficients used by Daly. According to the Koffsky data, a 10-percent increase in per-capita income is associated with a 4.8-percent increase in meat-animal utilization, given the total population and market prices. If live prices were to increase 10 percent, however, meat-animal utilization would decrease by 3 percent.

To establish the projected price levels, Daly presented two sets of assumed prices—one to approximate 1956 domestic price levels for farm products as a whole and the other to approximate 1956 world prices for major export crops and feed grains with livestock prices related through historical product-feed price relationships. These prices, along with the projected population and income levels, were involved in the derivation of the projected per-capita consumption of meat and related products.

Two sets of consumption projections were prepared based on the 1957 Daly projections. The two sets of data are summarized in table 11. The two

[8] See: Nathan M. Koffsky, Potential demand for farm products of the next quarter century. Paper presented at the Seminar on Dynamics of Land Use, Iowa State University, Ames, Iowa, May 3, 1960.

[9] Rex F. Daly, Prospective domestic demands for food and fiber. In: Policy for commercial agriculture. U. S. Govt. Print. Off., Washington, D. C. 1957. pp. 108-118.

Table 10. Reported and projected values of basic economic factors affecting consumer demand for meat, 1955-65.[a]

Year	Population[b]	Disposable personal income[c]	Per capita disposable income	Consumers' Price Index (1947-49 = 100)	
				All items	Food
	(millions)	(billions)	(dollars)	(percent)	(percent)
1955-57	168.2	$291.7	1,733	117.0	112.7
1958	174.1	316.5	1,818	123.5	120.3
1959	177.0	333.4	1,884	124.6	118.3
Projections:					
1960	180.1	345.8	1,920	124.6	118.3
1961	183.2	358.6	1,957	124.6	118.3
1962	186.2	371.9	1,997	124.6	118.3
1963	189.3	385.7	2,038	124.6	118.3
1964	192.5	400.0	2,078	124.6	118.3
1965	195.7	414.8	2,120	124.6	118.3

[a] Report from the U. S. Department of Agriculture: A statement from the Land-Grant Advisory Committee on Farm Price and Income Projections, 1960-65, Under Conditions Approximating Free Production and Marketing of Agriculture Commodities. Sen. Doc. No. 77, 86th Cong. 2nd Sess. Jan. 20, 1960. p. 5.

[b] Total population including armed forces overseas. Figures for 1960 and 1965 Census Series II projections. Data for 1960 to 1964 are based on interpolations of Census Bureau projections.

[c] Income projections assume a constant retail price level of 124.6 percent of 1947-49 average.

Table 11. Reported and projected per-capita consumption of meat and related items.[a]

Item	1954-58 average	1959	Projected 1965		Projected 1975	
			I[b]	II[c]	I[b]	II[c]
		(pounds)				
Meat	159	162	164	169	170	177
Poultry	30	30	30	31	32	33
Eggs	48	48	49	50	51	53
Milk	700	714	721	742	749	777

[a] Based on data obtained from: Rex F. Daly. Prospective domestic demands for food and fiber. **In:** Policy for commercial agriculture. U. S. Govt. Print. Off., Washington, D. C. 1957. p. 110.
[b] Approximates 1956 price levels for farm products as a whole.
[c] Approximates 1956 world prices for major export crops and feed grains with livestock prices related through historical product-feed price relationships.

levels of consumption for each of the two periods relate to the two assumed price levels just mentioned.

Intertemporal and Interspatial Differences in Consumer Demands

Because of geographical differences in per-capita consumer incomes, tastes and prices of competing goods and services, the quantity of meat consumed per person at a given price per pound will vary among areas. The meat consumed may be of identical quality in these areas, and yet the quantity consumed per person will differ. If the relationships between per-capita consumption and each of the factors affecting consumption are available, the effect of a specified change in the price of meat could be estimated for each area. For most areas, however, estimates of the relevant demand relationships are not available.

Intertemporal differences in consumer demand for meat include the long-run changes in consumer preferences which result in changes in the pattern of total expenditures among specified goods and services. Of more immediate consequence, however, are the week-to-week changes in meat prices which are associated with inverse changes in consumer purchases. Finally, seasonal changes in weather and eating patterns contribute to seasonal shifts in consumer demand for meat products.

The 1955 Household Food Consumption Survey undertaken by the USDA served as a principal source of information on interregional differences in meat consumption.[10] Major regional differences occur in the quality of beef and pork consumed (as measured by price per pound) and the distribution of specified pork cuts. Because of the high consumption of salt pork, per-capita consumption estimates of cured pork are quite large for the South. More stewing beef also is consumed in the South than elsewhere. In addition, the relative consumption of beef and pork in the South differs from the pattern in other regions. Though considerably less beef is consumed in the South than elsewhere, high-income urban households consumed more beef per capita than the average household in the United States in the high-income brackets ($8,000 and over).[11]

Consumers in the higher income groups in all regions purchase more of the expensive meat cuts. The higher income households buy not only higher priced cuts but also pay more per pound for each meat cut purchased. The positive relationship between family income and price per pound of beef purchased, which is illustrated in fig. 10, may arise because of a form of product discrimination among households. For example, in the purchase of federally graded beef, market price differentials correspond with grade differences. The price-income relationship, moreover, is positive though less pronounced for a particular beef cut such as round steak.

A positive price-income relationship is evident also for pork and pork cuts, as shown in fig. 11. For the United States as a whole, pork and beef price-income relationships parallel each other (though beef was the higher value product for each income group in 1955). In the case of pork cuts, however, the determination of quality is somewhat more difficult than with beef because of the lack of a comparable system of federal grading.

[10] Marguerite C. Burk and Thomas J. Lanahan. Use of 1955 food survey data for research in agricultural economics. Agr. Econ. Res. 10:73-87. 1958.

[11] Harold F. Breimyer and Charlotte A. Kause. Consumption patterns for meat. U. S. Dept. Agr. AMS-249, May 1958. pp. 20-21.

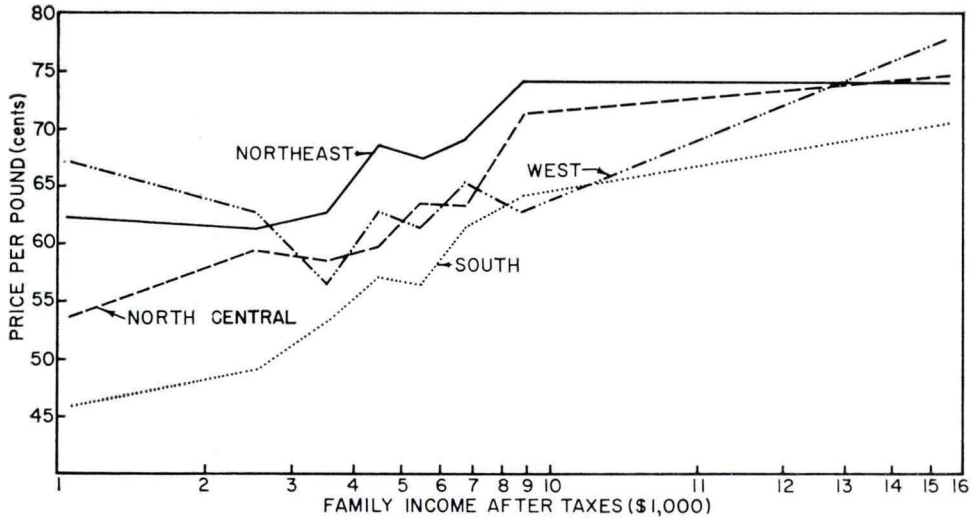

Fig. 10. Relation between family income after taxes and beef price per pound, April-June 1955.

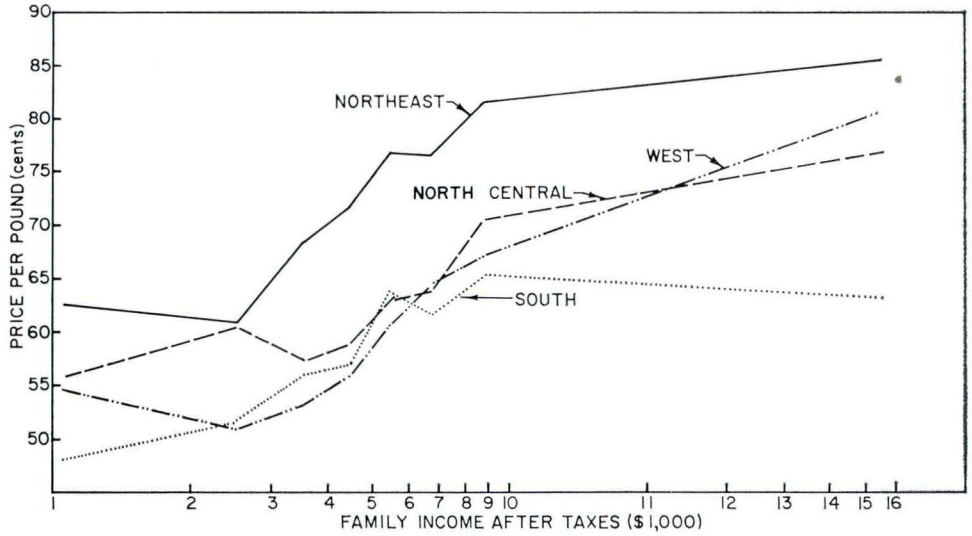

Fig. 11. Relation between family income after taxes and pork price per pound, April-June 1955.

In each of the two figures, substantial regional differences are evident in the value per pound of meat purchased. These differences result partly from the added costs of marketing incurred by products shipped from a surplus-production region to a deficit-production, or excess-consumption, region. These added costs of marketing are small, however, when compared with the price differentials reported in the 1955 survey cited earlier (see table 12). A major factor accounting for the substantial price differentials is the quality of meat consumed among the various regions.

To explain the occurrence of quality differentials in meat consumed in the United States and its regions, two factors are important: income and household composition.[12] For much of the United States, a positive consumption-income relationship and a negative consumption-household size relationship account for a major part of the spatial variability in the demand for meat. In a recent study to determine the influences of family income on food consumption at home, the findings (which were based on the 1955 Household Food Consumption Survey) show that, at the average income and consumption per person and household size, a 1-percent increment in income per person was associated with a 0.37-percent increase in the value of consumption per person in low-income households, a 0.31-percent increase in the value of consumption per person in medium-income households and a 0.16-percent increase in high-income households.[13] Meat consumption per person, furthermore, was smaller in the larger households. This latter pattern was attributed to several factors—the savings in values obtained through bulk purchases, the smaller proportion of waste and the higher proportion of children who eat less

[12] Merchandising practices and the availability of high-quality meat also are important considerations in accounting for existing meat consumption patterns. These factors, however, are assumed to be less important than income and household composition in the long run.

[13] George R. Rockwell, Jr. Income and household size: Their effects on food consumption. U. S. Dept. Agr. Marketing Res. Rept. 340. June 1959. p. 3.

Table 12. Estimated quantity of meat and related items purchased per capita and price per pound, by region, 1954.[a]

Item	Northeast		North Central		South		West	
	Quantity per person	Price per pound	Quantity per person	Price per pound	Quantity per person	Price per pound	Quantity per person	Price per pound
	(pounds)	(cents)	(pounds)	(cents)	(pounds)	(cents)	(pounds)	(cents)
Beef								
Steaks	19	88	20	77	11	73	18	80
Roasts	17	70	19	61	9	55	16	58
Other	26	60	27	52	18	41	22	56
Total[b]	62	70	65	59	38	55	56	60
Pork								
Fresh, frozen	22	63	26	57	19	53	20	60
Cured, smoked	23	68	27	61	34	50	26	62
Other	1	100	1	75	c/	100	3	85
Total[b]	46	65	54	59	53	52	49	63
Luncheon meat	18	63	21	60	15	50	19	58
Veal	6	82	4	62	2	64	4	65
Lamb	9	70	2	75	1	62	7	124
Poultry	39	54	27	51	26	50	26	58
Fish	19	62	10	57	13	44	12	65

[a] Converted to a 52-week basis from data reported for 1 week during April to June, 1954. In: U. S. Dept. Agr. 1955 Household Food Consumption Survey. Reports Nos. 1-5. U. S. Gov't Print. Off., Washington, D. C. 1957.

[b] Excluding luncheon meat.

[c] Less than 0.5 pound.

than adults.[14] In addition, the larger number of competing uses for each dollar of family income in the larger households should be taken into account.

Since income and household size account for much of the interregional differences in meat demand, these two variables are examined briefly in terms of the data reported in the 1955 Household Food Consumption Survey. With reference to 1954 money income after taxes, the North—comprising the Northeast, North Central and West census regions—differed substantially from the South. The percentage of people in each income group differed also according to residence. The urban population generally received a higher annual income per household than did the rural population.

According to the findings from the 1955 survey, the place of residence also accounted for sharp differences in family size and composition. Not only were rural households larger in each of the four age brackets for homemakers, but the percentage of children under 16 years also was larger. These differences associated with urbanization explained substantially the household characteristics of the more rural South. The degree of urbanization, however, represents a composite of factors including income distribution and social attitudes.

The evidence from the 1955 Household Food Consumption Survey leads to a series of conclusions as follows: Given the size and age composition of households, meat consumption and the value per pound of meat purchased is directly related to income. As the age composition of households varies, however, and the average size of household varies accordingly, the per-capita consumption of meat and the value per pound of meat purchased varies inversely with the change in average household size for any given income group (see tables 13 and 14). Finally, because income and household size generally are inversely correlated, meat consumption per person appears to decline with increasing income after a peak consumption level is reached which is somewhat above the average income level of the population. For purposes of long-range projections of meat consumption, estimates of both disposable income and household composition are needed to show their effects on the demand for meat products.

[14] Ibid. p. 40.

Feed-Livestock Economy

Though all meat packing and related businesses are affected in some way by consumer demands for meat products, the larger establishments in particular are influenced in their location by the availability of livestock supplies. To evaluate the feasibility of alternative geographical areas as potential sites for meat packing plants, estimates of prospective costs ranging from the costs of livestock production to the costs of meat distribution at each of these sites are useful. If the needed livestock supplies are not forthcoming in a particular area, then additional procurement costs are incurred to maintain plant operations at an economical level. Furthermore, if any of the components are substantially out of line in comparison with costs incurred by competitors, and if no compensating advantages accrue to a business at its present location, then major locational changes may be necessary. Thus, locational changes may

Table 13. Average household size and percent of households with children under 16 years, by age of homemaker and income group, April to June, 1955.[a]

Age of homemaker	Average household size						Households with children under 16 years					
	Region		Residence			All households	Region		Residence			All households
	North	South	Urban	Rural nonfarm	Rural farm		North	South	Urban	Rural nonfarm	Rural farm	
	(number)						(percent)					
Under 30 years	3.6	3.8	3.5	3.8	4.2	3.6	81	84	80	85	90	82
30-49 years	3.9	4.0	3.8	4.0	4.9	4.0	75	69	72	73	78	73
50-59 years	2.8	3.5	2.7	3.4	3.5	3.0	18	32	17	27	33	22
60 years and over	2.5	2.9	2.5	2.6	2.8	2.6	9	13	10	11	12	10

[a] U. S. Dept. Agr. Food consumption and dietary levels of households as related to the age of homemaker, United States, by regions. Household food consumption survey, 1955. Report No. 14. U. S. Govt. Print. Off., Washington, D. C. 1959.

Table 14. Pounds per person and value per pound of meat used in a week, April to June, 1955, by age of homemaker and family income after taxes.[a]

Age of homemaker	Family income after income taxes (dollars)									
	Under 2,000		2,000-3,999		4,000-5,999		6,000 and over		All incomes	
	Quantity per person	Value per pound	Quantity per person	Value per pound	Quantity per person	Value per pound	Quantity per person	Value per pound	Quantity per person	Value per pound
	(pounds)	(cents)	(pounds)	(cents)	(pounds)	(cents)	(pounds)	(cents)	(pounds)	(cents)
Under 30 years	2.08	49	2.66	54	2.94	61	3.06	64	2.78	58
30-49 years	2.22	47	2.90	55	3.19	61	3.36	67	3.06	60
50-59 years	2.52	50	3.12	58	3.58	64	3.64	71	3.30	63
60 years and over	2.29	53	3.07	59	3.33	65	3.42	67	2.89	59

[a] U. S. Dept. Agr. Food consumption and dietary levels of households as related to the age of homemaker, United States, by regions. Household food consumption survey, 1955. Report. No. 14. U. S. Govt. Print. Off., Washington, D. C. 1959.

occur because of changes in the competitive position of various areas in livestock production or because of related changes in the costs of procurement, manufacturing and distribution incurred by establishments at various sites.

Aggregate Feed and Livestock Production

According to USDA estimates of production prospects for feed and livestock, the production of feed grains will increase because of the prospects of continued increase in the yields per acre of feed grains.[15] Assuming 1959 acreages for individual crops and average weather, the prospective production of feed grains would be 5.5 million tons greater in 1964 than in 1960. Hay yields also are expected to increase gradually in 1960-65, which, despite a decrease in harvested acreage to allow for expansion of the Conservation Reserve, would mean expansion of hay production to the peak level reached in 1957-58 of about 120 million tons. Finally, because of improved pastures, feed consumed from pasture is expected to increase to 131 million feed units, or 1.21 feed units per roughage-consuming animal unit. Over the next 4 or 5 years, therefore, prospective feed supplies from current production are ample for substantial increases in the output of livestock products.

Intertemporal and Interspatial Differences in Feed and Livestock Production

In the USDA report cited earlier, regional differences were shown in the geographical pattern of feed-grain production from 1940 to 1958. The Plains states and the West (namely, regions VI and VII and the western half of regions III and V in fig. 4), which supplied 27 percent of the total feed-grain production in 1956-58, accounted for 36 percent of the 35.4 million tons increase in production over the period from 1940-42 to 1956-58. In the more recent period—1952-53 to 1957-58—this area of the United States accounted for 63 percent of the increase of 31.7 million tons in total production. Both yields and harvested acres increased in the Plains states and the West during this later period. The longer run production changes, however, were due largely to increases in yield per acre of feed grains. This same area, which accounted for 42 percent of the production of hay in 1956-58, also experienced the largest percentage increases in hay production during the period from 1940-42 to 1956-58. Pasture and range conditions in the West have fluctuated greatly, however, depending upon the weather.

The two Jennings reports cited in table 15 provide some further basis for comparing the distribution of feed production and consumption and production among the seven census regions. In table 15, the percentage distribution of production and consumption of major feed categories was computed from data reported both in actual weight (see footnote a) and in feed units (see footnote b). The statistical results show a rather close correspondence between production and consumption. In the case of concentrates, for example, only 20,388,000 tons from a total national production of 147,720,000 tons—13.8 percent of the total production — entered interstate commerce. Practically all of these shipments—all but 721,000 tons—originated from the 12 North Central states. Moreover, a major part of these shipments — 9,105,000 tons — represented inshipments in the 11 Northeastern states.

Geographical differences in the composition of feeds consumed by livestock are related to geographical differences in animal agriculture (table 16). East of the Mississippi River, for example, concentrate feeds made up the major part of total feed consumption, while, in the regions west of the Mississippi River, pasture and harvested forage were the most important feed sources. Because of the feed-oriented location patterns for most livestock production, considerable stability exists in relative livestock numbers in the seven-region feed-livestock economy.

PROSPECTIVE AGGREGATE DEMAND AND PRICE STRUCTURES IN THE LIVESTOCK-MEAT ECONOMY

Before estimating prospective regional patterns of livestock production and meat consumption, a series of equilibrium prices was developed for the

[15] Raymond P. Christensen, Sherman E. Johnson and Ross V. Baumann. Production prospects for wheat, feed and livestock, 1960-65. U. S. Dept. Agr. ARS 43-115. December 1959.

Table 15. Percentage of specified feeds produced and consumed by livestock in various regions, 1949-50.

Region	Concentrates[a]		Harvested forage[a]			
	Production	Fed to livestock	Production[c]	Fed to livestock	Pasture[b]	All feeds consumed by livestock[b]
Northeast	4.7	11.3	12.7	13.5	3.9	8.7
East North-Central	31.1	25.8	19.3	19.5	12.6	19.5
West North-Central	40.6	34.3	30.7	30.1	24.1	29.9
Southeast	11.1	14.8	11.9	12.1	15.9	14.9
West South-Central	6.4	7.1	5.4	5.1	23.2	13.2
Mountain	3.0	2.7	11.2	11.0	14.2	8.3
Pacific	3.1	4.0	8.8	8.8	6.1	5.5
All regions	100.0	100.0	100.0	100.0	100.0	100.0

[a] R. D. Jennings. Feed consumed by livestock, supply and disposition of feeds, 1949-50. U. S. Dept. Agr. Stat. Bul. 145. 1954. pp. 67, 70.
[b] R. D. Jennings. Relative use of feeds for livestock including pasture—by states. U. S. Dept. Agr. Stat. Bul. 153. 1955. p. 27.
[c] Hay only.

Table 16. Percentage of total feed consumption by livestock in specified regions, composed of various kinds of feed, 1949-59.[a]

Feed	Northeast	East North-Central	West North-Central	Southeast	West South-Central	Mountain	Pacific	All regions
Concentrates:								
Formula feed	37.8	7.9	5.0	13.7	7.9	2.9	22.1	10.9
Corn	11.9	35.1	33.9	27.6	10.5	2.9	3.4	23.8
Other grain	6.0	10.8	10.1	2.8	3.7	6.0	6.0	7.4
High-protein feeds	0.9	1.8	1.2	1.6	2.9	2.1	1.5	1.7
Other by-products	0.3	0.5	0.4	0.5	0.5	0.6	1.0	0.5
Total	56.9	56.1	50.6	46.2	25.5	14.5	34.0	44.3
Seeds and skimmilk	0.5	1.1	2.0	2.5	1.8	0.7	0.8	1.6
Harvested forage:								
Hay	19.8	13.6	13.8	10.8	5.3	19.7	23.7	13.7
Other dry roughage	0.3	0.5	0.8	1.4	2.6	0.6	0.2	1.0
Silage and beet pulp	6.1	5.0	2.6	0.7	0.3	1.7	0.9	2.6
Total	26.2	19.1	17.2	12.9	8.2	22.0	24.8	17.3
Pasture	16.4	23.7	30.2	38.4	64.5	62.8	40.4	36.8
All feed	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a]Based on data reported in: R. D. Jennings. Relative use of feeds for livestock including pasture — by states. U. S. Dept. Agr. Stat. Bul. 153. 1955. p. 27.

entire livestock-meat economy.[16] The series of equilibrium prices was generated by using a recursive system of equations depicting the performance of selected parts of the livestock-meat economy during the 12-year period, 1949-60. The predicted equilibrium prices were compared with reported prices for the 1949-60 period. The credibility of the forecasting procedure was ascertained from an examination of its predictive precision for the historical period. To present the price forecasting procedure, first the economic model is discussed in general terms, and finally the empirical results are listed in tabular form and described with reference to the specific research objectives.

Economic Model

Livestock prices were generated by derived demand functions for each of the major livestock species. The latter were based on wholesale demand relationships which included per-capita civilian consumption from commercial supplies of specified meat items, per-capita income and annual trend as explanatory variables. Commercial supplies of the major meat products were derived from estimates of livestock on hand Jan. 1. The latter forecasts were derived from statistical relationships depicting livestock on hand Jan. 1 as a function of specified livestock prices for one or more preceding time periods.

Supply Relationships

Each major livestock class included in this report—calves, cattle and hogs—was described, first, in terms of the USDA annual balance sheet estimates. In general form, the balance sheet estimates are prescribed by the algebraic expression,

$$\sum_{ij} H_{ijt} + B_{it} + I_{it} = M_{it} + D_{it} + \sum_{ij} H_{ijt+1} \qquad (2.1)$$

where H_{ijt} = number of head of i-th livestock (species), j-th market class, on hand Jan. 1, t-th year.

B_{it} = number of head of i-th livestock born and saved during t-th year.

I_{it} = number of head of i-th livestock state inshipments during t-th year.

M_{it} = number of head of i-th livestock marketings during t-th year.

D_{it} = number of head of i-th livestock deaths during t-th year.

To predict each of the balance sheet variables for future time periods, a large assortment of explanatory factors was identified and related to the dependent (balance sheet) variable by a mathematical equation of linear form in the variables. The regression relationships (accounting for the explained variation in the dependent variable) were based mostly on data covering the 12-year period 1949-60. The method of least squares was used to derive the regression coefficients.

The algebraic expression for estimating each set of supply coefficients was of the form,

$$\hat{X}_{it} = a_i + \sum_j b_{ij} Y_{jt-m} + \sum_k c_{ik} Z_{kt-n}, \qquad (2.2)$$

where X_{it} = number of i-th livestock for t-th period (specifically, one of the balance sheet variables included in equation 2.1).

Y_{jt-m} = value of j-th nonprice variable of (t−m)th period accounting variations in X_{it}.

Z_{kt-n} = value of k-th price variable of (t−n)th period accounting for variations in X_{it}.

The regression coefficients specified the b_{ij} units and c_{ik} units change in X_{it} associated with a 1-unit change, respectively, in Y_{jt-m} and Z_{kt-n}.

Each functional relationship used to predict the livestock numbers included in the balance sheet equation is listed in table 17. The explanatory

[16] The equilibrium price series was developed originally for a rather specialized purpose—short-term forecasting of livestock markets. Further discussion of these procedures will be included in a forthcoming publication of the Iowa Agr. and Home Econ. Exp. Sta. on "Programming Market Plant and Facilities Requirements in the Livestock-Meat Economy by Quarter Year," by Wilbur R. Maki and Charles Y. Liu.

Table 17. Selected balance sheet relationships: cattle, calves and hogs.

Item	Equation number	Dependent variable X_i	Nonprice variables X_j	Price variables Z_k
Cattle and calves on hand, Jan. 1:				
Calves, dairy	3.1	H_{11t}	H_{13t}	P_{1t-1}
Calves, other	3.2	H_{21t}	H_{23t-1}	P_{2ft-2}
Heifers, dairy	3.3	H_{11t}	H_{11t-1}	
Heifers, other	3.4	H_{22t}	H_{21t-1}	P_{2ft-1}
Cows, dairy	3.5	H_{13t}	T	P_{2ft-1}
Cows, other	3.6	ΔH_{23t}	ΔH_{22t-1} Cf_{2t-1}	ΔP_{31t-1}
Steers, bulls, stags	3.7	H_{24t}	H_{21t-1}	P_{2ft-1}
Cattle and calves on feed	3.7a	H_{26t}	H_{21t-1}	P_{2ft-1}
Calves born	3.8	B_{1t}	$H_{13t} + H_{23t}$, $\Delta (H_{12t-1} + H_{22t-1})$	
Inshipments, cattle and calves	3.9	I_{1t}	I_{1t-1}, ΔH_{23t}	$P_{2st-1/2}$
Marketings:				
Calves	3.10	M_{1t}	ΔH_{13t}, H_{23t}	$P_{2st-3/2}$
Cattle	3.11	M_{2t}	$\Delta \sum_{i=1}^{2} \sum_{j=2}^{3} H_{ijt}$, H_{24t}	$P_{2st-1/2}$
Deaths:				
Calves	3.12	D_{1t}	B_{1t}, T	
Cattle	3.13	D_{2t}	$\sum_{i=1}^{2} \sum_{j=1}^{4} H_{ijt}$, T	
Farm slaughter:				
Calves	3.14	F_{1t}	B_{1t}, T	
Cattle	3.15	F_{2t}	$\sum_{i=1}^{2} \sum_{j=1}^{4} H_{ijt}$, T	
Hogs and pigs on hand, Jan. 1:				
Hogs under 6 months	4.1	H_{31t}	H_{32t-1}, S_{32t-1}	P_{31t-1}
Hogs, 6 months and over, sows	4.2	H_{32t}	T	
Hogs, other	4.3	H_{33t}	H_{32t-1}, T	
Sows farrowing:				
Spring	4.4	S_{31t}	H_{23t}	
Fall	4.5	S_{32t}	S_{31t}, T	
Pigs saved:				
Spring	4.6	B_{31t}	S_{31t}, T	
Fall	4.7	B_{32t}	S_{32t}, T	
Inshipment, hogs	4.8	I_{3t}	$\Delta (B_{31t} + B_{32t})$, I_{3t-1}	
Marketings, hogs	4.9	M_{3t}	$B_{31t} + B_{32t-1}$,	$P_{32t-1/4}$
Deaths, hogs	4.10	D_{3t}	$B_{31t} + B_{32t}$, T	
Farm slaughter, hogs	4.11	F_{3t}	$B_{31t} + B_{32t-1}$, T	

variables for each equation are specified with respect to form of variable and time period—price or nonprice and number of years lagged—such as P_{t-1}, which denotes a price variable for the preceding year.

Each of the variables cited in table 17 is described in table 18. The sources of data also are listed. For this reason, only predicted data are presented in this report.

Commercial slaughter of calves, cattle and hogs was predicted next using 1949-60 relationships and selected inventory and price variables. In addition to the commercial slaughter equations, a composite average weight and average yield equation was derived for each livestock class. These prediction equations were used to translate the balance sheet data into estimates of aggregate beef, veal and pork production in carcass weight equivalents.

Demand Relationships

To predict live prices, the commercial slaughter data were converted into per-capita consumption estimates by deducting net exports, inventory increases and military utilization from the production estimates and then dividing the residual series by the estimated civilian population. Per-capita consumption of beef, veal and pork, together with per-capita disposable personal income, made up the major demand determinants for prediction purposes. Because of the critical importance of the wholesale markets in price determination, the empirical price-quantity and price-income relationships represented wholesale demand functions. The wholesale demand equations were linear in the variables and of the form:

$$\hat{P}^{w}_{it} = \alpha_i + \sum_j \beta_{ij} Q_{jt} + \gamma_{i1} \Delta I_t + \gamma_{i2} T + \delta_{ik} W_k, \quad (5)$$

where P^{w}_{it} = average wholesale price in cents (divided by Consumers' Price Index) per pound liveweight equivalent of i-th meat class for t-th period.

Q_{jt} = per-capita civilian consumption from commercial supplies of j-th meat class, in pounds carcass weight equivalent, t-th period.

ΔI_t = year-to-year change in per-capita disposable income, in dollars (divided by Consumers' Price Index), t-th period.

T = time, denoting consecutive quarter-year periods starting with first quarter, 1949 (T = 1).

Table 18. Description of selected variables for estimating balance sheet data: cattle, calves and hogs.

Variable X_i	Units of measure	Source of data	Description
(1) H_{11}	1,000 head	U. S. Dept. Agr. Stat. Bul. 230, table 7.	Heifer calves less than 1 year old kept mainly for milk, on hand, Jan. 1.
(2) H_{21}	"	"	Other calves less than 1 year old, on hand, Jan. 1.
(3) H_{12}	"	"	Heifers 1 to 2 years old kept mainly for milk, on hand, Jan. 1.
(4) H_{22}	"	"	Other heifers 1 to 2 years old, on hand, Jan. 1.
(5) H_{13}	"	"	Cows and heifers 2 years and over kept mainly for milk, on hand, Jan. 1.
(6) H_{23}	"	"	Other cows and heifers 2 years and older, on hand, Jan. 1.
(7) H_{24}	"	"	Steers, bulls and stags 1 year and over, on hand, Jan. 1.
(8) H_{25}	"	"	Cattle and calves on feed, Jan. 1.
(9) H_{31}	"	Ibid., table 9.	Hogs less than 6 months old, on hand, Jan. 1.
(10) H_{32}	"	"	Sows 6 months and over, on hand, Jan. 1.
(11) H_{33}	"	"	Other hogs 6 months and over, on hand, Jan. 1.
(12-13) B_i	"	Ibid., table 40.	Births: i = 1, calves.
(14-15) B_{3j}	"	Ibid., table 41.	Pigs saved: j = 1, Dec.-May; j = 2, June-Nov.
(16-17) S_{3j}	"	Ibid., tables 26-27.	Sows farrowing: j = 1, Dec.-May; j = 2, June-Nov.
(18-19) I_i	"	Ibid., tables 40-41.	Inshipments: i = 1, cattle and calves; i = 3, hogs and pigs.
(20-22) M_i	"	"	Marketings — sales by farmers (a) to packing plants, (b) through dealers and terminal markets and (c) through auction markets and to farmers in other states: i = 1, calves; i = 2, cattle; i = 3, hogs.
(23-25) D_i	"	"	Deaths on farms: i = 1, calves; i = 2, cattle; i = 3, hogs.
(26-28) F_i	"	"	Farm slaughter: i = 1, calves; i = 2, cattle; i = 3, hogs.
(29) P_1	$ per cwt.	U. S. Dept. Agr. Stat. Bul. 218, table 242.	Average wholesale milk price received by farmers in the U. S.
(30) P^*_1	"	U. S. Dept. Agr., Agr. Handb. 118, table 17.	Index of prices received by farmers for sale of dairy products.
(31) P_2	"	U. S. Dept. Agr. Stat. Bul. 230, table 156.	Average price of U. S. Choice grade slaughter steers sold at Chicago public terminal market.
(32) P_{2f}	"	Ibid., table 155.	Average price of U. S. Choice and Prime grade feeder calves sold at Kansas City public terminal market.
(33) P_{2s}	"	Ibid., table 154.	Average price of stocker and feeder steers sold at Kansas City public terminal market, July-Dec.
(34) P_{2b}	"	Ibid., table 166.	Average market price of vealer calves sold at Chicago public terminal market.
(35) P_3	"	Ibid., table 168.	Average price of slaughter barrows and gilts sold out of first hands at Chicago.
(36-37) P_{3j}	"	"	Average price of slaughter barrows and gilts sold out of first hand at Chicago: j = 1, Jan.-June; j = 2, July-Dec.
(38) P_6	$ per bu.	U. S. Dept. Agr. Stat. Bul. 159, table 25.	Average price, No. 3 yellow corn, Chicago.
(39) $\frac{P_{31}}{P_{61}}$		U. S. Dept. Agr. Stat. Bul. 230, table 168. U. S. Dept. Agr. Stat. Bul. 159, table 25.	Average price of slaughter barrows and gilts sold out of first hand at Chicago, Jan.-June, divided by the average price of No. 3 yellow corn at Chicago, Jan.-June.

W_k = dummy variable denoting recurrent quarter-year periods starting with $W_1 = 1$ for first quarter, Jan.-Mar., $W_1 = 0$ for all other quarters, and similarly for W_2, W_3 and W_4.

Thus, β_{ij} and γ_{i1} denote the price and income effects, respectively, while γ_{i2} and δ_{ik} denote the linear trend and recurrent seasonal effects, respectively, on P^w_{it}. The coefficient α_i, is the constant term for the regression equation, which denotes the value of the dependent variable when each of the explanatory variables is equal to zero.

A set of live-to-wholesale price relations translated the wholesale price relationships into equivalent primary market demand equations. On a quarter-year basis, live prices were depicted as a function of wholesale prices with some constant quarter-to-quarter or year-to-year shifts from the long-run average live-to-wholesale price relationships. A modification of the live price relation for beef cattle involved inclusion of total beef consumption as an additional explanatory variable. In algebraic form, the two principal live price equations were:

$$\hat{P}^l_{2t} = \alpha_2 + \beta_{21}P^w_{2t} + \gamma_{21}C_{2t-1} + \gamma_{22}T, \qquad (6.1)$$

$$\hat{P}^l_{3t} = \alpha_3 + \beta_{31}P^w_{3t} + \gamma_{2k}W_k, \qquad (6.2)$$

where P^l_{it} = average primary market price in cents (divided by Consumers' Price Index) per pound liveweight of the i-th livestock class (i = 2, beef cattle; i = 3, hogs), t-th period.

C_{2t-1} = total civilian consumption of beef from commercial supplies, (t − 1)th period.

Each of the remaining symbols is identical to the corresponding symbols in equation 5 and, hence, the earlier descriptions of these variables apply also to equations 6.1 and 6.2.

In addition to the slaughter livestock price equations, a feeder price equation was specified to generate the 6-month Kansas City feeder steer price series needed in the beef-calf inventory and other balance sheet equations (see table 17). According to the economic model developed for this study, Kansas City feeder calf prices are affected by current Chicago slaughter steer and corn prices, steers on hand Jan. 1, the current trend in the feeder calf price and the past trend (lagged 1 year) in the slaughter-steer price.[17]

[17] Actually, two feeder calf price equations were estimated as follows:

$$\hat{P}_{21ft} = 2.226 + \underset{(0.044)}{0.956}{**}P_{22ft-1} + \underset{(0.070)}{0.780}{**}\Delta P_{2st-1}, \; R^2 = 0.986 \quad (6.1a)$$

(Footnote continued on page 718)

Empirical Results

The economic model represents a recursive system of equations in which the equilibrium live prices are dependent upon a series of previously derived equilibria of production and other price variables. Because of the number of computational steps involved in the prediction of live prices by quarter-year, the prediction error could be quite large, particularly if future levels of the explanatory variables depart substantially from the average values of these variables over the 1949-60 period. Both the prediction equations and the predicted values are presented, therefore, for as complete an evaluation as possible of the credibility of the price forecasting procedures described in this study. The empirical results are examined, first, with reference to cattle and calves and, finally, with reference to hogs and pigs.

Cattle and Calves

Balance sheet data. Though three balance sheet variables were involved directly in the commercial slaughter predictions, the entire set of equations for cattle and calves corresponding to the equations listed in table 17 is presented in table 19. Later in this report, each of the balance sheet items is discussed with reference to the regional estimates of slaughter livestock marketings. At this time, however, the empirical relationships are available for an initial evaluation of the recursive system of equations as the technical means of generating the equilibrium price series upon which are based the analyses of interregional commodity shipments.

On the basis of the data in table 19, year-to-year changes in the three balance sheet variables —cows kept mainly for milk, H_{13}; other cows, H_{23}; and steers, H_{24}—were explained largely by six variables. Of these variables, two—wholesale milk price, P_{1t-2}; and time, T—were assigned fixed values for the forecast period from 1961-64. The remaining four variables—lagged beef-calf inventory, H_{21t-1}; first difference of beef-heifer inventory, ΔH_{22t}; lagged beef-cow inventory, H_{23-1}; and lagged slaughter-steer price, P_{2t-1}—were estimated with a rather high degree of precision, as suggested by the R^2's and the standard errors of the regression coefficients. In the beef-calf inventory equation, for example, the two variables—lagged beef-cow inventory, H_{23-1}; and lagged feeder-steer price, $P_{2ft-3/2}$—explained 95.2 percent of the variation in the dependent variable, H_{21t}, during the 12-year period 1949-60. For the lagged beef-cow variable, a 1-unit change was associated with a 0.692-unit change in the dependent variable. Since the standard error of the regression coefficient was 0.053 units, the t-value was substantially in excess of a t-value denoting a regression coefficient significantly different from zero at the 0.01 probability level (even with only 9 degrees of freedom).

To further evaluate the prediction errors of the balance sheet equations, the predicted values of each of the inventory variables were computed for the period 1954-64. For the first 7 years, the predicted values, which are shown in table 20, can be compared with the reported values for this period. These balance sheet equations were used also to generate cattle and calf inventory cycles for the entire forecast period, which served to illustrate the importance of the specified lag variables in terms of their cumulative effects on market price performance in the livestock-meat economy.

Commercial slaughter. Total commercial slaughter of cattle and calves was composed largely of steers, cull dairy cows and vealer calves. Year-to-year changes in beef herds, however, provided a major source of variability in both calf and cattle slaughter. Because dairy cow numbers were quite stable, except for the constant rate trend effect, the contribution of dairy enterprises to total cattle slaughter was represented by the constant terms in the empirical relationships. These relationships, which explained 89.4 percent of the year-to-year variation in total calf slaughter and 89.6 percent of the year-to-year variation in total cattle slaughter during the 12-year period 1949-60, are as follows:

Table 19. Estimated effects on specified balance sheet variables, in 1,000 head, of a 1-unit change in selected explanatory variables, cattle and calves, 1949-58.

Estimated balance sheet variable X_i	Effect on balance sheet variable of a 1-unit change in: Nonprice variable Y_j		Price variable Z_k	Constant term 1	R^2
Calves: H_{11}	0.263*		380.532*	−1,547.8	0.738
	(0.092)		(128.573)		
H_{21}[a]	0.692**		107.467**	−812.3	0.952
	(0.052)		(34.245)		
Heifers: H_{12}	1.139**			−1,513.6	0.982
	(0.054)				
H_{22}[a]	0.235**		37.114**	674.1	0.962
	(0.018)		(8.253)		
Cows: H_{13}[a]	−94.010**		−377.065**	27,579.5	0.881
	(29.04)		(48.410)		
ΔH_{23}[a]	2.095**	−0.130*	90.680*	2,701.5	0.875
	(0.406)	(0.049)	(31.940)		
Steers: H_{24}[a]	0.416**		87.236**	−486.6	0.946
	(0.033)		(15.848)		
On feed: H_{25}[a]	0.305**		45.643	−608.1	0.915
	(0.031)		(14.708)		
Calves born: B_1	0.925**	0.504*		−2,841.7	0.995
	(0.025)	(0.179)			
Inshipments: I_1	0.776**	−0.154	−59.126	4,007.5	0.843
	(0.194)	(0.206)	(45.646)		
Marketings: M_1	1.876	0.305**	−92.502	9,573.0	0.831
	(1.052)	(0.082)	(79.138)		
M_2	−0.190	2.708**	−441.801**	10,431.6	0.949
	(0.272)	(0.422)	(101.758)		
Deaths: D_1	0.040**	−35.714*		1,019.7	0.933
	(0.004)	(4.422)			
D_2	0.012**	−35.056**		595.9	0.603
	(0.004)	(10.824)			
Farm slaughter:					
F_1	0.007	−16.641**		318.6	0.765
	(0.004)	(4.100)			
F_2	0.009**	−1.093		42.7	0.878
	(0.002)	(6.018)			

* Significantly different from zero at the 0.05 probability level.
** Significantly different from zero at the 0.01 probability level.
[a] Based on data for the 12-year period, 1958-60.

(Footnote 17 continued)

$$\hat{P}_{22ft} = -0.456 + \underset{(0.174)}{1.400^{**}P_{2st}} - \underset{(3.371)}{7.310P_{6t}} + \underset{(0.101)}{0.447^{**}\Delta P_{22ft}}, \quad R^2 = 0.935 \quad (6.1b)$$

where P_{2jf} = average price, in dollars per 100 pounds of U. S. Choice and Prime grade feeder calves at Kansas City; $j = 1$, Jan.-June; $j = 2$, July-Dec.

P_{2s} = average annual price, in dollars per 100 pounds of U. S. Choice grade steers at Chicago.

P_6 = average annual price, in dollars per bushel, of No. 3 yellow corn at Chicago.

$$\hat{C}_{1t} = 250.7 + \underset{(0.139)}{0.459^{**}H_{13t}} - \underset{(0.265)}{1.786^{**}\Delta^2 H_{23t}}, \qquad R^2 = 0.894 \qquad (7.1)$$

$$\hat{C}_{2t} = 5{,}087.8 + \underset{(0.357)}{2.059^{**}H_{24t}} - \underset{(0.527)}{2.925^{**}\Delta^2 H_{23t}}, \qquad R^2 = 0.896 \qquad (7.2)$$

where C_{1t} = total commercial calf slaughter, in 1,000 head, t-th year.

C_{2t} = total commercial cattle slaughter, in 1,000 head, t-th year.

$$\Delta^2 H_{23t} = (H_{23t} - H_{23t-1}) - (H_{23t-1} - H_{23t-2}).$$

Each of the balance sheet variables, H_{13}, H_{23} and H_{24}, was defined earlier (see table 18).

The commercial slaughter relationships illustrate the critical importance of estimating precisely the beef-cow inventories inasmuch as a +1,000-head change in beef cows on hand Jan. 1 is associated with a −1,786-head change in commercial calf slaughter and a −2,925-head change in commercial cattle slaughter. A specified change in beef-cow numbers is associated, therefore, with a complex of changes involved in the withholding or release of female beef cattle for intended slaughter. Similarly, a specified change in steer inventories is associated with nearly a twofold change in cattle slaughter because of (1) a less than 1-year average length of feeding period for the steers reported on hand Jan. 1 and (2) a corresponding change in the average length of period on feed. To more precisely forecast prospective changes in calf and cattle slaughter, further investigation would be needed to measure the complex set of factors associated with changes in livestock inventories. For the purpose of this study, however, the empirical relationships result in a reasonably satisfactory set of predictions to warrant their use without further refinement.

Commercial beef and veal production. An additional set of empirical relationships was derived to transform the predicted commercial slaughter data into corresponding estimates of beef and veal production. These relationships, which show the quarter-to-quarter change in the total carcass weight of calves and cattle, beef and veal, respectively, per 1,000 head of commercial slaughter, are summarized in table 21.

Using the predicted data on commercial slaughter, commercial beef production was estimated for each year to illustrate the yearly and quarterly patterns of production (table 22).

Total beef and veal production. Commercial production and farm slaughter make up total production. To obtain the carcass weight equivalent of farm slaughter of cattle, average weight and yield

Table 22. Predicted commercial beef production, in million pounds, by quarter-year, United States, 1954-64.

Year	First quarter	Second quarter	Third quarter	Fourth quarter	Total annual
1954	3,207	3,261	3,439	3,408	13,315
1955	3,299	3,364	3,539	3,503	13,705
1956	3,477	3,530	3,701	3,657	14,335
1957	3,365	3,438	3,612	3,571	13,986
1958	3,016	3,048	3,231	3,210	12,505
1959	2,935	2,957	3,142	3,126	12,160
1960	3,234	3,291	3,469	3,436	13,430
1961	3,772	3,895	4,056	3,994	15,717
1962	3,612	3,718	3,884	3,830	15,047
1963	3,627	3,732	3,898	3,843	15,100
1964	3,638	3,744	3,910	3,855	15,147

Table 20. Predicted cattle and calves on hand, Jan. 1, in 1,000 head, 1954-64.

	Kept mainly for milk			Other				
	Calves	Heifers	Cows	Calves	Heifers	Cows	Steers	On feed
Year	$\hat{H}_{11}$	$\hat{H}_{12}$	$\hat{H}_{13}$	$\hat{H}_{21}$	$\hat{H}_{22}$	$\hat{H}_{23}$	$\hat{H}_{24}$	$\hat{H}_{26}$
1954	6,582	5,866	23,385	18,708	6,422	25,210	8,555	5,648
1955	6,266	5,767	23,040	18,740	6,223	25,544	8,749	5,796
1956	6,068	5,449	22,585	19,125	6,227	25,296	9,165	6,086
1957	6,001	5,371	23,346	19,015	6,140	24,424	9,063	6,039
1958	5,875	5,294	21,613	18,278	6,052	24,347	9,201	6,070
1959	6,005	5,117	20,454	18,429	6,481	24,990	9,873	6,411
1960	5,977	5,325	19,985	19,979	7,049	26,344	10,428	6,800
1961	5,949	5,293	20,057	20,937	7,118	27,416	10,435	6,893
1962	5,921	5,261	20,063	20,867	7,020	27,300	10,126	6,780
1963	5,893	5,230	19,668	19,984	6,672	26,503	10,279	6,850
1964	5,865	5,198	18,838	19,373	6,496	25,033	10,333	6,801

Table 21. Estimated effects of a 1,000-head change in specified total annual commercial slaughter on beef and pork production, in million pounds carcass weight equivalent, by quarter year, United States, 1949-60.

	Beef production			Veal production		
Quarter year	Cattle slaughter C_2	Constant term 1	r^2	Calf slaughter C_1	Constant term 1	r^2
First (Jan.-March)	0.130** (0.014)	−49.7	0.895	0.024** (0.004)	21.6	0.804
Second (April-June)	0.146** (0.012)	−387.8	0.932	0.031** (0.002)	−29.8	0.964
Third (July-Sept.)	0.142** (0.013)	−115.1	0.918	0.038** (0.003)	−48.9	0.942
Fourth (Oct.-Dec.)	0.135** (0.013)	31.2	0.917	0.032** (0.005)	4.8	0.820

** Significantly different from zero at the 0.01 probability level.

Table 23. Predicted total beef production for civilian consumption, in million pounds carcass weight equivalent, United States, 1954-64.

Year	Commercial production	Change in stocks	Net exports	Military consumption	Civilian consumption	Farm slaughter	Total civilian consumption
1954	13,315	−61	−163	450	13,089	444	13,533
1955	13,705	17	−157	403	13,442	461	13,903
1956	14,335	39	−95	404	13,987	457	14,444
1957	13,986	−110	−259	348	14,007	460	14,467
1958	12,505	40	−849	353	12,961	458	13,419
1959	12,160	28	−996	346	12,782	510	13,292
1960	13,430	−32	−706	343	13,825	486	14,311
1961	15,717	0	−954	342	16,329	501	16,830
1962	15,047	−3	−1,065	340	15,775	518	16,293
1963	15,100	0	−1,181	340	15,941	528	16,469
1964	15,147	0	−1,297	340	16,104	529	16,633

data were used with the farm slaughter estimates obtained earlier. Finally, beef production for civilian consumption, which is summarized in table 23 for the period 1954-64, involves an accounting of net imports, cold storage holdings and military utilization. For future years, estimates of the latter were based on 1949-60 relationships.

Beef cattle price. The data on civilian consumption from commercial supplies of beef related to quarter-year U. S. Choice grade beef-steer prices at Chicago. A beef-steer price equation was derived from a wholesale beef price equation and a live-to-wholesale margin equation, as indicated earlier in this discussion (see equation 5). The derived live price equation was as follows:

$$\hat{P}^{l}_{2jt} = 57.9 - 2.088Q_{1t} - 0.118S_{3t-1} - 0.002\Delta Y_t + 0.121T - 0.695W_1 + 2.660W_3 + 0.291W_4, \quad (8)$$

where P^{l}_{2jt} = average price in cents per pound liveweight of U. S. Choice grade beef steers at selected markets in the United States, j-th quarter year ($j = 1, \ldots, 4$), t-th year.

The live price prediction equation generated the predicted quarter-year price series listed in table 24. The predicted prices are shown in current dollars.

Hogs and Pigs

Balance sheet data. Balance sheet estimates of hogs and pigs were based on the empirical relationships shown in table 25. The predicted balance sheet values are summarized in table 26.

Each of the balance sheet equations, with the exception of equations 4.9 and 4.10, was estimated with a rather high degree of precision, at least

Table 24. Predicted price in cents per pound liveweight of U. S. Choice grade beef steers at selected markets and U. S. Prime and Choice grade feeder calves at Kansas City, 1954-64.

Year	Beef cattle[a]	Feeder calf[b]
1954	23.46	21.67
1955	22.58	21.01
1956	21.56	20.39
1957	23.32	23.76
1958	27.73	30.95
1959	27.09	31.00
1960	25.77	27.97
1961	22.86	24.54
1962	25.44	23.99
1963	26.48	28.81
1964	27.58	29.51

[a] Based on simple average of quarter-year prices and data for 11-year period ending in 1959.
[b] Based on simple average of half-year prices and data for 11-year period ending in 1960.

Table 25. Estimated effects on specified balance sheet variables, in 1,000-head, of a 1-unit change in selected explanatory variables, hogs and pigs, 1949-58.

Estimated balance sheet variable $\hat{X}_i$	Effect on balance sheet variable of a 1-unit change in: Nonprice variable Y_j		Price variable Z_k	Constant term 1	R^2
Hogs on hand:					
H_{31}	−2.830** (0.511)	10.111** (0.983)		3,497.4	0.956
H_{32}[a]	109.312* (39.197)		110.074** (29.072)	5,849.0	0.723
H_{33}	2.010** (0.333)	−702.488** (96.700)		−328.2	0.966
Sows farrowing:					
S_{31}[b]	0.918** (0.042)			−141.9	0.971
S_{32}[b]	0.490** (0.110)	186.135** (21.097)		701.3	0.933
Pigs saved:					
B_{31}	5.760** (0.391)	508.324** (108.112)		5,129.3	0.978
B_{32}	7.170** (0.298)	352.948** (24.049)		−3.977.9	0.988
Inshipments:					
I_3	1.134** (0.120)	0.006 (0.006)		24.8	0.927
Marketings:					
M_3	0.696* (0.203)		−586.238 (322.874)	21,751.0	0.722
Deaths:					
D_3	0.102* (0.042)	−291.291** (78.501)		2,849.2	0.753
Farm slaughter:					
F_3	0.052 (0.028)	−450.473** (33.424)		5,621.7	0.927

* Significantly different from zero at the 0.05 probability level.
** Significantly different from zero at the 0.01 probability level.
[a] Based on data for 8-year period ending Jan. 1, 1960.
[b] Based on data for 9-year period ending in 1960.

Table 26. Predicted sows on farms, Jan. 1, and sows farrowing, in 1,000 head, United States, 1954-64.

Year	Sows, 6 months and over, Jan. 1 H_{32}	Sows farrowing Dec.-May S_{31}	Sows farrowing June-Nov. S_{32}
1954	8,497	7,588	5,016
1955	9,090	8,179	5,540
1956	8,256	7,667	5,386
1957	8,005	7,261	5,385
1958	8,532	7,297	5,642
1959	8,994	7,955	6,245
1960	8,567	6,772	5,834
1961	8,551	7,664	6,006
1962	8,903	8,031	6,682
1963	8,532	7,691	6,702
1964	8,238	7,422	6,756

for the purposes of this study. Year-to-year changes of most variables were attributed almost entirely (from 72.3 percent to 98.8 percent of the total variation) to changes in the two or three explanatory variables specified earlier in table 17. The most important variable for prediction purposes, H_{32t}, was associated with hog price for the preceding 6-month period, January to June, and time, T. Because of the probable complementary effects of the actual level of hog prices and the probable limitations in expanding hog production at exceptionally high price levels, this prediction equation failed somewhat in fulfilling its purpose in the over-all model. The predicted number of sows on hand, however, is related to the number of sows farrowing during the 6-month period, December to May, which in turn is related to the commercial slaughter of hogs during the following 6-month period, June to November. Other factors also explain year-to-year changes in sows farrowing and in commercial hog slaughter.

Because of the large number of predicted values involved in the entire set of prediction equations, as illustrated by the shortcomings in the use of one of the more important explanatory variables, the long-range projections of hog numbers are subject to considerable prediction error. In comparison with cattle slaughter estimates, however, the predicted hog slaughter departs less from its average historical level than does the predicted cattle slaughter. For this reason, and also because of the generally satisfactory prediction accuracy of the entire set of equations, the estimates of future hog slaughter compare rather favorably with the estimates of calf and cattle slaughter, as illustrated by the predicted and reported data on commercial slaughter.

Commercial slaughter. Commercial hog slaughter was estimated on a half-year basis; namely, for the two periods January through June and July through December. The prediction equations were quite satisfactory in explaining year-to-year changes in commercial hog slaughter, as suggested by the R^2 and standard error values shown with the two equations. The two prediction equations included a set of empirical relationships as follows:

$$\hat{C}_{31t} = 7{,}865.1 + \underset{(0.864)}{5.560^{**}S_{32t-1}} - \underset{(139.574)}{277.250}\left(\frac{P_{32t-1}}{P_{62t-1}}\right) + \underset{(108.943)}{287.681^{*}}\,T \qquad R^2 = 0.913 \qquad (9.1)$$

$$\hat{C}_{32t} = 8{,}749.1 + \underset{(0.672)}{3.076^{**}S} - \underset{(180.082)}{171.733}\left(\frac{P_{31t}}{P_{61t}}\right) + \underset{(141.734)}{913.912^{**}T} \qquad R^2 = 0.947 \qquad (9.2)$$

where C_{31t} = total commercial hog slaughter, in thousands of head, January to June, t-th year.

C_{32t} = total commercial hog slaughter, in thousands of head, July to December, t-th year.

A further description of the variables in the two equations is included in table 18.

Commercial hog slaughter differs significantly from one half-year period to the next in terms of the quantitative relationships commonly specified as affecting hog production. Though hog production and pork production are directly related, hog and corn prices also affect the level of pork production (in addition to their specific effects on hog production). During the fall months, moreover, total pork production has increased significantly—an increase that is not explained by changes in the number of sows farrowing or in hog and corn prices.

Changes in the number of sows farrowing during the period of analysis were followed about 6 months later by changes in hog slaughter. A change in fall farrowings, however, was associated with twice as large changes in hog slaughter 6 months later as was the same magnitude of change in spring farrowings, but changes in hog and corn prices during the early fall months, July through September, were related only slightly to changes in hog slaughter 6 months later. The January to March hog and corn prices, on the other hand, were quite reliable predictors of hog slaughter.[18] Early spring hog and corn prices apparently conditioned producers' market expectations, and, hence, these producers withheld gilts from the spring pig crop.

Commercial pork production. A composite set of average weight and average yield relationships was derived to convert the predicted hog slaughter into equivalent carcass weight production of pork.

[18] In an alternative formulation of the hog slaughter function based on data for the 10-year period 1949-58, the price variables covered the first quarter of each 6-month period and were associated with commercial hog slaughter as follows:

$$\hat{C}_{3t} = 1{,}285.6 + \underset{(0.910)}{5.963^{**}S_{32t-1}} - \underset{(139.574)}{392.373}\,P'_{32t-1} + \underset{(18.100)}{53.179^{*}}P'_{62t-1} + \underset{(77.600)}{180.870^{*}}T, \qquad R^2 = 0.966 \qquad (9.1a)$$

$$\hat{C}_{32t} = 4{,}615.9 + \underset{(0.406)}{2.805^{**}S_{31t}} - \underset{(70.904)}{209.671^{*}}P'_{31t} + \underset{(12.596)}{52.998^{**}}P'_{61t} + \underset{(57.922)}{491.604^{**}}T, \qquad R^2 = 0.954 \qquad (9.2a)$$

Table 27. Estimated effect of a 1,000-head change in total semiannual commercial hog slaughter and other variables on pork production, in millions of pounds carcass weight equivalent, by quarter year, United States, 1949-60.

Quarter year	Half-year commercial hog slaughter C_{3j}	Hog Price P_{3w}	Time T	Constant term 1	R^2
First (Jan.-March) ..	0.065** (0.007)			271.5	0.905
Second (April-June) ..	0.049** (0.010)	−10.915 (11.432)	15.271	607.2	0.841
Third (July-Sept.)	0.060** (0.013)	−17.615 (8.866)		270.7	0.786
Fourth (Oct.-Dec.)	0.058** (0.008)	25.368** (6.950)		189.0	0.889

** Significantly different from zero at the 0.01 probability level.

Table 28. Predicted pork production, in millions of pounds carcass weight equivalent, by quarter year, United States, 1954-64.

Year	First quarter	Second quarter	Third quarter	Fourth quarter	Total annual
1954	2,210	1,933	1,937	2,846	8,926
1955	2,526	2,138	2,268	3,178	10,110
1956	2,887	2,395	2,286	2,901	10,469
1957	2,621	2,300	2,178	2,738	9,837
1958	2,507	2,254	2,114	2,812	9,687
1959	2,825	2,478	2,441	3,237	10,981
1960	2,977	2,568	2,274	2,803	10,622
1961	2,791	2,507	2,481	3,055	10,834
1962	2,967	2,653	2,683	3,265	11,568
1963	3,277	2,895	2,671	3,146	11,989
1964	3,300	2,963	2,691	3,056	12,010

Table 29. Predicted pork production for civilian consumption, in millions of pounds carcass weight equivalent, United States, 1954-64.

	Jan.-June					July-Dec.					Annual		
Year	Commercial production	Change in stocks	Net exports	Military use	Civilian consumption	Commercial production	Change in stocks	Net exports	Military use	Civilian consumption	Civilian consumption from commercial supplies	Farm slaughter	Total consumption
1954	4,143	20	−45	142	4,026	4,783	102	−34	136	4,579	8,605	954	9,559
1955	4,664	−73	−24	123	4,638	5,446	45	−25	111	5,315	9,953	945	10,898
1956	5,282	−27	−14	115	5,208	5,187	−114	2	114	5,185	10,393	873	11,266
1957	4,921	−1	6	103	4,813	4,916	−85	−6	110	4,897	9,710	795	10,505
1958	4,761	16	−31	95	4,681	4,926	−4	−44	97	4,877	9,558	750	10,308
1959	5,303	−86	−21	91	5,319	5,678	144	−21	91	5,464	10,783	765	11,548
1960	5,545	107	−26	102	5,362	5,077	−181	−21	81	5,198	10,560	711	11,271
1961	5,298	70	−19	91	5,156	5,536	157	−8	90	5,297	10,453	710	11,163
1962	5,620	−169	−11	90	5,710	5,948	212	−6	90	5,652	11,362	570	11,932
1963	6,172	−157	−5	90	6,244	5,817	79	−16	90	5,664	11,908	555	12,463
1964	6,263	−86	−8	90	6,267	5,747	19	−30	90	5,668	11,935	479	12,414

The empirical relationships, which describe the weight and yield estimates essentially as a linear function of time and of commercial hog slaughter in number of head, are summarized in table 27. The derivation of the total carcass weight of commercial hog slaughter is shown in table 28.

Total pork production. Since the farm slaughter of hogs is declining rapidly, commercial pork will nearly equal total pork production by 1964. Estimated average weight and yield data for commercial slaughter were used to convert farm slaughter into equivalent carcass weight production. Total pork production is shown in table 29 for both half-year periods from 1955-64. (Again, the estimates of net imports, changes in cold storage holdings and military utilization were based on 1949-60 relationships.)

Hog price. Finally, a predicted live price series was obtained with the live price equation,

$$\hat{P}_{3jt} = 58.8 - 0.433Q_{1t} - 2.186Q_{2t} - 0.006\Delta Y_t - 0.101T + 1.254W_1 + 0.681W_3 + 2.652W_4 \quad (10)$$

where P_{3jt} = average price in cents per pound liveweight of 200-220 pound slaughter barrows and gilts at Chicago, j-th quarter year, t-th calendar year.

Again, the remaining variables are described in table 17. The predicted hog prices, based on equation 16, are listed in table 30.

Table 30. Predicted price in cents per pound liveweight of 200-220 pounds slaughter barrows and gilts at Chicago, 1954-64.

Year	Annual average[a]
	(cents)
1954	22.60
1955	17.15
1956	16.00
1957	19.73
1958	21.24
1959	15.12
1960	15.96
1961	17.18
1962	14.12
1963	12.40
1964	12.68

[a] Based on simple average of quarterly prices.

Comparisons of Projected Price Structures

A comparison of the projected 1964 prices shown in tables 24 and 30 with those used in evaluating the farm-income effects of alternative farm programs—listed in table 31—reveals some differences in the two sets of estimates. The estimates for the farm program studies, however, depict the long-run rather than the yearly pattern of livestock and feed-grain prices. Moreover, the long-run estimates represent estimates of average prices received by farmers rather than primary market prices. Because of the use of a common set of regional estimates in the two studies, and the emphasis on a consistent procedure for deriving short-term estimates of livestock marketings and meat consumption, the projected 1964 livestock prices were not adjusted to account for the different assumptions used in estimates cited in table 31.

Table 31. Estimated farm prices under specified farm programs, 1959 and projected 1965.

Item	Unit of measure	Reported 1959		Price supports and control for five basic crops	Projected 1965[b]			
					Feed grain production limited to:		Price supports and production limitations removed	
		Market price[a]	Farm price[b]		150 million tons	140 million tons	Joint Economic Committee Report	Senate Document No. 77
Cattle	cwt.	$27.09	$22.51	$16.77	$18.30	$19.22	$17.08	$15.00
Calves	cwt.	[c]	27.10	18.06	19.61	20.53	18.39	[c]
Hogs	cwt.	15.12	14.20	10.23	13.85	16.44	10.95	11.20
Sheep and lambs	cwt.	[c]	17.94	16.44	18.02	18.97	16.78	[c]
Milk, wholesale	cwt.	4.15	4.15	3.70	4.10	4.22	3.67	3.60
Corn	bu.	1.23	1.07	0.71	1.00	1.23	1.77	0.77

[a] Annual average value of quarterly market prices described in table 17.
[b] Joint Economic Committee. Economic policies for agriculture in the 1960's. U. S. Govt. Print. Off., Washington, D. C. Nov. 26, 1960.
[c] Not available.

PROSPECTIVE REGIONAL LIVESTOCK MARKETINGS AND SLAUGHTER

Estimates of livestock marketings and slaughter for each livestock region are used later to estimate the annual volume of livestock and and meat shipments among the seven livestock regions. In this study, the estimates of interregional commodity flows and related prices were derived in three stages. First, an equilibrium set of livestock and meat prices was generated for selected markets. These prices, when lagged one or more time periods, served as the explanatory variables accounting for changes in total commercial slaughter of cattle, calves and hogs. Next, estimates of total commercial slaughter, when transformed into per-capita civilian consumption from commercial supplies, were used to predict the average quarterly live prices of beef cattle and hogs. Finally, the live prices were used to generate regional balance sheet estimates for each year from 1949 to 1964. In this study, however, only the estimates for 1954 and 1964 are reported.

Livestock Marketings

Aggregate Marketings

Estimates of prospective livestock marketings in the continental United States were developed as part of the procedures to estimate livestock slaughter. Though the use of alternative linear programming procedures may result in somewhat different estimates from those obtained by extending 1949-60 relationships to future years, only the latter procedure was used to estimate livestock marketings in this study. Efficient, or long-run optimal, levels of livestock production were not examined with reference to each livestock region. Rather, the 1949-60 structure of the livestock-meat economy was assumed to be stable enough with reference to the projected livestock-meat economy to allow the use of historical relationships for estimating specified future livestock numbers. Because of the indirect manner in which slaughter livestock marketings were estimated, an evaluation of the entire livestock balance sheet for 2 years—1954 and projected 1964—was undertaken as a part of this study.

Regional Marketings

To overcome the lack of adequate regional data on marketings of slaughter livestock, changes in the aggregate balance sheet variables were allocated among the seven livestock regions according to their 1949-60 (or 1949-58) relationships as prescribed by a series of simple regression equations. These equations were of the form,

$$\Delta\hat{B}_{irt} = a_{ir} + b_{ir} \sum_{r=1}^{7} \Delta B_{irt}, \qquad (11)$$

where ΔB_{irt} = numerical value of the year-to-year difference in the i-th balance sheet variables for the r-th region for the time period (t−1) to t.

In addition, a limited number of multiple regression equations were developed for each region. These prediction equations were used to generate a series of regional balance sheet variables; namely, sows on hand Jan. 1 and sows farrowing—the latter for both the spring and fall pig crops. The prediction equations for sows on hand Jan. 1 are of the form,

$$\hat{H}_{32rt} = a_{32r} + b_{32r}\left(\frac{P_{3t-k}}{P_{6t-k}}\right) + c_{32r}\left(\frac{P_{2t-k}}{P_{6t-k}}\right), \qquad (12.1)$$

$$\hat{H}_{32rt} = a_{32r} + b_{32r}\left(\frac{P_{3t-k}}{P_{6t-k}}\right) + c_{32r}T, \qquad (12.2)$$

where equation 12.1 pertains to the West South-Central region and the East North-Central region when k = 1 and k = 2, respectively, and where equation 12.2 pertains to the Northeast region when k = 2. All other regional prediction equations for sows on hand at the beginning of the year are denoted by equation 12.2 when k = 1. Each of the variables in these and following prediction equations are described in table 17.

To estimate the number of sows farrowing, spring and fall, two prediction equations were developed which served their purpose quite well for each of the seven regions (r = 1, . . . , 7). These equations for the spring and fall seasons, respectively, are of the general form,

$$\hat{S}_{31rt} = a_{31r} + b_{31r}H_{32rt} + c_{31}T, \qquad (13.1)$$

$$\hat{S}_{32rt} = a_{32r} + b_{32r}S_{31rt} + c_{32r}\left(\frac{P_{31t}}{P_{61t}}\right) + d_{32r}T. \qquad (13.2)$$

The predicted data on sows farrowing served later as explanatory variables in predicting commercial slaughter of hogs by regions.

Finally, regional livestock marketings were grouped into two market classes: livestock intended for slaughter and other livestock. In some regions, marketings of other livestock exceed marketings of slaughter livestock because of sales of feeders by farmers and ranchers through central or country markets or to other farmers and ranchers. Sales of feeder livestock within a state, however, are not included in the balance sheet estimates of livestock marketings. Essentially, only interstate shipments of other livestock are included in these estimates (though all market sales of slaughter livestock are included).

To obtain a breakdown of total marketings by regions, the data on livestock inventories and births were related to aggregate estimates of commercial livestock slaughter. In effect, changes in regional livestock marketings from one year to the next were accounted for by (1) changes in livestock births, inshipments and beginning inventories and (2) changes in deaths, farm slaughter and ending inventories. A residual component, which, in the aggregate, was equal to total commercial slaughter, comprised the regional marketings of slaughter livestock. The difference between total marketings and this residual component represented other marketings.

To illustrate the mechanical procedures involved in the estimation of slaughter marketings, 1954 balance sheet data were used to allocate the number of livestock on hand Jan. 1, 1954, and the number born during 1954 among the alternative uses for these livestock. These alternative uses would include the number of livestock on hand Jan. 1, 1955, and deaths, farm slaughter and commercial slaughter during 1954. Regional data are examined first with respect to the number of slaughter cattle and calves marketed during the 1954 calendar year.

Estimating number sold. After allocating the calves born during 1954 among (a) cows kept mainly for milk and (b) other cows on a basis proportional to the total number in each class, and allowing for an equal distribution of male and female calves in each class, the calves attributed to cows kept mainly for milk were allocated among the possible use categories; namely, replacement of heifer calves and replacement of dairy bulls on hand Jan. 1, 1955, and calf deaths and farm slaughter of calves during 1954. As shown in table 32, of the total of 12,746,000 calves slaughtered commercially in 1954, an estimated 28 percent, or 3,516,000 head, represented heifer calves in excess of the number required to cover the number on hand Jan. 1, 1955. In these estimates, the residual commercial calf slaughter of 9,230,000 head is comprised of male dairy calves. Thus, of the 13,418,000 dairy calves (i.e., calves attributed to cows and heifers 2 years and over kept mainly for milk) surviving death and slaughter on farms, 672,000 head were not allocated among any of the specified uses. This excess of dairy calves occurred because of differences in the methods of obtaining estimates of (a) commercial calf slaughter and (b) calf marketings and other balance sheet items.

Total commercial cattle slaughter, which reached 25,017,000 head in 1954, comprised 8,444.000 cows, 631,000 bulls, 3,347,000 heifers and 12,595,000 steers. The four market classes of cattle were proportional to the federally inspected slaughter under each of these market classes. In table 32, the total regional marketings of cattle slaughtered in 1954 are listed according to the

Table 32. Estimated marketings of cattle and calves slaughtered commercially, in 1,000 head, by originating regions, 1954.

Item	United States	Originating livestock regions						
		Northeast	East North-Central	West North-Central	Southeast	West South-Central	Mountain	Pacific
Calf slaughter:								
Female	3,516	552	921	939	569	311	71	153
Male	9,230	1,350	2,406	2,271	1,498	838	315	552
Total calves	12,746	1,902	3,327	3,210	2,067	1,149	386	705
Cattle slaughter:								
Cows	8,444	679	1,279	2,136	1,440	1,519	887	504
Bulls	631	42	75	172	99	123	73	47
Heifers:								
Calves born during year	506	8	80	138	89	114	41	36
Heifers on feed, Jan. 1	1,765	21	294	743	0	79	318	310
Other heifers on hand, Jan. 1	1,076	184	392	37	409	184	−41	−89
Total heifers (net)	3,347	213	766	918	498	377	318	257
Steers:								
Calves born during year	2,768	137	−618	−1,298	1,191	2,159	965	232
Calves on hand, Jan. 1	1,598	−179	−115	1,238	−114	747	436	−415
Steers on feed, Jan. 1	3,605	65	927	2,039	0	126	343	105
Others steers on hand, Jan. 1	4,624	177	500	1,129	881	747	512	678
Total steers (net)	12,595	200	694	3,108	1,958	3,779	2,256	600
Total cattle (net)	25,017	1,134	2,814	6,334	3,995	5,798	3,534	1,408

Table 33. Estimated marketings and inshipments of cattle and calves, in 1,000 head, 1954.

Item	United States	Originating livestock regions: Northeast	East North-Central	West North-Central	Southeast	West South-Central	Mountain	Pacific
Marketings, by origin:								
Calves	15,514	1,960	2,679	2,348	3,144	3,211	1,287	885
Cattle	30,622	1,062	4,677	11,391	2,967	4,717	3,754	2,054
Total	46,136	3,022	7,356	13,739	6,111	7,928	5,041	2,939
Inshipments, by destination	9,907	188	1,598	4,468	301	961	1,207	1,184
Inshipments, by origin:								
Beef calves born during year	2,768	137	−618	−1,298	1,191	2,159	965	232
Beef calves on hand, Jan. 1	1,598	−179	−115	1,238	−114	747	436	−415
Other steers on hand, Jan. 1	4,495	172	486	1,098	856	726	498	659
Other heifers on hand, Jan. 1	1,046	179	381	36	398	179	−40	−87
Total (net)	9,907	309	134	1,074	2,331	3,811	1,859	389
Marketings of slaughter livestock, by origin:								
Calves	12,746	1,902	2,500	2,272	3,030	1,677	507	858
Cattle	25,017	1,025	4,581	9,238	2,047	3,282	2,851	1,993
Total	37,763	2,927	7,081	11,510	5,077	4,959	3,358	2,851

originating region for the livestock (which, however, may not be the originating region for the slaughter marketings, if the livestock are sold first as feeders and then resold as slaughter livestock later in the year).

A substantial number of cattle, apparently destined for commercial slaughter during 1954 according to the balance sheet data, were misallocated to this category according to the data on commercial slaughter. Though the 1954 estimated commercial slaughter of heifers was 3,763,000 head, an additional 416,000 head of heifers 1-2 years old made up the residual category identified as marketings of heifers slaughtered during 1954. Furthermore, calves on hand Jan. 1, 1954, apparently diverted to commercial slaughter, totaled 2,147,000 head. Estimated commercial slaughter of this class of steers, however, was only 1,598,000 head. In addition, the estimated commercial slaughter of steers included 2,768,000 head of calves born during 1954, but even then, 58,000 head of other calves born during 1954 were unaccounted for in the balance sheet data. The balance sheet estimates of slaughter cattle and calf marketings were reduced accordingly in table 33 on the basis of the reported commercial slaughter of cattle and calves. The data on inshipments of cattle and calves, also shown in table 33, were used to adjust the estimated marketings of slaughter cattle and calves. The 1964 data on marketings of slaughter cattle and calves were obtained in the same manner as were 1954 data.

Marketings of slaughter hogs, lambs and sheep were derived by assuming, first, that the slaughter marketings were distributed among the livestock regions in the same proportion as were total marketings.

Estimating total carcass weight. The data on marketings of slaughter livestock were transformed into equivalent liveweight and carcass weight values by using estimated average weight per head and estimated carcass yield data. The total regional liveweight and carcass weight estimates were adjusted, finally, to the aggregate estimates cited in the preceding chapter.

Functional relationships. A set of regression coefficients, based on an allocation procedure comparable to the general form prescribed in equation 11 is shown in table 34. These regression coefficients were used to derive for each livestock region the predicted inventories and other balance sheet variables which are necessary to derive estimates of marketings of slaughter cattle and calves.

The regional balance sheet estimates were based on a general assumption of interdependence among livestock regions with respect to the specific factors affecting the regional inventories and movements of cattle and calves. Although the effects of the explanatory variables specified in table 34 differed among the seven livestock regions, these effects generally were estimated with a rather high degree of precision for the period covered by the data. As shown by these results, the constant year-to-year increase or decrease in cattle and calf inventories, inshipments, births, marketings, deaths and farm slaughter often represented the largest source of change in these variables.[19]

The prediction equations for pigs saved also are based on the more recent post-World War II data. Because of apparent changes in the structure of the hog-pork economy since 1952, the prediction equations for sows farrowing are based on quite limited information; nevertheless, some critical elements of the existing regional structure of the hog-pork economy are adequately illustrated by these data. The regional prediction equations are summarized in tables 35 and 36. In table 35 are summarized a set of prediction equations for ascertaining the number of sows on hand Jan. 1 which correspond with the regional prediction equations for sows farrowing (table 36).

Projected marketings. The empirical relationships depicting the effects of specified factors on livestock marketings, and the corresponding computational procedures outlined in the discussion of the economic model, were used to prepare the estimated marketings of slaughter cattle, calves

[19] In the first difference formulation, the economic model, the year-to-year change was represented by the value of the constant term, a.

Table 34. Basic balance sheet relationships showing the year-to-year effects of a 1,000-head change in specified variables, by region, 1949-58.[a]

Balance sheet variable	Symbol	Northeast		East North-Central		West North-Central		Southeast		West South-Central		Mountain		Pacific	
		a_{i1}	b_{i1}	a_{i2}	b_{i2}	a_{i3}	b_{i3}	a_{i4}	b_{i4}	a_{i5}	b_{i5}	a_{i6}	b_{i6}	a_{i7}	b_{i7}
Cattle and calves							(1,000 head)								
Cattle and calves on hand, Jan. 1:															
Kept mainly for milk:															
Calves	H_{11}	5.9	.296	6.2	.312	−6.3	.105	9.9	.210	−18.9	.027	−0.4	.008	3.6	.041
Heifers	H_{12}	9.1	.236	3.2	.300	−7.4	.133	7.3	.212	−17.0	.035	−0.2	.021	5.1	.063
Cows	H_{13}	35.7	.124	−12.6	.245	−22.7	.252	37.9	.184	−47.8	.128	−4.5	.028	13.9	.040
Other:															
Calves	H_{21}	−4.9	.013	48.0	.103	36.2	.385	31.7	.104	−96.0	.219	−23.0	.115	8.0	.062
Heifers	H_{22}	1.0	.017	14.4	.058	−12.9	.345	11.0	.168	−10.9	.202	−6.8	.120	4.2	.091
Cows	H_{23}	2.2	.012	15.3	.069	−51.2	.332	89.8	.186	−54.9	.243	−15.3	.111	14.1	.045
Steers, bulls	H_{24}	−4.1	.018	47.1	.092	−28.1	.540	26.1	.075	−25.9	.078	−29.3	.132	14.2	.067
Calves born[b]	B_1	−18.1	.047	−67.0	.115	−48.8	.320	117.8	.151	−22.3	.215	14.4	.102	24.1	.050
Inshipments	I_1	1.5	−.010	87.2	−.066	4.0	.621	−6.6	.011	40.4	.014	−31.6	.228	−94.9	.201
Marketings:															
Calves	M_1	9.4	.086	−87.1	.151	−45.0	.211	94.3	.173	6.8	.253	21.8	.064	−0.2	.061
Cattle	M_2	−9.7	.028	32.0	.157	137.1	.317	−12.8	.126	−128.4	.180	36.2	.086	−54.4	.106
Deaths:															
Calves[c]	D_1	−5.8	−.008	−7.2	.034	−6.1	.025	−2.3	.060	4.9	−.009	−1.1	.046	−1.0	.016
Cattle[d]	D_2	−1.5	.931	−0.6	−.014	0.6	.016	1.7	.008	−0.1	.002	−1.2	.022	−2.4	.019
Farm slaughter:															
Calves[c]	F_1	−2.8	−.006	−8.5	.021	−4.3	.001	−2.0	.018	0.5	.009	−1.7	.004	−3.0	−.015
Cattle[d]	F_2	−0.6	.019	−2.3	.036	−0.7	.018	−4.0	.013	−0.3	.003	−1.2	.006	−0.2	.005
Hogs and pigs															
Sows on hand, Jan. 1	H_{32}	−4.3	.011	16.1	.222	11.9	.551	8.7	.114	−22.6	.074	−7.0	.020	−2.8	.010
Pigs saved:															
Spring	B_{31}	−30.8	.011	89.5	.214	37.0	.589	76.2	.090	−118.5	.066	−37.1	.020	−16.3	.011
Fall	B_{32}	−33.6	.015	41.4	.303	290.7	.416	−81.7	.146	−165.8	.090	−32.2	.017	−18.8	.013
Inshipments	I_3	6.0	−.028	−28.8	.598	23.0	.400	5.2	−.037	0.7	.016	2.2	.001	−8.3	.049
Marketings[e]	M_3	41.9	.926	148.4	.783	241.2	.776	240.6	.688	46.3	.812	16.8	1.019	15.7	.997
Deaths[f]	D_3	2.4	.632	−11.3	.938	7.0	.789	10.8	.975	7.3	.690	0.5	.607	−2.0	.320
Farm slaughter[e]	F_3	−30.7	.122	−80.5	.014	−69.7	.016	−215.3	.122	−59.1	.109	−6.6	.093	−7.4	.082

[a] All coefficients, except those listed below, are based on the 1949-58 relationship between regional and aggregate national levels of the specified variables as specified by equation 11.

[b] Prediction equation of the form, $\Delta\hat{B}_{1rt} = a_{1r} + b_{1r}\Delta \sum_{i=1}^{2} H_{i3rt}$.

[c] Prediction equation of the form, $\Delta\hat{D}_{1rt}$ (or ΔF_{1rt}) $= a_{1r} + b_{1r}\,\Delta \sum_{i=1}^{2} H_{i1rt}$.

[d] Prediction equation of the form, $\Delta\hat{D}_{2rt}$ (or ΔF_{2rt}) $= a_{2r} + b_{2r}\,\Delta \sum_{i=1}^{2}\sum_{j=2}^{4} H_{ijrt}$.

[e] Prediction equation of the form, $\Delta\hat{M}_{3rt}$ (or ΔF_{3rt}) $= a_{3r} + b_{3r}\,\Delta\,(B_{32rt-1} + B_{31rt})$.

[f] Prediction equation of the form, $\Delta\hat{D}_{3rt} = a_{3r} + b_{3r}\,\Delta \sum_{j=1}^{3} H_{3jrt}$.

Table 35. Estimated effects on number of sows on hand Jan. 1 of a 1-unit change in specified variables, by region, 1953-59.

Region	Effect in number of sows on hand, of a 1-unit change in: Hog-corn ratio $\frac{P_{3t-k}}{P_{6t-k}}$	Beef-corn ratio $\frac{P_{2t-k}}{P_{6t-k}}$	Time T	Constant term 1	R^2
Northeast	3.074** (0.706)		−6.087** (0.891)	167.4	0.907
East North-Central	19.069 (11.200)	−32.990 (11.000)		2,828.6	0.608
West North-Central	103.146** (12.555)		−96.398** (13.323)	3,244.0	0.933
Southeast	9.120 (7.310)		54.182** (9.230)	899.2	0.915
West South-Central	6.992 (3.605)	2.272 (2.820)		197.3	0.578
Mountain	1.688* (0.525)		2.630** (0.662)	54.0	0.905
Pacific	1.779** (0.247)		−0.911* (0.311)	79.9	0.913

* Significantly different from zero at the 0.05 probability level.
** Significantly different from zero at the 0.01 probability level.

and hogs (table 37). Next, estimated average weight and yield data were employed to obtain the estimated total carcass weight of the marketings of slaughter livestock.

Commercial Slaughter

Aggregate Slaughter

Once the live price effects of predetermined demand factors (such as the quantity of commercial supplies available for civilian consumption and disposable incomes) were ascertained, the predicted prices could be related to prospective livestock marketings and slaughter. To ascertain the effect of changes in market prices in future livestock slaughter, however, three additional equations—one each for calves, cattle and hogs—were derived from 1949-60 data.

Given the explanatory variables for the commercial slaughter equations and given the average weight per head, the total liveweight of commercial livestock slaughter was obtained by multiplying the two values. Furthermore, given the meat yield per pound liveweight, the total carcass weight equivalent of commercial livestock slaughter was available to enter in the balance sheets showing specified meat production and disposition. To derive the average weight, annual data covering the 1949-58 period were used.

Regional Slaughter

Two different procedures were used to derive prospective regional levels of commercial livestock slaughter. First, historical (i.e., 1949-58) relationships were used to allocate the projected change in aggregate livestock slaughter among the seven livestock regions. A set of regional slaughter livestock demand relationships and a ratio method of regional allocation were available to obtain the regional estimates of commercial slaughter. Second, the spatial equilibrum solutions presented later in this report each have a set of equilibrium regional levels of livestock slaughter. In this section, however, the results of only the first of the two procedures are presented.

The ratio method used to estimate prospective regional levels of livestock slaughter involved an algebraic model of the form illustrated by equation 11. In this equation, the sum of the regression coefficients depicting the relationships between regional slaughter and aggregate slaughter equals unity for each livestock species. The values of these regression coefficients, based on 1949-58 data, are summarized in table 38.

The alternative procedure involved the estimation of quantity-price and other functional relationships for each region. These relationships depict essentially the demand structure for slaughter calves, cattle and hogs at the point of slaughter. Hence, market conditions, such as plant capacity

Table 37. Estimated marketings of slaughter cattle, calves and hogs, in 1,000 head, by regions, 1954 and projected 1964.

Region	Cattle 1954	Cattle 1964	Calves 1954	Calves 1964	Hogs 1954	Hogs 1964
Northeast	1,025	1,065	1,902	1,600	1,284	1,334
East North-Central	4,581	5,538	2,500	1,437	21,400	30,623
West North-Central	9,238	10,990	2,272	1,003	32,501	44,180
Southeast	2,047	2,508	3,030	3,015	6,672	12,429
West South-Central	3,282	2,571	1,677	1,289	1,712	1,087
Mountain	2,851	3,545	507	425	549	462
Pacific	1,993	2,114	858	730	710	907
Total	25,017	28,331	12,746	10,099	64,828	91,022

Table 36. Estimated effect on number of sows farrowing of a 1-unit change in specified variables by region, spring and fall, 1953-59.

Region	Spring (Dec.-May) Sows on hand H_{32rt}	Time T	Constant term 1	R^2	Fall (June-Nov.) Sows farrowing S_{3rt}	Hog-corn ratio $\left\{\frac{P_{3it}}{P_{6it}}\right\}$	Time T	Constant term 1	R^2
					(1,000 head)				
Northeast	0.887** (0.078)	−0.416 (0.281)	2.2	0.990	0.638 (0.412)	0.832 (0.572)	0.136 (1.279)	17.1	0.810
East North-Central	0.840** (0.086)	−1.778 (2.295)	192.2	0.959	1.127** (0.155)	22.657** (3.572)	13.796** (3.491)	−1,278.8	0.916
West North-Central	0.985** (0.118)	2.400 (8.197)	−365.5	0.968	0.552** (0.164)	21.868 (1.508)	41.136** (11.136)	−869.1	0.778
Southeast	0.902** (0.041)	0.755 (0.770)	−41.9	0.988	0.813** (0.136)	10.344 (4.987)	−4.062 (2.330)	−64.1	0.893
West South-Central	0.921** (0.038)	1.364 (0.667)	−47.4	0.996	0.868** (0.171)	7.435 (2.289)	0.201 (2.574)	−95.7	0.931
Mountain	0.849** (0.042)	0.144 (0.224)	2.1	0.995	0.614** (0.071)	0.982* (0.388)	0.368 (0.316)	−8.7	0.974
Pacific	0.945** (0.119)	0.231 (0.288)	−14.4	0.973	0.896** (0.109)	1.031** (0.282)	0.527 (0.234)	−27.3	0.966

* Significantly different from zero at the 0.05 probability level.
** Significantly different from zero at the 0.01 probability level.

Table 38. Proportional contribution of specified regions to total change in liveweight commercial slaughter of livestock in the United States, 1949-58.[a]

Region	Calves		Cattle		Hogs	
	Constant term a_{1r}	Regression coefficient b_{1r}	Constant term a_{2r}	Regression coefficient b_{2r}	Constant term a_{3r}	Regression coefficient b_{3r}
Northeast	−4.3	0.057	13.5	0.155	−19.0	0.088
East North-Central	−51.3	0.215	−3.0	0.290	−167.6	0.240
West North-Central	66.1	0.311	−53.8	0.165	112.9	0.410
Southeast	−21.9	0.128	22.3	0.119	244.8	0.099
West South-Central	−61.7	0.137	13.2	0.167	−92.3	0.065
Mountain	49.3	0.047	−0.8	0.019	−1.9	0.027
Pacific	23.8	0.104	8.6	0.085	−60.3	0.056

[a] The constant term, a_{ir}, denotes a constant year-to-year change in regional slaughter, while the regression coefficient, b_{ir}, denotes the change in regional slaughter associated with a 1-unit change in total U. S. slaughter.

or procurement practices among competing packers, would affect the values of the quantity-price coefficients and possibly would distort their comparable values at the retail market or consumer level in the distribution process. The estimated values of the slaughter demand relationships are summarized in tables 39, 40 and 41.

The algebraic model used to derive slaughter demand coefficients was of the form,

$$\hat{C}_{irt} = a_{ir} + \sum_{j=1}^{3} b_{ijr}P_{jt} + c_{i1r}\Delta Y_t + c_{i2r}T,$$

$$(i, j = 1, 2, 3) \qquad (14)$$

where C_{irt} = total commercial slaughter of calves (i = 1), cattle (i = 2), or hogs (i = 3) in thousands of head, in the r-th region during the t-th year.

P_{1t} = average live price in cents per pound liveweight of U. S. Choice and Prime grades of vealer calves at Chicago during the t-th year.

P_{2t} = average live price in cents per pound liveweight of U. S. Choice grade beef steers at selected markets during the t-th year.

Table 39. Effect on number of calves slaughtered commercially of a 1-unit change in specified variables, by regions, 1949-58.

Region	Effect on number slaughtered of a 1-unit change in:				
	Vealer price P'_{2t}	Disposable income ΔI_t	Time T	Constant term 1	R^2
		(1,000 head)			
Northeast	−48.2** (11.2)	3.1 (8.6)	−25.2 (20.1)	3,879.6	0.78
East North-Central	−85.8** (14.7)	5.8 (11.4)	−7.7 (26.5)	4,956.4	0.89
West North-Central	−54.9** (5.3)	−0.3 (4.1)	−6.9 (9.5)	3,032.7	0.96
Southeast	−34.1** (6.0)	6.4 (4.6)	21.7 (10.8)	1,718.0	0.92
West South-Central	−54.9** (7.1)	6.2 (5.5)	−13.4 (12.8)	2,560.5	0.93
Mountain	−6.8** (0.6)	0.6 (0.5)	−5.0** (1.1)	281.0	0.96
Pacific	−26.8** (4.7)	1.0 (3.6)	−0.1 (8.4)	1,266.0	0.89
United States	−311.4** (38.3)	22.8 (29.6)	−98.7 (68.8)	17,784.1	0.93

** Significantly different from zero at the 0.01 probability level.

Table 40. Effect on number of cattle slaughtered commercially of a 1-unit change in specified variables by regions, 1949-58.

Region	Effect on number slaughtered of a 1-unit change in:					
	Cattle price P_{2t}	Hog price P_{3t}	Disposable income ΔI_t	Time T	Constant term 1	R^2
			(1,000 head)			
Northeast	−32.9* (12.5)	15.2 (19.4)	10.1 (8.1)	46.9* (19.1)	2,312.2	0.87
East North-Central	−122.4** (17.1)	33.0 (26.6)	16.0 (11.1)	95.0** (23.5)	7,013.1	0.97
West North-Central	−193.6** (18.4)	24.7 (28.6)	9.5 (12.0)	187.6** (25.2)	10,542.0	0.99
Southeast	−71.8 (19.7)	20.2 (30.7)	14.1 (12.2)	109.5** (27.1)	2,873.1	0.93
West South-Central	−79.5* (27.0)	17.5 (42.0)	17.1 (17.6)	58.0 (37.1)	3,326.0	0.84
Mountain	−28.6** (7.3)	−1.6 (9.8)	3.3 (4.1)	79.4** (8.7)	1,570.2	0.98
Pacific	−64.0* (22.9)	2.8 (35.7)	13.8 (14.9)	87.3* (31.5)	3,691.1	0.88
United States	−592.7** (103.3)	111.9 (160.8)	83.9 (67.3)	663.7** (141.8)	31,327.6	0.96

* Significantly different from zero at the 0.05 probability level.
** Significantly different from zero at the 0.01 probablity level.

Table 41. Effect on number of hogs slaughtered commercially of a 1-unit change in specified variables, by regions, 1949-58.

Region	Effect on number slaughtered of a 1-unit change in:					
	Cattle price P_{2t}	Hog price P_{3t}	Disposable income ΔI_t	Time T	Constant term 1	R^2
			(1,000 head)			
Northeast	58.6 (32.4)	−106.9 (50.4)	19.3 (21.1)	59.4 (44.5)	7,685.0	0.72
East North-Central	225.3* (70.8)	−263.9 (110.3)	54.8 (46.1)	72.5 (97.3)	16,907.6	0.83
West North-Central	259.0* (77.7)	−591.1** (120.9)	65.2 (50.6)	292.0* (106.7)	30,629.6	0.91
Southeast	95.8 (45.2)	−100.7 (70.4)	24.1 (29.4)	379.3** (62.1)	4,977.2	0.91
West South-Central	57.8* (22.3)	−88.4 (34.7)	9.7 (14.5)	21.0 (30.6)	2,869.5	0.77
Mountain	23.1** (4.5)	−31.7** (7.1)	4.0 (3.0)	−1.8 (6.2)	1,461.2	0.93
Pacific	44.1 (18.5)	−99.1** (28.8)	12.1 (12.1)	−20.0 (25.4)	3,818.5	0.84
United States	763.7* (238.4)	−1,281.9* (371.1)	189.2 (155.3)	802.4 (327.4)	68,348.7	0.87

* Significantly different from zero at the 0.05 probability level.
** Significantly different from zero at the 0.01 probability level.

P_{3t} = average live price in cents per pound of 200-220 pound barrows and gilts at Chicago during the t-th year.

ΔI_t = year-to-year change in total disposable personal income in the United States, in billions of dollars, during the t-th year.

T = time, beginning calendar year 1949 with T = 1.

PROSPECTIVE REGIONAL POPULATION, INCOME AND CONSUMPTION

Regional population and income projections along with regional meat demand relationships were used to derive the estimated 1954 and projected 1964 consumption of beef, veal, pork and lamb and mutton. These estimates are based largely on aggregative data prepared by the U. S. departments of commerce and agriculture. In the case of population and income estimates, a rather simple procedure was used to allocate the projected changes for the United States (from 1959 to 1964) among the seven livestock regions. The regional estimates of future meat consumption, however, are based on more involved procedures because of the additional demand effects of prospective differences in regional price relationships for each of the major meat items. All regional projections are confined to the period from 1961 to 1964 because of the additional difficulties involved in the preparation of the more detailed long-range projections.

Population

The use of a ratio estimation procedure of the form,

$$\log \hat{H}_{rt} = \log a_r + b_r \log \left(\sum_{r=1}^{7} H_{rt} \right), \qquad (15)$$

where H_{rt} is the total civilian population in the r-th region on July 1 of the t-th year, resulted in a satisfactory set of regional population projections.[20] The total population projections, $\sum_{r=1}^{7} H_{rt}$, were the Series II population projections prepared by the U. S. Bureau of the Census. To the regional estimates were added the 1959 regional estimates of military population. Thus, the projected total regional population was obtained for the 1964 calendar year. In table 42, the projected regional populations are compared with the 1954 reported regional populations.

Income

Since one of the factors accounting for regional differences in per-capita meat consumption is disposable personal income, this variable was projected also for each of the seven livestock regions. Though the ratio method cited earlier was used also in estimating the future regional incomes, further manipulation of the data was necessary to establish a consistent set of estimates, as shown in table 43.

First, the ratio method was used to obtain the projected per-capita personal income for each region. Each of these estimates was multiplied by the 1955 (for 1954 estimates) or the 1959 (for 1964 estimates) ratio of disposable income to total personal income for each region. The regional per-capita disposable income was then multiplied by the regional population and aggregated to obtain an initial estimate of total disposable personal income for the region. These regional totals were adjusted to the projected total disposable income cited earlier. The adjusted total regional income for each region was divided by the total regional population to obtain the per-capita personal income cited in table 43.

Table 42. Civilian, military and total population in specified regions, 1954 and projected 1964.

Region	1954			Projected 1964		
	Civilian	Military	Total	Civilian	Military[a]	Total[b]
			(1,000,000)			
Northeast	45.0	0.4	45.4	50.1	0.3	50.5
East North-Central	33.0	0.1	33.1	40.3	0.1	40.3
West North-Central	14.5	0.1	14.6	16.0	0.1	16.1
Southeast	29.8	0.7	30.5	35.3	0.5	35.9
West South-Central	14.9	0.3	15.2	17.6	0.2	17.8
Mountain	5.6	0.1	5.7	7.7	0.1	7.8
Pacific	16.3	0.4	16.7	22.5	0.4	22.9
Total	159.1	2.1	161.2	189.6	1.7	191.3

[a] Assumed 1959 military population.
[b] Adjusted to U. S. Census population forecasts for 1965, Series II.

Table 43. Total and per person disposable personal income in specified regions, 1954 and projected 1964.

Region	1954		Projected 1964[a]	
	Total	Per person	Total	Per person
	(billion dollars)	(dollars)	(billion dollars)	(dollars)
Northeast	80.5	1,786	121.4	2,404
East North-Central	57.2	1,741	90.4	2,238
West North-Central	32.6	1,491	30.2	1,876
Southeast	34.2	1,134	53.3	1,489
West South-Central	19.9	1,314	30.3	1,702
Mountain	8.2	1,464	14.9	1,910
Pacific	30.9	1,861	57.0	2,489
Total	263.5	1,582	397.5	2,078

[a] Based on 1959 Consumers' Price Index of 124.6.

Meat Consumption

Regional meat consumption estimates were derived from both cross-sectional and time-series data. These data were used first to derive the regression coefficients, a_{ir}, b_{ijr} and c_{ijr} represented in the functional expression,

$$\hat{Q}_{irt} = a_{ir} + \sum_j b_{ijr} P_{jrt} + c_{i1r} I_{rt} + c_{i2r} T, \qquad (16)$$

where Q_{irt} = quantity of i-th item in pounds carcass weight consumed per capita in the r-th region during the t-th year.

[20] For studies using national projections primarily to forecast state or regional populations, see: Margaret J. Hagood and J. S. Siegel. Projections of the regional distribution of the population of the United States in 1975. Agr. Econ. Res. 3:41-52, 1951; Helen L. White and J. S. Siegel. Projections of the population in states, 1955 and 1965. Current Population Reports, Population Estimates, Series P-25, No. 56. U. S. Bureau of the Census, Washington, D. C. Jan. 27, 1952.

P_{jrt} = price in cents per pound of the j-th item consumed in the r-th region during the t-th time period.

I_{rt} = disposable personal income per capita in the r-th region during the t-th time period.

T = time, or the t-th year, numbered consecutively, starting with t = 1 for 1949.

In this expression, a_{ir} represents a constant term (which later is adjusted to account for regional differentials in the level of demand for the i-th meat item). The regression coefficient b_{ijr} denotes either an own-price effect (when i = j) or a cross-price effect (when i ≠ j) whereby a 1-unit change in the j-th price is associated with a b_{ij}-unit change in the i-th quantity demanded. Finally, c_{i1r} and c_{i2r} represent the effects of disposable income, I_{rt}, and time, T, on the quantity demanded.

Derivation of Functional Relationships

The method of least squares was used in the derivation of the aggregate demand relationships for beef, veal, pork, lamb and mutton, all meat and poultry. (The last two relationships are included to show the effects of specified price changes on total red meat and poultry consumption.) Since the linear programming procedure used later in this study requires data which are linear in the variables, the empirical approach in this study depends almost entirely on the use of arithmetic, rather than logarithmic, models of consumer demand and of marketing-clearing operations.

As suggested earlier, the four basic sets of demand relationships used later in this study describe the effects of a 1-unit change in a specified price, income or time variable on the per-capita consumption of beef, veal, pork, lamb and mutton in the United States as a whole. Later these relationships are modified to show regional consumption relationships. The aggregate demand relationships, however, are based on time-series data covering the entire United States and representing average annual levels of relevant demand factors over a 10-year period, 1949-58. The regression coefficients and their standard errors, which are shown in parentheses, are as follows:

$$\Delta\hat{Q}_{1t} = -0.535 - \underset{(0.030)}{0.153^{**}}\Delta P_{1t} + \underset{(0.005)}{0.010}\Delta I_t, \qquad R^2 = 0.807 \qquad (17.1)$$

$$\Delta\hat{Q}_{2t} = 0.188 - \underset{(0.151)}{0.939^{**}}\Delta P_{2t} + \underset{(0.207)}{0.258}\Delta P_{3t} - \underset{(0.351)}{0.048}\Delta P_{7t} + \underset{(0.023)}{0.050}\Delta I_t, \qquad R^2 = 0.914 \qquad (17.2)$$

$$\Delta\hat{Q}_{3t} = -0.279 + \underset{(0.069)}{0.332^{**}}\Delta P_{2t} - \underset{(0.094)}{0.798^{**}}\Delta P_{3t} + \underset{(0.159)}{0.186}\Delta P_{7t} + \underset{(0.010)}{0.008}\Delta I_t, \qquad R^2 = 0.963 \qquad (17.3)$$

$$\Delta\hat{Q}_{4t} = -0.105 - \underset{(0.014)}{0.132^{**}}\Delta P_{4t} - \underset{(0.001)}{0.001}\Delta I_t, \qquad R^2 = 0.936 \qquad (17.4)$$

$$\Delta\hat{Q}_{5t} = -0.730 - \underset{(0.148)}{0.785^{**}}\Delta P_{5t} + \underset{(0.377)}{0.106}\Delta P_{7t} + \underset{(0.025)}{0.062^{*}}\Delta I_t \qquad R^2 = 0.898 \qquad (17.5)$$

$$\Delta\hat{Q}_{7t} = 0.696 + \underset{(1.000)}{2.168}\Delta P_{5t} - \underset{(0.118)}{0.408^{*}}\Delta P_{7t} + \underset{(0.008)}{0.011}\Delta I_t, \qquad R^2 = 0.810 \qquad (17.6)$$

where ΔQ_{1t} = year-to-year change in civilian per-capita consumption from commercial supplies of veal, in pounds of carcass weight.

ΔQ_{2t} = year-to-year change in civilian per-capita consumption from commercial supplies of beef, in pounds carcass weight.

ΔQ_{3t} = year-to-year change in civilian per-capita consumption from commercial supplies of pork, in pounds carcass weight.

ΔQ_{4t} = year-to-year change in civilian per-capita consumption from commercial supplies of lamb and mutton, in pounds carcass weight.

ΔQ_{5t} = year-to-year change in civilian per-capita consumption from commercial supplies of red meat, in pounds carcass weight.

ΔQ_{7t} = year-to-year change in civilian per-capita consumption from total supplies of chicken and turkey, in pounds of equivalent ready-to-cook weight.

ΔP_{1t} = year-to-year change in average retail price, in cents per pound carcass weight equivalent, of U. S. Prime and Choice grade veal (divided by Consumers' Price Index).

ΔP_{2t} = year-to-year change in average retail price, in cents per pound carcass weight equivalent, of U. S. Choice grade beef (divided by Consumers' Price Index).

ΔP_{3t} = year-to-year change in average retail price, in cents per pound carcass weight equivalent, of major pork cuts (divided by Consumers' Price Index).

ΔP_{4t} = year-to-year change in average retail price, in cents per pound carcass weight equivalent, of U. S. Choice lamb (divided by Consumers' Price Index).

ΔP_{5t} = year-to-year change in index of retail cost of meat products (1947-49 = 100).

ΔP_{7t} = year-to-year change in average retail price, in cents per pound retail weight, of ready-to-cook frying chickens (divided by Consumers' Price Index).

ΔI_t = year-to-year change in average per-capita disposable personal income in dollars (divided by Consumers' Price Index).

Each of the variables represents an estimated average value of an item for the entire United States. Because of computational difficulties introduced by high intercorrelation among several series, first differences of the estimated average values were used in the derivation of the regression coefficients.

The national data were modified to account for regional differences in meat consumption by using the published reports on the 1955 Survey of Household Food Consumption.[21] These regional differences in meat consumption combined a number of factors which were not included explicitly in the derivation of the modified demand relationships but which presumably were related to regional income differences. Hence, interregional differences in per-capita consumption were estimated on the basis of per-capita income differences among the livestock regions comprising any one census region.

Regional Consumption Estimates

Specifically, the regional consumption estimates for 1954 and 1964 were derived from the 1955 survey data and the projected national consumption by use of an adjustment procedure based on the expression,

$$\hat{Q}_{irs} = Q_{ir} + E_{ir}\left(\frac{Q_{ir}}{I_r}\right)(I_{rs} - I_r), \qquad (18)$$

where Q_{irs} = quantity consumed per person of the i-th item in the r-th census region ($r = 1, \ldots, 4$) and s-th subregion ($s = 1, 2$),

Q_{ir} = quantity consumed per person of the i-th item in the r-th census region,

I_{rs} = disposable personal income per person in the r-th census region and s-th subregion,

I_r = disposable personal income per person in the r-th census region,

E_{ir} = estimated intratemporal income effect on quantity consumed (derived from 1955 survey data) showing the percentage change in pounds of meat per person associated with a 1-percent change in disposable income.[22]

The regional consumption projections for 1964 are based on a different procedure. (See table 44.) First, data on slaughter weight of livestock production in the United States served as the basis for a derived carcass weight equivalent of commercial slaughter. Farm slaughter was deducted from the production estimates to obtain the total liveweight of commercial slaughter. These totals were multiplied by carcass yield ratios to obtain commercial slaughter in carcass weight equivalent production. Then, net exports and military use were subtracted from the total commercial meat production. Estimates of beginning and ending stocks were based on their quantitative relation to commercial production during the 1949-60 period. Similarly, the estimates of exports and imports were based on historical relationships. Projected military utilization of meat was prescribed at the 1959 levels (which is consistent with the procedure for estimating the 1964 civilian population). The remainder, which represents the commercially produced meat available for civilian consumption in the United States, was divided by the civilian population. Regional per-capita consumption estimates were derived, finally, by using the procedure specified in equation 15.

PROSPECTIVE MARKETING COSTS

Locational patterns in livestock slaughtering are related primarily to the geography of livestock production and secondarily to the geography of population and consumer markets—provided, of course, that transfer costs for livestock and meat correspond with the costs of providing the transfer services. Among transfer services are included the gamut of activities involved in transforming the livestock into marketable meat products. Hence, differences in transfer costs occur because of regional differences in livestock procurement costs, slaughtering and processing costs and distribution costs. Transportation expenses contribute to both procurement and distribution costs. Although the transportation charges per unit of livestock or meat product are small, in the aggregate they are substantial. Moreover, the total

[21] U. S. Dept. Agr. 1955 household food consumption survey. Reports No. 1-5. U. S. Gov't. Print. Off., Washington, D. C. 1957.

[22] The theoretical basis for this procedure was presented in Wold and Jureen, while an empirical application has been presented in the Minnesota study on domestic food and fiber demand expansion. See: John A. Whetmore, Martin E. Abel, Elmer W. Learn and Willard W. Cochrane. Policies for expanding the demand for farm products in the United States. Part I. History and potentials. Minn. Agr. Exp. Sta. Tech. Bul. 231. 1959.

Table 44. Estimated regional consumption per person of specified meat products, 1954 and projected 1964.

Region	Beef		Veal		Pork	
	1954	1964	1954	1964	1954	1964
Northeast	90.2	89.2	16.4	9.6	49.9	59.0
East North-Central	100.4	97.3	9.8	5.6	58.7	68.0
West North-Central	96.3	92.6	9.5	5.4	57.2	66.0
Southeast	55.9	56.3	5.2	3.1	54.4	62.1
West South-Central	59.6	59.7	5.5	3.2	55.1	62.8
Mountain	101.3	99.5	9.3	5.4	49.5	59.2
Pacific	108.7	107.6	10.0	5.9	53.0	63.9
Average	82.3	84.9	10.0	6.0	54.1	63.0

transportation bill can be reduced by optimal location with respect to livestock supplies and consumer markets.

Aggregate Cost Structure

Total costs per pound of meat processed included transportation costs and the costs incurred in the related procurement, processing and merchandising activities. To ascertain the aggregate cost structure for beef and pork, market price relationships were derived for each of three levels in the marketing system—primary, wholesale and retail.

Aggregate retail price relationships were derived from the consumer demand equations cited earlier. The beef and pork equations were solved simultaneously to obtain a new set of equations with retail price as the dependent variable and with per-capita consumption as explanatory variables. The equivalent retail price equations for beef and pork, respectively, were as follows:

$$\hat{P}^{r}_{2t} = 72.197 - 1.202Q_{2t} - 0.388Q_{3t} + 0.015P_{7t} + 0.063I_t + 0.118T, \quad (18.1)$$

$$\hat{P}^{r}_{3t} = 110.588 - 0.500Q_{2t} - 1.414Q_{3t} + 0.239P_{7t} + 0.036I_t - 0.300T \quad (18.2)$$

where each of the variables are described as in equations 17.1 to 17.6, except for change from year-to-year differences to absolute levels of each variable.

The vertical price structure was obtained on an annual basis from the retail price data by use of two sets of marketing margin relationships—retailing and wholesaling—and the by-product relations. Changes in the retailing margins, M_{21t} and M_{31t}, were associated with changes in retail prices, while changes in the wholesaling margins, M_{22t} and M_{32t}, and changes in the by-product credits, M_{23t} and M_{33t}, were associated with changes in wholesale values of the beef cattle and hog carcasses. The vertical price relationships were as follows:

Retailing margins:

$$\hat{M}_{21t} = 3.652 + \underset{(0.034)}{0.094{*}P^{r}_{2t}} + \underset{(0.043)}{0.219{**}T},$$

$$R^2 = 0.791 \quad (19.1)$$

$$\hat{M}_{31t} = 5.598 - \underset{(0.047)}{0.026P^{r}_{3t}} + \underset{(0.026)}{0.090{*}T},$$

$$R^2 = 0.721 \quad (19.2)$$

Wholesaling margins:

$$\hat{M}_{22t} = 3.953 - \underset{(0.018)}{0.058{*}P^{w}_{2t}} - \underset{(0.024)}{0.073{*}T},$$

$$R^2 = 0.613 \quad (20.1)$$

$$\hat{M}_{32t} = 3.944 + \underset{(0.012)}{0.037{*}\Delta Q_{3t}} + \underset{(0.020)}{0.086{**}T},$$

$$R^2 = 0.798 \quad (20.2)$$

By-product credits:

$$\hat{M}_{23t} = -0.314 + \underset{(0.036)}{0.122{*}P^{w}_{2t}} - \underset{(0.047)}{0.059T},$$

$$R^2 = 0.856 \quad (21.1)$$

$$\hat{M}_{33t} = -0.294 + \underset{(0.087)}{0.189P^{w}_{3t}} - \underset{(0.054)}{0.037T},$$

$$R^2 = 0.605 \quad (21.2)$$

where M_{21t} = average price spread between retail value and wholesale value in cents per pound liveweight equivalent of U. S. Choice grade beef during t-th year (divided by Consumers' Price Index, 1947-49 = 100).

M_{31t} = average price spread between retail value and wholesale value in cents per pound equivalent of major pork cuts during t-th year (divided by Consumers' Price Index).

M_{22t} = average price spread between wholesale carcass value and primary market value per pound liveweight equivalent of U. S. Choice grade beef steers during t-th year (divided by Consumers' Price Index).

M_{32t} = average price spread between wholesale carcass value and primary market value per pound liveweight of 200-220 barrows and gilts at Chicago during t-th year (divided by Consumers' Price Index).

M_{23t} = average value per pound liveweight of by-product credits for beef-steer carcasses during t-th year (divided by Consumers' Price Index).

M_{33t} = average value per pound liveweight of lard, minor pork cuts and other by-product credits for hog carcasses during t-th year (divided by Consumers' Price Index).

P^{w}_{2t} = average value in cents per pound liveweight equivalent of U. S. Choice grade beef-steer carcasses during t-th year (divided by Consumers' Price Index).

P^{w}_{3t} = average wholesale value in cents per pound of major pork cuts at Chicago during t-th year (divided by Consumers' Price Index).

Other variables included in the six equations are described under equation 17.6 (without the superscripts, however).

When the marketing margin and by-product relations were transformed into an equivalent set of equations based entirely on retail prices rather than wholesale prices, for three of the relations—beef wholesaling and both beef and pork by-product credits — the estimation of wholesale prices was not involved; hence, the vertical price structure was obtained directly from the available data on retail prices and civilian consumption from commercial supplies. Multiplication of the retail price relations, equations 18.1 and 18.2, by

0.59 for beef and $\frac{1}{2.13}$ for pork converted these data to their equivalent liveweight basis for use in the marketing margins equation.

Regional Price Structure

To derive the vertical price structure, the estimated marketing margins and by-product credits were added to the estimated primary market prices for each livestock class. The wholesale margin, less the transportation cost per pound of beef steers, was assumed constant for all regions in any one year. The retailing margin, less the transportation cost per pound of beef steer carcass, also was assumed constant for all regions in any one year. Similarly, the unit value of by-product credits was equal to the average value for the United States. Therefore, average retail meat prices for any region were equal to the average live price of the specified market class of livestock plus the average live-to-wholesale and wholesale-to-retail price spreads and the average by-product credits. The derivation of a set of vertical market price relationships for beef and pork based on the various price equations is illustrated in table 45.

IMPLICATIONS OF PROSPECTIVE SHIFTS IN LIVESTOCK SLAUGHTER

Because of changes in the spatial patterns of livestock production, meat consumption and distribution costs, significant changes in the regional location of livestock and interregional pattern of livestock and meat movements can be expected to occur in the 1960's. By 1964, the effects on the livestock and meat industries of some of these changes will become more apparent as measured by the number and size of meat packing establishments in different regions of the United States. To illustrate the direction and magnitude of these changes, projected 1964 data are presented showing (1) the regional location of commercial livestock slaughter, (2) the interregional patterns of livestock and meat shipments and (3) selected industry characteristics.

Commercial Slaughter

Regional estimates of livestock slaughter for 1964 were prepared from the data cited earlier. Two approaches were involved in the development of these data; namely, a regional market-shares approach and a regional livestock-demand approach.

Table 45. Market prices and costs per pound liveweight and carcass weight of beef and pork production in the United States, 1954 and projected 1964.[a]

Item	Beef		Pork	
	1954	Projected 1964	1954	Projected 1964
	(cents)			
Live value	23.70	27.58	23.48	12.63
Plus: Wholesaling margin	2.61	1.93	5.04	6.76
Wholesale value (A)	26.31	29.51	28.52	19.44
Less: By-product credits	2.10	2.09	4.45	1.62
Wholesale value (B)	41.03	46.47	51.21	37.96
Plus: Retailing margin	13.77	21.36	13.34	18.34
Retail value	54.80	67.83	64.55	56.30

[a] Live value, wholesaling margin, wholesale values (A) and by-product credits are on a liveweight basis, while wholesale value (B), retailing margin and retail values are on a carcass weight basis.

Regional Market Shares

The projected regional market shares represent the results of the prediction procedure specified in equation 11. This procedure was based on the assumption that year-to-year changes in a region's livestock slaughter are dependent upon two major phenomena—the gradual increase or decrease in the relative importance of the region in aggregate livestock slaughter and the more rapidly changing results of the forces of competition responding to year-to-year changes in livestock supplies. These two sources of change, as described by the constant term and the regression coefficient, respectively, in equation 11, were measured generally with a rather high degree of precision for the 1949-58 period. Whether or not the historical relationships are stable enough over time to adequately predict the 1964 regional market shares is a question that eludes statistical tests of significance. The credibility of projected 1964 data on livestock slaughter, which are based on the regional market shares approach, can be examined qualitatively at least by using the alternative analytical approach.

Regional Livestock Demand

The alternative approach used to estimate regional livestock slaughter for future periods is based on the regression relationships listed in tables 38-41. According to these regression relationships, the quantity of regional livestock slaughter is dependent upon the price of livestock (including both the average price for the specified livestock class and the average price for a competing livestock class), year-to-year change in total disposable income and time. The price and income variables are the same for each of the regional prediction equations. Because market competition differs among the regions, and because of regional difference in livestock supplies and meat demands, the price and income effects on slaughter differ among regions.

Summary

Regional estimates of livestock slaughter for 1964, based on the two approaches, are cited in table 46. According to these data, the relative position of the West North-Central region, the Southeast and the Mountain region in total commercial slaughter will increase in importance by 1964 largely because of the percentage decline in livestock slaughter in the Northeast, the East North-Central region and the West South-Central region. Though substantial differences in regional slaughter estimates are revealed in the estimates based on the two approaches, as shown in table 46, these differences occur mostly between the West North-Central region and the two southern regions. The findings pertaining to the West South-Central region particularly, should be used cautiously in evaluating prospective shifts in the location of livestock slaughter. From an em-

Table 46. Estimated liveweight commercial slaughter of cattle, calves and hogs, in millions of pounds, by region, 1954 and 1964.[a]

Region	Cattle			Calves			Hogs		
		Projected 1964			Projected 1964			Projected 1964	
	Reported 1954	Market shares	Livestock demand	Reported 1954	Market shares	Livestock demand	Reported 1954	Market shares	Livestock demand
Northeast	2,441	2,552	2,757	429	360	314	1,607	2,034	2,058
East North-Central	5,331	5,601	5,580	601	435	476	4,204	5,180	5,332
West North-Central	7,395	9,475	8,375	409	106	249	6,650	9,250	8,786
Southeast	1,881	2,161	2,536	382	424	440	1,558	2,973	3,062
West South-Central	1,912	1,546	1,850	750	652	536	597	776	954
Mountain	1,316	1,992	2,032	50	20	1	303	454	419
Pacific	2,882	3,293	3,490	190	134	115	634	779	835
Total	23,158	26,620	26,620	2,811	2,131	2,131	15,554	21,446	21,446

[a] Based on projected 1964 average weight of livestock slaughter. Also, estimates based on the regional livestock-demand approach were adjusted to the total 1964 commercial slaughter estimates used in the regional market-shares approach.

piricai standpoint, however, the market-shares approach is the more reliable; hence, this approach was given precedence over the statistically less reliable livestock-demand approach.

Interregional Shipments

To evaluate the implications of the projected shifts in livestock slaughter, the linear programming procedures cited earlier in this report were used in a normative manner. First, the least-cost pattern of livestock and meat shipments for 1954 was ascertained. Later, projected 1964 patterns of livestock and meat shipments were obtained under different assumptions regarding transportation cost structures.

Derived 1954 Patterns

The net surplus or deficit position of each region was ascertained from the basic data on slaughter marketings, commercial production and civilian consumption. According to these data, the relative importance of cattle slaughter exceeds marketings in the Northeast, the East North-Central region and the Pacific region, while the relative importance of beef consumption exceeds cattle slaughter in the Northeast, the East North-Central region, the Southeast and the Pacific region. For calves and veal and also for hogs and pork, a pattern of international trade somewhat different from that for cattle and beef emerges from these data. The relative 1954 position of each region in livestock slaughter is summarized in table 47.

The interregional pattern of cattle shipments, as a percentage of total commercial slaughter in the United States, is summarized in table 48. Because of transportation economies, the West North-Central region exported slaughter cattle to both the Northeast and the East North-Central regions.

Table 47. Percentage distribution of livestock slaughter by regions, 1954.

Region	Cattle	Calves	Hogs
Northeast	10.5	15.2	10.3
East North-Central	23.0	21.4	27.0
West North-Central	31.9	14.6	42.8
Southeast	8.1	13.6	10.0
West South-Central	8.3	26.7	3.8
Mountain	5.7	1.8	2.0
Pacific	12.5	6.7	4.1
Total	100.0	100.0	100.0

In addition, part of the total cattle slaughter in the Northeast represented marketings of slaughter cattle from the West South-Central and Mountain regions.

As shown in table 49, beef shipments were represented by a pattern somewhat different from that for cattle shipments because of the greatly deficit position of the Northeast with respect to beef production. Moreover, the interregional shipments of beef originated largely from the major surplus-producing area—the West North-Central states.

Slaughter calves originated largely from the West North-Central states and the Southeast, as shown in table 50. Interregional shipments of slaughter calves were rather small, however, representing only 20 percent of total marketings in the United States.

Marked differences occurred in the estimated 1954 pattern of veal shipments when compared with the interregional shipments of slaughter calves. As shown in table 51, the North Central states were surplus in veal shipments while the Mountain states shifted into a slightly deficit position. Interregional trade in veal, according to these data, was substantially greater than interregional trade in slaughter calves. Both sets of data, however, may have considerable error in the regional estimates of slaughter calf marketings and veal consumption. Satisfactory data for estimating these two variables are lacking—a criticism that also can be leveled against the regional estimates of slaughter cattle marketings and beef consumption.

Interregional shipments of hogs and pork were confined entirely to outshipments from the North Central states, as shown in tables 52 and 53. A substantial trade in slaughter hogs occurred between the East North-Central region and the Northeast. The latter region imported, however, slightly less than half of its pork from the West North-Central region.

Projected 1964 Patterns

Changes in patterns of net interregional movements in slaughter livestock and meat are contingent upon changes in the relative distribution of livestock slaughter (see table 54). These data, when compared with the data for 1954 in table 47, reveal a shift in livestock marketings and slaugh-

Table 48. Estimated percentage distribution of least-cost shipments of cattle from surplus-producing regions, 1954.

Destination region	Farm production	Originating region of shipments					Commercial slaughter
		West North-Central	West South-Central	Southeast	Mountain	Total	
Northeast	5.0	2.7	0.9	....	1.9	5.5	10.5
East North-Central	20.2	2.8	....	....	....	2.8	23.0
Pacific	7.0	....	....	2.1	3.4	5.4	12.5

Table 49. Estimated percentage distribution of least-cost shipments of beef from surplus-slaughtering regions, 1954.

Destination region	Beef consumption	Originating region of shipments			
		West North-Central	West South-Central	Mountain	Total
Northeast	30.7	20.2	....	....	20.2
East North-Central	24.0	1.0	....	....	1.0
Southeast	11.3	0.6	1.5	1.1	3.2
Pacific	13.2	....	....	0.8	0.8

Table 50. Estimated percentage distribution of least-cost shipments of calves from surplus-producing regions, by destination region, 1954.

Destination region	Farm production	Originating region of shipments				Commercial slaughter
		West North-Central	Southeast	Mountain	Total	
Northeast	7.9	7.3	....	....	7.3	15.2
East North-Central	13.3	2.5	5.1	0.5	8.1	21.4
West South-Central	11.8	....	....	2.8	2.8	14.6
Pacific	4.9	....	....	1.8	1.8	6.7

Table 51. Estimated percentage distribution of least-cost shipments of veal for surplus-slaughtering regions, 1954.

Destination region	Consumption	Originating region of shipments				
		East North-Central	West North-Central	Southeast	West South-Central	Total
Northeast	46.9	....	7.2	5.7	18.0	31.7
Mountain	2.1	....	0.3	....	.....	0.3
Pacific	9.9	....	....	....	3.1	3.1

ter to the West North-Central and Southeast regions. Because of these locational shifts, corresponding shifts in the patterns of interregional livestock and meat shipments can be expected.

A normative, linear programming approach was used to evaluate the effects of a change from a value-of-service to a cost-of-service basis for establishing transportation changes, as a consideration in evaluating prospective changes in the locational pattern of the meat packing industry.[23] (Cost data prepared by the U. S. Department of Commerce were used in adjusting the projected 1964 transportation cost data. A shift to a cost-of-service basis would mean essentially a reduction in the relative cost of hauling meat.) The least-cost solutions to the over-all transportation problem based on the revised rates showed a further change in the pattern of net trade. Using the projected 1964 data on marketings and consumption, the Northeast and Pacific regions would show an increase in consumption and a decrease in meat production while the North Central region would increase production. With regard to beef production, the West South-Central region would increase in importance while the Mountain region would decline in importance (because of the favor-

Table 52. Estimated percentage distribution of least-cost shipments of hogs from surplus-producing regions, 1954.

Destination region	Farm production	Originating region of shipments			Commercial slaughter
		East North-Central	West North-Central	Total	
Northeast	1.8	7.0	1.5	8.5	10.3
Southeast	8.9	....	1.1	1.1	10.0
West So.-Central	2.4	....	1.4	1.4	3.8
Mountain	0.8	....	1.2	1.2	2.0
Pacific	0.9	....	3.2	3.2	4.1

Table 53. Estimated percentage distribution of least-cost shipments of pork from surplus-slaughtering regions, 1954.

Destination region	Consumption	Originating region of shipments		
		East North-Central	West North-Central	Total
Northeast	27.2	5.5	11.3	16.8
Southeast	18.4	....	8.4	8.4
West South-Central	9.4	....	5.6	5.6
Mountain	3.2	....	1.3	1.3
Pacific	9.7	....	5.6	5.6

[23] Wilbur R. Maki and William C. Motes. Economic effects of transportation on plant location in the meat packing industry. Iowa Agr. and Home Econ. Exp. Sta. (Unpublished report.) 1961.

Table 54. Percentage distribution of livestock slaughter, by regions, 1964.

Region	Cattle	Calves	Hogs
Northeast	9.6	16.9	9.5
East North-Central	21.0	20.4	24.2
West North-Central	35.6	5.0	43.1
Southeast	8.1	19.9	13.9
West South-Central	5.8	30.6	3.6
Mountain	7.5	0.9	2.1
Pacific	12.4	6.3	3.6
Total	100.0	100.0	100.0

able position of the West South-Central region which can ship either west or east). Also, the West South-Central region would become more important than any other region. Under 1954 conditions, both the East North-Central and the West North-Central regions were surplus regions. In 1964 the West North-Central region, however, would contribute an even larger share of the total pork exported—on the basis of the projected data.

Trends for veal would be similar to those observed for beef and pork when cost-of-service rates are used. As before, slaughter calf production and slaughter would be quite decentralized because of the continuing influence of the dairy industry.

A further modification of the locational pattern for livestock slaughter was obtained by relaxing the restriction on slaughter location. A linear programming procedure was used to obtain the least-cost pattern of livestock and meat shipments. Because of the lack of restrictions on plant location, the least-cost solution favored the location of slaughter in areas of livestock production.

Within the range of transportation costs used in this study, the findings show that it would be cheaper to slaughter livestock in supply areas and ship meat, rather than ship livestock for slaughter in areas where the meat is consumed.

Summary

Besides the substantial shifts in relative calf slaughter between the Southeast and the West North-Central regions, hog slaughter in the Southeast region and cattle slaughter in the West North-Central region are expected to increase in relation to total commercial slaughter from 1954 to 1964. The percentage increases in commercial slaughter would be associated with a corresponding decline in the relative position of the Northeast and the East North-Central regions. The percentage distributions of marketings of slaughter livestock are expected to change, also—although the changes for cattle and hogs appear somewhat smaller than for calves. Marketings of slaughter cattle are expected to increase in relative importance in the North Central and Southeast regions and decrease in the Northeast and West South-Central regions. The West North-Central region, however, is expected to maintain its relative importance with respect to marketings of slaughter hogs, despite the increasing importance of hog production in the Southeast.

The data on slaughter calf marketings, and the corresponding data on calf slaughter and veal consumption, are less reliable than comparable data on the other livestock and meat categories. For this reason, the expected changes in the percentage distribution pertaining to calves and veal provide a less satisfactory basis for evaluating prospective shifts in the location of calf slaughter.

Industry Characteristics

The intertemporal and interspatial differences in meat packing, meat consumption, livestock production and transportation costs cited earlier are reviewed briefly in terms of the various trends and projections presented in this report. This concluding discussion is addressed specifically to the question of prospective changes in the economic structure of the meat industries that can be attributed to aggregate and regional changes in livestock marketings, meat consumption and marketing costs. These aggregate and regional changes in the livestock-meat economy are reviewed with particular reference to their impact on the locational and size distribution of establishments in the meat packing industry.

Livestock Marketings

Though the location of feed-grain and forage production is quite stable from year to year, the location of livestock feeding may vary because of changing short-run supply and demand relationships for slaughter and feeder livestock. Despite the relatively stable projected regional levels of feed-grain and forage production, regional livestock marketings vary substantially from year to year, both in absolute numbers and as a percentage of total livestock marketings in the United States. According to the prediction equations used in this study, the cattle and hog cycles will continue to require considerable excess capacity in the livestock and meat industries to adequately handle the peak livestock marketings. Because of the cyclical variability in marketings, the regional levels of livestock slaughter will vary in a corresponding, though not necessarily a proportionate, manner. Moreover, the competitive processes in livestock and meat procurement during different stages of the livestock cycles will vary among the regions and, hence, the proportionate market shares of each region also will vary from year to year. To achieve less variability in regional livestock slaughter, however, will require important changes in the expectational structures of livestock producers.

The prediction equations for estimating commercial slaughter of cattle, calves and hogs involved inventories of breeding stock as the critical explanatory variables. Thus, for cattle and calves, the year-to-year shifts in the breeding intentions and market expectations of ranchers and farmers are revealed over the next several years in the changing rates of slaughter of calves, heifers, cows and steers. Similarly, changes in the breeding plans of hog producers are represented first, in changes in brood sows and gilts on hand Jan. 1 and, later, in sows farrowing and in pork production. In both areas of decision making, price stability would be associated with more general livestock market stability in succeeding years. Increased livestock price and market stability would allow for increased specialization in livestock production and slaughter and, hence, increased operational efficiencies in the meat packing industry. When the cyclical variability in the livestock markets is reduced substantially, however, year-around cattle feeding and multiple hog-farrowing programs may induce only a limited reduction in the industry's excess capacity of plant and facilities. Capital expenditures must be made pru-

dently in the light of existing capacity and prospective growth in consumer demand.

Meat Consumption

Consumer demands and preferences establish the critical limits to changes in livestock production and marketings through the rather stable quantity-price relationships that prevail for different socio-economic groups. As the distribution of these groups in our total population changes, the nature of the quantity-price relationships for meat changes also, as indicated earlier in this report. If livestock production or meat processing and distribution technology reduces the cost of meat, the average American consumer will increase the consumption of beef and pork, provided incomes, household composition and preferences remain unchanged.

Most demand projections use disposable personal income as the principal index of socio-economic change. To the extent that consumer incomes increase, meat consumption is also expected to change for a specified level of farm prices in a manner prescribed earlier in this report. Unfortunately, for regional projections of meat consumption, adequate data are lacking for estimating both the quantity-income and quantity-price relationships, particularly for specified meat classes or qualities.

The generally rising consumer incomes will result in expanded regional markets for beef and, to a lesser extent, pork. Thus, the substantial growth in population together with a positive, though small, income effect can be expected to sustain retail market prices, in constant dollars, at approximately 1949-60 levels during the 1960's. Changes in regional meat consumption patterns thus are confined largely to the effects of changes in regional population rather than changes in regional incomes and consumer tastes. The income effects on particular meat cuts and meat products are recognized as important factors, however, in accounting for changes in the regional distribution of prepared meats plants and also in the degree of specialization in meat packing plants.

Marketing Costs

Regional differences in marketing costs, except transportation, were quite difficult to obtain. The available data, largely from the 1954 Census of Manufactures, reveal a pronounced effect on employee wages of urbanization rather than of regional location. Differences in labor costs per worker among establishments within the same region are substantially greater than their differences among plants in comparably sized towns in different regions. Regional differences in labor costs may occur, however, because of regional differences in plant location with respect to urbanization.[24]

Although the available data suggest a lack of regional differences in labor and related costs, these same data, when obtained for different years, show some changes in total marketing costs from year to year. First, labor costs are expected to increase (though recent changes in reported employment in the meat packing industry reveal significant changes in total labor utilization). More and more marketing services are being incorporated into the final retail product, which, together with the rising rate of labor remuneration, would increase aggregate livestock and meat marketing margins. Competitive factors and technological changes in the livestock and meat industries, moreover, add to the cost-increasing pressures. As a result, the expected 1964 marketing costs cited in this report are expected to increase, in total, over their 1954 levels.

Industry Organization

The composite effects of intertemporal and interspatial changes in livestock production, meat consumption and marketing costs are represented in a preliminary manner in the reported shifts in the size and geographical distribution of meat packing and prepared meats plants. Two sources of data are available to show these changes in industry organization; namely, the U. S. Census of Manufactures for 1954 and 1958 and the U. S. Department of Agriculture reports on the number of slaughter plants, March 1, 1955, and March 1, 1960.

Shifts in size distribution of establishments. A significant reorganization in total labor utilization within the meat-product industries was evident by the end of 1958. In 1954, an average monthly employment of 252,200 persons was required to handle an average monthly commercial slaughter of 3,570 million pounds liveweight, including 1,934 million pounds of cattle, 234 million pounds of calves, 1,275 million pounds of hogs and 127 million pounds of sheep and lambs. By 1960, an average monthly slaughter of 3,961 million pounds liveweight was handled by 241,800 employees in the meat-product industry (meat packing and prepared meats establishments). By 1964, however, less than 240,000 employees are expected to handle a total monthly slaughter of 4 billion pounds.

A prediction equation was derived from the monthly data on employment in the meat-product industry reported in the Survey of Current Business and the monthly data on liveweight commercial slaughter reported in various U. S. Department of Agriculture publications. From these data, a conclusion was formed regarding the appropriate historical period on which to base the estimates of future employment in the meat packing and prepared meats industries (namely, the 36-month period since January 1958). During this period, 80.2 percent of the month-to-month change in employment (averaged over 3-month intervals starting Jan.-March 1958) was explained by the relation,

[24] Union contracts account for some differences in regional wage patterns by allowing for geographical wage differentials in industry-wide bargaining.

$$\left(\frac{\sum_{t}\Delta E_{wt}}{3}\right) = -0.804 + \underset{(0.004)}{0.019^{**}}\sum_{t}\Delta Q_{2wt-1} + \underset{(0.003)}{0.012^{**}}\sum_{t}\Delta(Q_{1wt-1} + Q_{3wt-1} + Q_{4wt-1}) \quad (22)$$

where E_{wt} = average monthly employment in meat products industry in thousands of employees, t-th month, w-th quarter.

Q_{wit} = total liveweight commercial slaughter i-th livestock class (i = 1, calves; i = 2, cattle; i = 3, hogs; i = y, sheep and lambs), in millions of pounds, t-th month, w-th quarter.

A change from the preceding month, t-1, to the current month, t, or from a lagged month, t-2, to the preceding month, t-1, was shown, respectively, by $\Delta E_{wt} = (E_{wt} - E_{wt-1})$ and $\Delta Q_{iwt-1} = (Q_{iwt-1} - Q_{iwt-2})$.

According to the prediction equation, average monthly employment declined 804 workers per quarter-year during the 1958-60 period independently of changes in commercial slaughter. In addition, an average month-to-month change during each 3-month period of 1 million pounds in commercial cattle slaughter was associated with a change of 18.9 employees in the meat-product industry, while a corresponding change in the commercial slaughter of hogs, calves and lambs was associated with a change of only 12.5 employees. Despite the larger labor requirements per million pounds of hog, calf and lamb slaughter, the month-to-month change in employment associated with changes in the commercial slaughter of these livestock classes was only two-thirds of the change in employment associated with a corresponding change in cattle slaughter.[25] The greater variability in hog slaughter and the greater uncertainty associated with this variability may account for the sluggishness of changes in employment to achieve efficient levels in short-term labor utilization in the meat packing and prepared meats industries. Again, the existing levels of employment in the meat industries are less than optimal because of the seasonal and cyclical instabilities in livestock marketing.

Because the recent decline in total employment has occurred during a period of growth in the total number of establishments, the average size of establishment has declined somewhat in the meat packing industry. The 1958 Census of Manufactures preliminary reports show a total of 203,887 employees in meat packing — a decrease of 16,307 from the reported 1954 employment. Meanwhile, the number of establishments with 20 or more employees increased from 933 in 1954 to 1,030 in 1958. (The U. S. Department of Agriculture report cited earlier shows an increase of slaughter plants under federal inspection from 455 on March 1, 1955, to 530 on March 1, 1960. Large and medium sized slaughter plants not under federal inspection declined in number, however, from 952 and 1,810, respectively, on March 1, 1955, to 902 and 1,712, respectively, on March 1, 1960.) A further examination of the census data revealed a trend toward a smaller average size of meat packing establishments in the North Central states, Oklahoma, Texas and California. Generally, in other states, an increase in the number of establishments was associated with an increase, rather than decrease, in total employment. The trend toward a smaller average plant size is revealed most clearly by the reported data for Illinois, which show a decline from 26,526 meat packing plant employees in 1954 to 16,628 employees in 1958, while the number of plants with 20 or more employees increased from 46 in 1954 to 61 in 1958. **Generally, however, small establishments not under federal inspection have declined in total number during recent years.**

Shifts in geographical distribution of establishments. In this report, the prospective regional redistribution of employment in meat packing is reviewed briefly in relation to the changing locational pattern of livestock slaughter.[26] According to the employment estimates on which the percentage distributions in table 55 are based, livestock slaughter in the West North-Central and Southeast regions may be expected to increase in relative importance, largely because of the decline of slaughter in the Northeast and East North-Central regions.

Because of the increasing efficiency of labor utilization and the changing size distribution of slaughter establishments, the projected regional redistribution of employment in the meat packing industry can be associated with a differential rate of increase or decrease in the number of slaughter establishments in each of the livestock regions. If the increased labor efficiencies were experienced simultaneously in all segments of the meat packing industry, the total number of establishments in 1964 (with 20 or more employees, for example) probably would exceed the 1954 level only in the West North-Central region.

[25] For further discussion of labor requirements in livestock slaughter, see: Wilbur R. Maki and Charles Y. Liu, **op. cit.**

[26] A more complete discussion of prospective regional changes in meat packing and prepared meats establishments is included in the report by Maki and Liu cited earlier.

Table 55. Percentage distribution of employment in meat packing industry, by regions, 1954 and 1964.

Region	Reported 1954	Projected 1964
Northeast	11.9	10.1
East North-Central	26.8	22.7
West North-Central	34.3	37.7
Southeast	9.9	12.7
West South-Central	7.1	6.2
Mountain	3.2	4.0
Pacific	6.8	6.6
Total	100.0	100.0

USES AND LIMITATIONS OF FINDINGS

Economic studies of the livestock and meat industries frequently deal with narrowly defined problems facing small or specialized segments of the livestock-meat economy. Because of the specific nature of these studies, the findings generally assume as given such economic phenomena as cattle and hog cycles, excess industry capacity or declining demand for pork. Though these events plague much of agriculture and agribusiness, prescriptions for the remedy of these ills are unlikely to come from partial economic analyses. This study was initiated, therefore, to provide (1) a broad, aggregative approach to later studies of major long-run problems facing the livestock and meat industries and (2) a currently useful regional breakdown of selected aggregative elements in the livestock-meat economy.[27] Calendar year 1964 was selected as the target year for testing the analytical techniques developed in the early stages of the study.

Like most predictions of our economic future, the findings are presented with the usual warnings of their limitations. For one or more reasons, the explanatory variables associated with past changes in specified livestock marketings, slaughter and utilization may assume a substantially different role in future years. Forecasting errors thus can be introduced into the set of predicted or projected values based on the outdated empirical relationships. Furthermore, a limited number of years are included both in the historical period upon which the forecasting equations are based and in the period covered by the projections. Yet during the short projection interval selected, unexpected, though significant, changes may occur in such farm policy variables as support prices, for example, that affect the level of livestock production and slaughter. The recursive approach, moreover, results in a substantial cumulative error if past trends or relationships change sharply during the early part of the forecast period. Finally, all regional projections are tied to corresponding national projections. Either or both the national projections and the interdependence coefficients that relate the regional values to their national totals may be estimated with substantial error.

Because of the "systems" approach used in the study of prospective changes in the livestock-meat economy, a large number of relevant economic variables, though estimated with varying degrees of reliability and precision, can be examined profitably in a comprehensive and systematic manner in terms of the over-all effects of these variables on at least two of the major questions that concern various segments of the livestock-meat economy; namely, the regional location of the meat packing industry and the reduction of excess plant and facilities for livestock slaughter. These basic data thus are available for purposes of long-range planning within the livestock-meat economy. Moreover, the procedures for obtaining these data are included to allow for their adaptation to the more specialized needs of particular segments of the economy.

By starting with the total livestock-meat economy and by showing the interrelationships existing among the regional livestock and meat industries from year to year, the effects of cyclical variability in aggregate livestock marketings were related to each region's competitive position in livestock slaughter. According to the findings of this study, a reduction of year-to-year variability in livestock marketings and slaughter, for example, would have the greatest impact on the efficiency of slaughtering plants located in the areas of most extreme variability in livestock production and marketings. These findings thus point to a potential source of substantial change in the reorganization and subsequent further relocation of the meat industries.

The nature of the economic projections obviously prescribes the recommendations that might follow from the research findings. The continuation of historical patterns of yearly livestock marketings does not imply, however, an inevitable inconsistency between market expectations and subsequent market performance. For this reason, the price-generating mechanism was presented early in this report to illustrate the sequence of market events as they appear to affect production and marketing decisions in each livestock region. A further stage in this particular line of investigation could profitably examine the elements of the decision processes of livestock producers and the possibilities of modifying these processes and, thus, the outcome of production plans extending over a planning horizon of several years.

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[27] The organization and results of this study relate particularly to the current regional research project of the North Central Livestock Marketing Research Committee, "Adjustments in Livestock Marketing in the North Central States to Changing Patterns of Production and Consumption."

SUMMARY

The economic structure of the meat-products industry is described in this report in terms of the changing patterns of livestock marketings, meat consumption and marketing costs. A system of prediction equations based largely on data covering the 1949-60 period was constructed to estimate for the United States, and for each of seven livestock regions, projected 1964 levels of livestock prices, marketings and slaughter, and meat consumption. The projected data then were compared with predicted and reported data for 1954. The latter year, for which rather extensive data from the U. S. Census of Manufactures were available, thus served as a base year from which changes in regional and national components of the livestock-meat economy were measured.

This report describes for much of the livestock-meat economy a period of substantial growth from 1954 to 1964. It indicates that an expanding population and rising levels of personal incomes are expected to sustain essentially the same patterns of livestock marketings, meat consumption and market prices that prevailed during 1949-60.

The report also indicates, however, that significant departures from these recent historical patterns can be expected in specific segments of the regionally differentiated livestock-meat economy. Livestock slaughter, for example, will tend to occur more and more in the producing areas, particularly in the West North-Central and Southeast regions. Furthermore, a significant decrease in year-to-year variability of livestock marketing is expected. This will improve labor efficiency and, thus, further increase the prospective levels of livestock slaughter in the West North-Central region.

While livestock slaughter is supply-oriented, meat processing is market-oriented. Despite some freight advantage obtained by locating prepared meats establishments near the place of slaughter, rising consumer incomes and increasing demands for locally differentiated processed meat products continue to favor the growth of meat processing in the major metropolitan areas. Increased plant specialization, together with the locational factors cited earlier, would contribute to further spatial segregation of slaughtering and processing activities in the over-all meat-products industry—locating most of the slaughtering plants in the producing territory and most of the processing plants in the consuming territory.

Essentially three types of conclusions may be drawn from this study. First, to estimate the size of each regional "slice" it was necessary to estimate the size of the "pie." For each projected regional variable, a corresponding variable for the United States was obtained as well as a set of interdependence coefficients specifying the nature of the association between the two sets of variables. In addition, a second set of relationships was derived to show the effects of aggregate market prices on regional demands for and supplies of livestock and meat. These prediction equations were used, finally, in the allocation of total national livestock and meat production among the seven livestock regions. Thus, the question of regional adjustments in livestock marketing to changing patterns of production and consumption was approached systematically within an analytical framework that represented the entire livestock-meat economy as a set of mutually determined economic activities.

Second, to estimate the nature and magnitude of prospective changes in the location of livestock slaughter, it was necessary to consider the impact on regional slaughter of (1) the cyclical variability in livestock marketings and (2) the recent improvements in labor efficiency in the meat-products industry. Changes in livestock production and slaughter were related to changes in national market phenomena in a somewhat different manner in each livestock region. Improvements in labor utilization also were associated with somewhat different patterns of change in the average size of establishment. The greatest variability in livestock marketings and slaughter occurred in the West North-Central region. Also, the average size of plant has declined in this region.

Finally, to estimate the effects of livestock and meat transportation on industry location, it was deemed desirable to include transportation policy variables in the linear programming procedures. A further shift from a value-of-service to a cost-of-service basis in pricing rail transportation services, for example, was shown to increasingly favor the location of livestock slaughter in the major areas of livestock feeding.