INVESTMENT PLANNING IN THE MEAT PACKING INDUSTRY

by

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INTRODUCTION

Investment decisions are perhaps the most important decisions made by business entrepreneurs. These decisions are made on the basis of more or less well-defined investment plans. Thus, investment planning is the process of developing information which is useful in arriving at investment decisions. This study is concerned with the informational inputs into investment decision making in the meat packing industry.

Investment in meat packing facilities involves long-term commitments of funds; a new meat packing plant would be expected to have a useful life of at least 10 years. Therefore, long-term projections of the relevant variables are needed to evaluate the profitability of a new meat packing facility.

The investment decision involves not only decisions concerning the type and size of plant to be built, but also the choice of location. The meat packing industry is supply oriented in the sense that livestock slaughter plants tend to be located near the livestock supply. Thus, long-term projections of the geographical distribution of the livestock supply are extremely important for investment planning. These projections are important to meat packing firms which are planning to expand their facilities, or to prospective entrants into the industry. Thus, the need exists to organize an information system that would provide this service for prospective investors.

The proposed information system could be a governmental agency or a meat packing trade association. One of its functions would be to collect data on livestock supply, project future livestock supplies and make this information available to prospective investors. The purpose of this study is to develop methods for projecting livestock supplies and to specify an information system for investment planning in the meat packing industry.

The relationship of the proposed information system to investment planning is illustrated in Figure 1.1. Before an entrepreneur commits funds to an investment project, he acquires information concerning the profitability of the project. The profitability estimates are based upon information from both private and public sources. Public information sources include statistical reporting agencies of the state and federal governments, public research organizations such as the agricultural experiment stations of the land-grant universities, and trade associations such as the American Meat Institute. Private information sources are internal records (accounting data, plant layouts, equipment lists, etc.), consulting firms and other sources too numerous to mention. The information from the various sources are inputs into the investment analysis, as shown by the arrows in Figure 1.1. The investment analysis can take on various forms. It may consist of only a cursory analysis of readily available data. On the other hand, it may be a thorough analysis by a staff of engineers, financial analysts, economists and other specialists. The results of the analysis flow to

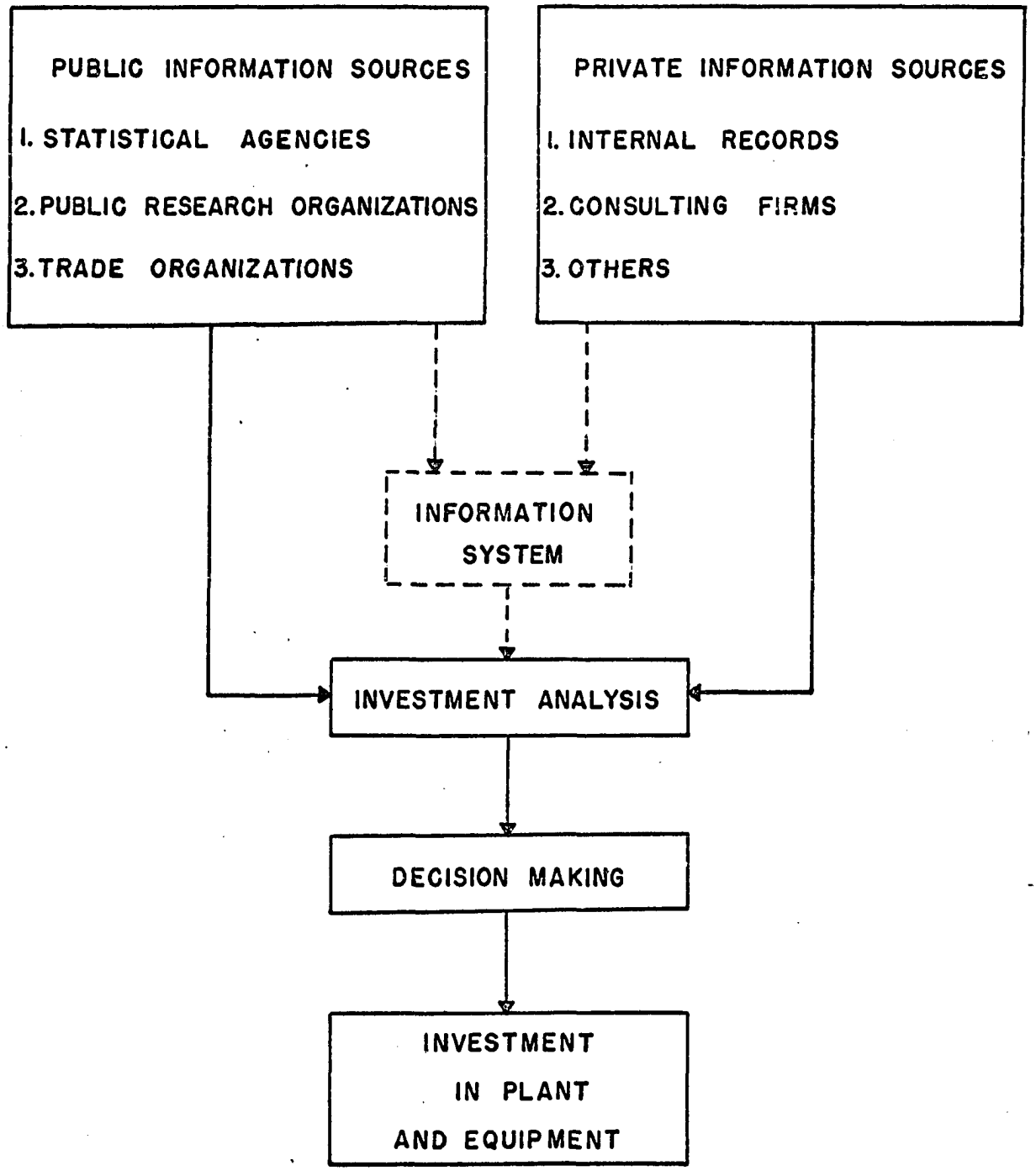


Figure 1.1. Relationship of information system to investment planning

the decision maker, who makes the investment decision on the basis of information generated in the investment analysis. The decision maker may be the same person who conducted the investment analysis. At the other end of the continuum, the decision maker may be the president or the board of directors of a large corporation.

The proposed information system, as shown in Figure 1.1, could draw upon both public and private information sources and would provide informational inputs into the investment analysis activities of prospective investors. Thus, the output of the information system would include projections of livestock supplies and other types of information which would be useful in the analysis of investment alternatives.

These considerations lead to the following objectives for this study: The first objective is to delimit the informational framework for investment planning in the meat packing industry. This will involve specifying the information used in arriving at decisions of location and size of plant, and determining how this information can be generated. The second objective is to develop methods for projecting the future production and marketing patterns of slaughter livestock for relatively small geographical regions. Given the future supply of livestock, the third objective is to predict the level of slaughter and the amount of investment in meat packing facilities. These last two objectives will involve the analysis of livestock marketing and slaughter in the Upper Midwest Region, consisting of six states--Wisconsin, Minnesota, Iowa, North Dakota, South Dakota and Nebraska. The fourth

objective is to outline and discuss an information system incorporating the techniques developed previously.

The procedures used in achieving the second and third objectives are shown schematically in Figure 1.2. Given national consumption, exports and imports of meat, the national production of slaughter livestock can be derived by simply applying the appropriate conversion factors. Next, total production is allocated among the various regions. In Figure 1.2 the first and last regions are shown explicitly; the dots indicate that the data are generated for all N regions. Next, the marketing system must be analyzed to determine the inshipments and outshipments of slaughter livestock. By definition, slaughter is equal to production plus inshipments minus outshipments of slaughter livestock. Finally, the amount of investment in slaughter facilities is a function of the increase in slaughter and the existing capacity of the industry.

Several benefits would accrue from the information system. Many investors, who would otherwise make their decisions on the basis of rather fragmentary information, would have access to much more complete information. Those investors who conduct thorough analyses of alternatives could use the output of the information system, thus saving time and money in their investment analysis activities. The data on livestock production and marketing would also be useful to other livestock marketing agencies such as terminal markets and livestock auction markets. In general, the information system would induce a more ef-

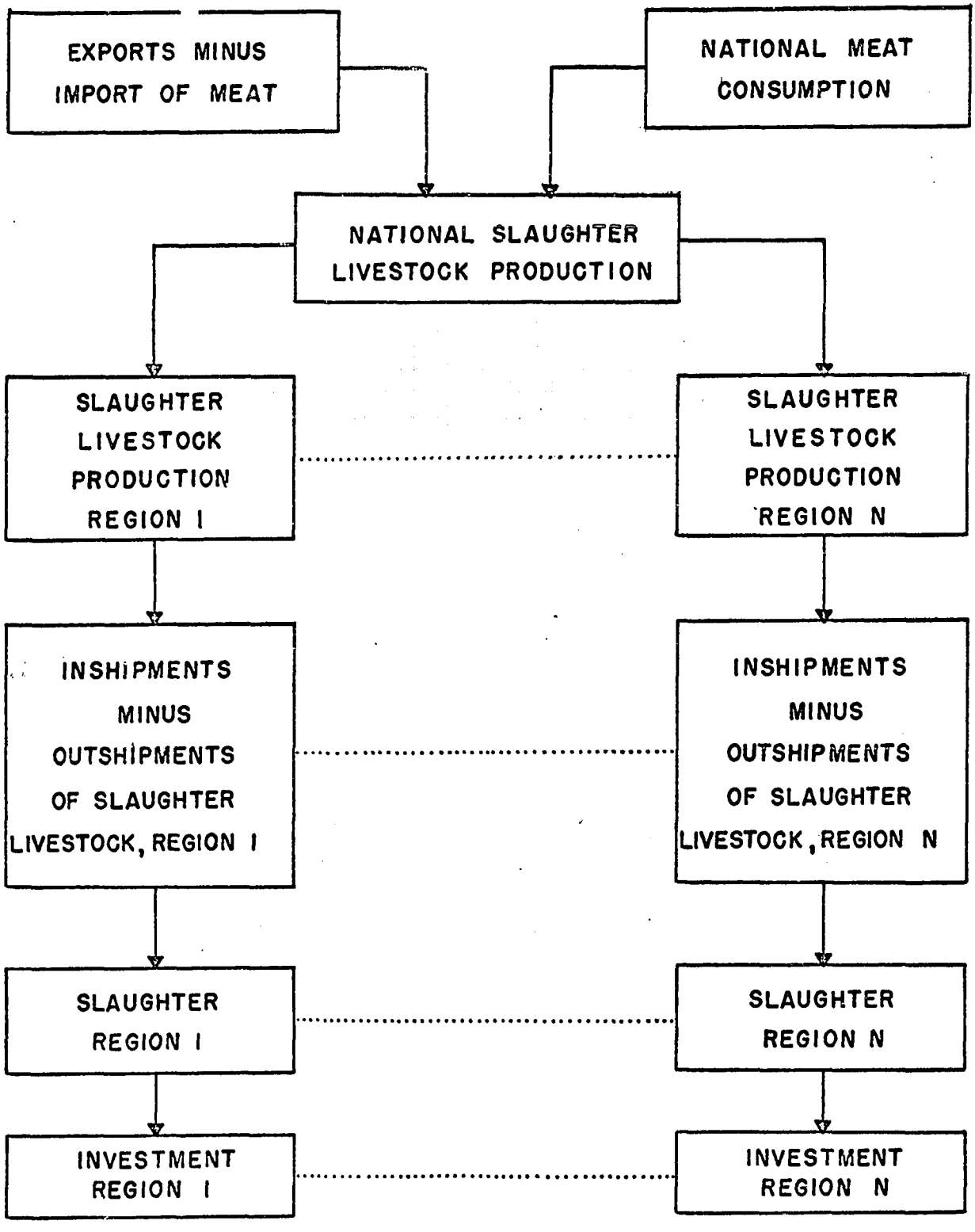


Figure 1.2. Procedures for projecting production, marketing patterns, slaughter, and investment

ficient allocation of investment funds in the livestock meat marketing complex.

The basic parts of this study will be organized into five chapters. The first chapter will be devoted to a discussion of investment planning and to delimiting the informational needs. The production of slaughter livestock during a base period, 1959-61, and in a future year, 1975, will be the subject of the second chapter. The marketing patterns and marketing channels for slaughter livestock will be discussed in the third chapter. Particular attention will be given to the role of terminal markets. The location of slaughter and investment in the meat packing industry will be discussed in the fourth chapter. The present location of the industry will be examined and the prospective changes in location, derived largely from the changing pattern of slaughter livestock production and marketing, will be discussed. The fifth chapter will be concerned with an investment decision model and the information system for investment planning.

ECONOMIC INFORMATION FOR INVESTMENT DECISION MAKING IN THE MEAT PACKING INDUSTRY

A brief description of the structure of the meat packing industry, and the costs and returns in the industry will be the first subject of this chapter. This will be followed by a discussion of the relationship between investment planning and investment decision making. An attempt will then be made to delineate the economic information relevant to investment decisions in the meat packing industry. Finally, the sources of this information will be discussed.

The Meat Packing Industry

The Census of Manufacturers defines the Meat Packing Industry, Standard Industrial Classification 2011, as follows:

> This industry comprises establishments primarily engaged in the slaughtering, for their own account or on a contract basis for the trade of cattle, hogs, sheep, lambs, calves, horses and other animals except small game, for meat to be used on the same premises in canning and curing and in making sausage, lard and other products (24, p. 20A-1).

In general, this definition will be used in this study.

Industry structure

It is clear from the definition that a meat packing plant could be specialized or integrated vertically. The degree of integration varies from the specialized slaughter plant to the fully integrated plant which slaughters livestock, and produces a full line of fresh meats and prepared meats (smoked meats, sausages, canned meats, etc.).

A specialized slaughter plant, sometimes referred to as a "shipper type" plant, is one usually specializing in the slaughter of a particular grade or class of one species, and shipping carcasses to large-volume intermediate handlers or large retail accounts. Logan and King (12, p. 17) define a slaughter plant as an establishment which includes the following functions:

(1) yard operations in receiving and feeding of livestock;

(2) production operations in killing, dressing of carcasses, and handling by-products;

(3) carcass cooling and loading operations;

(4) maintenance and clean-up operations;

(5) administrative operations in buying livestock and selling meat.

In general, a meat packing plant is one which includes these five functions, and may include other meat processing functions. Many plants perform slaughtering operations and break carcasses into wholesale or retail cuts of meat. Some plants also render inedible by-products, cure hides, and/or operate sausage kitchens.

Meat packing establishments can also be classified according to the species of livestock slaughtered. Table 2.1 shows the number of meat packing plants by species slaughtered in 1959 in the United States, and in Iowa. Commercial slaughter data (see Table 2.2) show that cattle and hogs are by far the most important species slaughtered.

Table 2.1. Number of meat packing establishments by species slaughtered in the United States and Iowa, 1960[a]

Species slaughtered	Number of establishments U.S.	Iowa
Cattle and calves, hogs, and sheep and lambs	962	9
Cattle and calves only	513	17
Cattle and calves and hogs	1,251	20
Cattle and calves and sheep and lambs	241	1
Hogs only	165	4
Hogs and sheep and lambs	3	0
Sheep and lambs	9	0
Total	3,144	51

[a]Source: (28).

The size of meat packing plants varies widely. Table 2.3 presents the distribution of meat packing establishments in the United States by employment size group. Over half the establishments employ less than 20 workers, while only 40 employ 1,000 or more. Those plants with less than 50 employees typically serve a small trade area and usually do not enter into interstate commerce. Those plants which sell across state lines are subject to inspection by federal authorities, and are known as Federally Inspected (FI) plants. Many of the plants with employment between 50 and 249 probably slaughter cattle and calves,

Table 2.2. Commercial slaughter: number of head and total live weight, United States, 1962[a]

Species	Number	Live weight
	(thousand head)	(million pounds)
Cattle	26,083	26,220
Calves	7,494	1,660
Hogs	79,334	18,983
Sheep and lambs	16,837	1,639

[a]Source: (27).

Table 2.3. Meat packing establishments, by employment size group, in the United States, 1958[a]

Employment size group	Establishments
1 - 19	1,824
20 - 49	456
50 - 99	212
100 -249	156
250 -499	75
500 -999	38
1,000 -or more	40

[a]Source: (25).

and/or hogs. Some of these are specialized slaughter plants; however, many of them also break carcasses into retail or wholesale cuts. Most of the plants in the 250 to 999 employment class carry on multi-specie slaughter operations, and perform at least some of the meat processing operations. Nearly all the plants with over 1,000 employees slaughter cattle and calves, and hogs, and probably most of them also slaughter sheep and lambs. Most of them perform many of the meat processing operations.

The meat packing industry has been dominated by a few large firms for several decades. In 1955 the four largest firms (Swift, Armour, Wilson and Cudahy) slaughtered 30.8 percent of the cattle, 34.7 percent of the calves, 36.4 percent of the hogs, and 58.5 percent of the sheep and lambs (37, p. 355). However, there has been a tendency for the market share of these firms to decline in recent years.

There has also been a tendency toward greater specialization by firms in the industry.

> With the principal exception of the larger firms, meat packers, generally speaking, have been stripped of functions other than slaughtering. Specialized nonslaughtering processors developed, and ... the national packers have been concentrating more heavily on processing. Accordingly, independent packers have tended to leave the production of sausage and variety meats to the national packers and to the processing specialist (37, p. 357).

The meat packing industry has been plagued by excess capacity for many years. It is reported that United States packing plants can slaughter 55,000 hogs and 15,000 cattle per hour. Assuming a 40 hour

week, the annual average utilization of capacity for the years 1950 through 1960 varied between 53 and 86 percent for cattle, and between 57 and 71 percent for hogs (37, p. 365). The capacity of individual plants is not reported, however, the largest capacities for any single plant are approximately 150 head per hour for cattle and 600 head per hour for hogs.

Costs and returns

The American Meat Institute (1) publishes yearly estimates of sales, raw material costs, expenses and net earnings of the meat packing industry. These data for 1963 are presented in Table 2.4. The cost of raw materials is 73.3 percent of total sales; in addition, wages and salaries, and employee benefits account for 13.6 percent of total sales, or over half of the gross margin. Also, net earnings are a very small percent of total sales. Meat packers suffer from relatively wide fluctuations in net earnings from year to year. During the period 1947 through 1963, net earnings ranged from $48 million in 1954 to $152 million in 1947 (1).

The earnings-to-sales ratio and earnings-to-net worth ratio are low in the meat packing industry. Data from 28 meat packing companies showed a earnings-to-net worth ratio of 5.9 percent. This is very low when compared with other food processing industries; the earnings-to-net worth ratio for selected companies was 11.0 percent in the baking products industry, 10.8 percent in the dairy products industry, and 10.4 percent in the sugar products industry (1, p. 5). Although these

Table 2.4. Sales, expenses, and net earnings in the meat packing industry, 1963[a]

Item	Million dollars	Percent of total sales
Total sales	14,250	100.0
Cost of livestock and other raw materials	10,450	73.3
Gross Margin	3,800	26.7
Expenses		
Wages and salaries	1,655	11.6
Employee benefits	274	2.0
Interest	30	0.2
Depreciation	117	0.8
Rents	43	0.3
Income taxes	107	0.8
All other taxes	44	0.3
Supplies and containers	550	3.9
All other expenses	860	6.0
Total Expenses	3,680	25.9
Net earnings	120	0.8

[a]Source: (1).

data are drawn from fairly small samples of firms, they do lend support to the contention that earnings are relatively low in meat packing. Net profits as a percent of stockholders' equity for 11 meat packers was 4.8 percent for 1950-55, 5.8 percent for 1955-59, and 5.1 percent during 1960-61 (37, p. 366). Again, these figures are lower than for other food processing industries.

The cost structure of individual meat packing firms differ widely, depending upon the amount of meat processing performed by the firm. Using data from Logan and King's study, published livestock, meat, and by-product prices, and information obtained from interviews with people in the industry, the following estimates for a specialized beef slaughter plant were obtained:

(1) the cost of livestock is approximately 90 percent of total sales;

(2) labor costs are about 2 or 3 percent of total sales;

(3) the cost of transportation may be as high as 5 percent of total sales.

Transportation costs tend to be high for a large slaughter plant, located in a surplus producing region, which transports meat long distances to large consuming centers.

Economies of scale are important in specialized slaughter plants. Average cost data for a set of eight synthesized beef slaughter plants are exhibited in Table 2.5. These data, developed by Logan and King (12) refer only to the cost of yard operations in receiving and feeding the livestock, the slaughtering operations, the buying of livestock, and selling of meat. Three of the model plants, the first, third, and fifth, utilize the conventional bed-type system, while the other plants use the more automated "on-the-rail dressing" system. Economies of scale exist throughout the entire range of outputs, except in the case of plants A, B and C. This is the result of the inefficiency of "on-

Table 2.5. Estimated long-run costs of eight synthesized beef slaughter plants[a]

Plant	Annual output	Average cost per head
	(thousand head)	(dollars)
One-bed	32	9.48
A	38	9.74
Two-bed	66	8.48
B	76	8.96
Three-bed	95	8.41
C	113	8.45
D	142	7.75
E	227	7.28

[a]Source: (12).

the-rail" operations in small plants. Since pork slaughter plants utilize on-the-rail systems similar to those found in beef plants, it is probable that similar economics of scale exist in pork slaughtering operations.

Diseconomies of scale may become important for very large slaughter plants, because of the increasing cost of procurring livestock, the higher price of livestock, lower value of meat output, and higher cost of distributing meat. Logan and King assumed constant average cost of procurement operations for their model plants, however, they

acknowledged that procurement costs "may be dependent on the distances the buyer is required to go to supply the plant with the raw material" (12, p. 95). The larger a plant's output, the larger the supply area. Also, when a plant expands its supply area it may face increasing competition from other packing plants, thus, increasing the cost of livestock.

As a plant's output increases it may be forced to transport its meat products longer distances, lower the price of its products, or both. Therefore, it is likely that at some point the diseconomies of scale will outweigh the economies of scale. However, the optimum size plant cannot be easily determined, since the costs and returns of a specific plant will be influenced by the degree of competition in buying slaughter livestock and in selling carcasses and meat products.

Investment Decisions and Investment Planning

The term "investment" is defined as "commitments of resources, made in the hope of realizing benefits that are expected to occur over a reasonably long period of time" (2, p. 3). An investment decision is simply a decision to commit resources in a certain manner, i.e., to invest resources. And investment planning is the process of developing information which is useful in arriving at investment decisions. A normative model of investment planning consists of three phases: (1) searching for and defining investment alternatives, (2) estimating the

cash flows associated with the investment alternatives, and (3) economic analysis of the alternatives.

Investment alternatives

Ideally, a prospective investor would investigate all possible investment alternatives before committing his resources to a specific project. But, since there are costs involved in obtaining information, the decision maker limits himself to a relatively small number of possible investment alternatives.

The investment alternatives investigated will depend upon the nature of the information available to the investor. For example, a national meat packing firm will have experience with various types of livestock slaughter and meat processing in various sections of the country. Therefore, a firm of this type would most likely consider investment in a large integrated plant, as well as specialized plants, in any part of the country. On the other hand, a small regional packer may limit itself to opportunities in the region in which it is located, and may limit its interests to only specialized types of plants.

Recently many small communities have established local industrial development organizations with the prime purpose of financing new industry in the community. The investment opportunities considered by these organizations are clearly limited by the type of resources available in the community. Thus, many communities in Iowa may consider a livestock slaughter plant as a distinct investment possibility because

of the availability of livestock, labor, and other resources needed by meat packing plants.

The search activity of a prospective investor is influenced by the goals, the knowledge, and the experience of the organization. The more relevant knowledge and experience an investor possesses, the better he is able to judge the prospective return of an investment, and the less search activity needed in selecting relevant alternatives. An aggressive firm with growth as one of its major goals will spend more resources in searching for investment alternatives than will a firm which is not attempting to grow.

Estimating cash flows

A prerequisite to a thorough analysis of the consequences of a prospective investment is a clear definition of the investment itself. Bierman and Smidt state that a set of investment alternatives should "consist of independent investment proposals for which an accept or reject decision is appropriate; or they should comprise a set of mutually exclusive proposals, such that either the whole set must be rejected or only one of the mutually exclusive alternatives can be accepted" (2, p. 69). Investment A is independent of investment B if it is technically possible to undertake A whether or not B is accepted, and the net benefits expected from A are not affected by the acceptance or rejection of B (2, p. 66). Two investments are mutually exclusive if the potential benefits to be derived from one will completely disappear if the other is accepted, or it is technically impossible to

undertake one when the other has been accepted (2, p. 67). For example, an investment in a meat packing plant would normally be independent of an investment in an automobile factory, and a proposal to build a meat packing plant utilizing an automated on-the-rail dressing system may be mutually exclusive to a proposal to build a similar plant using the conventional bed-type system.

To completely define a proposal to construct a manufacturing plant, it would be necessary to specify the processes to be performed, the capacity, and the site on which the plant is to be located. For example, one proposal may be to build a plant, located at a specific site, with capacity for slaughtering 120 head of cattle per hour. The search procedure must produce a relatively small number of investment alternatives, which can then be analyzed more thoroughly.

After a relatively small number of well-defined investment alternatives have been selected, the cash flows from each of the alternatives can be estimated. The net cash flows (the money value of benefits minus the money value of expenditures) for each year in the prospective lifetime of the project is part of the data needed for evaluating an investment alternative. However, there are almost always certain benefits and costs associated with an investment which cannot be readily described in money terms. If a large meat packing firm is considering building a new plant, it can estimate the cost of constructing and operating the plant and the returns from the sale of meat and meat

products, but it is almost certain that this investment will have some effects which cannot be easily measured in money terms. For example, construction of the new plant, may make it possible for the firm to capture a larger share of the market, and thus exercise more control over a regional, or even a national, market. Note also that future investment opportunities could hardly be considered independent of an investment of this type. If a firm can exercise more market control by expanding its capacity, then the profitability of future investment proposals will certainly be affected by the acceptance or rejection of the original proposal.

Economic analysis

After the cash flows of the investment alternatives have been estimated, the tools of economic analysis can be used to generate information useful to management in making investment decisions. In general, economic analysis is used to compare different alternatives. A choice criterion, such as present value of the net cash flows from an investment can be used as a basis for accepting or rejecting the investment.

Bierman and Smidt (2) list six different "measures of investment worth" which either are used in current business practice or have logical arguments in their favor. Four of these methods, the payback period, proceeds per dollar of outlay, average annual proceeds per dollar of outlay, and average income on the book value of the investment are rejected because they are obviously poor decision criteria

when applied to simple examples. The other two methods, the investment yield method and the present value method provide the same ranking of alternatives under certain conditions, however, the present value method is found to give the proper ranking in all instances in which the investment yield method does, plus some additional cases. Therefore, Bierman and Smidt recommend the use of the present value method.

Hirschleifer (9) compares the yield method and the present value method, and also concludes that the present value method is superior. He uses the concept of a perfect capital market, one in which the borrowing and the lending rates are equal, and in which the two rates are constant with respect to the amount borrowed or lent.

Assuming a perfect capital market and independent investment opportunities, use of the present value method in making investment decisions would have the result of maximizing the firm's present value. The present value, P, of an investment is:

$$P = K_o + \frac{K_1}{(1+i_1)} + \frac{K_2}{(1+i_1)(1+i_2)} + \cdots + \frac{K_n}{(1+i_1)(1+i_2)\cdots(1+i_n)} \qquad (2.1)$$

where K_j is the net cash flow in period j, j = 1, 2, ..., n; i_1, is the discount rate between income in period 0 and period 1, i_2 is the discount rate between period 1 and period 2, and so forth. "The principle is to push productive investment to the point where the highest attainable level of present value is reached" (9, p. 350). That is, all investment proposals which have a positive value of P will be accepted

under the present value rule.

Complications arise if the assumption of a perfect capital market is dropped. There has been disagreement among investment theorists as to whether the borrowing rate or the lending rate should be used as the discount rate in calculating present value. Hirschleifer concludes, by means of his analysis, that the proper rate could be either the borrowing rate, the lending rate, or an internal shadow rate determined by the productivity of investments and the firm's income preference with respect to time. A straightforward application of the present value rule, using either the borrowing or the lending rate, may lead to incorrect decisions.

Bierman and Smidt suggest that, in applications of the present value rule, an average cost of capital should be used as a discounting rate. They point out that investment financing can be obtained in a number of ways: "by borrowing from banks, by allowing short term liabilities to expand, by selling marketable securities such as government bonds, by selling other assets..., by issuing additional securities (either bonds, preferred stocks, or common stock), or by committing funds generated by operations," as well as other ways (2, p. 133). Because a specific project usually cannot be related to a specific source of funds, they recommend a weighted average of all sources as "the cost of capital," which is then used as the discount rate in computing present value.

A hypothetical example is useful for illustrating the use of the present value rule. Assume that four proposed cattle slaughter plants (two different sizes of plants at two different sites) are being considered as part of a meat packing firm's expansion plans. The investment proposals could be stated as follows:

(1) build a 60 head per hour plant at site number 1;

(2) build a 120 head per hour plant at site number 1;

(3) build a 60 head per hour plant at site number 2;

(4) build a 120 head per hour plant at site number 2.

Alternatives 1 and 2 are mutually exclusive, as are 3 and 4. However, some of the alternatives are neither mutually exclusive nor independent, since if a plant is built at site 1 it will affect the profitability of a plant at site 2. But we can construct a set of alternatives which are mutually exclusive by adding the following alternatives:

(5) build a 60 head per hour plant at both sites;

(6) build a 60 head per hour plant at site 1, and a 120 head per hour plant at site 2;

(7) build a 120 head per hour plant at site 1, and a 60 head per hour plant at site 2;

(8) build a 120 head per hour plant at both sites;

(9) build no plants.

Then the present value for each of these nine proposals could be calculated, and one of the proposals selected.

We will assume that the initial cost (building, equipment, land, and inventories) is $1,500,000 for the 120 head per hour plant and $875,000 for the 60 head per hour plant. The prospective useful life of the facilities is 10 years, after which time new technological advances are expected to make it profitable to replace the old equipment. After 10 years the salvage value of the land, building, and equipment is $300,000 for the 120 head plant and $175,000 for the 60 head plant. These data and the net cash flows from operations are presented in Table 2.6.

The net cash flows from operations are assumed to be the same in each of the 10 years. The 60 head per hour plant is more profitable at site 2, and the 120 head per hour plant is more profitable at site 1. Conditions like this could arise from the nature of the livestock supply. For example, the density of slaughter cattle in the supply area of site 1 may be higher than the density in supply area 2. Then, if we assume that there is more competition for slaughter cattle in the higher density area, it is quite possible that the per unit cost for relatively small numbers of livestock would be lower in the low density area. However, if large numbers of slaughter cattle are needed (such as would be needed for a 120 head per hour plant), the per unit cost could be lower in the high density area than in the low density area.

The net cash flows from operations for two plants is always less than the sum of the flows from the two plants operating in isolation.

Table 2.6. Initial costs, net cash flows from operations, and salvage value for nine hypothetical investment alternatives

Alternative	Initial cost	Net annual cash flows from operations	Salvage value
		(thousand dollars)	
1	875	120	175
2	1,500	240	300
3	875	126	175
4	1,500	234	300
5	1,750	240	350
6	2,375	342	475
7	2,375	354	475
8	3,000	450	600
9	0	0	0

This is a result of the lower price of meat, which follows from the assumption of a downward sloping demand curve for the firm's output.

It is clear from an inspection of the data in Table 2.6 that alternatives 1, 4, and 6 can be immediately rejected because they have the same initial cost and salvage value as alternatives 3, 2 and 7, respectively, but they have lower cash flows from operations. The present value of alternative 9 is, by definition, zero. Thus, only the present value of alternatives 2, 3, 5, 7 and 8 need be calculated.

The results of these calculations, assuming an 8 percent discount rate, are presented in Table 2.7.

Since the nine alternatives are all mutually exclusive, one, and only one of them must be chosen. Therefore, the one with the highest present value, alternative 8 (two 120 head per hour plants) is chosen.

If the firm's goal is the maximization of present value, and if its financial resources are adequate, the simple present value model is appropriate. But if the firm is unable to finance all of its potentially profitable projects, models of capital rationing become important. Weingartner (36) uses linear programming and integer programming to analyze capital rationing situations.

Until now it has been assumed that the cash flows associated with the investment alternatives are known with certainty. However, estimates of cash flows for a long lived investment may be subject to a large degree of uncertainty, especially the estimates for periods in the distant future. Many strategies have been suggested for handling uncertainty. For example, decisions may be made on the basis of the most likely outcome, or the expected value of the discounted cash flows. Another approach involves the use of sensitivity analysis; the analytical model is solved repeatedly while using different values of the critical coefficients. The various solutions provide a basis for evaluating the effects of uncertainty in the different alternatives.

The information generated by an analytical model can be very useful in arriving at investment decisions, but the model does not provide

Table 2.7. Discounted cash flows for five hypothetical investment alternatives

Year	Compounded discount rate	Investment alternatives 2	3	5	7	8
		(thousand dollars)				
0	1.000	-1,500	-875	-1,750	-2,375	-3,000
1	1.080	222	117	222	328	417
2	1.166	206	108	206	304	386
3	1.259	191	100	191	281	357
4	1.360	177	93	177	260	331
5	1.469	164	86	164	241	306
6	1.587	152	80	152	223	283
7	1.714	141	74	141	206	262
8	1.851	131	69	131	191	243
9	1.999	121	64	121	177	225
10	2.159	250	139	273	384	486
Total=present value		255	55	28	220	296

a mechanical decision making procedure. The decision maker must weigh various pieces of information, such as the long range competitive position of the firm, the degree of uncertainty associated with an investment proposal and the financial position of the firm. In addi-

tion, the goals of the firm usually are not clearly defined. For example, the firm may be interested in maximizing profit and in obtaining a high level of growth, two goals which may be conflicting at times.

Positive models

The investment planning procedures discussed earlier are normative in the sense that, given certain simplifying assumptions, use of these procedures will result in optimal decisions. However, the assumptions never perfectly describe the actual decision making environment, and investment planning procedures that are actually used do not correspond exactly to any one theoretical framework.

The large national meat packing firms plan their investments with a two step procedure. First, a global investment target is established. The firm establishes a market share target, and on this basis determines the additional capacity needed to achieve the market share target. Second, given the desired addition to capacity, the locations of new plants are determined. The global investment target is determined by the higher levels of management on the basis of broad economic trends (among other factors), while much detailed analysis is needed to accomplish the second phase.

The second phase consists of several steps, and follows a plan similar to the following. First, it is decided in what general area of the country (e.g., the North Central Region) the new plant (or plants) will be located. Then, the density of production of the live-

stock species to be slaughtered are determined for smaller areas (perhaps individual counties) within the general area. Next, the expected trends in the density of production are estimated, and those areas which exhibit the most rapid growth are selected as potential locations for a packing plant. In some areas terminal markets have a strong influence on marketing patterns, and thus sales of slaughter livestock through the terminals is taken into account.

The next task is to estimate the nature of the competition for the livestock supply in the selected areas. If, after taking into account the competition, an area still appears favorable, then further analysis will be undertaken. This involves estimating the wage rates, the labor supply, and other factors which influence the profitability of the plant. Finally, a specific site is selected, and the size of plant is determined.

Relevant Economic Information

The normative present value model requires information on cash flows from the investment alternatives. These cash flows are based upon the income from sales, the operating expenses, the initial costs of the investment, and the salvage value of the plant, equipment and land. The prospective supply of livestock and the nature of the competition for the limited supplies are important for the positive model of investment planning, as are the income and cost data required in the present value model. The data on the slaughter livestock market

are also important for the present value model, because the cost of the raw materials is an important element in the cash flows from operations. The following six sections are devoted to a discussion of the economic information which is relevant to investment planning in the meat packing industry.

Meat sales

The primary source of income in meat packing plants is the sale of fresh meats, processed meat products, or both. The product mix depends upon the degree of integration of the plant. A second important source of income is the sale of by-products: hides, liver, tongue, heart, tallow, bones, and miscellaneous products. The value of the by-products, depending upon the amount of processing, may be as high as 10 percent of the total sales.

The value of meat packing sales have varied widely between weeks, and between years, because of widely fluctuating meat and by-product prices. Seasonal and cyclical variations in livestock marketings add to the instability of meat packers' incomes. During low supply periods some packers may find it difficult to fulfill the needs of their regular customers.

Initial costs

Initial costs, also referred to as investment costs, are the costs of durable items which remain useful for more than one production period. They are termed initial costs because they are incurred before

production can begin, and before any other costs are incurred. In the case of meat packing plants, the cost of buildings, corral, land and equipment compose the initial costs (12, pp. 55-72). Equation 2.2 relates initial costs, I,

$$I = a_1 + b_1 K \qquad (2.2)$$

to plant capacity, K. The symbols a_1 and b_1 represent constant coefficients.

Table 2.8 presents the initial cost data for the eight beef slaughter plants synthesized by Logan and King. The Table also includes equation 2.2 fitted to the data for the eight plants. The coefficients are in terms of dollars. The capacity of these plants can be meaningfully measured because they are designed to operate for one eight hour shift per day, for a five day week. Thus, the annual capacity is defined as the number of cattle that can be slaughtered during a year consisting of 252 work days, with 7.5 working hours per day.

Considerable economies of scale exist in the initial costs for the beef slaughter plants. The average cost per unit of capacity is relatively high for a plant of small capacity, but as capacity becomes larger average cost approaches an asymptote of $4.98 per head of annual capacity.

Fixed costs

Fixed costs are usually defined as those costs which are incurred regardless of the level of production. However, for the purposes of

Table 2.8. Initial costs for eight model beef slaughter plants[a]

Plant	Annual capacity	Initial costs[b]
	(thousand head)	(dollars)
One-bed	32	258,305
A	38	307,738
Two-bed	66	369,509
B	76	469,094
Three-bed	95	503,048
C	113	704,699
D	142	821,773
E	227	1,229,772
$I = 96,205 + 4.97783\ K$		$R^2 = 0.99$

[a]Source: (12).

[b]Initial costs are the sum of building costs, cost of corrals and fencing, cost of land, equipment costs, and architectural costs.

this analysis, we are concerned with the costs of a plant which can operate at various levels of capacity utilization, but which does not completely shut down at any time. Therefore, fixed costs will be redefined to be those costs which are incurred during the normal operations of a plant, but which are not affected by the level of capacity utilization. Fixed costs in beef slaughter plants include (1) fixed

labor costs, which are composed of the costs of office, buying, selling, and management personnel, (2) taxes, (3) insurance, and (4) utilities. Equation 2.3 relates fixed costs to capacity, where F is annual fixed costs, and K is annual capacity, i.e.,

$$F = a_2 + b_2 \ K \tag{2.3}$$

The fixed costs for the eight model beef slaughter plants are presented in Table 2.9, along with equation 2.3 fitted to the data in the table. Sizeable economies of scale exist, with an asymptotic average fixed cost of $1.84 per head of annual slaughter capacity.

The usual procedure in cost studies is to distribute the costs of durable assets over the lifetime of the asset in the form of depreciation allowances. However, in analyzing investment alternatives the emphasis is on the cash flows aspect of costs (8), and initial costs are used in the analysis in place of annual depreciation changes.

Most cost studies compute an interest charge on the value of fixed assets, which measures the opportunity cost, or the return foregone from alternative investments. However, in discounted cash flow analysis the time element is accounted for by the discounting procedure, and the calculation of opportunity costs is not needed.

Variable costs

Variable costs, those costs dependent upon the level of production, would be expected to also be dependent upon the capacity of the plant. Therefore, equation 2.4, expressing variable costs in year t, V_t, as a

Table 2.9. Fixed costs for eight model beef slaughter plants[a]

Plant	Annual capacity	Fixed costs[b]
	(thousand head)	(dollars)
One-bed	32	79,925
A	38	92,909
Two-bed	66	153,737
B	76	179,229
Three-bed	95	218,816
C	113	277,703
D	142	297,499
E	227	434,529
$F = 36{,}039 + 1.83563\ K$		$R^2 = 0.98$

[a]Source: (12).

[b]Fixed costs are the sum of fixed labor costs, taxes, insurance and utilities.

function of annual capacity, and annual slaughter, S_t, was assumed.

$$V_t = a_3 + b_3K + C_3S_t \qquad (2.4)$$

Variable costs for the model beef slaughter plants consist of union labor costs and the cost of miscellaneous supplies and services (repair and maintenance, office costs, telephone costs, etc.). The cost of raw materials, although obviously dependent upon the level of production, will be treated as a separate cost item rather than including it

in the variable cost category.

The variability of production must be taken into account when dealing with variable costs. One way of handling this is by means of a "constant production period," which is defined as the longest period of time during which the rate of production is always constant. Depending upon the industry, the constant production period may be a week, a day, an hour or any other appropriate time period. In the following analysis it will be assumed that a week is the constant production period for a meat packing plant.

The choice of a week as the constant production period for meat packing plants can be justified on the basis of (1) labor union contracts, and (2) the daily pattern of livestock marketings. Labor contracts in the meat packing industry typically guarantee a 40 hour week (11). Therefore, a slaughter plant operator endeavors to keep his union labor fully employed during the week, and to change the rate of production on a week-to-week basis only.

Daily market receipts at terminal livestock markets are almost always highest on Mondays and Tuesdays (3). Consequently, livestock slaughterers tend to buy enough livestock early in the week to assure full employment of union labor during the entire week. Daily slaughter data for federally inspected packers during a three-month period in 1956 supports the assumption of uniform slaughter rates during the week.

> The regional average slaughter of cattle and hogs varied but little Monday through Friday ... Furthermore, there was little variation among the various slaughter points ... This indicates that the rate of utilization (slaughter) by packers is fairly constant throughout the week (3, p. 8).

A processing plant's capacity must be large enough to handle the output of the plant during all constant production periods. This condition is expressed symbolically as:

$$K \geq 52\, s' \tag{2.5}$$

where s' is the highest weekly production during the year. The inequality can be expressed in terms of S_t by introducing a "variability coefficient," α, and defining s as the average weekly production. Then, we have:

$$s' = \alpha\, s \tag{2.6a}$$

$$52s' = \alpha\, 52s = \alpha\, S_t \tag{2.6b}$$

and the inequality can be written as:

$$K \geq \alpha\, S_t \tag{2.7}$$

In fitting the variable cost function (equation 2.4) it is assumed that the coefficient c_3 does not depend upon the week-to-week variability in production. The coefficient is assumed to be the same whether production is the same during every week of the year, or whether production in some weeks are much higher than in others. However, because of restriction 2.7, the initial costs (equation 2.2), fixed costs (equation 2.3), and variable costs (equation 2.4), will be higher when the variability in production is high.

The variable costs for the eight model beef slaughter plants appear in Table 2.10. Costs for less than capacity operation are available only for the three plants employing the bed-type technology. Two variable cost functions were fitted, and both are shown in Table 2.10. The coefficient on the capacity variable was not significantly different from zero at the 50 percent level, when a t-test was applied. Therefore, the second equation was fitted using only one explanatory variable. In both of these equations substantial economies of scale for variable costs exist.

Cost of raw materials

The cost of raw materials in the meat packing industry is between 70 and 75 percent of the value of total sales. These raw material costs consist almost entirely of the cost of livestock, meat and meat products. Raw material costs are particularly important for specialized slaughter plants in which the cost of livestock is about 90 percent of the value of total sales.

The price paid will depend upon the source of the livestock. If livestock is procurred from a terminal market, a relatively high price must be paid. The lowest prices would probably be found in circumstances where livestock is purchased direct from farmers, in an area in which buyers are not active, and which is a long distance from alternative outlets such as terminal markets.

Table 2.10. Variable costs for eight model beef slaughter plants[a]

Plant	Annual output	Union labor costs	Misc. costs[b]	Total variable costs[c]
	(head)	(dollars)	(dollars)	(dollars)
One-bed	18,900	94,676	48,881	143,557
One-bed	22,680	107,504	54,293	161,797
One-bed	28,224	127,857	62,223	190,080
One-bed	32,004	134,497	67,646	202,143
A	37,800	173,435	75,946	249,381
Two-bed	37,800	153,514	75,746	229,260
Two-bed	47,124	191,781	89,298	281,079
Two-bed	56,700	238,224	103,011	341,235
Two-bed	66,024	258,557	116,362	374,919
B	75,600	328,753	130,075	458,828
Three-bed	56,700	250,209	103,011	353,220
Three-bed	66,024	277,355	116,362	393,717
Three-bed	75,600	329,530	130,075	459,605
Three-bed	84,924	349,258	143,427	492,685
Three-bed	94,500	376,511	157,140	533,651
C	113,400	436,978	184,205	621,183
D	141,624	506,029	224,621	730,650
E	226,800	766,881	346,594	1,113,475

$V_t = 66{,}920 + 0.22686K + 4.51855\ S_t$ $\quad R^2 = 0.99$

$V_t = 70{,}392 + 4.72807\ S_t$ $\quad R^2 = 0.99$

[a]Source: (12).

[b]Cost of miscellaneous supplies and services.

[c]Sum of union labor costs and miscellaneous costs.

Meat packers must also keep fairly large inventories of livestock and meat. For example, beef must be kept in the plant's coolers for about two days. Livestock may be purchased early in the week, and

slaughtered later in the week. In sum, the inventory could easily amount to one week's production. Thus, a large slaughter plant with a weekly kill of, say 4,000 head of cattle, may hold an inventory of close to one million dollars. Interest charges on inventories of this size would be a sizeable cost item. Inventory holding costs can be handled in the present value calculations of a project as follows: (1) the value of inventories at the time the plant begins operation constitutes a negative cash flow at that time, (2) the value of inventories at the time the plant ceases operations constitutes a positive cash flow, and (3) the value of changes in inventories in any intermediate period becomes positive or negative cash flows at that time.

Slaughter livestock marketing channels and prices are obviously important considerations in any decision about the location and size of a packing plant. For this reason, and because of the complexity of the subject, an extended discussion of these topics will be undertaken in later chapters. The present discussion will be limited to the more general aspects of the procurement operations of meat packers.

The cost of transporting livestock may be a fairly sizeable cost item. Trucking rates in Iowa per hundredweight of livestock are $0.20 for a 25 mile haul; $0.25 for 50 miles, and $0.35 for 100 miles. Thus, in general, commercial trucking rates for trips of 100 miles or less could be estimated by the equation,

$$H = 0.15 + 0.002D \qquad (2.8)$$

where H is the cost per hundredweight, and D is the distance travelled

in miles.

The price of livestock at terminal markets tends to be higher than the price of livestock sold directly to the packing plants. If the cost of transporting the livestock from the terminal to the packing plant, and the cost of shrinkage of the animals enroute are added, then substantial savings can be had in buying livestock from the nearby area. Of course, if a plant is located at, or near, a terminal market, the cost differences may be negligible. Also, the relative ease of securing livestock at the terminal, may outweigh the small cost differences.

Other considerations are important for interior plants, those located at some distance from a terminal market. Ideally, an interior plant would be located in an area of high density of production and a long distance from competing plants. The higher the density of production, the less the cost of procurring livestock. In a high density area livestock buyers do not need to travel as far to procure a given amount of livestock. If a series of buying stations are operated, as is done by many hog slaughter plants, the packer must bear the cost of transporting the livestock from the buying stations to the slaughter plant. In a high-density area the buying stations can be located closer to the slaughter plant, thus saving transportation costs.

The price which must be paid for livestock will be influenced by the distance between competing plants. Williamson (38) has developed

a model which implies that higher prices will be paid at the points where the supply areas of competing plants meet, and that the lowest prices will be paid to producers nearest the plants. The model also implies that the price surface will fall as competing plants become further apart. Unfortunately, there is at present no price data reported for purchases of livestock by individual plants to test these hypotheses.

Optimum plant size and location

The purpose of investment planning is to facilitate better investment decisions. In this study we are specifically interested in decisions concerning the size and location of meat packing plants. The role of economic information in investment planning in the meat packing industry can be evaluated by tracing through the steps involved in a typical investment planning procedure.

The first step is to determine the amount of expansion of the firm's capacity. This is analogous to determining the firm's capital budget. In determining capacity expansion, management must take into account the expected demand for meat and meat products, and the long-range objectives of the firm. The long-range objectives frequently are tied closely to the desire to maintain a certain market share, or to increase the market share. Management must also take into account the costs associated in achieving its goals. In particular, the firm must control enough financial resources to finance the proposed capacity

expansion, and there must be some assurance that the new plants will show at least a minimum profit. However, the size and location of the new plants are determined by more detailed analysis.

The next step is to locate areas of expected rapid growth in livestock supply, and to roughly estimate the extent of competition for the livestock in these areas. Thus, by means of a screening process, a number of favorable areas can be located.

The remaining alternative areas are then analyzed more thoroughly. There must exist a labor pool large enough to supply the labor needs of a new plant. There must be a specific site within the area with proper transportation, sewer and water and other facilities. In addition, the local people should be favorable, at least not hostile, to the idea of having a meat packing plant in their community. After this screening process, a set of feasible sites remain.

Next the comparative cost advantages of the feasible sites are studied. Wage rates tend to be lower in nonindustrialized areas. Tax rates, utility rates and insurance costs may differ significantly among different sites. Costs of transporting livestock and meat may also differ significantly among sites. Livestock transportation costs, as well as procurement costs, may be lower in areas of high density of production. The cost of transporting meat will be lower for those sites closest to the meat consuming centers.

Economies of scale are taken into account in determining the size and location of new plants. The initial costs will probably not differ much among alternative sites, but must be considered in determining the optimum size of plant at a specific site. Economies of scale of fixed costs will vary between sites because of differences in utility rates and wage rates. Differences in wage rates can substantially affect the economies of scale in variable costs.

The market of slaughter livestock is of overriding importance. The amount of livestock available in the area, the prices of livestock, the seasonal characteristics of the supply, and the sources of supply outside of the area (e.g., terminal markets) are all important considerations. Large plants can make use of the economies of scale of in-plant costs, but will suffer from diseconomies of scale in the higher price of livestock, and higher average costs of procurring and transporting livestock.

After this thorough analysis, the more promising project proposals (alternative plant sizes at the selected sites) can be subjected to present value analysis. Then one or more projects are selected, such that the desired addition to the firm's capacity is achieved. The objective would be to minimize the cost, in terms of the present value of cash flows, of the additional capacity. There will always be considerable uncertainty attached to the present value calculations, but the procedure does produce valuable information for decision making.

Sources of Information

Meat packers use several sources of information in their investment planning activities. Some of this information is generated internally or on a contractual basis by consulting agencies, while other types of information can be generated by public information producing agencies.

Private information sources

Meat packing firms usually possess much of the technical data needed for investment planning in the form of accounting records. They can also draw upon the experience and technical knowledge of their engineers and other staff personnel. In addition they can draw upon the knowledge and experience of equipment manufacturers, and management and engineering consulting firms. These, and other sources, may be termed private information sources since the information generated by these sources is usually intended for the use of a single firm rather than the industry as a whole.

The in-plant cost data can be readily obtained from the private information sources. The initial costs of plant and equipment can be estimated from accounting records, and on the basis of data made available by meat packing equipment manufacturers and construction companies. Good estimates of inventory costs can be based on past experience and accounting records. Labor costs can be estimated from accounting records and by consultation with labor unions. Transportation compa-

nies (railroads and truckers) can provide the data needed for estimating the costs of transporting livestock and meat. The prices of livestock, meat and by-products can be estimated on the basis of past experience and published market data. Procurement and selling costs can be estimated from the past experiences with plants operating in similar market situations.

Much of this information is of a detailed nature and is specific to the unique investment decision. Thus it is appropriate that it be generated on a private basis for each specific situation. However, it may also be appropriate for some aspects of this information to be generated on a public basis and distributed to the industry as a whole. An example of this is the work done by Logan and King (12) in determining the costs of different slaughtering techniques. The data generated by this study, although it had an independent value for later research, was partly intended as an information source for California meat packers. Information distributed on this basis would probably be of most use to small meat packers with little accumulated experience, and to prospective entrants into the industry.

Public information sources

Public information sources include governmental agencies such as the U.S. Department of Agriculture and state supported agricultural experiment stations, and trade associations of the meat packing industry such as the American Meat Institute and National Independent Meat Packers Association. These agencies can generate and distribute

information pertinent to investment decisions on a public or industry-wide basis. They should not be concerned with the information needs of particular firms, but rather the types of information which are potentially useful to all members of the industry and prospective entrants into the industry.

Projected demands for meat in various geographical regions would be useful to all members of the industry, as would information concerning the changing structure of the livestock producing, livestock marketing, meat packing, and meat wholesaling and retailing industries. Prospective changes in the geographical distribution of slaughter livestock production is of utmost importance. The prospects for various slaughter livestock marketing channels, and the relative costs of obtaining slaughter animals from different marketing agencies (such as terminals and auctions) are also important. The prospective location of the meat packing industry in the future, and its ramifications for individual firms is important. Other useful types of information which could be generated on a public basis are general methods and techniques of investment planning especially tailored for use by meat packing firms, and standardized cost data which are applicable to several firms. This is not an exhaustive list, but it does point out some of the more obvious areas where investment planning information could be generated on a public basis.

Research in the areas listed has been conducted by governmental agencies and by the trade associations. There often are great advan-

tages in such research results being distributed on a public basis, since this eliminates the need for individual firms to duplicate the research for themselves. Research of this type is useful, not only to the meat packing industry, but also to the economy as a whole, since it helps create a more efficient industry. In particular, it can help in avoiding unwise location decisions and overexpansion of capacity, which result in excessive transportation costs and unused capacity.

The Upper Midwest Region

The next three chapters are concerned with some aspects of the research outlined in the previous paragraphs. We are first concerned with methods for projecting the geographical pattern of slaughter livestock production. The description of present, and a projection of future, slaughter livestock marketing channels follows. The prospective location of packing plants and future needs for capacity expansion in the industry is based on the trends in slaughter livestock production and marketing channels.

The empirical part of this study is confined to the Upper Midwest Region. This region is composed of six states: Wisconsin, Minnesota, Iowa, North Dakota, South Dakota, and Nebraska. A sizeable proportion of the United States meat packing industry is located in this region, and one of these states, Iowa, leads the nation in both livestock and meat production. Three of the nation's leading terminal markets are located at South Saint Paul, Minnesota, Omaha, Nebraska, and Sioux City,

Iowa. The region is bounded on the north and west by areas of only light livestock production, while to the east and south are heavy livestock producing regions. In sum, the region serves to illustrate the livestock production-marketing-processing complex of the United States.

LOCATION OF SLAUGHTER LIVESTOCK PRODUCTION

The Upper Midwest Region (Wisconsin, Minnesota, Iowa, North Dakota, South Dakota, and Nebraska) produces a large share of the nation's total livestock production. This region accounted for 34 percent of the United States production of slaughter cattle during the 1959-1961 period, 21 percent of slaughter calf production, 41 percent of slaughter hog production, and 23 percent of slaughter sheep and lamb production. A detailed description of the locational patterns of slaughter livestock production in these six states is the subject of the first two parts of this chapter. Projected slaughter livestock production in the six states is discussed in the remaining sections.

Production and Interstate Flows, 1959-1961

Several data sources can be used in estimating slaughter livestock production by state. Since different data gathering and estimation procedures are used in collecting the data, it is very possible for inconsistencies to arise when different data series are used in deriving state slaughter livestock production estimates.

Methods of estimation

There are at least three methods of estimating slaughter livestock production by states. One method is through the use of "marketings" data. Marketings are "shipments to markets and packers within a state and all shipments out of the state. It includes retail slaughter of

animals originating in the state, but does not include interfarm sales within the state or farm slaughter" (35, p. 4).

Marketings data are not completely satisfactory because they include livestock flows which are irrelevant for the purposes of this study. The goal of this inquiry is to estimate the production of "slaughter livestock," i.e., those animals moving ultimately to packing plants. (The term "slaughter livestock production" will be used henceforth to mean sales of slaughter livestock from farms, ranches, and feedlots. The term "slaughter livestock marketings" will be reserved for a later discussion of marketing channels.) Therefore, we exclude marketings of breeding stock and livestock destined for further feeding before slaughter. To estimate slaughter livestock production from the published marketings data it would be necessary to first estimate the non-slaughter component of marketings.

A second method of estimation is through the use of "livestock production" data.

> Livestock production for each state is the live weight produced on farms and ranches in that state during the calendar year. It is obtained for each state by deducting the weight of livestock shipped into the state from the total pounds of marketings and farm slaughter and adding or subtracting, as the case might be, the difference in the inventory poundage between the beginning and the end of the year (35, p. 4).

This data series is inadequate for the same reason as marketings: the estimates include non-slaughter livestock production. For example, the live weight produced on farms would include the total weight of

young livestock which are shipped to other states as feeders or breeding stock. Also, the estimates include a farm slaughter component which would have to be deducted to estimate the slaughter livestock component.

The data on "commercial slaughter" provides the basis for a third method of estimation. Commercial slaughter in a state is the number of livestock slaughtered in the state, excluding farm slaughter. The time series data on commercial slaughter is considered one of the most accurate data series of all livestock and meat statistical series. In particular, it is probably more reliable than the marketings or production series.

Slaughter livestock production in an individual state can be estimated by adding slaughter livestock outshipments and subtracting inshipments from commercial slaughter. This can be expressed symbolically as,

$$P = S + O - I \qquad (3.1)$$

where P is production, O is outshipments, I is inshipments of slaughter livestock, and S is commercial slaughter.

There are no regularly published data on interstate flows of slaughter livestock, however, unpublished data (34) on interstate flows for the years 1959 through 1961 are available. These data, although not as accurate as the commercial slaughter data, were used in estimating the production and interstate flows which follow.

Cattle

The commercial slaughter, production, and interstate flows of slaughter cattle in the Upper Midwest States for the years 1959 through 1961 are presented in Table 3.1. North Dakota and South Dakota are shown as one region because the interstate flow data was available only on that basis.

The importance of Iowa in the production of slaughter cattle is obvious from the inspection of the table. The production of the states of Nebraska and Minnesota are also sizeable when compared with total United States cattle slaughter, which was about 25 and 26 million head for these years. The relationship between slaughter and production will be important in later stages of this study. Note that production is substantially larger than slaughter in Iowa and the North Dakota-South Dakota Region, while the reverse is true for Minnesota and Nebraska.

The production estimates were checked for consistency with the published marketings data. Marketings should always be larger than the slaughter livestock production estimates. All of the production estimates were consistent, except for the Wisconsin estimate, which was about 200,000 head larger than marketings. Despite this inconsistency, the estimates in Table 3.1 will be used for the rest of this study.

Table 3.1. Commercial slaughter, outshipments, inshipments, and production of slaughter cattle, 1959-61[a]

	Wisc.	Minn.	Iowa	N.D. S.D.	Nebr.
			(thousand head)		
1959					
Commercial slaughter	912	1,308	2,279	430	1,960
Outshipments	150	213	1,896	548	628
Inshipments	108	486	883	192	959
Production	954	1,035	3,292	787	1,629
1960					
Commercial slaughter	978	1,424	2,499	435	2,137
Outshipments	165	252	1,818	478	675
Inshipments	120	518	895	213	923
Production	1,023	1,158	3,422	700	1,899
1961					
Commercial slaughter	918	1,409	2,738	554	2,186
Outshipments	162	289	1,555	484	708
Inshipments	127	488	977	249	839
Production	953	1,210	3,316	789	2,055

[a]Source: (27, 34).

Calves

The production, interstate flows, and commercial slaughter data for slaughter calves in 1959-1961 are presented in Table 3.2. Production in all states, except Wisconsin, is small. The large Wisconsin production stems from the large dairy industry in that state; a large portion of calf slaughter consists of male dairy calves. The Wisconsin production, comprising about 15 percent of U.S. commercial calf slaugh-

Table 3.2. Commercial slaughter, outshipments, inshipments, and production of slaughter calves, 1959-61[a]

	Wisc.	Minn.	Iowa	N.D. S.D.	Nebr.
			(thousand head)		
1959					
Commercial slaughter	1,088	256	369	1	12
Outshipments	183	27	64	95	10
Inshipments	68	82	290	9	0
Production	1,203	201	144	87	22
1960					
Commercial slaughter	1,133	261	390	1	11
Outshipments	195	24	81	80	9
Inshipments	91	105	279	8	0
Production	1,237	180	192	73	20
1961					
Commercial slaughter	993	222	383	1	9
Outshipments	189	22	89	69	9
Inshipments	93	79	285	7	0
Production	1,089	165	187	63	18

[a]Source: (27, 34).

ter, is important in the national picture, while calf production in the remainder of the Upper Midwest States is relatively unimportant.

Hogs

Slaughter hog production, interstate flows, and commercial slaughter for the years 1959 through 1961 are presented in Table 3.3. Iowa is, by far, the largest producer of slaughter hogs in the country, producing about 23 percent of U.S. commercial hog slaughter. Minnesota

Table 3.3. Commercial slaughter, outshipments, inshipments, and production of slaughter hogs, 1959-61[a]

	Wisc.	Minn.	Iowa	N.D. S.D.	Nebr.
			(thousand head)		
1959					
Commercial slaughter	3,701	5,611	15,162	2,480	4,425
Outshipments	780	1,506	6,749	1,306	2,424
Inshipments	1,743	1,330	2,692	1,091	2,808
Production	2,738	5,787	19,219	2,695	4,041
1960					
Commercial slaughter	3,441	5,428	14,455	2,172	4,044
Outshipments	699	1,229	5,914	839	1,986
Inshipments	1,509	1,353	2,470	1,073	2,410
Production	2,631	5,304	17,899	1,938	3,620
1961					
Commercial slaughter	3,140	5,654	14,231	2,326	4,206
Outshipments	658	1,242	5,688	911	1,989
Inshipments	1,212	1,460	2,402	1,083	2,364
Production	2,586	5,436	17,517	2,154	3,831

[a]Source: (27, 34).

and Nebraska are also among the top hog producing states.

Iowa is also the leading state in hog slaughter; however, the state produces 3 to 4 million slaughter hogs more than it slaughters. The other states are nearly in balance between slaughter and production, although Wisconsin's slaughter is substantially larger than its production.

Sheep and lambs

Slaughter sheep and lamb production, interstate flows, and commercial slaughter are shown in Table 3.4. Iowa is the leading state in the Upper Midwest Region in terms of both production and commercial slaughter. However, Iowa production accounts for only 9 percent of total U.S. slaughter.

Table 3.4. Commercial slaughter, outshipments, inshipments, and production of slaughter sheep and lambs, 1959-61[a]

	Wisc.	Minn.	Iowa	N.D. S.D.	Nebr.
			(thousand head)		
1959					
Commercial slaughter	193	870	1,375	736	1,026
Outshipments	65	146	527	527	179
Inshipments	93	518	566	258	711
Production	165	498	1,336	1,005	494
1960					
Commercial slaughter	186	1,074	1,481	571	1,081
Outshipments	64	162	491	607	237
Inshipments	100	649	642	255	722
Production	150	587	1,330	923	596
1961					
Commercial slaughter	152	1,261	1,635	480	1,148
Outshipments	71	174	573	809	140
Inshipments	118	774	589	228	767
Production	105	661	1,619	1,061	521

[a]Source: (27, 34).

There is a fairly large inshipment of slaughter sheep and lambs into Nebraska, resulting in a level of slaughter about twice that of production. Slaughter is also much larger than production in Minnesota, while the reverse is true for the North Dakota-South Dakota Region.

Production in Substate Regions, 1959-1961

The density of slaughter livestock production varies widely among geographical regions within each of the Upper Midwest states. To study this variation, each of the states were divided into substate regions, and 1959-61 production allocated to these smaller regions.

Delineation of regions

For ease in data assembly, the substate regions must consist of counties or groups of counties. Different types of livestock data are available for the Upper Midwest States on a county basis, but there are no published data for smaller geographical units. However, this is of little importance since even single county regions are usually too small and numerous for analytical purposes (e.g., there are 99 counties in Iowa).

Several criteria could be suggested for grouping counties into regions. One criterion is density of production, i.e., combine into one region contiguous counties with similar densities. An attempt was made to delineate regions in Iowa on this basis, but it proved unsuccessful. An excessively large number of regions were needed to establish the desired degree of homogeneity among the counties in each

region. Another difficulty arises because of different densities for different species of livestock, e.g., two counties may have almost identical densities of slaughter cattle production, but widely differing densities of slaughter hog production.

Nodel regions are another possibility. Cities which are possible locations for meat packing plants could be identified, and these cities would serve as center points for their regions. All counties would be assigned to the closest nodel city, thus forming an exhaustive set of regions. This alternative is unsatisfactory because the number of cities and towns which are possible packing plant locations is too large. It would probably be impossible to exclude any town of 1,000 or more population as a possible site for a packing plant.

The regions which were finally used were the crop reporting districts. These are the regions which the crop and livestock reporting services in each state use for reporting their data. This is a desirable delineation because county livestock data are reported for these regions; thus county data do not have to be aggregated for the substate regions. All of the Upper Midwest states contain nine crop reporting districts, except Nebraska, which contains eight. All these regions are approximately equal in size, although somewhat smaller regions tend to be found in more intensive farming areas. The substate regions are shown in Figures 3.1 through 3.6. Each of the regions will be referred to by the numbers shown on the maps. The maps also show the location of the terminal markets.

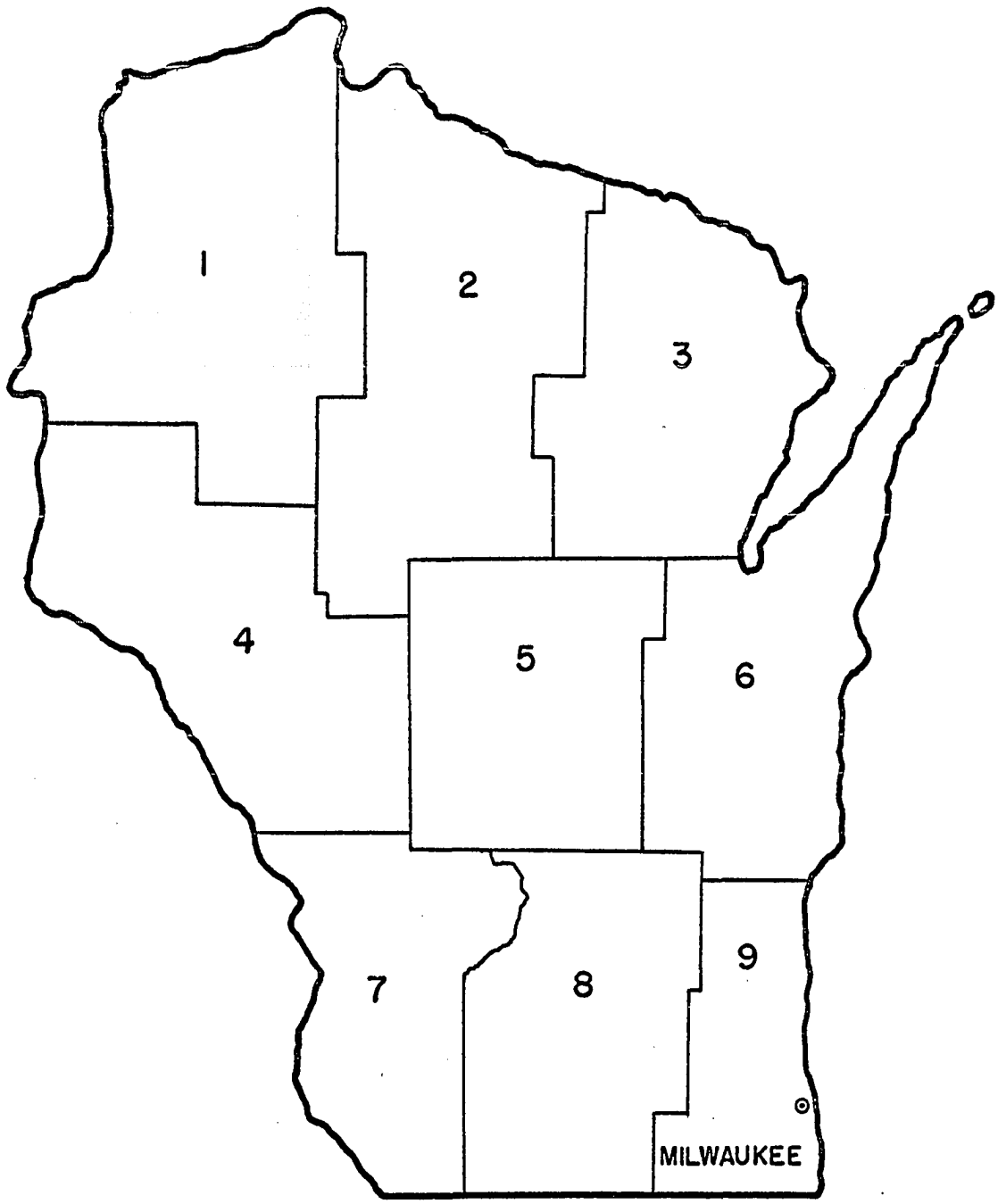


Figure 3.1. Substate regions in Wisconsin

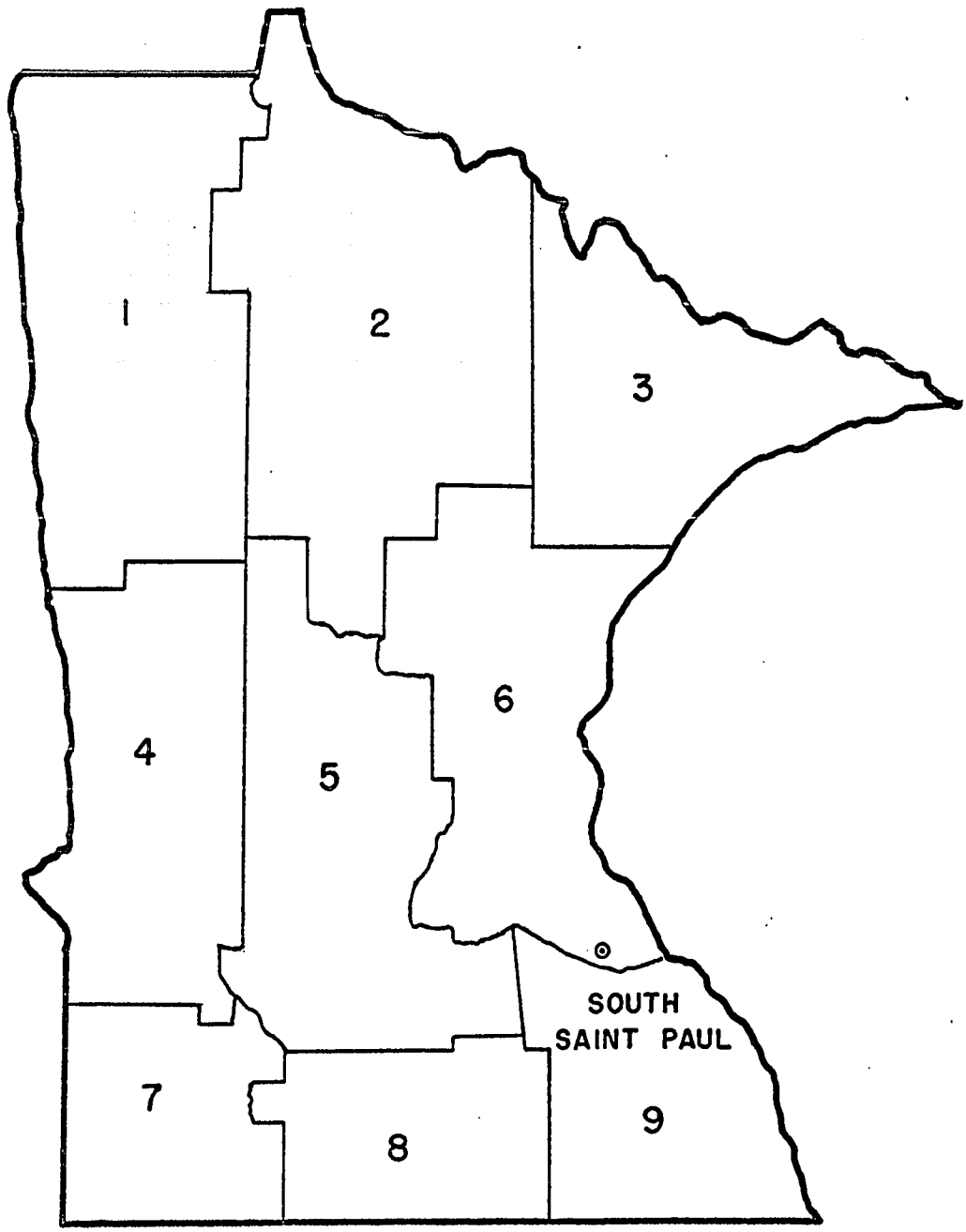


Figure 3.2. Substate regions in Minnesota

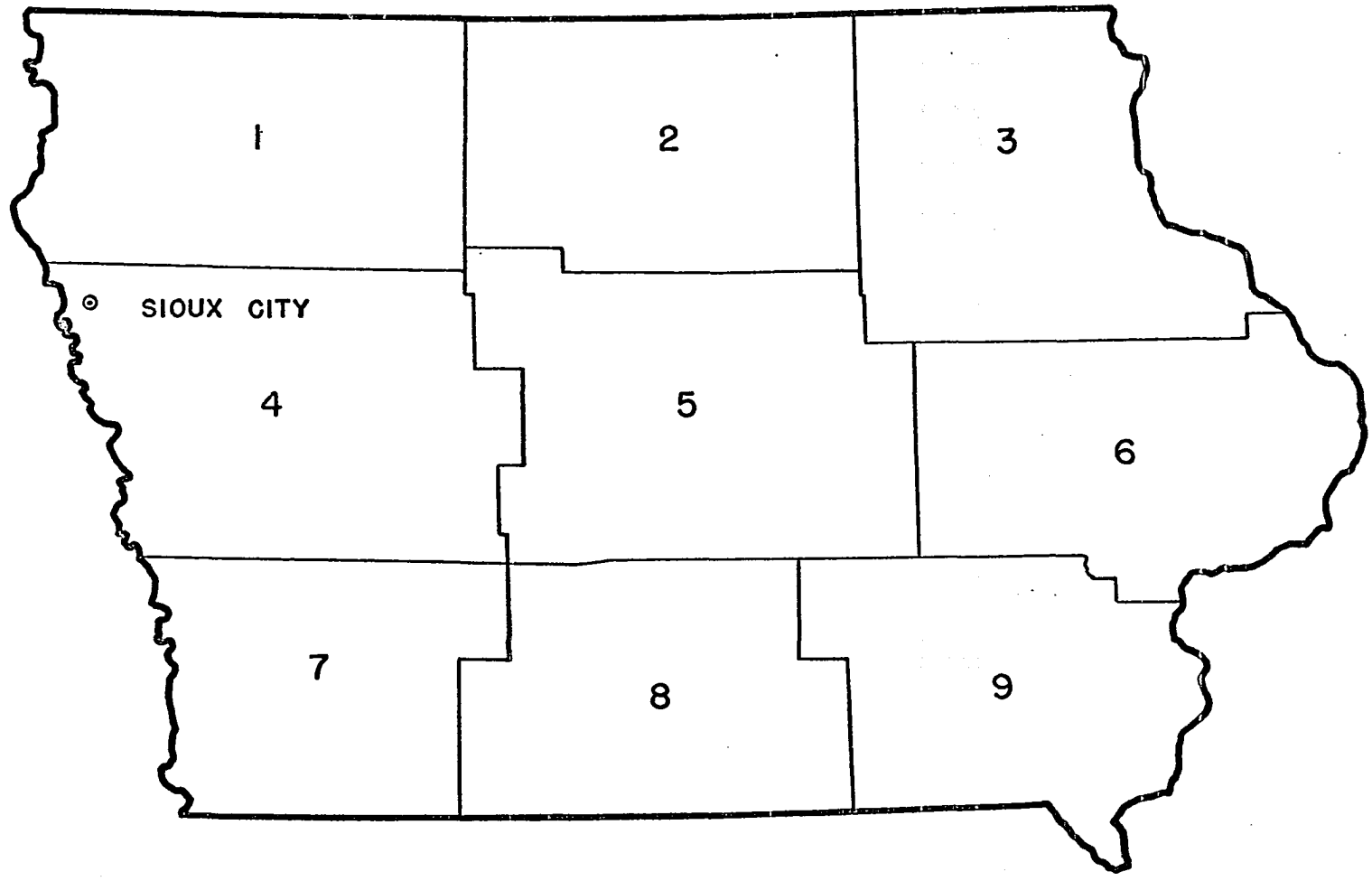


Figure 3.3. Substate regions in Iowa

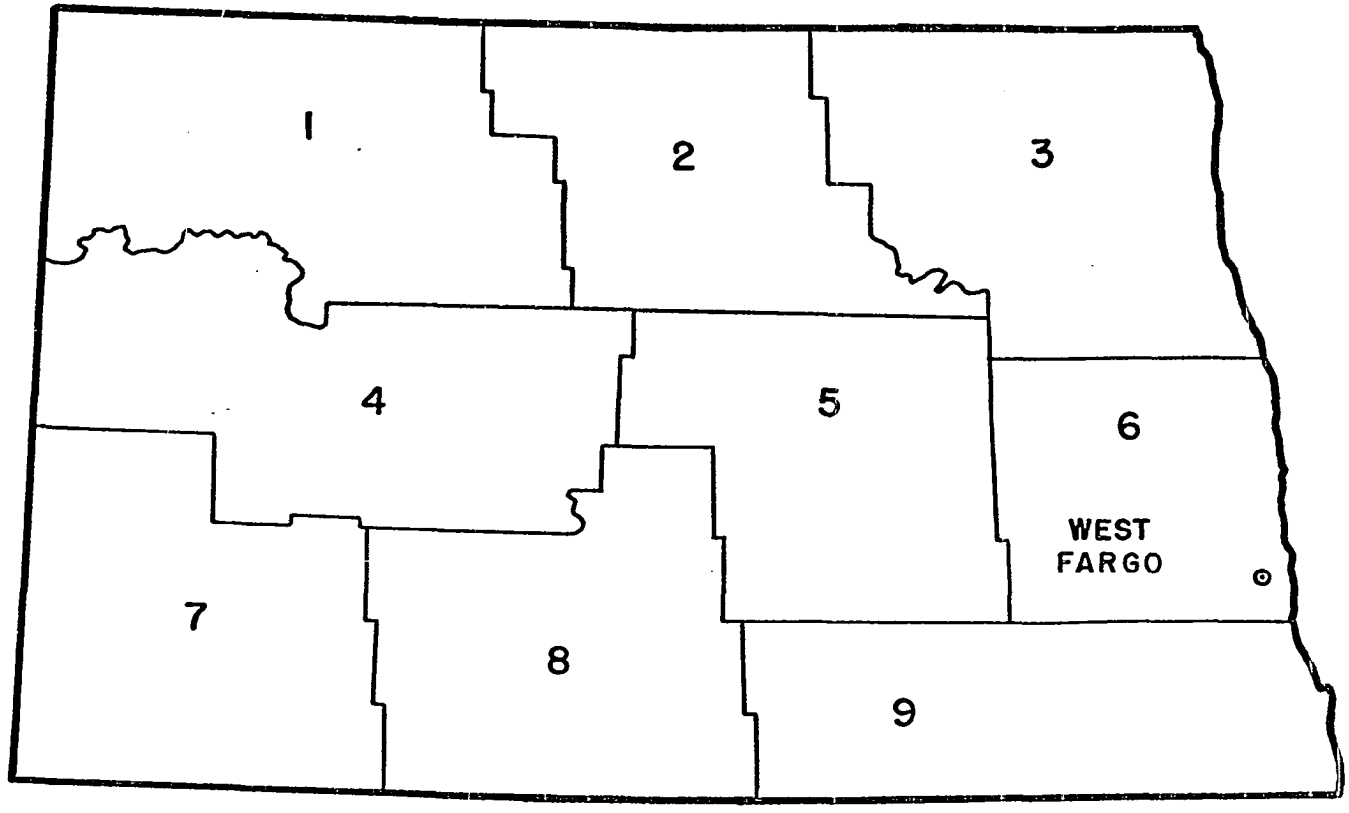


Figure 3.4. Substate regions in North Dakota

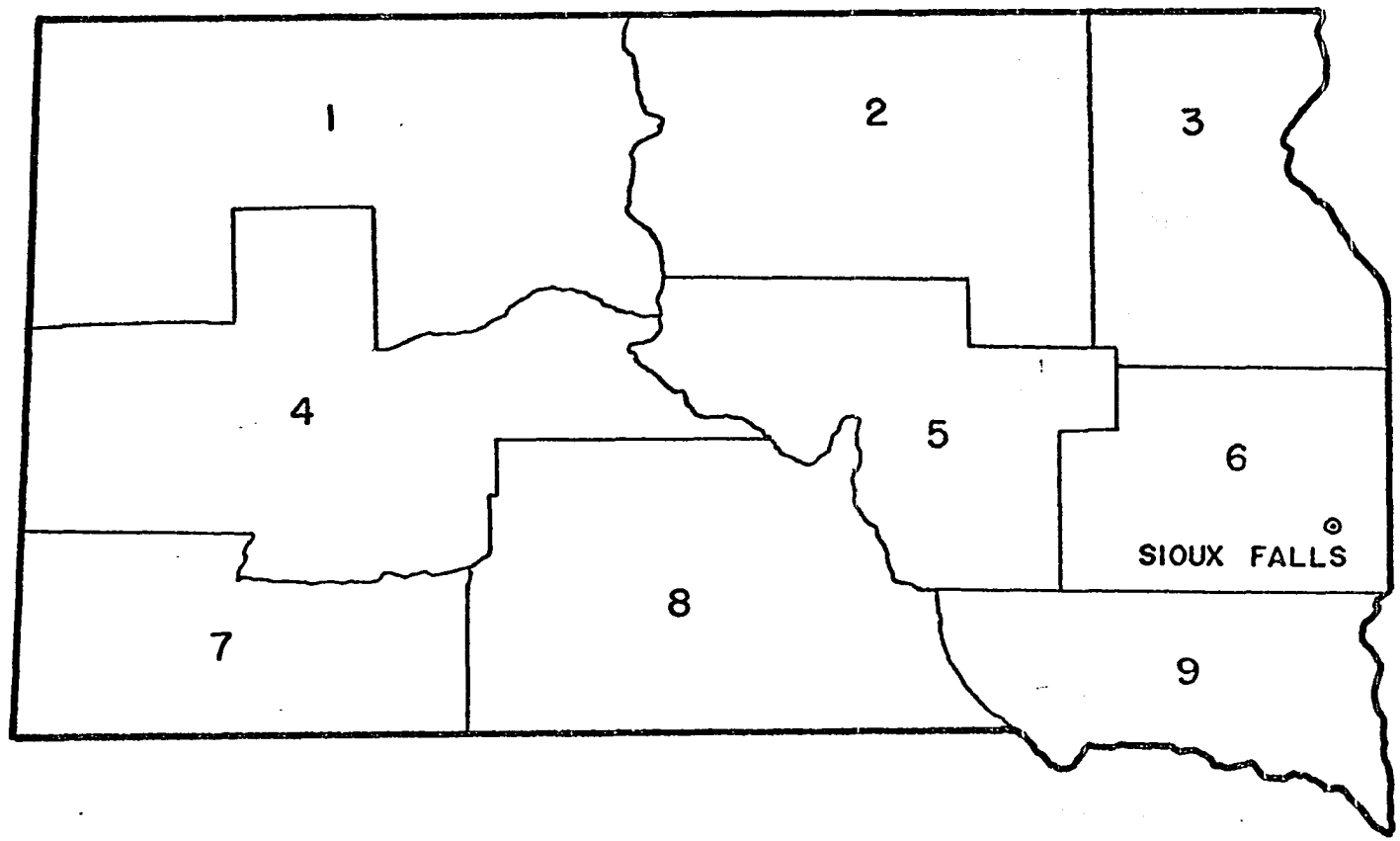


Figure 3.5. Substate regions in South Dakota

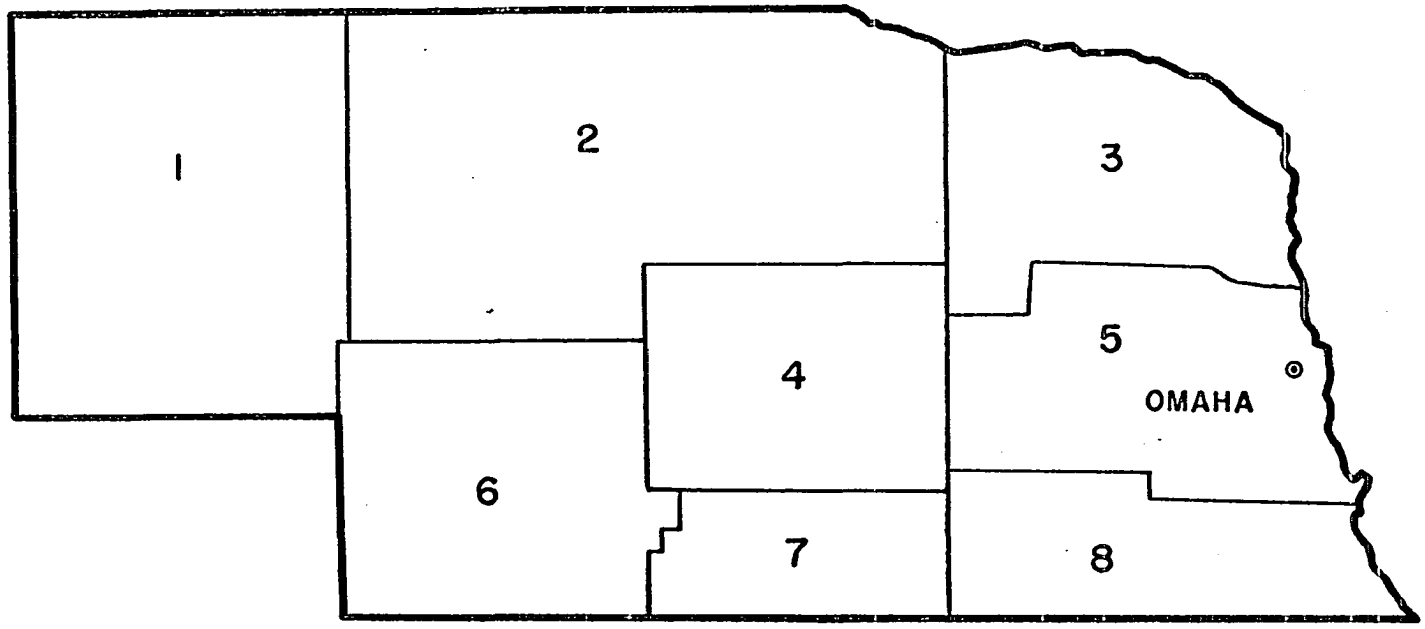


Figure 3.6. Substate regions in Nebraska

Allocation procedures

The total slaughter livestock production of each state was allocated among the substate regions. The allocation methods were different for different states, because of the differences in data availability. The Annual Farm Census of Iowa (10) reports "grain fed cattle marketed" by county, which accounted for about 90 percent of total slaughter cattle production in 1959-61. The other 10 percent was allocated to the substate regions according to the number of milk cows in the region, since a good share of these residual marketings are composed of cull dairy cows.

The number of cattle placed on grain feed (15) was used to allocate the Nebraska production to the substate regions. The number of cattle and calves on farms was used as the criterion for the remaining states (14, 18, 20, 39, 40). These latter estimates are probably not as precise as the Iowa estimates, because they provide no direct measure of slaughter cattle production.

The calf crop was used to allocate slaughter calf production in Wisconsin (39, 40), Iowa (10), and Nebraska (15). The number of milk cows (14) was used for allocating Minnesota's production, while the number of cattle and calves on farms (18, 20) was used in the North Dakota-South Dakota Region.

The number of pigs saved was used to allocate slaughter hog production in Wisconsin (39, 40), Minnesota (14), and Nebraska (15).

Farrowings were used to allocate Iowa's production (10), and "all hogs on farms" were used in North Dakota (18) and South Dakota (20).

Iowa's slaughter sheep and lamb production was allocated to the substate areas in proportion to grain fed sheep and lambs marketed (10). The number of sheep and lambs on feed in Nebraska (15) was used to allocate that state's production. The number of stock sheep was used in Wisconsin (39, 40), Minnesota (14), and North Dakota (18), while sheep and lambs on farms were used in South Dakota (20).

In evaluating the allocation methods, it is apparent that the allocations in some states are better than those of others. For example, sales of grain fed livestock account for almost all sales of slaughter livestock. However, these data were available for Iowa and Nebraska only. The Iowa and Nebraska allocations appear superior, especially in the allocations for cattle, and sheep and lambs. Perhaps the most important point is that the allocations are, in general, better in the more important producing states. Thus, the relatively poor quality allocations in the less important producing states do not greatly depreciate the substate allocations for the Upper Midwest Region as a whole.

Cattle

Slaughter cattle production for the substate regions is presented in Table 3.5. The largest production of all the substate regions occurs in Nebraska's third region; however, most of the top producing regions

Table 3.5. Slaughter cattle production by substate regions, 1959, 1960 and 1961

Substate region	Wisconsin			Minnesota			Iowa		
	1959	1960	1961	1959	1960	1961	1959	1960	1961
	(thousand head)			(thousand head)			(thousand head)		
1	93	99	92	85	93	96	642	636	679
2	96	103	96	22	24	25	306	332	319
3	52	55	51	6	6	6	245	285	237
4	142	153	143	144	160	169	512	553	563
5	70	75	70	227	257	268	446	456	437
6	145	155	147	88	96	99	521	520	469
7	146	158	146	150	164	178	354	365	370
8	148	161	148	147	166	169	92	96	89
9	62	64	60	166	192	200	173	179	153
State Total	954	1,023	953	1,035	1,158	1,210	3,292	3,422	3,316

Substate region	North Dakota			South Dakota			Nebraska		
	1959	1960	1961	1959	1960	1961	1959	1960	1961
	(thousand head)			(thousand head)			(thousand head)		
1	21	19	23	46	41	44	80	98	105
2	24	21	25	59	52	58	20	25	25
3	21	20	21	53	45	51	587	676	709
4	37	32	39	50	44	46	172	217	240
5	35	30	36	68	60	67	487	521	578
6	23	21	24	74	66	74	46	59	70
7	30	25	31	28	25	25	77	110	129
8	42	36	43	59	55	60	160	183	199
9	45	41	46	73	67	76	-	-	-
State Total	278	245	288	509	455	501	1,629	1,889	2,055

are in Iowa. The lowest level of production occurs in Minnesota's third region, but most of the lowest producing regions are in North Dakota.

Calves

Table 3.6 contains the substate slaughter calf production estimates. All of the important slaughter calf production regions are in Wisconsin; all nine of Wisconsin's regions produce more than any region in the other five states.

Hogs

Slaughter hog production by substate areas is shown in Table 3.7. Iowa dominates the other states with the top seven substate regions. Other leading regions, Nebraska's third region, Minnesota's seventh, eighth and ninth regions, Wisconsin's seventh region and South Dakota's ninth region, border Iowa. Thus, there is an extraordinary concentration of slaughter hog production in Iowa and the bordering regions of the other four states. The only state which does not have any heavy producing regions is North Dakota. The high concentration of hog production is illustrated by the fact that four of the Iowa regions each produced about 3 percent of the total U.S. hog slaughter.

Sheep and lambs

Slaughter sheep and lamb production in the substate regions is presented in Table 3.8. The major producing areas are found in scattered locations; northwest Iowa is the leading producing region, followed by northwest South Dakota and northwest Nebraska.

Table 3.6. Slaughter calf production by substate regions, 1959, 1960, 1961

Substate region	Wisconsin			Minnesota			Iowa		
	1959	1960	1961	1959	1960	1961	1959	1960	1961
	(thousand head)			(thousand head)			(thousand head)		
1	117	119	103	17	15	14	12	16	15
2	129	136	120	5	5	4	12	17	16
3	71	73	64	2	2	1	27	36	36
4	171	176	157	24	22	20	15	20	20
5	89	90	81	57	51	47	16	21	20
6	190	195	171	24	21	19	18	24	24
7	178	184	162	14	13	12	13	17	16
8	180	186	162	24	21	20	18	24	23
9	78	78	69	34	30	28	13	17	17
State Total	1,203	1,237	1,089	201	180	165	144	192	187

Substate region	North Dakota			South Dakota			Nebraska		
	1959	1960	1961	1959	1960	1961	1959	1960	1961
	(thousand head)			(thousand head)			(thousand head)		
1	2	2	2	5	4	4	3	3	3
2	3	2	2	7	5	5	6	6	5
3	2	2	2	6	5	4	3	2	2
4	4	3	3	5	5	4	3	2	2
5	4	3	3	7	6	5	2	2	2
6	3	2	2	8	6	5	2	2	2
7	3	3	2	3	3	2	1	1	1
8	5	4	3	7	6	5	2	2	1
9	5	5	4	8	7	6	-	-	-
State Total	31	26	23	56	47	40	22	20	18

Table 3.7. Slaughter hog production by substate regions, 1959, 1960 and 1961

Substate region	Wisconsin			Minnesota			Iowa		
	1959	1960	1961	1959	1960	1961	1959	1960	1961
	(thousand head)			(thousand head)			(thousand head)		
1	107	87	91	174	143	141	2,364	2,219	2,242
2	115	103	96	58	53	65	2,095	1,951	1,962
3	77	68	62	1	5	1	2,729	2,631	2,434
4	361	368	336	793	684	756	2,210	2,076	2,085
5	225	203	191	1,313	1,204	1,260	2,422	2,184	2,137
6	359	353	310	185	175	169	2,844	2,668	2,592
7	744	733	765	1,065	987	984	1,461	1,342	1,314
8	630	605	621	1,278	1,231	1,234	1,172	1,038	1,034
9	120	111	114	920	822	826	1,922	1,790	1,717
State Total	2,738	2,631	2,586	5,787	5,304	5,436	19,219	17,899	17,517

Substate region	North Dakota			South Dakota			Nebraska		
	1959	1960	1961	1959	1960	1961	1959	1960	1961
	(thousand head)			(thousand head)			(thousand head)		
1	11	12	9	27	21	15	89	83	77
2	24	16	15	253	165	177	194	152	161
3	40	29	28	232	145	155	1,510	1,395	1,463
4	35	23	22	19	12	9	445	376	418
5	46	28	28	253	165	194	905	825	862
6	86	61	56	590	444	526	154	123	126
7	43	25	26	11	10	6	174	148	172
8	75	36	41	110	87	86	570	518	552
9	157	115	117	683	544	644	-	-	-
State Total	517	345	342	2,178	1,593	2,154	4,041	3,620	3,831

Table 3.8. Slaughter sheep and lamb production by substate regions, 1959, 1960 and 1961

Substate regions	Wisconsin			Minnesota			Iowa		
	1959	1960	1961	1959	1960	1961	1959	1960	1961
	(thousand head)			(thousand head)			(thousand head)		
1	17	17	12	110	132	148	352	395	433
2	9	8	6	32	41	46	142	189	194
3	5	4	3	3	4	3	51	53	57
4	33	29	20	95	94	102	171	146	225
5	12	12	8	43	57	69	143	142	176
6	10	9	7	23	32	33	100	78	100
7	34	30	21	82	94	108	87	69	96
8	32	29	20	48	58	66	116	114	149
9	13	12	8	62	75	86	174	144	189
State Total	165	150	105	498	587	661	1,336	1,330	1,619

Substate regions	North Dakota			South Dakota			Nebraska		
	1959	1960	1961	1959	1960	1961	1959	1960	1961
	(thousand head)			(thousand head)			(thousand head)		
1	18	17	23	219	187	203	197	206	176
2	23	21	25	70	66	80	10	9	8
3	34	29	34	79	74	86	60	91	82
4	16	15	16	60	56	59	52	71	53
5	52	50	58	80	78	94	136	160	143
6	35	31	36	104	97	119	13	17	13
7	39	41	45	27	26	29	12	18	22
8	19	18	20	28	28	31	14	24	24
9	50	45	50	48	44	53	-	-	-
State Total	290	267	307	715	656	754	494	596	521

Projected National and State Production

Slaughter livestock production is projected on three levels: (1) national, (2) state, and (3) substate region. National production is projected to 1975, then the production of each state is projected as a share of national production. Finally, production in each substate region is projected as a share of the state production.

National production in 1975

A definitional equation concerning the production and distribution of meat is:

$$P + S_B + I = S_E + E + A + D_M + D_C \qquad (3.2)$$

where, P = meat produced from U.S. commercial slaughter,

S_B = commercial stocks on January 1,

I = imports,

S_E = commercial stocks on December 31,

E = commercial exports and shipments,

A = U.S. Department of Agriculture net purchases for export,

D_M = domestic disappearance, military,

D_C = domestic disappearance, civilian.

If we assume that beginning stocks equal ending stocks, and Department of Agriculture purchases (which have been negligible since 1947) are zero, then equation 2 can be rewritten as,

$$P = D_M + D_C + E - I \qquad (3.3)$$

By ignoring the small amount of foreign trade in slaughter livestock, U.S. commercial meat production is equal to the production of slaughter livestock (expressed in terms of carcass weight).

Projected 1975 production of beef, veal, pork, and lamb and mutton are presented in Table 3.9. Civilian domestic disappearance, the largest component of meat consumption, is based upon an unpublished report by Duewer (5). Military domestic disappearance was assumed to be the same as the average of the 1958-1960 period (33). Commercial exports and shipments, and imports, were assumed to be in the same relationship to civilian domestic disappearance as during the period 1958-1960 (33). That is, it was assumed that the trade balance would grow at the same rate as civilian domestic disappearance.

The homothetic model

A homothetic model is used to allocate national production to the individual states:

$$\frac{P_{it}}{P_t} = a_i + b_i t \qquad (3.4)$$

where, P_{it} = production in state i in year t,

P_t = national production in year t,

t = time in years; t = 0 for 1960.

The coefficients a_i and b_i were estimated for each of the six states of the Upper Midwest Region. The a_i were estimated by dividing the slaughter livestock production of state i in 1959-61 by the United

Table 3.9. Projected domestic disappearance, exports, imports, and production of meat, 1975

	Beef	Veal	Pork	Lamb & Mutton
	(million pounds carcass weight)			
Domestic disappearance, military[a]	347	36	185	4
Domestic disappearance, civilian[b]	26,207	699	15,710	605
Commercial exports and shipments[a]	92	1	185	2
Imports[a]	1,641	31	264	58
Meat production[c]	25,005	705	15,816	553

[a]Based on data in (33).

[b]Source: (5).

[c]Domestic disappearance, military and civilian, plus commercial exports and shipments, minus imports.

States production during the same period (27).

The b_i were estimated from marketings or production data, using peak and trough years of the commercial slaughter cycle. Symbolically, b_i was estimated as b_i:

$$b_i = \left[\frac{(X_1 - X_2)}{n} + \frac{Y_1 - Y_2}{m} \right] \Big/ 2 \qquad (3.5)$$

where, X_1 and X_2 represent the ratio of marketings, or production, in state i to U.S. marketings, or production, in two peak years of the commercial slaughter cycle;

Y_1 and Y_2 represent the ratio of marketings, or production, in state i to U.S. marketings, or production, in two trough years of the commercial slaughter cycle;

n is the number of years between the two peak years;

m is the number of years between the two trough years.

Marketings data (26, 27, 30, 31) are used for calculating the b_i for cattle and calves, while production data (26, 27, 30, 31) are used for hogs, and sheep and lambs. The peak years used were 1956 and 1947 for cattle, 1954 and 1947 for calves, 1959 and 1952 for hogs, and 1961 and 1955 for sheep and lambs. The trough years were 1959 and 1951 for both cattle and calves, 1961 and 1954 for hogs, and 1958 and 1951 for sheep and lambs.

State production in 1975

Projected 1975 production of slaughter cattle and calves are shown in Table 3.10, along with the coefficients (a_i and b_i) of the homothetic equations, each state's share of national production in 1975, and the increase in production over the 1959-61 period. All states, except Wisconsin, increased their share of national production between 1959-61 and 1975. This resulted in an increase in the share of the Upper Midwest Region from 33.5 percent to 37.5 percent. Iowa has the largest 1975 production, 40 percent of the Upper Midwest total, followed by Nebraska and Minnesota. Iowa also showed the greatest increase in production over 1959-61.

Table 3.10. Projected slaughter cattle and calf production, 1975

Region	a_i	b_i	1975 share	1975 production	Increase[a]
				(million pounds carcass weight)	
Cattle					
Wisconsin	0.04090	-0.00033	0.03595	898.9	334.2
Minnesota	0.04750	0.00069	0.05785	1,446.5	791.0
Iowa	0.14001	0.00086	0.15191	3,798.5	1,866.2
North Dakota	0.01132	0.00017	0.01387	346.8	190.7
South Dakota	0.02044	0.00074	0.03154	788.7	506.6
Nebraska	0.07500	0.0058	0.08370	2,092.9	1,019.0
Upper Midwest	0.33517	0.00271	0.37482	9,372.3	4,707.7
Calves					
Wisconsin	0.15013	-0.00031	0.14548	102.6	-43.2
Minnesota	0.02323	-0.00203	0.00000	0.0	-22.6
Iowa	0.02225	-0.00062	0.01295	9.1	-12.5
North Dakota	0.00340	0.00054	0.01150	8.1	4.8
South Dakota	0.00608	0.00138	0.02678	18.9	12.9
Nebraska	0.00255	-0.00054	0.00000	0.0	-2.5
Upper Midwest	0.20764	-0.00158	0.19671	138.7	-63.1

[a]1975 production minus average production for 1959-61.

Slaughter calf production in the Upper Midwest decreased, both in terms of the Region's share of national production, and in terms of actual production. The projections show Minnesota's and Nebraska's production going to zero by 1975. These projections, along with the increases in production in North Dakota and South Dakota, appear to be unrealistic. However, the Wisconsin and Iowa projections seem more reasonable, and since Wisconsin is the only large producer of slaughter

calves, the projection for the Upper Midwest Region merit more confidence.

Table 3.11 contains the projections of slaughter hog, and sheep and lamb production. The hog production shares of four states, Wisconsin, Minnesota, Iowa, and Nebraska declined from 1959-61 to 1975, while South Dakota's share increased, and North Dakota's share did not change. However, the actual production of all states increased over the period, with Iowa showing the largest increase.

Slaughter sheep and lamb production shares decreased in Wisconsin and Nebraska, while the other states substantially increased their shares. However, production increased in only three states, Minnesota, North Dakota and South Dakota, while production in the six states combined decreased.

Projected Substate Production

Slaughter cattle production and hog production in the substate regions are projected to 1975. Calf production and sheep and lamb production are not projected because of their relatively small amounts in the Upper Midwest. Homothetic equations of the same form as equation 3.2, discussed earlier, are used to allocate the states' production to their respective substate regions. The a_i coefficient for a substate region is the ratio of 1959-61 production in the substate region to total 1959-61 production in the state. The data used to estimate the b_i coefficients are the same as the data series used in

Table 3.11. Projected slaughter hog and sheep and lamb production, 1975

Region	a_i	b_i	1975 share	1975 production	Increase[a]
				(million pounds carcass weight)	
Hogs					
Wisconsin	0.03343	-0.00061	0.02428	384.0	18.0
Minnesota	0.06945	-0.00019	0.06660	1,053.3	293.1
Iowa	0.22959	-0.00171	0.20394	3,225.5	712.2
North Dakota	0.00506	0.00000	0.00506	80.0	24.7
South Dakota	0.02346	0.00054	0.03156	499.2	242.4
Nebraska	0.04829	-0.00015	0.04604	728.2	199.5
Upper Midwest	0.40928	-0.00212	0.37748	5,970.2	1,489.7
Sheep and Lambs					
Wisconsin	0.00871	-0.00005	0.00796	4.4	-2.3
Minnesota	0.03620	0.00112	0.05300	29.3	1.4
Iowa	0.08885	0.00111	0.10550	58.3	-10.2
North Dakota	0.01791	0.00099	0.03276	18.1	4.3
South Dakota	0.04406	0.00232	0.07886	43.6	9.6
Nebraska	0.03340	-0.00059	0.02455	13.6	-12.2
Upper Midwest	0.22913	0.00490	0.30263	167.3	-9.4

[a]1975 production minus average production of 1959-61.

allocating 1959-61 production to the substate regions.

Cattle

Table 3.12 contains projected 1975 slaughter cattle production, and the increase in production from the 1959-61 base, for the substate regions.

Table 3.12. Projected slaughter cattle production by substate regions, 1975

Substate region	Wisconsin 1975 production	Wisconsin Increase[a]	Minnesota 1975 production	Minnesota Increase[a]	Iowa 1975 production	Iowa Increase[a]
	(million pounds carcass weight)					
1	73.7	18.9	95.5	42.4	683.7	307.0
2	90.8	33.8	8.7	-5.1	474.8	291.2
3	48.5	18.0	0.0	-3.3	345.7	198.8
4	147.4	63.3	219.9	128.8	391.2	76.2
5	52.1	10.9	315.3	171.1	676.1	419.1
6	151.0	64.6	98.4	44.0	687.6	395.8
7	138.4	51.4	250.2	155.2	186.1	-24.5
8	153.8	65.7	224.2	131.1	106.4	52.3
9	43.2	7.6	234.3	126.8	246.9	150.3

Substate region	North Dakota 1975 production	North Dakota Increase[a]	South Dakota 1975 production	South Dakota Increase[a]	Nebraska 1975 production	Nebraska Increase[a]
	(million pounds carcass weight)					
1	21.8	9.6	70.2	45.1	75.3	20.5
2	19.4	6.0	102.5	70.1	27.2	13.2
3	16.0	4.1	80.4	51.6	519.0	140.0
4	51.3	30.5	63.9	36.8	142.3	20.9
5	48.6	29.1	104.9	67.4	879.1	573.1
6	29.1	16.0	127.0	85.8	96.3	63.0
7	42.0	25.5	30.0	15.0	150.7	89.5
8	62.1	38.8	93.9	60.3	203.0	98.8
9	56.5	31.1	115.9	74.5	-	-

[a]1975 production minus 1959-61 average production.

All regions, except two Minnesota and one Iowa region, showed increases in production. The largest increase occurred in Nebraska's east region (number 5), which is also the largest producing region in the six state area. Large increases also occurred in Iowa's northwest, central and east central regions.

Hogs

Projected slaughter hog production by substate region is presented in Table 3.13. The seven largest hog producing regions in 1975 are located in Iowa, the northeast Iowa region being the largest. Minnesota's south central and southwest districts, and Nebraska's northeast district follow, in that order. The largest increase over 1959-61 also occurred in Iowa's northeast region.

Table 3.13. Projected slaughter hog production by substate regions, 1975

Substate region	Wisconsin		Minnesota		Iowa	
	1975 production	Increase[a]	1975 production	Increase[a]	1975 production	Increase[a]
	(million pounds carcass weight)					
1	13.8	0.6	0.0	-21.3	403.2	89.0
2	20.7	6.4	27.4	19.0	354.8	78.3
3	10.0	0.5	0.0	-0.3	509.5	150.2
4	51.5	2.5	158.0	55.4	377.4	83.3
5	35.7	7.2	271.8	97.8	300.0	-9.1
6	54.9	8.1	33.7	9.4	480.5	106.0
7	108.7	5.0	209.6	69.8	193.5	5.0
8	72.2	-13.1	284.3	112.6	238.9	90.6
9	16.5	0.8	68.5	-49.3	367.7	118.9

Substate region	North Dakota		South Dakota		Nebraska	
	1975 production	Increase[a]	1975 production	Increase[a]	1975 production	Increase[a]
	(million pounds carcass weight)					
1	0.0	-1.5	0.0	-2.8	16.0	4.4
2	2.5	0.0	67.4	39.9	32.0	8.7
3	4.1	-0.4	38.9	14.5	265.0	64.6
4	2.9	-0.7	0.0	-1.8	89.6	32.5
5	3.2	-1.5	61.4	33.2	153.7	34.2
6	17.0	7.7	130.8	59.2	25.5	7.0
7	8.6	4.3	2.5	1.2	31.3	8.6
8	7.7	0.7	17.0	3.9	115.1	39.5
9	34.0	16.1	181.2	95.1	-	-

[a]1975 production minus 1959-61 average production.

LIVESTOCK MARKETING PATTERNS

The location of slaughter livestock production provides the initial basis for analyzing the location of livestock slaughter. However, a large percentage of slaughter livestock passes through one or more marketing agencies between the farm and the packing plant. In passing through these marketing channels the livestock may move out of the region of production. Thus, livestock production data for a region may give an exaggerated picture of the available slaughter livestock supply.

Slaughter Livestock Marketing Channels

The marketing of slaughter livestock takes place through various channels, and involves several types of marketing agencies. The channels are complicated by the fact that individual animals may be involved in several transactions between different types of agencies and between different agencies of the same type.

Marketing agencies

Slaughter livestock marketing channels may be classified into three major types: (1) terminal marketing, (2) direct marketing, and (3) other marketing channels. All slaughter livestock which at any time are sold at a terminal market will be said to pass through the terminal marketing channel. All livestock which are sold by the producer directly to the packer, without the use of any other marketing

agency, will be said to pass through the direct marketing channel. Finally, all other slaughter livestock pass through the third type of channel.

The principle marketing agencies are terminal markets, auctions, local dealers, meat packers, and order buyers. The terminal market is the most complex and hard to define. Newberg provides the following definition:

> Livestock is consigned to commission firms for selling at these markets. Two or more commission firms must operate on such a market. A stockyard company owns and maintains the physical facilities, such as yards, alleys, scales, loading and unloading docks, office buildings, facilities for feeding and watering livestock. Individuals, partnerships, corporations, and cooperative associations operate as commission agencies on terminal public markets (16, pp. 5-6).

Auctions receive and sell livestock to buyers on an auction basis, in which bidding and selling are open to the public. Dealers are individuals who buy and sell livestock on their own account. Local markets comprise fixed facilities, such as pens and chutes, for handling livestock. Functionally, local markets are the same as dealers, although dealers purchase primarily at the farm, while local markets buy mostly at their own yards. Order buyers differ from dealers in that they act as agents for other livestock buyers, and do not take title to the livestock.

Farmers may sell their livestock at a meat packing plant or at packer buying stations which are owned by the packing company, but are

located some distance away from the slaughter plant. Packers also procure livestock through packer buyers, i.e., employees of the packing company who travel in the country and buy directly from the farmer.

A small amount of slaughter livestock is sold to locker plants and retailers which slaughter and sell meat on their own account.

Direct marketing is the simplest of the three channels since it involves only the meat packing company buying livestock at the slaughter plant or buying station, or in the country through a packer buyer.

Most of the livestock passing through the terminal marketing channel move directly from the farmer, through the terminal, to the packer. However, some dealers buy slaughter livestock directly from farmers or through auctions and resell them through the terminals. Dealers may also buy and resell livestock at a terminal.

The third type--other marketing channels--includes many variations and combinations of marketing agencies. The most important is the sale of livestock by farmers, to packers, through auctions. Dealers and local markets buy most of their livestock from farmers and sell a sizeable proportion of their purchases direct to packers. Order buyers usually buy from terminals, auctions, dealers, or local markets. Other channels, too numerous to mention, are possible.

The numbers of terminal markets, auctions, dealers, local markets, and slaughtering establishments in the six Upper Midwest States are exhibited in Table 4.1. Each state contains only one terminal market, while there are large numbers of auctions and dealers in each state.

Table 4.1. Estimated number of livestock market outlets in the Upper Midwest, 1956[a]

State	Terminals	Auctions	Dealers	Local markets	Slaughtering establishments[b]	
					Wholesale	Local
			(number)			
Wisconsin	1	15	1,005	187	47	12
Minnesota	1	44	478	99	19	24
Iowa	1	170	453	34	28	21
North Dakota	1	27	150	5	4	7
South Dakota	1	63	640	0	8	9
Nebraska	1	110	316	4	29	21
Upper Midwest	6	429	3,042	329	135	94

[a]Source: (16).

[b]Slaughtering establishment data are for 1955.

Producers' sales outlets

In 1957 a survey of livestock marketing channels in the North Central States was conducted. The survey results are based on personal interviews with 7,000 farmers. The questionnaire provided for a complete enumeration of all of the lots of livestock sold by the farmer for the calendar year 1956 (16).

Tables 4.2 and 4.3 show the percentage of slaughter cattle and calves sold by farmers through various outlets in 1956. Terminal markets were the leading outlet in all the Upper Midwest States for cattle and calves, excluding vealers and deacon calves. The direct to packer sales accounted for 25 percent of Iowa farmers' sales and lesser percentages in the other states. Terminal markets were the leading outlets for vealer and deacon calves in Wisconsin, Minnesota, North Dakota and South Dakota, while the leading outlets in Iowa and Nebraska were auctions and packers, respectively.

Table 4.2. Percentage of slaughter cattle and calves (excluding vealers and deacon calves) sold by farmers through various types of outlets, 1956[a]

State	Terminal	Auction	Dealer	Local market	Packer	Local retailer	Other
				(percent)			
Wisconsin	34.9	0	19.6	6.6	22.2	1.1	15.6
Minnesota	79.3	4.5	2.8	0	11.8	0.5	1.1
Iowa	57.4	12.2	4.2	0	25.0	0.5	0.7
North Dakota	53.0	14.0	8.8	0.7	21.9	1.1	0.5
South Dakota	50.2	26.4	4.0	0.5	18.3	0	0.6
Nebraska	58.7	32.3	0.4	0.5	0.2	0	7.9

[a]Source: (16).

Table 4.3. Percentage of vealer and deacon calves sold for slaughter by farmers through various types of outlets, 1956[a]

State	Terminal	Auction	Dealer	Local market	Packer	Local retailer	Other
				(percent)			
Wisconsin	27.4	0	21.7	10.1	19.6	0.2	21.0
Minnesota	78.2	4.6	5.3	0.2	9.1	0.9	1.7
Iowa	0.7	77.5	9.2	0	12.6	0	0
North Dakota	81.2	0	8.2	3.5	5.9	1.2	0
South Dakota	51.4	48.6	0	0	0	0	0
Nebraska	10.3	0	0	0	72.4	0	17.3

[a]Source: (16).

Terminal markets, as shown in Table 4.4, are the leading outlets for slaughter hogs in Minnesota and North Dakota. Meat packers are the leading outlets in Wisconsin, Iowa and South Dakota, while auctions are most important in Nebraska.

Due to the small number of farmers selling sheep and lambs, data for individual states are not reported. However, data in Table 4.5 for the West North Central Region show that terminals are by far the most important outlets for slaughter sheep and lambs.

Table 4.4. Percentage of slaughter hogs sold by farmers through various types of outlets, 1956[a]

State	Terminal	Auction	Dealer	Local market	Packer	Local retailer	Other
				(percent)			
Wisconsin	15.5	0	11.8	4.6	58.2	0.1	9.8
Minnesota	57.4	0.2	12.7	1.5	27.7	0	0.5
Iowa	14.4	1.1	25.6	0	57.5	0	1.4
North Dakota	55.1	7.1	2.4	7.3	25.5	0.8	1.8
South Dakota	31.1	21.1	1.8	0	44.6	0	1.4
Nebraska	30.7	40.3	10.9	0	9.5	0	8.6

[a]Source: (16).

Table 4.5. Percentage of slaughter sheep and lambs sold through various outlets in the West North Central Region,[a] 1956[b]

Outlet	Sales
	(percent)
Terminal	68.5
Auction	4.2
Dealer	2.9
Local market	0
Packer	23.1
Local retailer	0
Other	1.3

[a]West North Central Region contains the following states: Minnesota, Iowa, North Dakota, South Dakota, Nebraska, Kansas, Missouri.

[b]Source: (16).

Meat packers' procurement patterns

Meat packers located close to terminal markets procure a large percentage of their livestock from this source. Table 4.6 shows the estimated percentage of slaughter livestock obtained by packers from various sources in three areas in the North Central Region (17, pp. 53-54). Areas VII and VIII contain no terminal markets, while Area III contains several terminals, including the South St. Paul, Sioux Falls, Sioux City and Omaha terminals. These three areas are shown in Figure 4.1. Packers obtain more of each species from terminals than any other source in Area III. The direct marketing channel (farmer to packer) dominates in Area VII, particularly for pigs and hogs. In Area VIII terminals are the leading source for pigs and hogs and sheep and lambs, while auctions are the leading source for cattle and calves. The importance of the terminal source in Area VIII may be explained by the low density of production in that area; packers are forced to obtain livestock from terminals because of the low supply in their immediate supply areas.

A more complete picture of the slaughter livestock marketing system in the North Central Region is shown in Table 4.7. These data show the relative importance of the different marketing agencies. The volume of slaughter cattle and calves handled by all marketing agencies was more than double the sales by farmers in the North Central Region; however, total volume in relation to sales by farmers was considerably

Table 4.6. Estimated percentage of slaughter livestock obtained by packers from various sources in three areas, North Central Region, 1957[a]

Source	Cattle and calves			Pigs and hogs			Sheep and lambs		
	Area III	Area VII	Area VIII	Area III	Area VII	Area VIII	Area III	Area VII	Area VIII
	(percent)			(percent)			(percent)		
Terminal	82.0	21.9	12.8	43.2	1.9	39.9	63.6	8.2	78.7
Auctions	6.0	15.1	47.9	6.5	-[b]	33.5	1.8	2.8	4.2
Dealers and local markets	4.1	13.5	1.4	8.5	13.7	1.7	1.7	10.8	-[b]
Farmers	7.9	49.5	37.9	41.7	89.8	24.9	32.9	78.2	17.1
Others	-[b]	-[b]	-[b]	-[b]	-[b]	-[b]	-[b]	-[b]	-[b]

[a]Source: (17).

[b]Less than 0.05 percent.

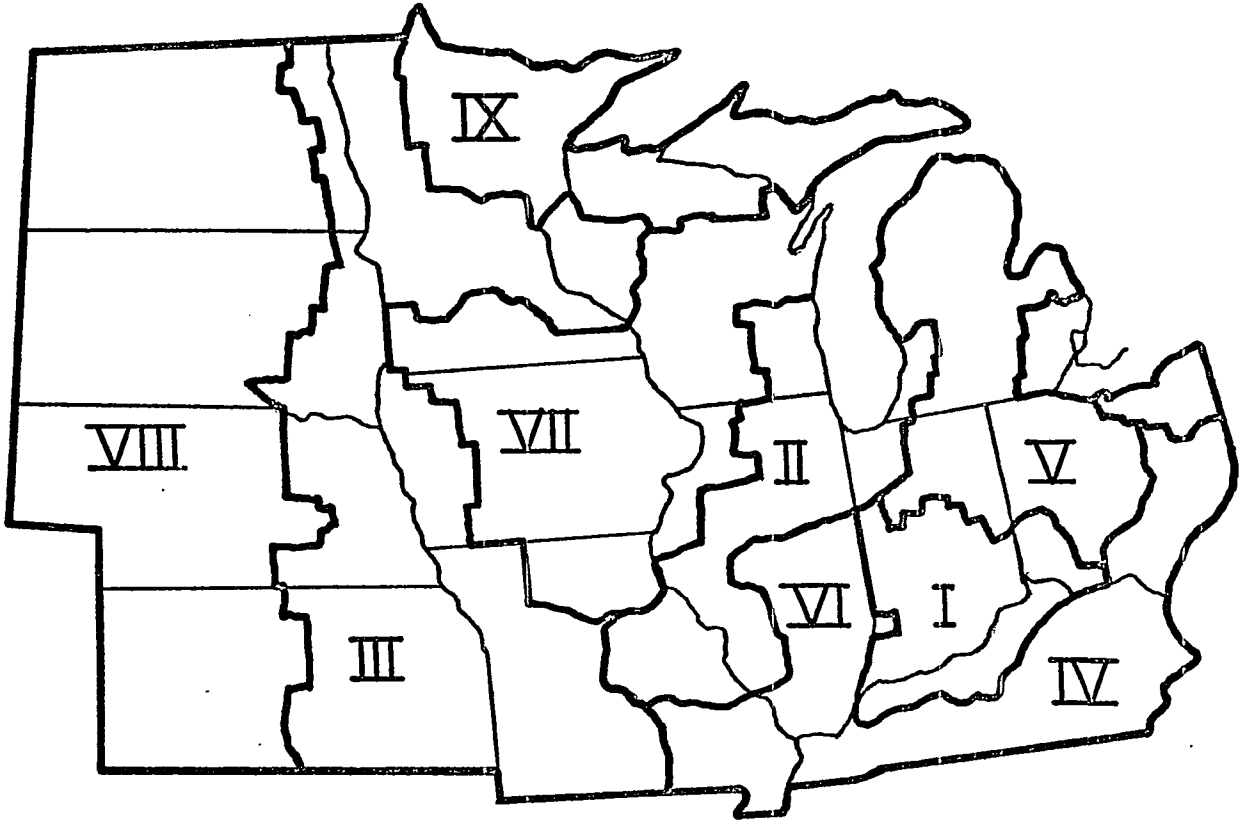


Figure 4.1. North Central Region

Table 4.7. Estimated percentage of slaughter livestock handled by marketing agencies, North Central Region, 1957[a]

Item	Cattle and calves	Hogs and pigs	Sheep and lambs
		(percent)[b]	
Marketing agencies (except packers)			
Terminals	67.1	34.2	40.2
Auctions	28.6	9.8	21.7
Dealers	21.6	28.0	11.0
Local markets	5.4	28.0	7.6
Total volume	122.7	100.0	80.5
Packers			
Direct purchases	13.8	40.4	26.8
Other purchases	71.3	41.1	49.1
Total volume	85.1	81.5	75.9
Total volume of all marketing agencies	207.8	181.5	156.4
Sales by farmers	100.0	100.0	100.0

[a]Source: Based on data in (17).

[b]The percentage figures were derived by dividing the volume handled by each type of marketing agency by farmers' sales, and multiplying the result by 100.

smaller for hogs and pigs, and sheep and lambs. Packers were the leading marketing agencies, followed by terminal markets. However, the total volume (slaughter) of packers was considerably less than the sales of slaughter livestock by North Central farmers.

Available Slaughter Livestock Supply

The livestock production data derived in the previous chapter are adjusted according to the spatial movements of the livestock from the point of production to the point of slaughter. The 1959-61 slaughter cattle and hog production data along with the 1975 projections, are adjusted to obtain the "available slaughter livestock supply".

The spatial aspect of marketing channels

For purposes of this study the only important movement of slaughter livestock between substate regions takes place through the terminal market channel. There is only one terminal in each of the six Upper Midwest States, while a large number of other outlets are found in each state. The terminal markets are important because of their large volume. For example, the Omaha Terminal Market has handled close to 2 million head of slaughter cattle and over 2 million head of slaughter hogs in one year, while the volume handled by any individual auction, dealer, or local market would be much less than these figures.

Because of the large number and wide dispersion of the non-terminal marketing agencies, the movement of slaughter livestock through the two

non-terminal marketing channels do not greatly effect the available livestock supply in the various substate regions. In deriving the available livestock supply for a specific region it is assumed that the outflow of livestock produced in a region and marketed through the non-terminal marketing channels in another region is equal to the inflow of livestock produced in other regions and marketed in the first region. In particular, if none of a region's slaughter livestock is sold through terminals, production equals the available supply. This can be expressed more compactly with reference to equation 4.1:

$$Y = P - T - E + M \qquad (4.1)$$

where, Y = the available supply of slaughter hogs or cattle in a substate region.

P = the region's production.

T = sales to terminal markets from the region.

E = slaughter cattle or hogs produced in the region and marketed in a non-terminal marketing agency outside the region.

M = slaughter cattle or hogs produced outside the region and marketed in a non-terminal marketing agency in the region.

The assumption is that E equals M in each substate region for both slaughter hogs and cattle. Thus, the available supply is production minus the sales through terminal markets.

Data on the distance slaughter livestock are hauled to the various outlets provide empirical support for the above assumption. Table 4.8

Table 4.8. Estimated percentage of slaughter livestock sold by Iowa farmers and hauled a specified distance, by market, 1954[a]

Distance in miles	Terminal markets	Packing plants	Local dealers	Auctions
		(percent)		
Cattle and calves				
Under 10	0	7	50	37
10 to 24	1	33	35	53
25 to 49	18	19	13	10
50 to 99	42	27	0	0
100 and over	39	14	2	0
Total	100	100	100	100
Hogs				
Under 10	0	59	79	58
10 to 24	3	28	18	36
25 to 49	30	10	1	6
50 to 99	56	3	1	0
100 and over	11	0	1	0
Total	100	100	100	100

[a]Source: (13).

shows that, in 1954, 81 percent of the slaughter cattle and calves sold by Iowa farmers to terminals were hauled at least 50 miles, while nearly all of the sales to auctions and local dealers were hauled less than 50 miles. Similarly, 67 percent of the slaughter hogs sold to terminals were hauled 50 miles or more (13). Data for the West North Central States in 1956 are presented in Table 4.9. Again, the length of haul to terminal markets is significantly greater than to other outlets.

Four classes of livestock are found at terminal markets: salable receipts, resales, directs, and throughs.

> Salable receipts and resales consist of livestock offered for sale at the terminal, either initially or after the initial purchase. Resales are livestock "planted" or placed by dealers, yard traders, commission agents, or others for resale usually the day following the initial purchase. "Directs" and "throughs" are not offered for sale at the yard.... "Directs" are livestock moving directly to a buyer who is located at the terminal market or very near the terminal market....."Throughs" are livestock that are in transit to distant points, usually to new owners but possibly to another market (37, p. 216).

We will be chiefly interested in estimating the salable receipts of slaughter cattle and hogs at the terminal markets. Most slaughter livestock which fall into the direct or through categories are purchased by the packers in the area in which they are produced. Resales are not important for our purposes, since we wish to estimate the number of slaughter livestock sold through the terminals, and resales would only introduce an element of "double counting".

Table 4.9. Percentage of slaughter livestock sold by farmers at various distances, by outlet, West North Central States, 1956[a]

Distance in miles	Terminal	Auction	Dealer	Local market	Packer
			(percent)		
Steers and heifers					
1 to 9	0.1	31.3	50.9	33.2	9.9
10 to 24	2.8	37.9	13.4	42.6	21.4
25 to 49	17.2	22.0	34.5	12.0	27.7
50 to 99	47.8	7.3	0.6	12.2	26.8
100 and over	32.1	1.5	0.6	0	14.2
Total	100.0	100.0	100.0	100.0	100.0
Hogs and pigs					
1 to 9	2.0	32.7	63.1	58.2	40.9
10 to 24	8.2	50.9	16.7	34.7	34.7
25 to 49	33.2	15.2	5.8	6.9	16.9
50 to 99	37.8	1.2	0.2	0.2	6.9
100 and over	18.8	0	14.2	0	0.6
Total	100.0	100.0	100.0	100.0	100.0

[a]Source: (16).

Farmers sell their slaughter livestock through terminals even though several alternative market outlets may be closer. Farmers may sell at the terminal because they feel that the professional services of the commission firms in selling their livestock make up for their own inadequacies in selling to packers, dealers or other marketing agencies. The increased return obtained from selling at terminals is thought to be greater than the increased cost of transportation and the marketing charges incurred at the terminals. But, regardless of the reasons for terminal marketing, it must be taken into consideration in estimating past, and predicting future, available supplies of livestock to meat packers. The available supply in a region is defined as production minus sales to terminal markets.

Most of the salable receipts of livestock at terminals are consigned by farmers. Table 4.10 shows that 91 percent and 97 percent of cattle and calves, and hogs and pigs, respectively, are consigned to terminals by farmers. However, dealers consign 6.5 percent of the cattle and 2.3 percent of the hogs.

In summary, the available supply of slaughter livestock in a substate region is estimated as production minus the sales through terminal markets. Most of the consignments to terminals are by farmers; however, the consignments by other marketing agencies also are considered in estimating available supplies. Finally, six new supply regions are defined. These are the six terminal markets, where large quantities of slaughter livestock are brought together. Therefore,

Table 4.10. Estimated percentage of slaughter livestock consigned to terminals by farmers, dealers, local markets and auctions, North Central Region, 1957[a]

	Farmer	Dealer	Local markets	Auctions
			(percent)	
Cattle and calves	90.9	6.5	2.5	0.1
Hogs and pigs	97.0	2.3	0.6	-[b]
Sheep and lambs	93.2	4.5	0.3	2.0

[a]Source: (17).

[b]Less than 0.05 percent.

including the 53 substate production regions, which will be termed "interior markets", there are a total of 59 slaughter livestock supply regions in the Upper Midwest Region.

Terminal markets

The terminal markets located at South St. Paul, Sioux City and Omaha are among the largest in the country. Each of these markets had estimated salable receipts of over 2 million head of slaughter hogs in 1963 (Table 4.11). The Sioux Falls market is relatively large with salable receipts approaching 1 million head. The Milwaukee and West Fargo markets are considerably smaller.

Salable receipts data, as reported by the U.S. Department of Agriculture (26, 27, 30, 31, 32), include both slaughter and nonslaugh-

Table 4.11. Estimated salable receipts of slaughter hogs at Upper Midwest terminal markets

	Milwaukee	South St. Paul	Sioux City	West Fargo	Sioux Falls	Omaha	Total[a]
				(thousand head)			
1953	275.7	2,249.9	1,732.0	154.7	668.1	1,784.0	6,864.4
1954	218.9	2,340.4	1,621.7	191.0	706.0	1,842.9	6,920.8
1955	265.2	2,959.6	1,847.9	250.9	879.8	2,344.3	8,547.7
1956	267.2	2,868.9	1,593.7	259.6	801.9	2,068.7	7,860.0
1957	255.5	2,513.5	1,353.3	246.0	739.3	1,673.4	6,781.0
1958	242.9	2,444.5	1,646.2	289.0	841.9	1,853.7	7,318.1
1959	214.2	2,923.6	2,154.5	395.3	1,034.3	2,413.1	9,135.0
1960[b]	270.7	2,500.8	1,837.5	295.7	799.4	2,119.9	7,824.0
1961[b]	216.3	2,412.1	1,893.3	285.4	866.7	2,183.4	7,857.3
1962[b]	180.7	2,372.4	1,961.5	287.0	919.4	2,429.0	8,149.9
1963[b]	117.7	2,273.9	2,000.4	282.2	899.3	2,486.2	8,059.6

[a]Sum of six terminal markets.

[b]Salable receipts of nonslaughter hogs in all markets, except Milwaukee, were estimated as follows: (1) The average of the ratio of stockers and feeders to total salable receipts in 1953-59 was calculated for each market; (2) These ratios were then applied to total salable receipts in the years 1960 through 1963. The number of feeder and stocker hogs in Milwaukee in 1960-63 was assumed to be the same as the average of 1956-59.

ter livestock. The salable receipts of slaughter livestock are estimated by subtracting feeder and stocker salable receipts from total salable receipts. Stocker and feeder hogs compose a very small percentage of salable receipts, and, consequently, these data are not reported by the U. S. Department of Agriculture. However, the Drover's Journal of Chicago (4) published estimates of "stocker and feeder hogs at public markets" for years prior to 1960. These data were used to adjust the total salable receipts data to derive the slaughter hog salable receipts estimates presented in Table 4.11. The 1960 through 1963 stocker and feeder data were estimated on the basis of trends in the previous years.

The three leading terminal markets also had salable receipts of slaughter cattle greater than 1 million head in most of the years exhibited in Table 4.12. The Omaha market was the largest with a high of 1.9 million head in 1955.

Salable receipts of stocker and feeder cattle are fairly sizeable in all of the Upper Midwest terminal markets except Milwaukee. Also, the U. S. Department of Agriculture provides fairly comprehensive data on stocker and feeder cattle movements. Three of these data series important for our purposes are (1) shipments of stocker and feeder cattle and calves, (2) shipments of feeder cattle, and (3) shipments of feeder calves. All three of these series are reported for the South St. Paul, Sioux City and Omaha markets. Therefore, the nonslaughter

Table 4.12. Estimated salable receipts of slaughter cattle at Upper Midwest terminal markets, 1953-63

	Milwaukee	South St. Paul	Sioux City	West Fargo	Sioux Falls	Omaha	Total[a]
				(thousand head)			
1953	196.7	1,020.2	1,029.2	162.7	298.7	1,824.8	4,532.1
1954	242.7	1,053.4	1,013.0	237.7	308.0	1,851.9	4,706.9
1955	240.2	1,056.1	1,028.1	232.5	351.2	1,925.3	4,833.4
1956	212.4	1,082.6	1,020.7	295.0	330.0	1,831.0	4,771.6
1957	241.8	1,061.3	944.6	273.3	328.7	1,632.5	4,482.1
1958	248.7	988.4	1,127.6	231.0	347.2	1,651.2	4,594.0
1959	224.2	980.6	1,213.8	233.3	352.6	1,718.7	4,723.1
1960	233.7	1,001.1	1,163.8	214.0	318.6	1,731.5	4,662.8
1961	221.4	1,007.5	1,174.7	269.0	343.9	1,721.2	4,737.6
1962	225.3[b]	998.7	1,158.0	210.8[c]	367.2[c]	1,745.2	4,705.1
1963	206.2[b]	929.2	1,046.8	168.8[c]	354.1[c]	1,733.5	4,438.6

[a]Sum of six terminal markets.

[b]1962 and 1963 nonslaughter salable receipts were estimated as the average of the 1959-61 feeder cattle at the Milwaukee market, as reported by the Drovers Journal.

[c]Salable receipts of nonslaughter cattle were estimated as follows: (1) The 1961 Drover's Journal data on feeder cattle was divided by the 1961 shipments of stocker and feeder cattle and calves; (2) These ratios were then multiplied by 1962 and 1963 shipments of stocker and feeder cattle and calves.

components of salable receipts in these three markets were computed as follows: (1) the ratio of feeder cattle shipments to the shipments of feeder cattle and calves was computed; (2) this ratio was multiplied by the shipments of stocker and feeder cattle and calves.

Feeder cattle shipments and feeder calf shipments are not reported for the other three Upper Midwest terminals. Therefore, the Drovers Journal (4) data on "feeder cattle at terminal markets" was used for these three terminals. (These data are also reported for the South St. Paul, Sioux City and Omaha markets, but the estimation procedure described earlier provides better estimates of nonslaughter salable receipts for these markets.) This data series was not published after 1961, and, hence, the 1962 and 1963 estimates are based on the 1953 through 1959 data.

Salable receipts of slaughter cattle at the six Upper Midwest terminal markets have varied between 4.4 and 4.8 million head in the period 1953-63. However, salable receipts as a proportion of total marketings in the Upper Midwest, exhibited in Table 4.13, declined steadily over the 11-year period. In contrast, the salable receipts of slaughter hogs as a proportion of total marketings show no trend.

Linear regressions relating the proportions in Table 4.13 to time were fitted for use in projecting the consignments of slaughter livestock to terminal markets. The regression equation for slaughter cattle was:

$$C_t = 0.5076 - 0.0105t \qquad (4.2)$$

Table 4.13. Salable receipts of slaughter livestock at Upper Midwest terminal markets as a proportion of marketings in the Upper Midwest States, 1953-63[a]

	Cattle	Hogs
1953	0.5406	0.2223
1954	0.5353	0.2290
1955	0.5174	0.2408
1956	0.5000	0.2340
1957	0.4769	0.2197
1958	0.4926	0.2295
1959	0.4778	0.2476
1960	0.4704	0.2318
1961	0.4733	0.2303
1962	0.4600	0.2365
1963	0.4079	0.2184

[a]The proportions shown in this table were derived by dividing total salable receipts of slaughter livestock exhibited in Tables 4.11 and 4.12 by total marketings in the six Upper Midwest States.

where C_t is the ratio of salable receipts of slaughter livestock at Upper Midwest terminals to total marketings in the Upper Midwest States, and t is time in years (t = 0 for 1956). The time variable explained 87 percent of the variance in C_t, and the coefficient on the time variable was significant at the 1-percent level.

An equation of the same form, when fitted to the corresponding data for slaughter hogs, yielded a nonsignificant coefficient on the time variable; the time variable explained less than 1 percent of the variance of C_t. Consequently, the mean for the years 1953-63 is used in projecting slaughter hog consignments; the projection equation is given by equation 4.3:

$$C_t = 0.2309 \tag{4.3}$$

Variability in C_t for the years 1953-61 is a function of the hog cycle. The highest values of C_t were in 1955 and 1959, peak years in hog marketings, while two of the lowest values occurred in 1953 and 1957, years of low hog marketings. Thus, in years of high slaughter hog supplies, a larger percentage tends to be sold through terminal markets, although the percentage does not vary greatly from year to year.

Interior markets

The available supply of slaughter livestock in the interior markets is derived in three stages. First, the consignments of slaughter livestock to terminals are estimated for each state. Second, the state total is allocated among the substate regions. Finally, terminal market consignments from each substate region are subtracted from production to obtain available supply. The terminal market consignments are obtained from equations 4.4 and 4.5:

$$\bar{P}_{it} = A_{it} P_{it} \tag{4.4}$$

$$\bar{P}_{ijt} = B_{ijt} \bar{P}_{it} \tag{4.5}$$

where P_{it} is production of slaughter cattle or hogs in state i, year t; $\bar{P}_{it}$ is consignments of slaughter cattle or hogs to terminal markets from state i, year t; $\bar{P}_{ijt}$ is consignments of slaughter cattle or hogs from substate region j in state i, year t; A_{it} and B_{ijt} are allocation coefficients for year t. The two equations are identities; since the allocation coefficients are dated, the two relationships are tautological.

The first task in empirically implementing the model is to devise a means for estimating the state level allocation coefficients. The percentages of farmers' slaughter livestock sales which were sold at terminals were presented in Tables 4.2 through 4.5. However, an A_{it} coefficient is the proportion of the state's total production that is sold through terminals. Thus, it is necessary to account for livestock that are sold to dealers, country markets or other marketing agencies, and then resold at a terminal. Table 4.10 shows that 90.9 percent of the slaughter cattle and calves and 97 percent of the slaughter hogs were consigned to terminals (in the North Central Region in 1957) by farmers. The reciprocals of these numbers can then be used for adjusting the coefficients from Tables 4.2 and 4.4. The resulting coefficients, which are presented in Table 4.14, are the estimated state level allocation coefficients for 1956.

The 1956 coefficients serve as a base for estimating the coefficients for later years (t = 0 for 1956) by means of equation 4.6:

Table 4.14. State level allocation coefficients for 1956 and 1960[a]

	Cattle		Hogs	
	1956	1960	1956	1960
Wisconsin	0.384	0.352	0.160	0.160
Minnesota	0.872	0.800	0.592	0.592
Iowa	0.631	0.579	0.148	0.148
North Dakota	0.583	0.535	0.568	0.568
South Dakota	0.552	0.506	0.321	0.321
Nebraska	0.646	0.593	0.317	0.317

[a]A state level allocation coefficient is the proportion of slaughter livestock production in a specific state which is sold at terminal markets.

$$A_{it} = \frac{C_t}{C_o} A_{io} \tag{4.6}$$

Equations 4.2 and 4.3 provide the value of C_t, and A_{it} becomes a function of time. In the case of cattle, C_t declines over time resulting in a decline in A_{it}, while C_{it} remains constant for hogs, resulting in A_{it} being constant over time. The A_{i4} coefficients (t = 4 for 1960) are presented in Table 14 along with the A_{io} coefficients.

The next task is the estimation of the substate allocation coefficients. Two considerations are important in estimating the B_{ijt} for a specific substate region: (1) the level of production in the region and (2) the distance from the region to the nearest terminal market.

Thus, equation 4.7 was used to estimate the substate allocation coefficients:

$$B_{ijt} = \frac{d_{ij} P_{ijt}}{\sum_j d_{ij} P_{ijt}} \qquad (4.7)$$

The d_{ij} are "distance weights", which are defined by equation 4.8 for cattle and by equation 4.9 for hogs:

$$d_{ij} = 88.25 - 0.2206X \qquad (4.8)$$

$$d_{ij} = 70.82 - 0.2911X \qquad (4.9)$$

where X is the distance from the region to the nearest terminal market.

Equations 4.8 and 4.9 were fitted from data obtained from the 1957 survey of livestock marketing in the North Central Region (17). The dependent variable, d_{ij}, was measured as the percent of slaughter cattle or hogs sold by farmers in regions II, III, VII and VIII. (See Figure 4.1 for a description of these regions.) The independent variable, X, was measured as the average distance from a point in the region to the nearest terminal market. Most of the area in regions II and III is close to a terminal, while most of the area of regions VII and VIII is relatively far from terminals. Equations 4.8 and 4.9, although based on a meager amount of data, provide a necessary basis for estimating the substate allocation coefficients. The distance weights can be interpreted as the likelihood (or probability) of a head of livestock n miles from the nearest terminal being sold at a terminal in relation to the likelihood of a head of livestock located

m miles from the terminal being sold at a terminal. For example, a region located 30 miles from the nearest terminal would have a weight of 62 (using equation 4.8 for hogs), while a region located 137 miles from a terminal would have a weight of 31. Thus, slaughter hogs produced in the first region would be twice as likely to be sold at a terminal as those produced in the second region.

In summary, the state level allocation coefficients are based upon (1) the 1956 proportion of farmers' slaughter livestock sales which were consigned to terminal markets, (2) the proportion of total terminal consignments which were made by farmers and (3) the trend in the ratio of terminal consignments of slaughter livestock to total marketings. The substate allocation coefficients are based on (1) the livestock production in the region and (2) the distance from the region to the nearest terminal market. The distance weights and substate allocation coefficients for 1960 are exhibited in Table 4.15.

The terminal sales and available supplies for the 1959-61 base period are estimated by applying the 1960 state and substate allocation coefficients to the 1959-61 production data. The coefficients in Tables 4.14 and 4.15 are used in calculating the data appearing in Table 4.16. The spatial distribution of the available supplies is quite different than that of production. Many of the heavy producing regions are located fairly close to terminals, and, consequently, their available supplies are sharply reduced by the large amount of terminal sales. A case in point is Minnesota's fifth region, which is the

Table 4.15. Distance to nearest terminal market, distance weights and substate allocation coefficients for 1960

Substate region	Distance in miles	Distance weights		Allocation coefficients	
		Cattle	Hogs	Cattle	Hogs
Wisconsin					
1	140	57.37	30.07	0.086	0.025
2	200[a]	44.13	12.60	0.069	0.011
3	154	54.28	25.99	0.045	0.016
4	126	60.45	34.14	0.139	0.106
5	140	57.37	30.07	0.065	0.054
6	70	72.81	50.44	0.173	0.150
7	98	66.63	42.29	0.159	0.279
8	56	75.90	54.52	0.184	0.296
9	28	82.07	62.67	0.080	0.063
Minnesota					
1	112	63.54	38.22	0.078	0.025
2	200[a]	44.13	12.60	0.014	0.003
3	200[a]	44.13	12.60	0.003	0.001
4	98	66.63	42.29	0.139	0.135
5	98	66.63	42.29	0.221	0.228

[a]These regions are at least 200 miles from the nearest terminal market. However, since the data used in fitting the distance weight functions referred to regions no more than 200 miles from a terminal, 200 miles was used in calculating the distance weights for these regions.

Table 4.15. (Continued)

Substate region	Distance in miles	Distance weights		Allocation coefficients	
		Cattle	Hogs	Cattle	Hogs
6	77	71.26	48.41	0.089	0.037
7	84	69.72	46.37	0.152	0.201
8	105	65.09	40.25	0.139	0.215
9	98	66.63	42.29	0.165	0.155
Iowa					
1	84	69.72	46.37	0.217	0.172
2	126	60.45	34.14	0.092	0.111
3	196	45.01	13.76	0.055	0.058
4	84	69.72	46.37	0.181	0.160
5	154	54.28	25.99	0.116	0.095
6	161	52.73	23.95	0.128	0.106
7	63	74.35	52.48	0.130	0.116
8	140	57.37	30.07	0.026	0.052
9	91	68.18	44.32	0.055	0.130
North Dakota					
1	200[a]	44.13	12.60	0.066	0.011
2	200[a]	44.13	12.60	0.073	0.019
3	175	49.64	20.38	0.073	0.055

Table 4.15. (Continued)

Substate region	Distance in miles	Distance weights		Allocation coefficients	
		Cattle	Hogs	Cattle	Hogs
4	200[a]	44.13	12.60	0.113	0.027
5	140	57.37	30.07	0.137	0.084
6	49	77.44	56.56	0.125	0.313
7	200[a]	44.13	12.60	0.089	0.032
8	200[a]	44.13	12.60	0.126	0.052
9	112	63.54	38.22	0.198	0.407
South Dakota					
1	200[a]	44.13	12.60	0.068	0.003
2	200[a]	44.13	12.60	0.088	0.032
3	105	65.09	40.25	0.115	0.090
4	200[a]	44.13	12.60	0.073	0.002
5	147	55.82	28.03	0.128	0.073
6	49	77.44	56.56	0.195	0.372
7	200[a]	44.13	12.60	0.041	0.002
8	161	52.73	23.95	0.108	0.029
9	70	72.81	50.44	0.184	0.397

Table 4.15. (Continued)

Substate region	Distance in miles	Distance weights		Allocation coefficients	
		Cattle	Hogs	Cattle	Hogs
Nebraska					
1	200[a]	44.13	12.60	0.034	0.007
2	189	46.56	15.80	0.009	0.017
3	63	74.35	52.48	0.402	0.484
4	175	49.64	20.38	0.086	0.054
5	77	71.26	48.41	0.311	0.267
6	200[a]	44.13	12.60	0.021	0.011
7	200[a]	44.13	12.60	0.038	0.013
8	98	66.63	42.29	0.099	0.147

largest producer in the state. The available supply of both slaughter hogs and cattle is much smaller than total production, with over 80 percent of slaughter cattle production and nearly 60 percent of slaughter hog production sold to terminal markets. Other outstanding examples are Iowa's first and fourth regions and Nebraska's third and fifth regions. All farms in these four regions are within close driving distance to either the Sioux City or Omaha markets.

Table 4.16. Available supplies and terminal market sales of slaughter livestock, 1959-61 average

Substate region	Cattle		Hogs	
	Terminal sales	Available supply	Terminal sales	Available supply
	(million pounds carcass weight)			
Wisconsin				
1	17.1	37.7	1.5	11.7
2	13.7	43.3	0.6	13.7
3	8.9	21.6	0.9	8.6
4	27.6	56.5	6.2	42.8
5	12.9	28.3	3.2	25.3
6	34.5	51.9	8.8	38.0
7	31.6	55.4	16.3	87.4
8	36.6	51.5	17.4	67.9
9	15.9	19.7	3.7	12.0
State total	198.8	365.9	58.6	307.4
Minnesota				
1	40.9	12.2	11.3	10.0
2	7.3	6.5	1.4	7.0
3	1.6	1.7	0.3[a]	0

[a]The calculated values of terminal sales for these regions were slightly larger than production. Therefore, terminal sales were set equal to production, and the excess was distributed among the other regions in the state.

Table 4.16. (Continued)

Substate region	Cattle		Hogs	
	Terminal sales	Available supply	Terminal sales	Available supply
	(million pounds carcass weight)			
4	72.9	18.2	60.8	41.8
5	115.9	28.3	102.5	71.5
6	46.7	7.7	16.7	7.6
7	79.7	15.3	90.4	49.4
8	72.9	20.2	96.8	74.9
9	86.5	21.0	69.8	48.0
State total	524.4	131.1	450.0	310.2
Iowa				
1	242.9	133.8	64.0	250.2
2	102.9	80.7	41.3	235.2
3	61.5	85.4	21.6	337.7
4	202.5	112.5	59.5	234.6
5	129.8	127.2	35.3	273.8
6	143.2	148.6	39.4	335.1
7	145.4	65.2	43.2	145.3
8	29.1	25.0	19.3	129.0
9	61.5	35.1	48.4	200.4
State total	1,118.8	813.5	372.0	2,141.3

Table 4.16. (Continued)

Substate region	Cattle		Hogs	
	Terminal sales	Available supply	Terminal sales	Available supply
	(million pounds carcass weight)			
North Dakota				
1	5.5	6.7	0.4	1.1
2	6.1	7.3	0.6	1.9
3	6.1	5.8	1.8	2.7
4	9.4	11.4	0.9	2.7
5	11.5	8.0	2.7	2.0
6	10.4	2.7	9.3[a]	0
7	7.4	9.1	1.1	3.2
8	10.5	12.8	1.7	5.3
9	16.6	8.8	12.9	5.0
State total	83.5	72.6	31.4	23.9
South Dakota				
1	9.7	15.4	0.2	2.6
2	12.6	19.8	2.6	24.9
3	16.4	12.4	7.4	17.0
4	10.4	16.7	0.2	1.6
5	18.3	19.2	6.0	22.2
6	27.8	13.4	30.7	40.9

Table 4.16. (Continued)

Substate region	Cattle		Hogs	
	Terminal sales	Available supply	Terminal sales	Available supply
	(million pounds carcass weight)			
7	5.9	9.1	0.2	1.1
8	15.4	18.2	2.4	10.7
9	26.2	15.2	32.7	53.4
State total	142.7	139.4	82.4	174.4
Nebraska				
1	21.7	33.1	1.2	10.4
2	5.7	8.3	2.8	20.5
3	256.0	123.0	81.1	119.3
4	54.8	66.6	9.1	48.0
5	198.0	108.0	44.8	74.7
6	13.4	19.9	1.8	16.7
7	24.2	37.0	2.2	20.5
8	63.0	41.2	24.6	51.0
State total	636.8	437.1	167.6	361.1

An overview of the Upper Midwest slaughter cattle and hog marketing system is provided by Table 4.17. Fifty-eight percent of the slaughter cattle produced in the Upper Midwest were consigned to terminals, while only 26 percent of the slaughter hogs were sold through this channel. Salable receipts of slaughter cattle and hogs at the six terminal markets in the region were approximately equal to terminal consignments from within the region. Thus, the total available supply at the 53 interior markets (substate supply regions) and six terminal markets was approximately equal to total production in the Upper Midwest.

However, available supply differed significantly from production in the individual states. This is largely a function of the fact that the six Upper Midwest terminal markets are located near their respective state borders. Wisconsin's terminal consignments were greater than the receipts at the Milwaukee terminal. This could probably be largely accounted for by sales of Wisconsin's slaughter cattle and hogs to the South St. Paul and Chicago terminals. The excess of South St. Paul's terminal receipts of slaughter cattle over Minnesota's terminal consignments may be largely explained by the sale of Wisconsin's slaughter cattle at South St. Paul. The receipts of slaughter cattle and hogs at Sioux Falls and West Fargo are larger than the consignments of South Dakota's and North Dakota's slaughter livestock, respectively. This would suggest sizeable movements of livestock from northwestern Minnesota to the West Fargo market, and from southwestern Minnesota and

Table 4.17. Summary of available supplies, terminal sales and terminal receipts in the Upper Midwest, 1959-61 base period[a]

State	Cattle			Hogs		
	Available supply	Terminal sales	Terminal receipts	Available supply	Terminal sales	Terminal receipts
	(million pounds carcass weight)					
Wisconsin	365.9	198.8	130.9	307.4	58.6	32.3
Minnesota	131.1	524.4	575.9	310.2	450.0	360.5
Iowa	813.5	1,118.8	684.4	2,141.3	372.0	270.7
North Dakota	72.6	83.5	138.0	23.9	31.4	44.9
South Dakota	139.4	142.7	195.6	174.4	82.4	124.2
Nebraska	437.1	636.8	996.4	361.1	167.6	309.0
Upper Midwest	1,959.6	2,705.0	2,721.2	3,318.3	1,162.0	1,141.6

[a]Terminal sales are sales of slaughter livestock, produced in the specified state, at terminal markets. Available supply is production minus terminal sales. Terminal receipts are the salable receipts of slaughter livestock at terminals located within the state. These terminals are Milwaukee, Wisconsin; South St. Paul, Minnesota; Sioux City, Iowa; West Fargo, North Dakota; Sioux Falls, South Dakota; and Omaha, Nebraska. Available supplies and terminal sales are taken from Table 4.16. Terminal receipts are derived from data in Tables 4.11 and 4.12. The average of terminal receipts of cattle in 1959-61 was multiplied by 0.578 to convert to carcass weight units. The conversion factor for hogs was 0.138.

northwestern Iowa to the Sioux Falls market.

Iowa's consignments of slaughter livestock are much greater than the receipts at the Sioux City terminal market. This indicates sales to the Omaha, Sioux Falls and South St. Paul markets in the Upper Midwest Region, and to the Chicago, Peoria, St. Louis, St. Joseph and Kansas City terminal markets outside of the region. The excess of the Omaha market's receipts over Nebraska's consignments is largely a reflection of sales of Iowa, Missouri and Kansas slaughter livestock at Omaha, with the Iowa sales predominating.

Projected available supply

The projections of slaughter livestock production in 1975 provide a basis for projecting terminal sales and available supplies in 1975. The 1975 state level allocation coefficients are derived from equation 4.6 by setting "t" equal to 19. The substate allocation coefficients are computed by means of equation 4.7, using the distance weights in Table 4.15 and the 1975 production levels presented in the previous chapter. The projected available supplies and sales to terminal markets are presented in Table 4.18.

Finally, salable receipts of slaughter livestock at the six terminal markets must be projected to 1975. This is accomplished by relating each of the terminal markets to a "consignment region". Each of the 53 Upper Midwest production regions is assigned to one of the six consignment regions. A consignment region for an individual terminal market is composed of those production regions which are located closer

Table 4.18. Projected available supplies and terminal market sales of slaughter livestock, 1975

Substate region	Cattle		Hogs	
	Terminal sales	Available supply	Terminal sales	Available supply
	(million pounds carcass weight)			
Wisconsin				
1	14.4	59.3	1.6	12.2
2	14.4	76.4	1.0	19.7
3	9.4	39.1	1.0	9.0
4	32.2	115.2	6.7	44.8
5	10.9	41.2	4.1	31.6
6	39.8	111.2	10.6	44.3
7	33.3	105.1	17.5	91.2
8	42.2	111.6	15.0	57.2
9	12.8	30.4	3.9	12.6
State total	209.4	689.5	61.4	322.6
Minnesota				
1	48.2	47.3	0	0
2	3.1	5.6	5.0	22.4
3	0	0	0	0
4	115.5	104.4	94.2	63.8
5	166.9	148.4	162.0	109.8

Table 4.18. (Continued)

Substate region	Cattle		Hogs	
	Terminal sales	Available supply	Terminal sales	Available supply
	(million pounds carcass weight)			
6	55.1	43.3	23.1	10.6
7	137.7	112.5	137.2	72.4
8	115.5	108.7	160.9	123.4
9	123.2	111.1	41.2	27.3
State total	765.2	681.3	623.6	429.7
Iowa				
1	304.0	379.7	82.1	321.1
2	181.9	292.9	53.5	301.3
3	98.9	246.8	31.0	478.5
4	173.1	218.1	77.3	300.1
5	232.7	443.4	34.4	265.6
6	229.9	457.7	50.6	429.9
7	87.3	98.8	44.9	148.6
8	39.3	67.1	31.5	207.4
9	107.7	139.2	72.1	295.6
State total	1,454.8	2,343.7	477.4	2,748.1

Table 4.18. (Continued)

Substate region	Cattle		Hogs	
	Terminal sales	Available supply	Terminal sales	Available supply
	(million pounds carcass weight)			
North Dakota				
1	6.5	15.3	0	0
2	5.8	13.6	0.5	2.0
3	5.4	10.6	1.4	2.7
4	15.4	35.9	0.6	2.3
5	18.9	29.7	1.6	1.6
6	15.4	13.7	16.1	0.9
7	12.5	29.5	1.8	6.8
8	18.5	43.6	1.6	6.1
9	24.4	32.1	21.8	12.2
State total	122.8	224.0	45.4	34.6
South Dakota				
1	17.7	52.5	0	0
2	25.9	76.6	6.4	61.0
3	30.1	50.3	11.9	27.0
4	16.1	47.8	0	0
5	33.6	71.3	13.1	48.3
6	56.5	70.5	56.1	74.7

Table 4.18. (Continued)

Substate region	Cattle		Hogs	
	Terminal sales	Available supply	Terminal sales	Available supply
	(million pounds carcass weight)			
7	7.7	22.3	0.2	2.3
8	28.3	65.6	3.0	14.0
9	48.3	67.6	69.5	111.7
State total	264.2	524.5	160.2	339.0
Nebraska				
1	19.7	55.6	1.6	14.4
2	7.4	19.8	3.9	28.1
3	230.5	288.5	109.0	156.0
4	41.8	100.5	14.3	75.3
5	375.0	504.1	58.4	95.3
6	25.4	70.9	2.5	23.0
7	39.4	111.3	3.0	28.3
8	81.2	121.8	38.1	77.0
State total	820.4	1,272.5	230.8	497.4

to that terminal market than any other of the Upper Midwest terminals. For example, the Omaha market's consignment region consists of all the Nebraska producing regions, except the northernmost Nebraska regions (which are part of the Sioux City consignment region), plus the three southernmost Iowa regions.

The projected terminal market receipts for an individual terminal market is given by equation 4.10:

$$M_{kt} = \left(\frac{\bar{P}_{kt}}{\bar{P}_{k4}}\right) M_{k4}, \quad t>4 \qquad (4.10)$$

where M_{kt} is the salable receipts of slaughter livestock at terminal k in year t (t = 0 for 1956), and $\bar{P}_{kt}$ is the sales of slaughter livestock to terminal markets from consignment region k in year t. The terms M_{k4} and $\bar{P}_{k4}$ stand for the terminal receipts of market k and terminal consignments of the corresponding consignment region, respectively, in the base period 1959-61. In words, equation 4.10 states that salable receipts of slaughter livestock at a terminal market will grow at the same rate as the consignments from the terminal's consignment region. Thus, terminal market receipts for any year beyond the base period can be projected by using an estimate of terminal consignments from the consignment region in the specified year. The "constants" in equation 4.10 are taken from Table 4.16 (terminal sales from the substate regions in 1959-61) and Table 4.17 (terminal receipts in 1959-61). Then the 1975 projected terminal receipts are derived by inserting the 1975

projected terminal consignments from Table 4.18.

The terminal market projections, along with the definitions of the specific consignment regions, are presented in Table 4.19. The Sioux Falls market showed the highest projected growth rates, 81 percent growth in salable receipts of slaughter cattle and 72 percent growth in salable receipts of slaughter hogs. However, the Omaha market showed the highest absolute growth for both species.

An overview of the 1975 projections is provided by Table 4.20; the data are presented in the same framework as the 1959-61 estimates in Table 4.17 to facilitate comparisons between the base period estimates and the projections. The most dramatic change over the 1959-61 to 1975 period was the 193 percent increase in the available supply of slaughter cattle in the interior markets. This was because of the large increase in production and the declining percentage of slaughter cattle sold to terminals. However, despite the decline in the percentage of slaughter cattle production consigned to terminals, terminal receipts increased 36 percent. Because of the relatively small increase in slaughter hog production, available supplies in the interior markets increased only 32 percent and terminal market receipts increased 36 percent.

Table 4.19. Projected 1975 terminal market salable receipts of slaughter livestock

Terminal market	1959-61 receipts[a]	Consignments[b] 1959-61	Consignments[b] 1975	Consignments ratio[c]	1975 receipts[d]
	(million pounds carcass weight)				
Cattle					
Milwaukee	130.9	140.4	148.4	1.0570	138.4
South St. Paul	575.9	546.4	802.5	1.4687	845.8
Sioux City	684.4	1,001.8	1,197.3	1.1951	817.9
West Fargo	138.0	204.6	289.6	1.4154	195.3
Sioux Falls	195.6	222.4	401.9	1.8071	353.5
Omaha	996.4	589.4	797.1	1.3524	1,347.5

[a]1959-61 terminal salable receipts of slaughter cattle or hogs.

[b]Terminal market consignments from the consignment regions. The consignment regions are composed of the following substate production regions: Milwaukee market, Wisconsin substate regions 3, 5, 6, 7, 8, 9; South St. Paul market, Minnesota 3, 5, 6, 8, 9, Wisconsin 1, 2, 4, Iowa 2, 3; Sioux City market, Iowa 1, 4, 5, 6, Nebraska 1, 2, 3; West Fargo market, all North Dakota regions, Minnesota 1, 2, 4; Sioux Falls market, all South Dakota regions, Minnesota 7; Omaha market, Nebraska 4, 5, 6, 7, 8, Iowa 7, 8, 9.

[c]1975 consignments from individual consignment regions divided by 1959-61 consignments.

[d]Projected 1975 terminal salable receipts of slaughter cattle or hogs derived by applying consignments ratio to 1959-61 terminal salable receipts shown in first column.

Table 4.19. (Continued)

Terminal market	1959-61 receipts[a]	Consignments[b] 1959-61	Consignments[b] 1975	Consignments ratio[c]	1975 receipts[d]
	(million pounds carcass weight)				
Hogs					
Milwaukee	32.3	50.3	52.1	1.0358	33.5
South St. Paul	360.5	357.3	481.0	1.3462	485.3
Sioux City	270.7	283.3	358.9	1.2669	342.9
West Fargo	44.9	104.9	144.6	1.3785	61.9
Sioux Falls	124.2	172.8	297.4	1.7211	213.8
Omaha	309.0	193.4	264.8	1.3692	413.8

Table 4.20. Summary of projected available supplies, terminal sales and terminal receipts in the Upper Midwest, 1975

State	Cattle			Hogs		
	Available supply	Terminal sales	Terminal receipts	Available supply	Terminal sales	Terminal receipts
	(million pounds carcass weight)					
Wisconsin	689.5	209.4	138.4	322.6	61.4	33.5
Minnesota	681.3	765.2	845.8	429.7	623.6	485.3
Iowa	2,343.7	1,454.8	817.9	2,748.1	477.4	342.9
North Dakota	224.0	122.8	195.3	34.6	45.4	61.9
South Dakota	524.5	264.2	353.5	339.0	160.2	213.8
Nebraska	1,272.5	820.4	1,347.5	497.4	230.8	413.8
Upper Midwest	5,735.5	3,636.8	3,698.4	4,371.4	1,598.8	1,551.2

LOCATION OF THE MEAT PACKING INDUSTRY

The location of livestock slaughter in the 1959-61 base period and the projected 1975 marketing patterns provide a basis for projecting the location of slaughter in 1975. These data can, in turn, be used for estimating investment in meat packing facilities over the fifteen year period.

Interregional Flows of Slaughter Livestock

Interstate flows of slaughter livestock in 1959-61 have been estimated (34). Comparable data are not available for the substate regions; however, employment and slaughter plant location data, along with the estimates of production, available supplies and terminal market receipts, give some idea of the flows between the smaller regions.

Interstate flows

It was shown in a previous chapter that outshipments minus inshipments of slaughter livestock equals production minus commercial slaughter in the specified region. This is expressed symbolically in equation 5.1:

$$O - I = P - S \qquad (5.1)$$

where O is outshipments, I is inshipments, P is production of slaughter livestock, and S is commercial slaughter. In the previous chapter production was divided into two components, sales to terminal markets and available supply. Also, commercial slaughter is composed of two com-

ponents, slaughter at terminal markets and slaughter in the interior. Thus, equation 5.1 can be reformulated as equation 5.2:

$$(O - I) = (A + T) - (S_1 + S_2) \qquad (5.2)$$

where A is available supply in the interior market, T is sales to terminal markets, S_1 is slaughter in the interior, and S_2 is slaughter at the terminal markets. Equation 5.2 can, in turn, be reformulated as equation 5.3 by adding and subtracting salable receipts of slaughter livestock at terminal markets, R, and regrouping the terms on the right hand side of the equation:

$$(O - I) = (A - S_1) + (R - S_2) + (T - R) \qquad (5.3)$$

Thus, net outshipments are composed of three components, the difference between available supply in the interior market and interior slaughter, the difference between the salable receipts of slaughter livestock and slaughter at the terminal markets, and the difference between sales (consignments) to terminal markets and the salable receipts of slaughter livestock at terminals within the region. These three components are referred to as the interior surplus, the terminal surplus, and the marketing surplus, respectively.

The available supplies, salable receipts at terminal markets, and sales to terminals in the six Upper Midwest States were estimated in the previous chapter. Slaughter at terminal markets is reported for years previous to 1962 (4), and interior slaughter can be calculated as the residual component of commercial slaughter. These data are presented in Table 5.1 for the 1959-61 base period.

Table 5.1. Terminal market receipts, slaughter at terminals, sales to terminals, available supplies, interior slaughter, and net outshipments, 1959-61[a]

	Available supply	Interior slaughter	Interior surplus[b]	Terminal receipts[c]	Terminal slaughter	Terminal surplus[d]	Terminal sales[e]	Marketing surplus[f]	Net outshipments[g]
				(million pounds carcass weight)					
Cattle									
Wisconsin	365.9	371.9	-6.0	130.9	169.2	-38.3	198.8	67.9	23.6
Minnesota	131.1	354.4	-223.3	575.9	443.4	132.5	524.4	-51.5	-142.3
Iowa	813.5	1,019.2	-205.7	684.4	428.9	255.5	1,118.8	434.4	484.2

[a]All data refer to slaughter livestock only.

[b]Available supply minus interior slaughter.

[c]Salable receipts of slaughter livestock at terminals within the region.

[d]Terminal receipts minus terminal slaughter.

[e]Sales (consignments) to terminal markets from the region.

[f]Terminal sales minus terminal receipts.

[g]Outshipments minus inshipments of slaughter livestock. This is the sum of interior surplus, terminal surplus, and marketing surplus.

Table 5.1. (Continued)

	Available supply	Interior slaughter	Interior surplus[b]	Terminal receipts[c]	Terminal slaughter	Terminal surplus[d]	Terminal sales[e]	Marketing surplus[f]	Net outshipments[g]
	(million pounds carcass weight)								
North Dakota	72.6	9.8	62.8	138.0	21.3	116.7	83.5	-54.5	125.0
South Dakota	139.4	136.9	2.5	195.6	105.4	90.2	142.7	-52.9	39.8
Nebraska	437.1	390.0	47.1	996.4	820.5	175.9	636.8	-359.6	-136.6
Upper Midwest	1,959.6	2,282.2	-322.6	2,721.2	1,988.7	732.5	2,705.0	-16.2	393.7
Hogs									
Wisconsin	307.4	422.7	-115.3	32.3	50.3	-18.0	58.6	26.3	-107.0
Minnesota	310.2	437.4	-127.2	360.5	330.5	30.0	450.0	89.5	-7.7
Iowa	2,141.3	1,787.1	354.2	270.7	229.9	40.8	372.0	101.3	496.3
North Dakota	23.9	5.0	18.9	44.9	1.6	43.3	31.4	-13.5	48.7
South Dakota	174.4	276.4	-102.0	124.2	38.0	86.2	82.4	-41.8	-57.6
Nebraska	361.1	228.5	132.6	309.0	354.6	-45.6	167.6	-141.4	-54.4
Upper Midwest	3,318.3	3,157.1	161.2	1,141.6	1,004.9	136.7	1,162.0	20.4	318.3

Interior slaughter exceeded available supply in the interior, and terminal slaughter exceeded terminal salable receipts in Wisconsin, resulting in negative interior surplus and terminal surplus. However, the large positive marketing surplus (sales to terminals greater than receipts at the Milwaukee market) for slaughter cattle more than offset the two negative components, resulting in positive net outshipments. The marketing surplus for hogs was also positive, but was not large enough to offset the two negative components, resulting in negative net outshipments (inshipments greater than outshipments).

Minnesota had a negative interior surplus and positive terminal surplus in both cattle and hogs. The State had a negative marketing surplus and sizeable negative outshipments of cattle. Net outshipments of slaughter hogs were also negative, but were sharply reduced by the positive marketing surplus.

Iowa had the largest net outshipments in the Upper Midwest Region. The large negative interior surplus in cattle was offset by the even larger (positive) terminal surplus and marketing surplus. All three components of net outshipments of slaughter hogs were positive.

North Dakota had positive net outshipments in both species. This was the result of positive interior surplus and terminal surplus and negative marketing surplus. South Dakota had the same pattern for cattle, however, the large negative interior surplus for hogs resulted in negative net outshipments of hogs. Nebraska had negative outship-

ments of both species. The large negative marketing surplus of cattle overwhelmed the two positive components, while the negative marketing surplus and terminal surplus in hogs combined to outweigh the positive interior surplus.

The net outshipments can also be viewed in terms of the destination of the shipments. The net outshipments of slaughter livestock from five regions in the Upper Midwest to these same five regions and to regions outside of the Upper Midwest are presented in Table 5.2. These data can be used to give a spatial dimension to the data in Table 5.1.

Wisconsin's shipments of slaughter cattle to Minnesota exceeded the shipments from Minnesota to Wisconsin by 46.8 million pounds. These data, along with the fact that Wisconsin had a marketing surplus of 67.9, is probably largely a function of shipments of slaughter cattle by Wisconsin farmers to the South St. Paul terminal market. Likewise, the excess of Wisconsin's inshipments over its outshipments with regions outside the Upper Midwest Region reflects the inflow of cattle from Illinois to Wisconsin for slaughter. A similar pattern of slaughter hog movements between Minnesota and Wisconsin exists. However, a much larger quantity of hogs flow into Wisconsin from outside the Upper Midwest, and a sizeable quantity flows from Iowa to Wisconsin. These flows are largely the result of Wisconsin's interior slaughter being greater than its available supply in the interior.

Table 5.2. Net outshipments of slaughter livestock by destination, 1959-61[a]

	Destination of shipments						
	Wisc.	Minn.	Iowa	N.D.-S.D.	Nebr.	Other regions	Total
	(million pounds carcass weight)						
Cattle							
Wisconsin	-	46.8	8.1	*	*	-31.3	23.6
Minnesota	-46.8	-	-50.3	-20.8	-9.2	-15.2	-142.3
Iowa	-8.1	50.3	-	-137.6	140.3	439.3	484.2
N.D.-S.D.	*	20.8	137.6	-	7.5	-1.1	164.8
Nebraska	*	9.2	-140.3	-7.5	-	2.0	-136.6
Total	-54.9	127.1	-44.9	-165.9	138.6	393.7	393.7
Hogs							
Wisconsin	-	32.9	-47.7	0	*	-92.9	-107.0
Minnesota	-32.9	-	-51.3	76.1	5.1	-4.7	-7.7
Iowa	47.7	51.3	-	-2.0	242.4	156.9	496.3
N.D.-S.D.	0	-76.1	2.0	-	-1.2	66.4	-8.9
Nebraska	*	-5.1	-242.4	1.2	-	191.9	-54.4
Total	14.8	3.0	-339.4	75.3	246.3	317.6	318.3

[a]Source: Based on data in (34).

Net outshipments from Iowa to Minnesota indicate sales of Iowa livestock at the South St. Paul terminal market and the excess of Minnesota's interior slaughter over the available supply in the interior. On the other hand, the net outshipments of slaughter hogs to North Dakota and South Dakota indicate the sale of Minnesota-produced hogs at the Sioux Falls and West Fargo markets, and to a lesser extent

the slaughter of Minnesota-produced hogs in South Dakota.

Iowa's outshipments of slaughter cattle and hogs to Nebraska are very large. This may be largely explained by movements of Iowa-produced livestock to the Omaha terminal market and to eastern Nebraska meat packers. This would agree with the positive marketing surplus in Iowa and the negative marketing surplus in Nebraska. Iowa also shipped large quantities of slaughter livestock outside of the Upper Midwest Region. This may be largely a function of sales by Iowa producers at the Chicago, St. Louis, St. Joseph, and Kansas City terminal markets. On the other hand, there is a large net outshipment of slaughter cattle from North Dakota and South Dakota to Iowa. This reflects movements from southeastern South Dakota producers to the Sioux City terminal and northwestern Iowa slaughter plants, however, the size of the net outshipments (137.6) would indicate that sizeable quantities of slaughter cattle were shipped long distances from points in North Dakota and South Dakota into Iowa. Also, a sizeable quantity of slaughter hogs was shipped from North Dakota and South Dakota to points outside of the Upper Midwest Region. This may indicate long shipments to terminal markets such as Chicago.

As noted earlier, there was a large net movement of slaughter livestock from Iowa to Nebraska. However, there is also a large net movement of slaughter hogs from Nebraska to points outside the Upper Midwest. This indicates the sale of Nebraska-produced slaughter hogs at terminal markets and to meat packers in Missouri and Kansas. This

correlates with the fact that Nebraska had a large interior surplus of slaughter hogs.

On the basis of Tables 5.1 and 5.2, it is possible to establish the patterns of livestock movements from producers to terminals and meat packers, and from terminals to interior packers. The previous chapters have been concerned with interstate movements, however, some indication of intrastate movements can also be obtained from Table 5.1. For example, the positive terminal surplus and negative interior surplus of slaughter cattle in Minnesota and Iowa indicate that a sizeable portion of the slaughter cattle receipts at Sioux City and South St. Paul markets flow back to the interior for slaughter.

The discussion of livestock movements is based upon the data in Tables 5.1 and 5.2 and reasonable interpretations of these data. To estimate these movements with more certainty, it would be necessary to interview producers, marketing agencies, and meat packers, concerning where they buy and sell slaughter livestock. However, by analyzing the aggregate data it appears that some fairly precise statements can be made. The data on interior slaughter, terminal market slaughter, and terminal receipts are the most reliable statistics, while the accuracy of the terminal sales and available supply data are more questionable. Inaccuracies in estimating these latter data would lead to inaccurate estimates of the interior surplus and the marketing surplus. For example, an overestimate of terminal sales (and, consequently, an under-

estimate of available supply) would cause an overestimate of the marketing surplus and an underestimate of the interior surplus.

Substate regions

A comparison of livestock slaughter with available supplies in the substate regions provides further insight into the production-marketing-slaughter complex. There is no reported data on slaughter in the substate regions; however, estimates were made on the basis of several types of information. The most important source was the 1958 Census of Manufacturers reports on the location of meat packing plants by employment size groups (25). It was then possible to estimate the number of workers employed in commercial livestock slaughter in each county. Other sources gave some indications of the species slaughtered at the larger plants (22, 28). The resulting estimates of employment in the cattle and hog slaughtering activities in the various counties was then used to allocate interior cattle and hog slaughter to the substate regions. These estimates, along with the available supplies in the substate regions, are presented in Table 5.3. Also, the location of all meat packing plants with 50 or more employees in 1958 in Wisconsin, Minnesota, Iowa, South Dakota, and Nebraska are shown on the maps in Figures 5.1 through 5.5.

Interior slaughter in Wisconsin is highly concentrated in Regions 8 and 9. Sixty-seven percent of the state's interior slaughter of cattle, and 87 percent of the interior hog slaughter occurs in these

Table 5.3. Interior slaughter and available supply of slaughter livestock, 1959-61

Region	Cattle		Hogs	
	Interior slaughter	Available supply	Interior slaughter	Available supply
	(million pounds carcass weight)			
Wisconsin				
1	22.7	37.7	1.3	11.7
2	2.6	43.3	3.4	13.7
3	0.3	21.6	0.8	8.6
4	19.4	56.5	27.0	42.8
5	16.0	28.3	1.3	25.3
6	61.0	51.9	18.2	38.0
7	2.6	55.4	3.4	87.4
8	132.9	51.5	218.5	67.9
9	114.6	19.7	148.8	12.0
Total	371.9	365.9	422.7	307.4
Minnesota				
1	1.4	12.2	2.6	10.0
2	0	6.5	0	7.0
3	45.0	1.7	61.2	0
4	14.9	18.2	0.9	41.8
5	23.1	28.3	3.5	71.5

Table 5.3. (Continued)

Region	Cattle		Hogs	
	Interior slaughter	Available supply	Interior slaughter	Available supply
	(million pounds carcass weight)			
6	18.1	7.7	29.3	7.6
7	7.1	15.3	8.7	49.4
8	106.6	20.2	170.2	74.9
9	138.2	21.0	168.8	48.0
Total	354.4	131.1	437.4	310.2
Iowa				
1	121.3	133.8	123.3	250.2
2	110.1	80.7	153.7	235.2
3	345.6	85.4	462.8	337.7
4	6.1	112.5	8.9	234.6
5	183.5	127.2	420.0	273.8
6	125.4	148.6	457.5	335.1
7	15.3	65.2	1.8	145.3
8	2.0	25.0	3.6	129.0
9	110.0	35.1	155.5	200.4
Total	1,019.2	813.5	1,787.1	2,141.3

Table 5.3. (Continued)

Region	Cattle		Hogs	
	Interior slaughter	Available supply	Interior slaughter	Available supply
	(million pounds carcass weight)			
South Dakota				
1	0.8	15.4	1.4	2.6
2	3.0	19.8	5.2	24.9
3	29.4	12.4	51.4	17.0
4	11.4	16.7	19.9	1.6
5	57.2	19.2	100.1	22.2
6	28.6	13.4	87.1	40.9
7	0	9.1	0	1.1
8	0.8	18.2	1.4	10.7
9	5.7	15.2	9.9	53.4
Total	136.9	139.4	276.4	174.4
Nebraska				
1	66.5	33.1	3.1	10.4
2	1.0	8.3	0.4	20.5
3	2.9	123.0	1.1	119.3
4	5.8	66.6	2.3	48.0
5	228.5	108.0	218.5	74.7

Table 5.3. (Continued)

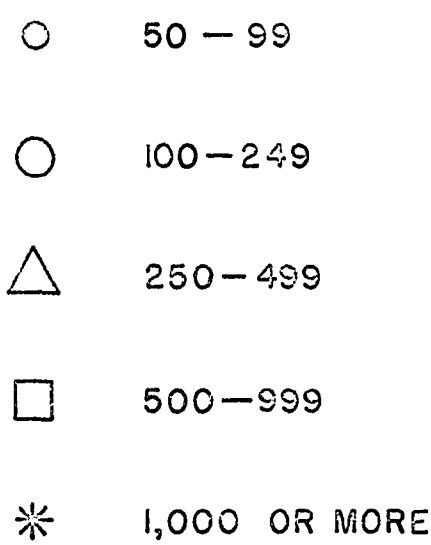
Region	Cattle		Hogs	
	Interior slaughter	Available supply	Interior slaughter	Available supply
	(million pounds carcass weight)			
6	40.7	19.9	0.8	16.7
7	14.2	37.0	0.8	20.5
8	30.4	41.2	1.5	51.0
Total	390.0	437.1	228.5	361.1

two regions. Available supply exceeds slaughter in all other regions, except Region 6 where cattle slaughter approximately equals available supply. This suggests sizeable movements of slaughter livestock from the North and West to the two major slaughter regions in the Southeast.

A similar concentration of slaughter occurs in Minnesota's 8th and 9th Regions, where 69 percent of the interior cattle slaughter and 78 percent of the hog slaughter occur. The next most important slaughter region is the northeast Region 3 where one large plant slaughters more than the available supplies in that and adjoining regions. The location of two large plants close to the Iowa border suggests sizeable movements from Iowa to these plants.

Iowa has a widely dispersed meat packing industry, with high levels of slaughter in six of the nine regions. The low level of slaughter in Region 8 can be explained by the location of large slaughter plants

Figure 5.1. Location of meat packing plants in Wisconsin according to size of employment, 1958



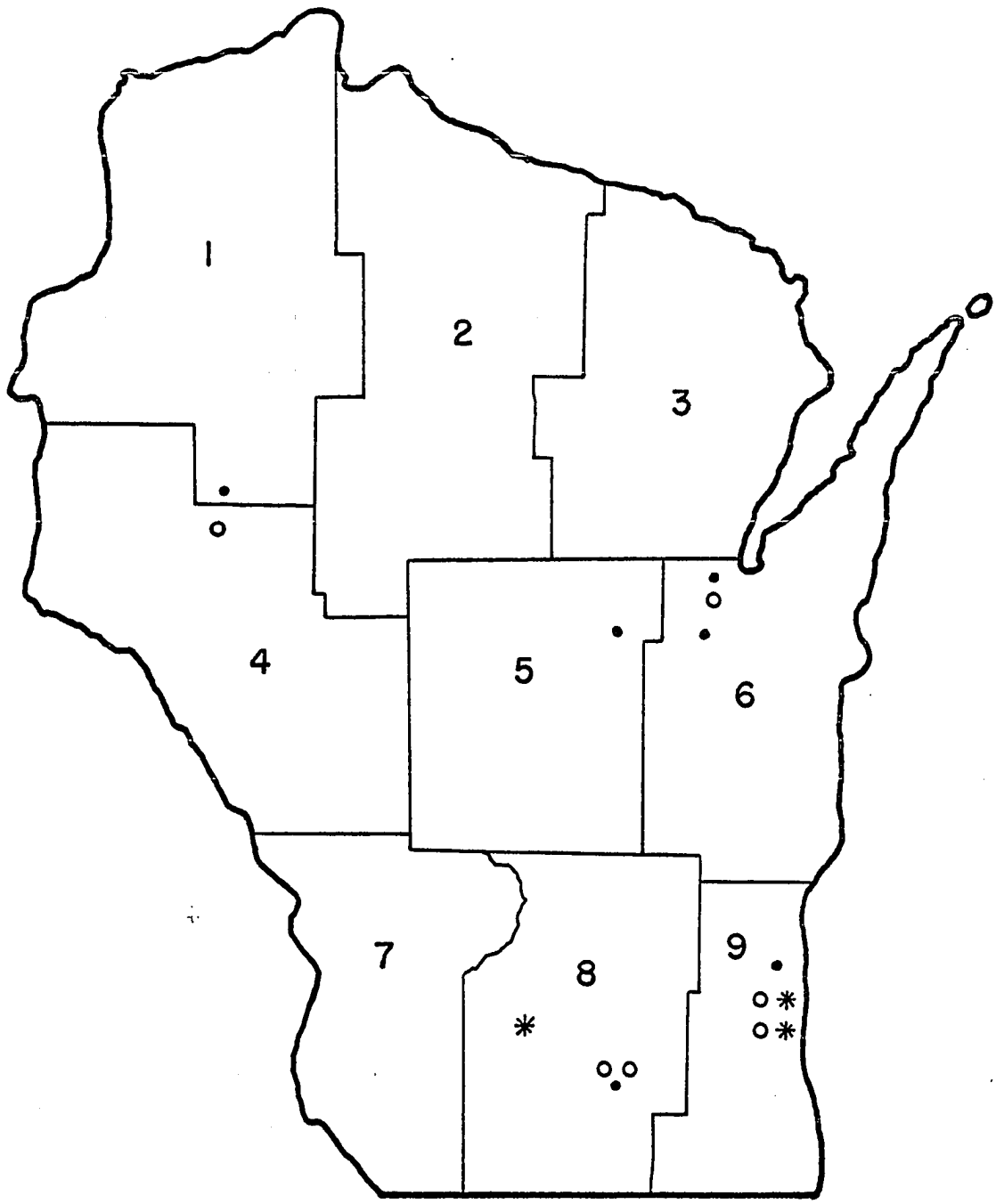

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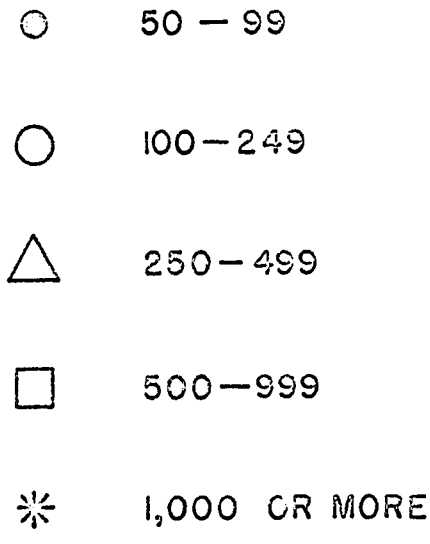
Figure 5.2. Location of meat packing plants in Minnesota according to size of employment, 1958



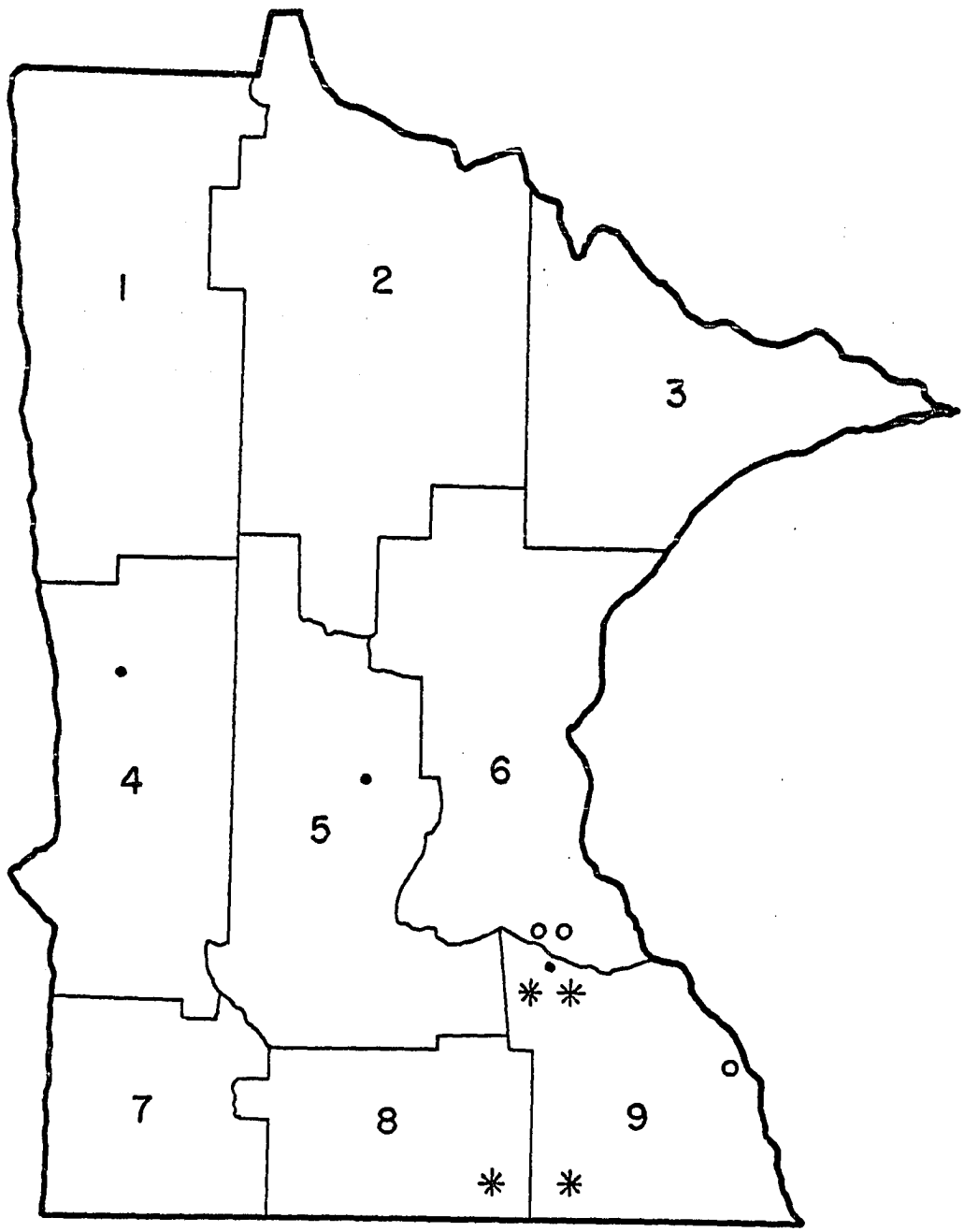

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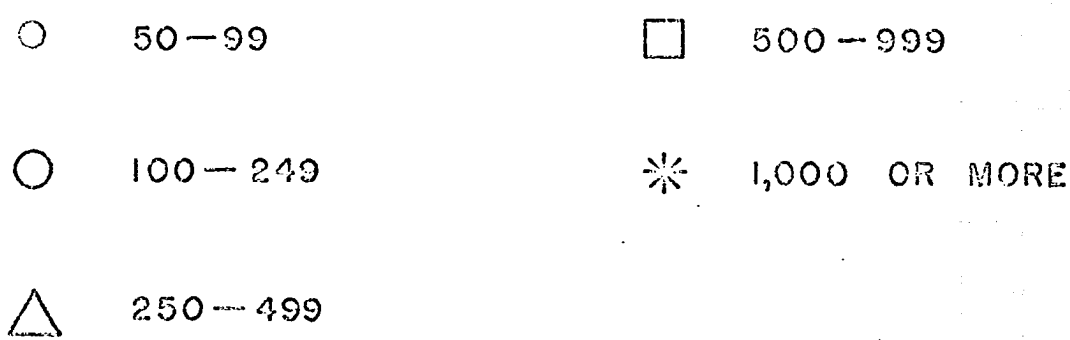
Figure 5.3. Location of meat packing plants in Iowa according to size of employment, 1958



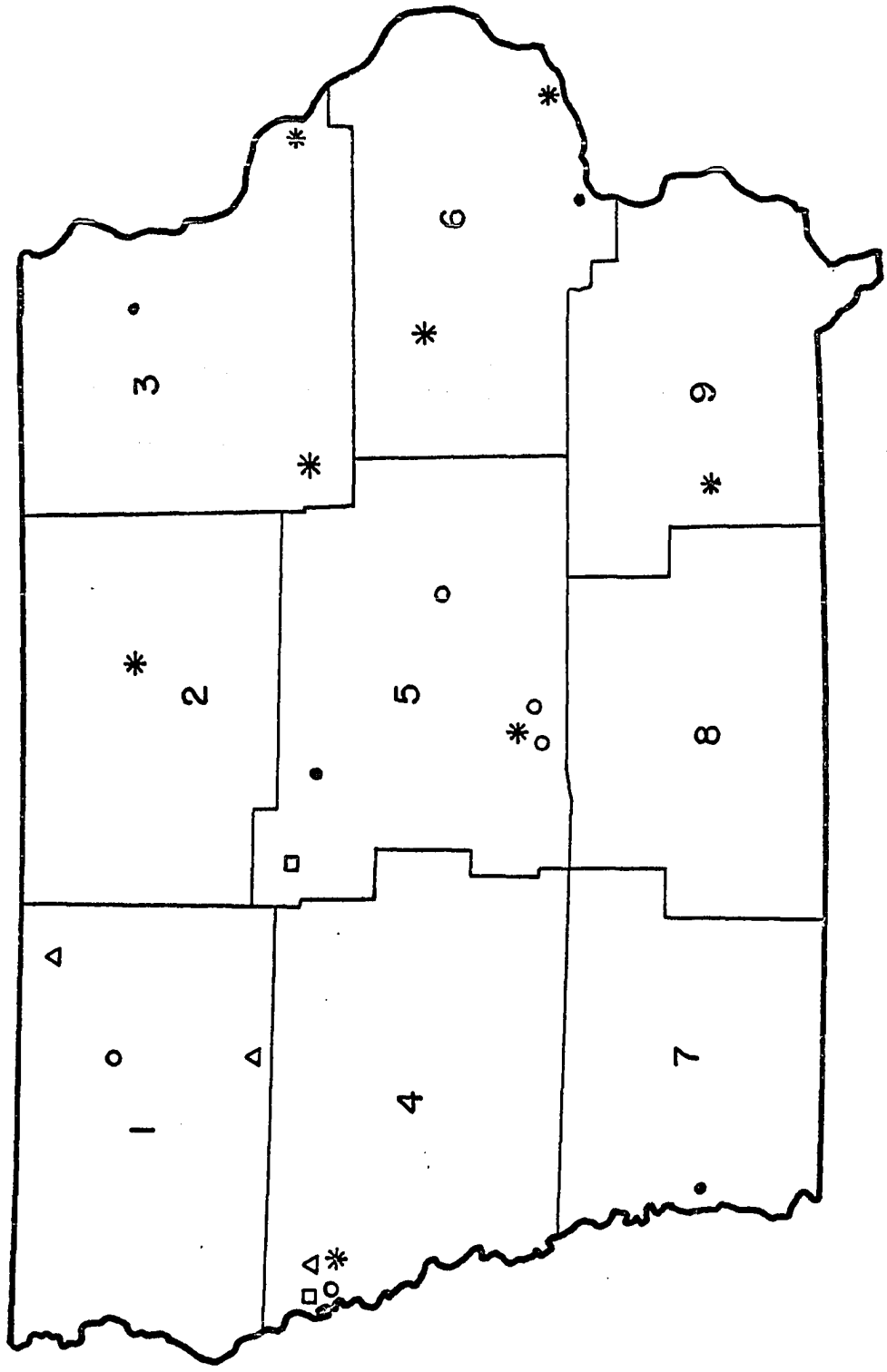

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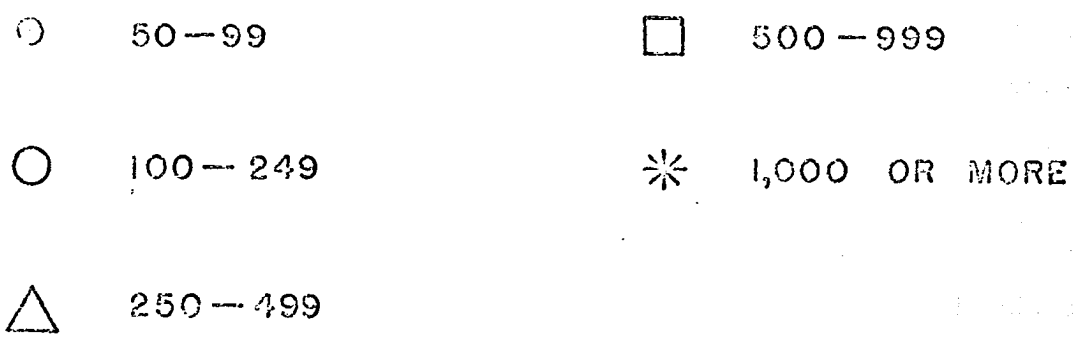
Figure 5.4. Location of meat packing plants in South Dakota according to size of employment, 1958



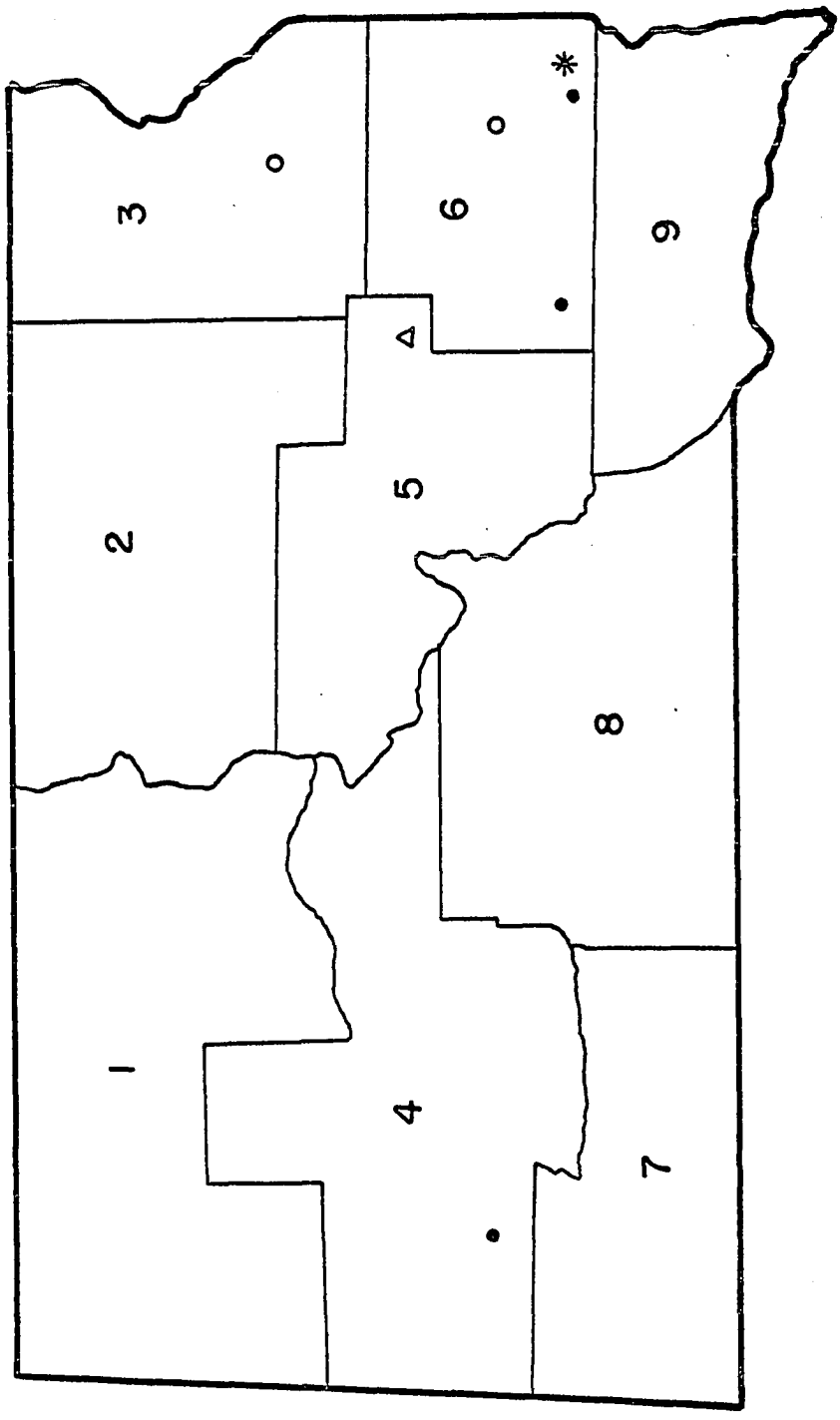

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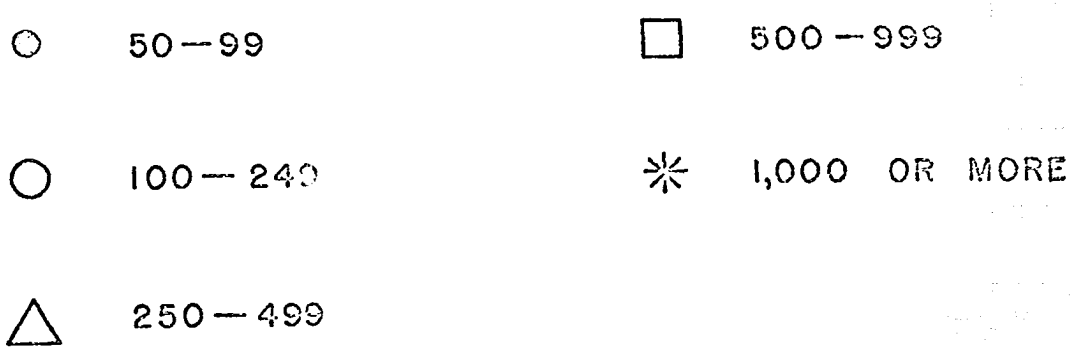
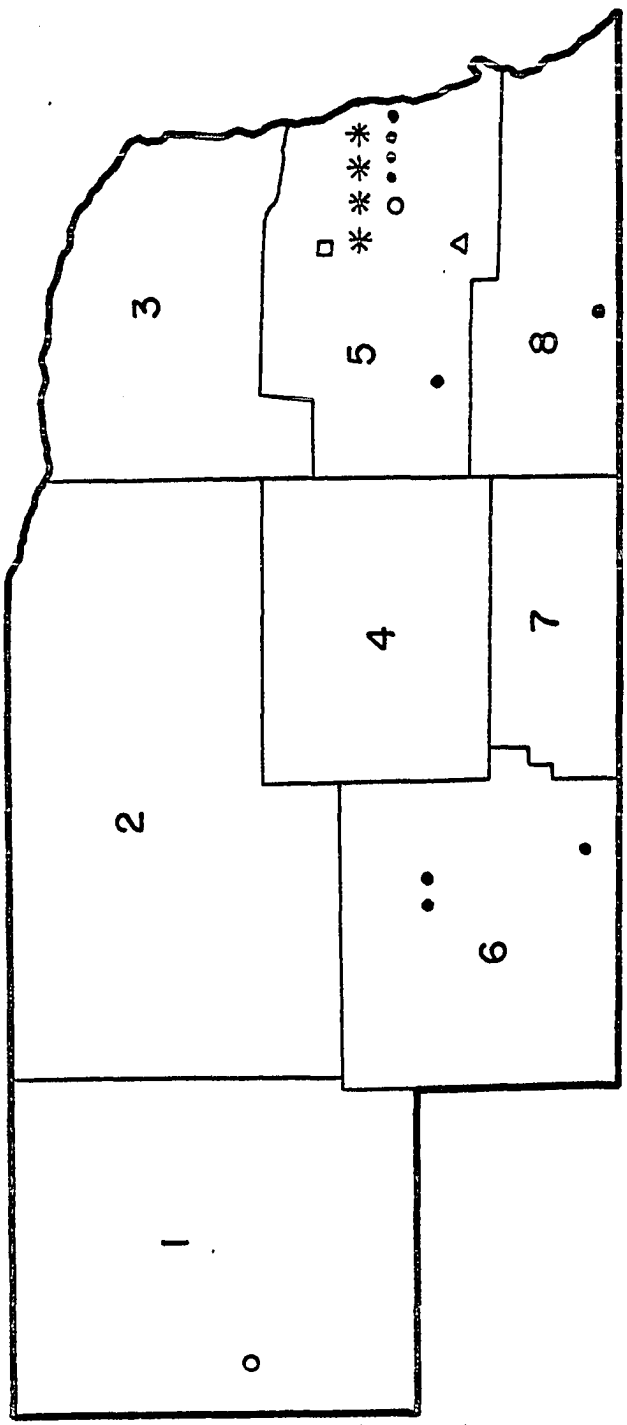
Figure 5.5. Location of meat packing plants in Nebraska according to size of employment, 1958

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adjacent to this region in Regions 5 and 9. However, the low levels of slaughter in Regions 4 and 7 are hard to explain. The Sioux City terminal market, in which salable receipts greatly exceed slaughter, is located in the northwest corner of Region 4. Thus, it would be expected that the excess slaughter livestock at the Sioux City terminal would move into Regions 1 and 4 and Nebraska's northeast Region 3. However, slaughter in all three of these regions is less than the available supply. Therefore, they would appear to be likely locations for new plants, and recent information on new meat packing plant construction (7, 22) indicates that most of the new or proposed meat packing plants in Iowa are located in Regions 1 and 4. Region 7 appears to be an especially good location for another sizeable cattle slaughter plant because of the excess of available supply over slaughter in that region, and because of the excess of salable receipts over slaughter at the nearby Omaha terminal market. But there have been no large plants established there in recent years, and there is no proposed major construction in that region.

The excess of slaughter over available supplies in Iowa's Regions 2, 3, 5, and 6 suggests that much of the excess livestock from the Sioux City terminal moved to these regions for slaughter. Indications are that slaughter capacity is expanding slower in these regions than in Regions 1 and 4, which may indicate that the movement of slaughter livestock from western Iowa to the meat packing plants in eastern Iowa has been reduced.

Because of the low level of slaughter and available supply in North Dakota, no attempt was made to allocate that state's slaughter to the substate regions. There was only one interior meat packing plant in North Dakota in 1958 with more than 50 employees; this plant was located in Grand Forks County and had 50 to 99 employees (25).

South Dakota's interior slaughter is concentrated in Regions 3, 5, and 6. The one large meat packing plant in Region 5 and a medium size plant in Region 4 probably accounted for nearly all of the slaughter in the six westernmost regions. Plants in Region 3 and 6 probably draw considerable amounts of livestock from the Sioux Falls terminal market.

Nebraska's interior slaughter is concentrated in Region 5 which accounts for 59 percent of the interior cattle slaughter and 96 percent of the interior hog slaughter. Sizeable numbers of cattle are slaughtered in Regions 1, 6, and 8. The most likely region for expanded slaughter capacity would appear to be Region 3 which has a high density of production, and which could draw supplies from southeastern South Dakota, and the Sioux City and Sioux Falls terminal markets.

In summary, heavy concentrations of livestock slaughter are found in Wisconsin, Minnesota, and Nebraska. Hog slaughter is more heavily concentrated than cattle slaughter, which may be due to the greater importance of economies of scale in hog slaughtering operations (37, p. 717). On the basis of these data, it appears that sizeable expansions in plant capacity were warranted in the area of the Sioux City

terminal market (northwestern and west central Iowa and northeastern Nebraska), and sizeable capacity growth has occurred in northwestern and west central Iowa since 1960.

Projected Slaughter and Investment in Slaughter Facilities

Livestock slaughter at the terminal markets can be projected on the basis of salable receipts of slaughter livestock at the terminals, and slaughter in the interior markets can be projected on the basis of available supplies in the interior. Increases in slaughter will create the need for increased capacity. Investment in meat packing facilities will be needed to create new slaughter capacity and to replace old, less efficient meat packing facilities.

Projected slaughter

The meat packing industry is a supply-oriented industry; meat packing plants tend to locate in areas where there is an ample year-round supply of slaughter livestock. This phenomenon can be explained by the relative costs of transporting livestock and meat. If the costs per mile of transporting a live animal are greater than the costs per mile of transporting the meat, meat products and by-products derived from the animal, then it is advantageous for the meat packer to slaughter in the area where the livestock is located and ship its output to consumption areas. In recent years the transportation rates have favored the supply orientation of meat packing. Also, ". . . with modern

means of transportation and refrigeration, losses due to shrinkage, death and bruising are greater and more costly in shipping the live animal" (37, p. 84). Thus, a basic assumption in projecting livestock slaughter in 1975 is that the industry (in the Upper Midwest Region) will be supply oriented.

A simple projection method is to project livestock slaughter equal to projected slaughter livestock production. The chief weakness of this method is the lack of any reference to the livestock marketing system. This weakness is overcome by an alternative method based on equation 5.3. Using this method, available supplies in the interior markets, sales of slaughter livestock to terminal markets, and terminal market receipts are projected. Then slaughter at the terminal markets and interior slaughter are projected by assuming certain relationships between these variables and the previously projected variables. This method requires more information than the first method. The production projections (which are the only informational inputs into the first method) must be divided into sales to terminals and available supplies, and the salable receipts at the individual terminal markets must be projected. However, the second method also provides more information, since total slaughter is divided into terminal market slaughter and interior slaughter components. For this reason, and because the livestock marketing system is explicitly considered, the method based on equation 5.3 is used.

Slaughter livestock production, sales to terminal markets, available supplies, and salable receipts at terminals in the Upper Midwest Region were projected to 1975 in the previous chapters. These projections will be used in making the 1975 slaughter projections. Thus, the remaining problem is to determine exactly how slaughter will be related to these variables.

It seems reasonable to assume that interior slaughter in each state will equal the available supply in that state, and that slaughter at each terminal market will equal salable receipts of slaughter livestock at that market. However, in 1959-61 terminal salable receipts exceeded slaughter in several of the Upper Midwest terminal markets, and interior slaughter differed by large amounts from available supply in some of the states.

An examination of recent trends yields some insights into these problems. There has been a definite trend toward decentralization of cattle slaughter, i.e., a relative shift of slaughter from the terminal markets to the interior. The percentage of commercial cattle slaughter in the Upper Midwest which occurred at the terminal markets decreased from 51 percent in 1954 to 46 percent in 1961. On the other hand, there was no apparent trend toward decentralization of hog slaughter; on the average, 25 percent of the region's commercial hog slaughter occurred at terminal markets. Further investigation shows that the relative decline of terminal cattle slaughter is linked directly to the relative decline of salable receipts of slaughter cattle at the

terminals. Cattle slaughter at the six terminals averaged 72 percent of salable receipts of slaughter cattle for the years 1954 through 1961, and there was no apparent trend in this percentage. Likewise, hog slaughter at terminals, as a percent of salable receipts of slaughter hogs, exhibited no marked trends over the years 1953 through 1961, and averaged 87 percent. These data give support to the assumption that terminal slaughter will be dependent upon the salable receipts of slaughter livestock at the terminals.

The six Upper Midwest terminals show widely differing characteristics. Slaughter of both hogs and cattle at the Milwaukee market exceeded salable receipts in every year from 1954 through 1961, while slaughter at the West Fargo market was only a small percentage of salable receipts. These data for the six terminal markets are exhibited in Table 5.4. Those markets located in the largest cities, Milwaukee, South St. Paul and Omaha, had the highest ratio of slaughter to receipts. This ratio decreases monotonically with population in the other three markets: Sioux City has a larger population than Sioux Falls, and Fargo is the smallest of the six metropolitan areas. This suggests that slaughter at the terminal markets is related to the amount of meat processing performed in the surrounding metropolitan area. Meat processing plants tend to be located in large consuming centers. Thus, there would tend to be a greater demand for pork and beef carcasses in the larger consuming centers. This would result in more

Table 5.4. Slaughter at terminal markets as a proportion of salable receipts of slaughter livestock, 1953-61

Terminal market	Cattle[a]	Hogs[b]
	(percent)	
Milwaukee	1.318	1.685
South St. Paul	0.814	0.920
Sioux City	0.587	0.730
West Fargo	0.155	0.081
Sioux Falls	0.465	0.298
Omaha	0.786	1.167

[a]The proportion of cattle slaughtered at each terminal to salable receipts of slaughter cattle was calculated for each year from 1954 through 1961. The arithmetic means of these figures at each market was then calculated.

[b]These figures are based on data for the years 1953 through 1961.

slaughter at the terminal markets and less livestock being shipped back to the interior for slaughter. However, if there were a relatively low demand for carcasses in the metropolitan area, there would be more tendency for slaughter plants to be located outside of the metropolitan area where livestock could be obtained from the surrounding farms as well as being hauled short distances from the terminal.

With these considerations in mind, the projections of terminal slaughter in 1975 are made as follows: (1) slaughter at the Milwaukee,

South St. Paul and Omaha markets are set equal to salable receipts of slaughter livestock at these markets, and (2) slaughter at the Sioux City, Sioux Falls and West Fargo markets are the same proportion of salable receipts of slaughter livestock as during the 1953-61 period (see Table 5.4). Thus, it is assumed that slaughter at Milwaukee will adjust downward to salable receipts, as will cattle slaughter at Omaha. Similarly, hog and cattle slaughter at South St. Paul and cattle slaughter at Omaha are predicted to adjust upward to equal salable receipts. In effect, it is assumed that slaughter will equal the available supply at these markets.

Interior slaughter differed somewhat from available supplies in the Upper Midwest States in 1959-61. However, interior hog slaughter in the Upper Midwest Region was very close to the available supply, and the excess of interior cattle slaughter over the available supply could be more than compensated for by the flow of cattle from the terminal markets to the interior for slaughter (the terminal surplus of slaughter cattle was 732.5 million pounds). Much of the state-by-state discrepancy between interior slaughter and available supplies may be explained by the location of large slaughter plants near state borders. However, these considerations fail to explain certain phenomena, such as the large interior surplus of slaughter hogs in Iowa (354.2 million pounds) and the negative interior surplus of slaughter hogs in Wisconsin. Perhaps these phenomena reflect a lag in the adjustment of ca-

pacity to increasing slaughter hog supplies in Iowa and an overexpansion of capacity in Wisconsin.

Estimates of capacity utilization in 1960 (19) are presented in Table 5.5. There is some uncertainty in evaluating these data because of the method used in estimating capacity; the capacity of slaughter plants in a region was defined as the hourly capacity of the plants multiplied by the number of working hours per year assuming a normal 8-hour work day. Thus, capacity will be underrated because some plants have capacity for operating 16 or 24 hours per day. However, the data in Table 5.5 does give some indication of the relative capacity utilization among different regions. Wisconsin's capacity utilization is the lowest in the Upper Midwest Region and is lower than the United States' average, while Iowa's capacity utilization is the highest in the Upper Midwest.

Because of the low level of utilization of capacity in Wisconsin, there is a tendency to bring additional livestock into the state for slaughter, while in Iowa the high level of utilization has resulted in shipments of livestock to other states for slaughter. Thus, it would be profitable to increase capacity in Iowa, and to limit capacity expansion in Wisconsin until the existing capacity is more heavily utilized. This in turn supports the hypothesis that interior slaughter in Wisconsin and Iowa will become more nearly balanced with available supplies in the respective states.

Table 5.5. Estimated percentage capacity utilization in livestock slaughter plants, 1960[a]

Region	Cattle	Hogs
	(percent)	
Wisconsin	41.0	53.5
Iowa	146.7	121.4
Minnesota	109.3	74.4
Nebraska	90.4	64.7
North Dakota - South Dakota	114.7	93.0
United States	76.6	63.4

[a]Source: Based on data in (19). Capacity was estimated by multiplying the hourly capacity by the number of hours worked each year. Hours worked per year was assumed to be 252 work days times 7.2 hours per day. Commercial slaughter was then divided by the estimated capacity to obtain the capacity utilization rates.

On the basis of the foregoing discussion, 1975 slaughter is projected as follows: (1) slaughter at South St. Paul, Omaha and Milwaukee is equal to the salable receipts of slaughter livestock at these terminals; (2) slaughter at Sioux City, Sioux Falls and West Fargo is the same proportion of salable receipts of slaughter livestock at these terminal markets as in 1953-61; (3) one-half of the terminal surplus (the excess of salable receipts of slaughter livestock over slaughter) at the Sioux City market is allocated to each of the states of Iowa and Nebraska; (4) one-half of the terminal surplus at Sioux Falls is allo-

cated to each of the states of South Dakota and Minnesota; (5) one-half of the terminal surplus at West Fargo is allocated to each of the states of North Dakota and Minnesota; (6) interior slaughter in each state is equal to the available supply plus the "spillover" from terminal markets described in points 3, 4 and 5. These projections appear in Table 5.6.

The format of Table 5.6 is the same as that of Table 5.1, thereby allowing easy comparisons between the 1959-61 base period estimates and the 1975 projections. The most rapidly increasing component of slaughter in the Upper Midwest Region is the interior slaughter of cattle, which increased 138 percent. This was due to the rapid increase in slaughter cattle production, the relative decline of sales to terminals and the increased number of cattle moving from the terminal to the interior for slaughter. All states showed large increases in interior cattle slaughter and varying amounts of increase in terminal cattle slaughter. Both interior and terminal hog slaughter decreased substantially in Wisconsin. This was the result of the two assumptions that interior slaughter would equal available supply and terminal slaughter would equal salable receipts in Wisconsin. All other states exhibited increases in both components of hog slaughter.

The two methods of projection discussed earlier can be compared by means of the net outshipments column of Table 5.6. If slaughter were projected by setting it equal to projected production, then net

Table 5.6. Projected terminal and interior slaughter in million pounds carcass weight, 1975

Item	Available supply	Interior slaughter[a]	Interior surplus	Terminal receipts	Terminal slaughter[b]	Terminal surplus	Terminal sales	Marketing surplus	Net outshipments
				(million pounds carcass weight)					
Cattle									
Wisconsin	689.5	689.5	0	138.4	138.4	0	209.4	71.0	71.0
Minnesota	681.3	858.3	-177.0	845.8	845.8	0	765.2	-80.6	-257.6
Iowa	2,343.7	2,512.6	-168.9	817.9	480.1	337.8	1,454.8	636.9	805.8

[a]Wisconsin's interior slaughter is equal to available supply. Minnesota's interior slaughter is available supply plus one-half of North Dakota's terminal surplus and one-half of South Dakota's terminal surplus. Interior slaughter in Iowa and Nebraska is the available supply in the respective states plus one-half the Iowa terminal surplus. Interior slaughter in North Dakota and South Dakota is the available supply plus one-half the terminal surplus in the respective states.

[b]Terminal slaughter is set equal to terminal receipts in Wisconsin, Minnesota and Nebraska. Terminal slaughter in Iowa is 0.587 times terminal receipts of slaughter cattle and 0.730 times terminal receipts of slaughter hogs. Terminal slaughter in North Dakota is 0.155 times receipts of cattle and 0.081 times receipts of hogs. South Dakota's terminal slaughter is 0.465 times receipts of cattle and 0.298 times receipts of hogs.

Table 5.6. (Continued)

Item	Available supply	Interior slaughter[a]	Interior surplus	Terminal receipts	Terminal slaughter[b]	Terminal surplus	Terminal sales	Marketing surplus	Net outshipments
				(million pounds carcass weight)					
North Dakota	224.0	306.5	-82.5	195.3	30.3	165.0	122.8	-30.3	52.2
South Dakota	524.5	619.1	-94.6	353.5	164.4	189.1	264.2	-89.3	5.2
Nebraska	1,272.5	1,441.4	-168.9	1,347.5	1,347.5	0	820.4	-527.1	-696.0
Upper Midwest	5,735.5	6,427.4	-691.9	3,698.4	3,006.5	691.9	3,636.8	-19.4	-19.4
Hogs									
Wisconsin	322.6	322.6	0	33.5	33.5	0	61.4	27.9	27.9
Minnesota	429.7	533.1	-103.4	485.3	485.3	0	623.6	138.3	34.9
Iowa	2,748.1	2,794.4	-46.3	342.9	250.3	92.6	477.4	134.5	180.8
North Dakota	34.6	63.1	-28.5	61.9	5.0	56.9	45.4	-16.5	11.9
South Dakota	339.0	414.1	-75.1	213.8	63.7	150.1	160.2	-53.6	21.4
Nebraska	497.4	543.7	-46.3	413.8	413.8	0	230.8	-183.0	-229.3
Upper Midwest	4,371.4	4,671.0	-299.6	1,551.2	1,251.6	299.6	1,598.8	47.6	47.6

outshipments would be zero. However, Table 5.6 shows sizeable net outshipments in Minnesota, Iowa and Nebraska. For example, net outshipments of 805.8 million pounds is the amount by which Iowa's production of slaughter cattle exceeds slaughter. On the other hand, Nebraska's slaughter cattle production is 696 million pounds less than slaughter. Thus, the net outshipments measure the spatial effects of the slaughter livestock marketing system.

Projected investment

Projecting investment in meat packing facilities is fraught with difficulties. The problem is to project the amount of investment between 1959-61 and 1975. Two types of investment may be distinguished: the construction of new plants, and improvements in existing plants. The latter includes projects ranging from the replacement of specific pieces of equipment to the complete renovation of old plants. Investments of this type are extremely difficult to predict, because they are influenced by changing technology, among other things. The widespread adoption of more efficient means of production in new plants may necessitate extensive investment in old plants. On the other hand, if no major advances in meat packing technology occur, there will probably be little investment for purposes of "modernizing" existing plants.

Economies of scale cause additional problems in estimating aggregate investment. The investment per unit of capacity is higher in small plants. Thus, some assumption regarding the scale of plant must

be made for purposes of projecting aggregate investment.

Investment in new meat packing plants can be more readily predicted, although serious difficulties are present. First, allowance must be made for the week-to-week variation in slaughter, which necessitates increased capacity. The variability coefficient (the highest weekly slaughter during the year divided by average weekly slaughter) discussed in an earlier chapter explicitly accounts for this factor. Weekly federally inspected slaughter at major meat packing centers (29) were used to estimate the variability coefficients for cattle and hog slaughter. (Total commercial slaughter is not reported on a weekly basis.) The Upper Midwest Region encompasses four major meat packing centers (as defined by the U. S. Department of Agriculture): the Iowa-Southern Minnesota Area, the St. Paul-Wisconsin Area, the Sioux City-South Dakota Area and the Omaha Area. The ratio of the highest weekly slaughter to average weekly slaughter was computed for each of these four centers in several recent years. There was no marked difference between the ratios for the different major centers; however, the ratio was generally higher for hog slaughter than for cattle slaughter. The ratios varied for different years, but were never more than 1.4 for cattle and 1.7 for hog slaughter. These two values are used as variability coefficients in projecting 1975 investment.

The investment of beef slaughter plants, as estimated by Logan and King (12), ranges from $9,163 to $13,988 per unit of capacity. A unit of capacity is defined as the capacity to produce 1 million pounds of

dressed meat (carcasses before they are broken into wholesale cuts) per year. Truesdale (22) has estimated per unit investment in hog slaughter plants ranging from $19,182 for a relatively small plant to $10,863 for a large plant. The per unit investment in "medium" sized plants will be used to project aggregate investment in the Upper Midwest. These figures are $10,792, the per unit investment in a beef slaughter plant with a yearly capacity of 65.3 units, and $15,984, the per unit investment in a hog slaughter plant with a yearly capacity of 78.2 units. It should be noted that these data apply to plants designed to operate on only one 40-hour shift per day. The per unit investment in plants designed to operate for two or three shifts per day would be somewhat lower.

These data are used in making the projections shown in Table 5.7. The growth in capacity is estimated by multiplying the projected growth in livestock slaughter times the variability coefficient. Then capacity growth is multiplied by the appropriate per unit investment figure to estimate investment. This method results in projected investment of $78 million in cattle slaughter plants and $51 million in hog slaughter plants. A total of over $51 million is projected for investment in Iowa, while only $4 million is projected in Wisconsin, a state in which hog slaughter is expected to decrease, resulting in no new hog slaughter plants.

Table 5.7. Projected investment in new livestock slaughter plants from 1959-61 to 1975

Region	Slaughter[a]		Capacity[b]		Investment[c]	
	Cattle	Hogs	Cattle	Hogs	Cattle	Hogs
	(million pounds)		(capacity units)		(thousand dollars)	
Wisconsin	286.8	-116.9	401.5	0	4,333	0
Minnesota	906.3	250.5	1,268.8	425.9	13,693	6,808
Iowa	1,544.6	1,027.7	2,162.4	1,747.1	23,337	27,926
North Dakota	305.7	61.5	428.0	104.6	4,619	1,672
South Dakota	541.2	163.4	757.7	277.8	8,177	4,440
Nebraska	1,578.4	374.4	2,209.8	636.5	23,848	10,174
Upper Midwest	5,163.0	1,760.6	7,228.2	3,191.9	78,007	51,020

[a]Projected 1975 slaughter minus 1959-61 slaughter expressed in million pounds carcass weight.

[b]Slaughter times the variability coefficient. The variability coefficient is 1.4 for cattle slaughter and 1.7 for hog slaughter.

[c]Capacity times per unit investment. Per unit investment is $10,792 for cattle slaughter plants and $15,984 for hog slaughter plants. Projected investment is expressed in thousands of dollars.

The predicted amount of investment would be sufficient to handle the expected increase in slaughter. Thus, if all plants operating in the 1959-61 base period were slaughtering the same amounts in 1975, the projected new plants would be able to handle the remaining amount of slaughter. And if the peak weekly cattle slaughter in 1975 were 1.4

times the average weekly slaughter and the peak weekly hog slaughter were 1.7 times the average weekly slaughter, then the new plants would be operating at capacity during the peak slaughter weeks. In other words, it is assumed that the old plants will continue to operate at the same level of capacity utilization as in 1959-61 (except for Wisconsin's hog slaughter plants), and that new plant construction is just sufficient to handle the increased slaughter.

These simplifying assumptions rule out certain additional investment. As mentioned earlier, it does not take account of the "modernization" of old plants, which is a function of changing technology. In fact, if revolutionary technological changes were to take place, investment may be much higher than the projections in Table 5.7. For example, if some new technical breakthrough occurred in, say 1970, perhaps nearly all plants existing at that time would be replaced by new, more efficient plants. If the per unit investment were about the same as for the old plants, then actual investment would be much larger than that projected. Thus, another way of qualifying the projections is to state that this investment would result if technology were to remain unchanged from 1959-61 to 1975, old plants would not be modernized, and new plants would have capacity just sufficient to handle increased slaughter.

Nothing has been said about the intervening years between the base period and the projection year. It is well known that livestock pro-

duction and slaughter fluctuates significantly from year to year. Thus, it is quite possible that one of the intervening years, say 1973 or 1974, would be a year in which slaughter was greater than in 1975. This would tend to bring about greater investment by 1975 than that projected.

The projected investment represents an optimum in that it is just enough to handle the increased slaughter; it does not allow for any misallocation of the invested resources. It assumes that the new plants will be located and operated such that they will, in the aggregate, just absorb the increased supplies of slaughter livestock. Any deviation from this norm would result in excess capacity in at least one of the new plants, and aggregate investment greater than that projected, or not enough capacity to handle available supplies of livestock.

"Building ahead" of capacity utilization will tend to increase investment. There are certain indivisibilities which may make it profitable to operate a plant at less than full capacity for several years. For example, a plant may be designed with the capacity to slaughter the available supply of livestock (which is growing over time) in a specified area surrounding the plant. The plant may have the capacity to handle the available supply in that area in, say, the fifth year of operation. It would be unrealistic to expand the plant capacity every year to accommodate the increased supply of livestock because of the costs associated with the disruption of work and the

increased costs of constructing small additions to capacity. Thus, it is to be expected that unused capacity will occur in optimally planned slaughter plants.

Meat packers may also build ahead for reasons of flexibility and competitive advantage. For example, a firm may have a good chance to expand its market share at some future time. Thus, it may be advantageous to have some excess capacity to allow for rapid increases in production at some future time. There may also be large unexpected orders for meat products at some future time which would cause a need for rapid, although temporary, production increases.

There may be one reason why the investment projections will tend to be too high. If the existing plants in a region possess substantial excess capacity in 1959-61, then they may absorb some of the increased supplies of slaughter livestock, resulting in a lowered need for capacity expansion.

In sum, it appears that the projections in Table 5.7 represent minimum expected investment between 1959-61 and 1975. Given the projected increases in slaughter livestock supplies, at least this much will be invested in slaughter plants, unless there is an extremely large amount of unused capacity in existing plants. It should be noted that these projections refer only to the slaughter operations of meat packing plants. Meat processing facilities will require additional investments.

THE INVESTMENT DECISION

A normative decision model for investment planning in the meat packing industry is developed in this chapter. Also, an information system that can be maintained on a permanent basis is discussed. The implications of the decision model and the information system for individual investors are discussed in the final section.

A Decision Model

The normative investment planning procedures, or models for evaluating alternative investments, discussed in an earlier chapter can be elaborated to include an analysis of the various cash flows associated with an investment. In particular, the cash flows associated with meat packing plants can be analyzed by components such as meat sales, cost of livestock, and procurement costs, as well as in-plant costs. These components can, in turn, be functionally related to other variables such as livestock supplies.

The general model

The present value of alternative investments was suggested as a criterion for accepting or rejecting investment proposals in an earlier chapter. Present value, P, is defined by equation 6.1:

$$P = K_o + \frac{K_1}{(1 + i_1)} + \frac{K_2}{(1 + i_1)(1 + i_2)} + \ldots + \ldots + \frac{K_n}{(1 + i_1)(1 + i_2) \ldots (1 + i_n)} \qquad (6.1)$$

where K_t is the net cash flow in period t, i_1 is the discount rate between period 0 and period 1, i_2 is the discount rate between period 1 and period 2, and so forth. Several components of cost in meat packing plants were discussed earlier. In addition, the one regular source of income from meat packing operations, the sale of meat, meat products, and by-products was discussed. Thus, net cash flows can be analyzed as summations of income (positive cash flows) and costs (negative cash flows). However, income and costs are defined as occurring at the time the resulting cash flows occur. For example, the cost of plant and equipment appears as a cost in period o, when the actual cash flow occurs, rather than being allocated over the useful life of the plant and equipment. The net cash flows can then be defined by equations 6.2 and 6.3:

$$K_o = I \tag{6.2}$$

$$K_t = M_t - (F_t + L_t + R_t + N_t + V_t),\ t = 1, 2, \ldots, n \tag{6.3}$$

where I is initial costs, or investment costs; F_t is fixed costs in period t; M_t is income from sales of meat, meat products, and by-products in period t; L_t is the cost of livestock in period t; R_t is procurement costs in period t; N_t is the cost (or income) incurred in increasing (or decreasing) inventories in period t; and V_t is all other variable costs incurred in period t. All these variables were discussed in the section entitled "Relevant Economic Information." It was hypothesized that initial costs, fixed costs, and other variable costs could be

estimated by the linear functions 6.4, 6.5, and 6.6:

$$I = a_1 + b_1 K \tag{6.4}$$

$$F_t = a_2 + b_2 K \tag{6.5}$$

$$V_t = a_3 + b_3 K + c_3 S_t \tag{6.6}$$

where K is annual capacity (in terms of head of livestock slaughtered) and S_t is the number of livestock slaughtered in year t.

Inventory holding costs are a function of the level of output. Increased inventories of cattle or meat, or both, require outlays of money. Thus, they give rise to negative cash flows. It was suggested that cash flows arising from changes in inventories be handled as follows: (1) the value of inventories at the time the plant begins operation constitutes a negative cash flow at that time, (2) the value of inventories at the time the plant ceases operations constitutes a positive cash flow, and (3) the value of changes in inventories in any intermediate period becomes a positive or negative cash flow at that time. Inventories in a specialized slaughter plant in any period would be approximately proportional to slaughter. Therefore, changes in inventories between any two periods would be proportional to the change in slaughter, and inventory costs in period t could be estimated by equation 6.7:

$$N_t = a_4 (S_t - S_{t-1}) \tag{6.7}$$

where a_4 is a constant representing the value of inventories per head of annual slaughter. In particular, inventory costs in period 1 (the

first period of operations) would be $a_4 S_1$. In the last period of operations (period n) there would be an additional negative cost of $a_4 S_n$. Also, the term N_n will be interpreted to include the salvage value of plant and equipment.

Income from sales is, of course, directly related to slaughter. The price received for the various products may depend upon the quantity sold, resulting in a downward sloping demand curve for the firm's output. If a slaughter plant only produces carcass meat which is input into processing plants for the same firm, then an appropriate accounting price could be assigned to the slaughter plant's output. Thus, the derived demand for the plant's output may also be downward sloping. In either situation the total annual return from a plant's output may be estimated by equation 6.8:

$$M_t = (a_5 + b_5 S_t) S_t \qquad (6.8)$$

The term $(a_5 + b_5 S_t)$ is the amount of money received for meat, meat products, and by-products derived from a head of livestock. The coefficient b_5 would be negative if the firm faced a downward sloping demand curve, but b_5 would be zero if the firm could always sell its entire output at a fixed price.

The cost of livestock and procurement costs

Most of the livestock purchased by meat packers will be procured either from terminal markets or from the area around the plant. Livestock may be purchased direct from farmers, through auctions, or from

local dealers or markets. At times livestock may be purchased from other distant sources (e.g., a dealer in another state), but this is relatively unimportant in cattle and hog slaughter plants. The costs of livestock purchased in the interior and at terminals will differ. For example, the price of U. S. No. 1 and 2 Barrows and Gilts between 200 and 220 pounds was $15.36 per hundredweight at the Sioux City terminal market during a week in February, 1964. The corresponding price in the Interior Iowa-Southern Minnesota market was $14.83 (29). Price statistics on slaughter cattle in interior markets are not reported, but logically a similar spread can be expected in cattle prices between terminal and interior markets.

Meat packers procure most of their interior supplies of livestock through salaried buyers. The buyers may do most of their buying at fixed points such as buying stations or at the slaughter plant, or they may travel extensively and purchase livestock at farms, auctions, and other markets. In general, buying stations are more extensively used in procuring hogs than cattle.

Livestock purchased at a terminal market may be procured through salaried buyers, order buyers, or other marketing agencies. The cost of procuring livestock, whether it be salaries and expenses of salaried buyers, commission charges of agents, or dealer markups, will differ between terminal and interior markets.

With these considerations in mind, equations 6.9 and 6.10 were formulated to represent the cost of livestock and procurement costs:

$$L_t = (a_6 + b_6 S_{1t}) S_{1t} + (a_7 + b_7 \overline{H_t}) S_{2t} \quad (6.9)$$

$$R_t = a_8 S_{1t} + (a_9 + b_9 \overline{H_t}) S_{2t} \quad (6.10)$$

where S_{1t} is the number of head of livestock procured from terminal markets in period t, S_{2t} is the number of head of livestock procured from interior markets in period t, $\overline{H_t}$ is the average distance from the point of purchase in the interior supply area to the slaughter plant in period t, and the a's and b's are constant coefficients. The terms within the parenthesis in equation 6.9 represent the average cost per head of livestock from the two major sources. Thus, they include the purchase price of the livestock and any cost of transporting the livestock which is incurred by the packer. The cost of transportation includes losses due to shrinkage, bruising or death of livestock in transit, as well as the truck or railroad fees. All the coefficients in equation 6.9 are assumed to be positive. As the amount of livestock purchased from terminals increases, the cost per head of livestock is expected to increase. Likewise, as the number of head of livestock procured in the interior markets increases the cost per head is expected to increase. As more livestock is purchased the average distance will increase. As average distance increases, average costs may increase for two reasons: (1) increased competition for livestock supplies from competing packers will increase the price of livestock, and

(2) increased transportation costs may be incurred. The relative importance of these two factors will depend upon the type of procurement system used. For example, if buying stations are used, transportation costs may be an important item; but if traveling buyers are used exclusively, transportation costs incurred by the packer may be nonexistent. In summary, equation 6.9 is formulated so that the cost of livestock procured through widely differing methods may be estimated. The equation can be easily expanded to take account of additional sources of livestock supply, e.g., an additional term may be added to take account of livestock procured from outside the normal supply region.

Procurement costs (equation 6.10) are functionally related to slaughter in a manner similar to the cost of livestock. Procurement costs include salaries and traveling expenses of buyers who are employed by the meat packing firm, the commissions of livestock buying agents, and the markup of independent dealers. It is assumed that the per head costs of buying livestock at terminal markets is constant, while the per head cost of procuring livestock in the interior increases as the average distance from the plant, $\overline{H}_t$, increases. As the amount purchased in the interior increases, buyers must travel further from the plant resulting in increased traveling expenses and salaries per head of livestock purchased. However, if buying stations are used, procurement costs per head may not increase appreciably since livestock buyers conduct business at the buying stations and do not travel ex-

tensively. But transportation costs, which are accounted for in the cost of livestock, will increase. As in equation 6.9, it is possible to expand equation 6.10 to take account of livestock procured from several different sources with several different types of procurement systems.

It was noted earlier that the average distance, $\overline{H_t}$, is related to the number of livestock purchased in the area surrounding the plant. The average distance can be measured exactly if we assume a homogeneous plane in which the available supply is distributed evenly over all portions of the plane, and if we assume specific geometrical shape of the supply area. French has pointed out that in the Upper Midwest States the average distance is minimized (for given purchases of livestock) if the supply area is diamond-shaped:

> In most of the central part of the United States, country roads follow along section lines, presenting a square grid system of roads. In this case the least costly area to haul from is ... a square tilted 45° to the road net ... With this system the road distance to any supply point is x + y, where x and y are the rectangular coordinates of the point (6, pp. 771-772).

This least distance (or least cost) supply area is illustrated in Figure 6.1. If the distance from the plant to the perimeter of the supply area is A (see Figure 6.1) and the density of the available supply of livestock (number of head of slaughter livestock sold per square mile per year) is D_t, then the average distance from the plant to a point in the supply area is given by equation 6.11:

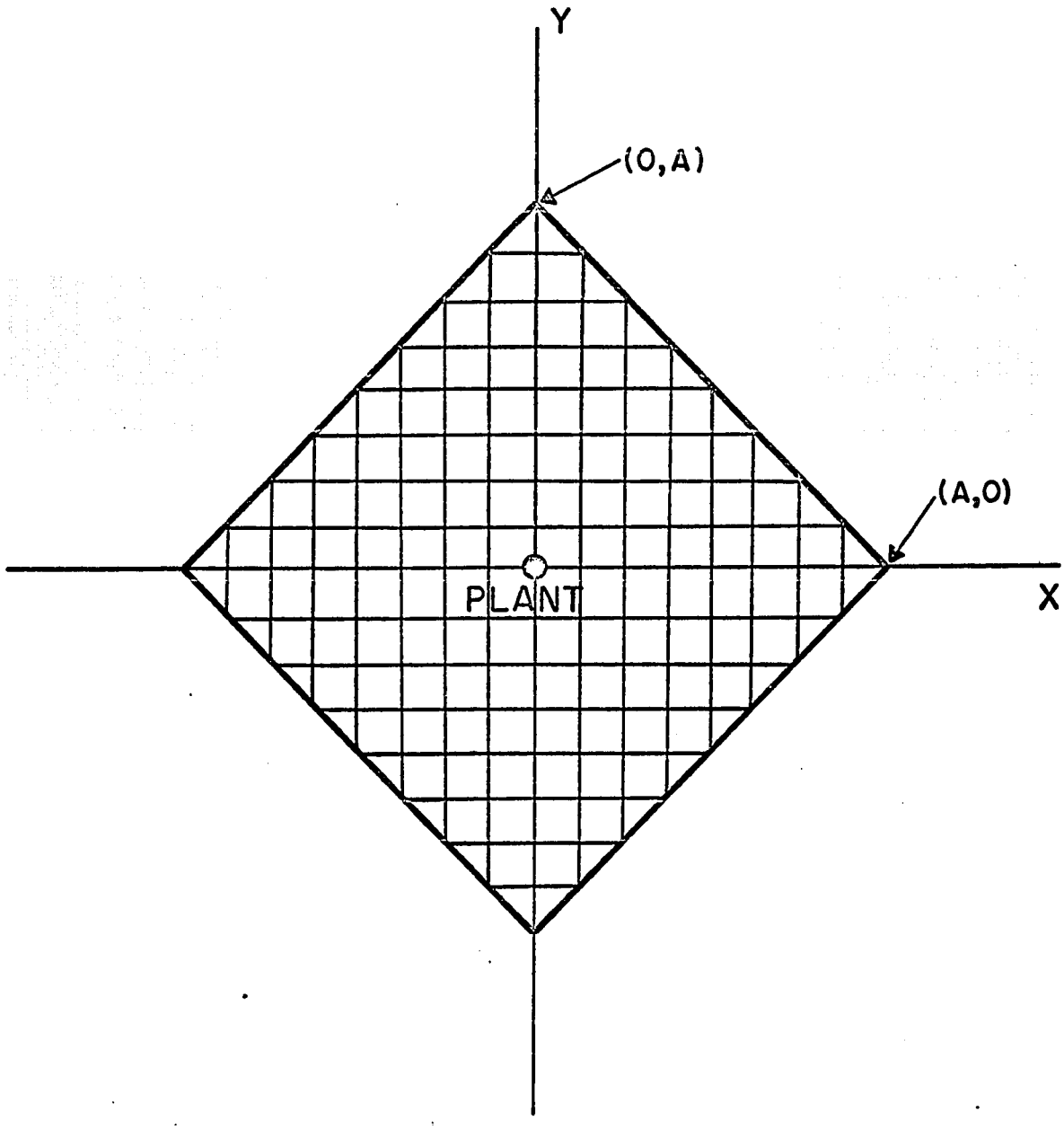

Figure 6.1. Least cost supply area for meat packing plant

$$\overline{H_t} = (2/3)A = .4714 \sqrt{S_{2t}} \Big/ \sqrt{D_t} \qquad (6.11)$$

Thus $\overline{H_t}$ in equations 6.9 and 6.10 can be approximated by use of equation 6.11. Equation 6.11 defines a minimum average distance, since if the supply area were of any other shape, the average distance for a given S_{2t} would be greater. In practice, supply areas are probably irregularly shaped; however, equation 6.11 does give some basis for estimating H_t.

The estimation of the coefficients in equations 6.9 and 6.10 is highly problematic. Williamson (38) has developed a model which gives some insight into this problem. Given the assumptions of his monopolistically competitive model ... "it follows that prices paid ... are lowest at the plant. Prices rise as one moves out from the plant in any direction. Thus, the average at-farm cost of commodity rises ... as the plant increases its output by expanding its supply area outward from the plant" (38, pp. 959-960). In Williamson's model the price paid for livestock is equal to the net product, or value of the livestock to competing plants. That is, a meat packing plant must pay a price which is equal to or greater than the price competing firms can afford to pay. Thus, as a firm expands its supply area outward, it buys livestock at farms which are located closer to competing plants. Consequently, the livestock purchased at the perimeter of the supply area becomes more valuable to the competing plants. This, in turn, forces the first plant to offer a higher price.

Williamson's model provides theoretical justification for the tendency of increasing per head costs of livestock as the supply area increases, but it does not provide an adequate basis for quantitatively estimating these effects. An estimation of the value of livestock to competing firms provides some difficulties. For example, the value will differ depending upon whether the plant is operating at capacity. If it is operating at less than full capacity, it would be profitable to pay a price equal to the return derived from a head of livestock minus the variable costs incurred. If it is operating at capacity, the value of an additional unit would be zero. When institutional factors, such as the week-to-week and day-to-day variations in supply are taken into account, a meaningful empirical implementation of the model becomes even more difficult. Nevertheless, the model does provide some insight into the problem.

The estimates of the parameters for the various functions comprising the decision model will be different for different prospective sites. Ideally, the model would be estimated for each of several proposed sites for meat packing plants. Then, various values of the livestock input variables, S_{1t} and S_{2t}, could be tried. In effect, various scales of plant and procurement policies would be simulated for each of the proposed sites. The results of the simulations would provide information to management for making decisions concerning plant size and location. Management may wish to select the alternative which

exhibits the highest present value. On the other hand, because of the inherent uncertainties involved in the estimations, they may make other choices. However, the decision model, when empirically implemented, provides a framework for organizing the different types of information relevant to investment decision making.

An example

The decision model is applied to five hypothetical projects to illustrate its use; the discounted present value of five proposed beef slaughter plants of different scales are calculated. The coefficients used in equations 6.4 through 6.11 are shown in Table 6.1, and the description of the hypothetical beef slaughter plants and the discounted present value of each of the proposals are shown in Table 6.2. We assume that a specific site has been selected and the parameters of the model estimated for that site. The problem then is to determine the optimum scale of plant. To simplify the calculations, the same rate of slaughter for each of the 10 years of the plants' operations is assumed, and the density of production in the interior market is assumed constant. In addition, it is assumed that 90 percent of the livestock is procured from the interior market (the area surrounding the plant) and 10 percent is procured at a terminal market. Assuming a variability coefficient of 1.4, annual plant capacity is set at 140 percent of annual slaughter.

Table 6.1. Coefficients used in computing decision model example

Equation	Parameter	Numerical value
6.4	a_1	96,205.00
6.5	a_2	36,039.00
6.6	a_3	70,392.00
6.8	a_5	286.00
6.9	a_6	275.00
6.9	a_7	272.00
6.11	D	100.00
6.4	b_1	4.97783
6.5	b_2	1.83563
6.6	b_3	0
6.6	c_3	4.72807
6.7	a_4	5.29
6.8	b_5	-0.00003
6.9	b_6	0.00001
6.9	b_7	0.04
6.10	a_8	0.10
6.10	a_9	0.10
6.10	b_9	0.01

Table 6.2. Results of decision model applied to five hypothetical meat packing investment proposals[a]

Plant	Annual slaughter	Livestock purchases		Annual capacity	Discounted present value
		Terminal	Interior		
	(head)	(head)	(head)	(head)	(dollars)
A	25,000	2,500	22,500	35,000	-142,682
B	50,000	5,000	45,000	70,000	218,888
C	75,000	7,500	67,500	105,000	299,782
D	100,000	10,000	90,000	140,000	103,064
E	150,000	15,000	135,000	210,000	-855,569

[a]The net cash flows were computed by means of equations 6.4 through 6.11. The parameters used in this example are shown in Table 6.1. A discount rate of 8 percent was used in calculating discounted present value. It was assumed each plant would operate for 10 years at a constant annual slaughter, and that the salvage value of the fixed assets in the tenth year were 20 percent of the initial costs.

Among the five hypothetical plants, plant C with an annual slaughter of 75,000 head of cattle, yielded the highest present value. Both plants A and E yielded a negative present value. Thus, the economies of scale in initial costs, fixed costs, and other variable costs, were more than offset by the effects of lower meat and by-product prices, and higher livestock prices and unit procurement costs in the large plant. On the other hand, high average in-plant costs in plant A caused a negative present value. It is probable that the maximum present value, given the assumptions of this example, would result

from a plant with between a 50,000 and 100,000 annual slaughter rate. The data in Table 6.2 are plotted in Figure 6.2.

A total of 18 coefficients were estimated for equations 6.4 through 6.11. The coefficients for equations 6.4, 6.5, and 6.6 (initial cost, fixed cost, and other variable costs) were estimated in an earlier chapter. It appears that these coefficients can be quite accurately estimated. Also, the inventory cost equation (equation 6.7) can be estimated fairly accurately. However, the coefficients of equation 6.8 and 6.9 (sales and the cost of livestock), which are vitally important in projecting the net cash flows of a proposed meat packing plant, pose great difficulties. A large meat packing firm may be able to fairly accurately estimate the prospective returns from slaughter plant operations on the basis of past experience. But to project the average cost of livestock at different sites over the lifetime of a proposed plant requires a great deal of information, as well as sound judgment and experience. Projected available supplies of slaughter livestock in the interior markets and projected salable receipts of slaughter livestock at the terminal markets would be important informational inputs needed to project future livestock costs.

In the example, the decision model was used to estimate the returns from alternative scales of plant at a specified site. The model could also be used for calculating the returns from a plant of specified scale at alternative sites. In that case, it would be necessary to estimate the cost of livestock function and the procurement cost func-

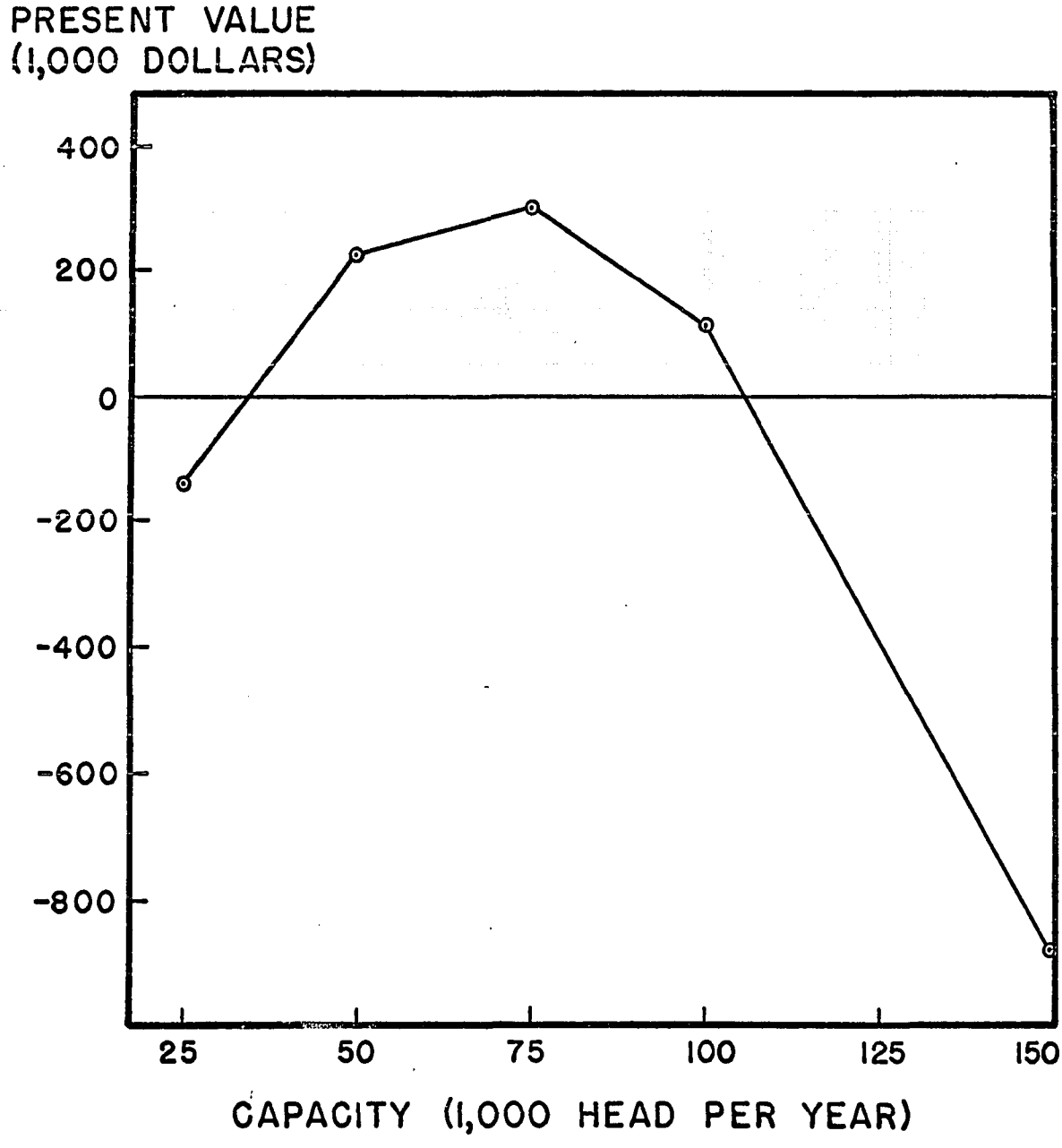

Figure 6.2. Results of decision model applied to five hypothetical meat packing investment proposals

tion for each site. And if other costs, (labor costs, etc.) were the same at each site, then the choice of site would depend only upon the nature of the livestock supply at the alternative sites. If such costs as labor differ among sites, it would be necessary to also estimate equations 6.5 and 6.6 for each site.

In summary, the decision model can be used to generate information which is relevant to decisions concerning the scale and location of meat packing plants. It is formulated so that different scales of plant at the same site, the same scale of plant at different sites, or both can be compared. Thus, alternative investment proposals could be simulated by means of the model, and the simulation results used as a basis for accepting or rejecting each of the proposals. The model could be expanded to include details of week-to-week or even day-to-day operations. An expanded, highly complex model could be formulated as a computer program and be used to simulate investment alternatives on an electronic computer.

An Information System

An information system, which is periodically updated and revised, could be developed to provide some of the informational inputs for investment planning in the meat packing industry. This information system could include, among other things, the types of information generated in this study.

Public information

It was pointed out in an earlier chapter that it is appropriate to generate certain types of economic information on a public, rather than a business firm, basis. It is socially desirable to make some types of research findings freely available to all, thus creating a "spill-over" from research institutions to other segments of society:

> ....research product is essentially information and almost always has a "spill-over" dimension of income distribution because it may be shared directly with other organizations in the economy ... Spill-over, then, is an important factor in assessing research payoffs. Through deliberate decision-making processes, private firms conducting research may exert controls: to conduct primarily applied research; to maximize direct benefits (as opposed to spill-over); and to prevent spill-over via secrecy, patents and similar arrangements ... In contrast public research institutions are not concerned with the retention of direct benefits of research products. "Spill-over" is the only dimension of their returns; it is usually their raison d'etre (21, p. 38).

It is feasible to shift some of the information generating functions from individual meat packing firms to a public or quasi-public institution. The meat packing firms could then benefit from the spill-over effects of the research.

It has been shown repeatedly that supplies of slaughter livestock in the interior markets and at the terminal markets, both at the present time and in future years, are important informational inputs for deciding on location and size of meat packing plants. All meat packing plants must consider these factors before investing large sums of money in plant and equipment. Thus, it may be desirable for one organization

to provide this information to all members of the industry. This organization may be a government agency such as the U. S. Department of Agriculture, or a trade agency such as the American Meat Institute or the National Independent Meat Packers Association.

More specifically, several different types of information could be provided by the information system: (1) the production of slaughter livestock in recent years and projected production; (2) the channels through which slaughter livestock are marketed and projected trends for these channels; (3) the location of existing meat packing plants and the area from which they draw their supplies of livestock; (4) the cost of livestock at various sources. These data could be provided for individual counties or for larger regions. An overall picture of the supplies of slaughter livestock, such as that developed for the Upper Midwest States in this study, would be developed for the entire United States. However, the livestock supply regions, at least in the important livestock producing areas, should probably be smaller than those used in this study. Information on costs of livestock and the supply regions for individual packing plants would be secured from individual meat packing firms and other marketing agencies.

Information systems similar to this could be developed for other agricultural processing industries. For example, production of various types of fruits and vegetables are important variables in determining the location of fruit and vegetable processing plants. Thus, an infor-

mation system for providing continuously updated projections of these variables would be useful.

Implementing the information system

The implementation of the proposed information system could be accomplished with the cooperation of existing statistical reporting agencies, the meat packing industry, and the other livestock marketing industries. Livestock production data is presently collected by federal-state cooperative Crop and Livestock Reporting Services in nearly every state. Different data series such as the number of livestock on farms and marketings of grain fed livestock are reported for individual counties. Thus, it may be feasible for the Crop and Livestock Reporting Service in each state to prepare estimates of the number of slaughter livestock produced and the number sold through the various marketing channels in each county of their respective states. However, if this method is too costly, it is possible to make county-by-county estimates by the methods employed in this thesis. That is, available data series would be used to formulate consistent estimates of slaughter livestock production and marketing patterns.

The current production and marketing data would be stored in a central information system which would be maintained by a governmental unit or a trade association. The central information files would be updated each year as the most recent statistics become available. The projections of the livestock production and marketing data series would

be computed by staff economists and statisticians of the central information system. These projections would be revised each year on the basis of the most recent statistics. Also, the methods used in making the projections could be refined as new techniques become available. In addition, better projection methods could be developed by researchers in government, industry, and the universities. One of the objectives of research projects on the livestock-meat economy could be to improve the information system.

The various trade agencies of the meat packing industry, terminal markets, auctions, and other livestock marketing agencies could be responsible for providing data on the volume of livestock handled, prices paid for livestock, and the areas from which individual meat packers draw their supply of livestock. Alternatively, various U. S. Department of Agriculture statistical reporting agencies, which now report much of this type of data on an aggregate basis, could provide more detailed data for use in the information system. Unfortunately, to assume cooperation to this extent between the various livestock industry trade associations, individual firms, and the governmental agencies may be utopian. Plant capacity, slaughter volume, sources of livestock supply, and prices paid for livestock are considered trade secrets by most of the larger meat packers. Most of the meat packers are willing to report data of this type only under the condition that it be used only in compiling aggregate statistical series.

Since it is probably impractical to secure and distribute on a public basis detailed operating information for individual meat packing plants, other means of estimating these data should be developed. Earlier in this chapter, estimates of slaughter in the various substate regions were developed mainly from published data (such as the location of meat packing plants by employment size class). These estimates can be made on a county basis. Other data of this type could be estimated by similar means, although the accuracy of these estimates would not be as good as published national and state data series. Table 6.3 contains a description of the variables projected in other chapters of this study. The method of projection for each variable, and the data sources used in making the projections are also presented. These methods and data sources could be used for making the information system projections.

All historical statistics and projections in the information system would be made available to all interested parties. Meat packers could make use of these data in their investment planning procedures, thus relieving them of the task of generating these data. Also, the data would be available to prospective entrants into the industry. This would give them a more sound basis for evaluating their prospects.

The exact nature of the information system should be determined on the basis of the costs and returns involved in providing the various types of information. Perhaps the information system should be con-

Table 6.3. Variables, methods of projection, and data sources for information system

Stage	Variable	Method of projection	Data source
1	National slaughter livestock production	Based on projections of national consumption, exports, and imports of meat	Statistical demand studies
2	State slaughter livestock production	Based on state's share of national livestock marketings	U. S. Department of Agriculture statistical series
3	Substate region slaughter livestock production	Based on trend in substate region's share of state production	Crop and Livestock Reporting Service statistical series
4	Sales to terminal markets from each state	Based on trends in ratio of terminal market receipts to total marketings	U. S. Department of Agriculture statistical series, and North Central Region survey data for 1956
5	Sales to terminal markets from substate regions	Substate region's share of state total is based on distance from nearest terminal market	North Central Region survey data for 1956

Table 6.3. (Continued)

Stage	Variable	Method of projection	Data source
6	Receipts at individual terminal markets	Based on sales to terminals from surrounding production regions	Data generated in stage 5
7	Slaughter in interior markets	Based on projected production and sales to terminals	Data generated in stages 2 and 4
8	Slaughter at terminal markets	Based on projected receipts at terminal markets	Data generated in stage 6
9	Investment in slaughter facilities	Based on increase in slaughter between 1959-1961 and 1975	Data generated in stages 7 and 8

cerned only with estimates of current production and projections of future production of slaughter livestock, or perhaps it would be worthwhile to include both production and marketing estimates and projections. In addition, the returns from providing other types of information may exceed the cost involved.

Value of the information system

The value of the proposed information system is the returns accruing from the information provided minus the costs incurred in operating the system. Two types of returns can be distinguished: direct and indirect benefits. Direct benefits arise from the fact that meat packing firms will be relieved of the need for generating certain types of in-

formation. For example, if livestock production projections are provided to meat packers through the information system, then they no longer need to incur costs in making these projections themselves. Indirect benefits are those arising from a more efficient allocation of capacity in the meat packing industry. The information system may also be useful to other livestock marketing agencies, resulting in benefits in these industries. If the information system effects a decrease in excess capacity, then both initial costs (the cost of plant and facilities) and fixed costs will be decreased. Also, if meat packing plants are better located, savings in procurement costs will result.

The costs of the information system include the direct costs of operating the system, the increased costs of statistical reporting agencies in compiling data for the information system, and costs incurred by private firms in providing data for the system. The direct costs include salaries of the staff of the information system, data processing costs (e.g., computer rental) and other costs involved in collecting, storing, retrieving and disseminating information. The costs to private firms consist mainly of time spent in providing data on operations and answering questionnaires.

Different types of information should be evaluated separately. Each type of information should be handled by the information system if, and only if, the returns are greater than the costs. For example, if the cost of generating, maintaining, and disseminating slaughter

livestock production data is less than the returns, then it should be part of the information system.

The long-term effect of an efficient information system would be the same as the expressed goal of applied marketing research: to reduce the marketing margin. A reduction in the livestock-meat marketing margin would result in increased returns to farmers, lower meat prices for consumers, or both. The reduced margin would result from lowered average costs in the meat packing and livestock marketing industries.

Implications for Investment Planning

The information system is designed to provide informational inputs into the investment planning procedures, and thus, induce better investment decisions, lowered costs of investment planning, or both. The benefits will accrue to investors in the meat packing industry.

The investment decision maker

In this study we are concerned with two types of organizations: meat packing firms planning new facilities, and organizations considering entering the meat packing industry. The latter type includes firms specializing in other activities, community industrial development organizations, and others. Each group has different information needs.

The large meat packing firms employ economists and financial analysts to conduct their investment analysis activities. It is likely that these firms conduct adequate analyses of alternatives. If the

information system were established, it probably would have no marked effect on the quality of their investment decisions. However, part of the direct benefits from the information system would accrue to these firms, i.e., they would be relieved of the need for generating certain types of information used in their investment analyses. Smaller meat packing firms with less adequate investment analysis procedures may share in both the direct and indirect benefits from the information system, i.e., they may be able to make better investment decisions (indirect benefits) and also reduce the cost of investment analysis (direct benefits).

In the case of firms outside of the meat packing industry, the same general statements could be made. The large firms would receive primarily direct benefits, while smaller firms would receive both direct and indirect benefits.

The community industrial development organizations are concerned with improving the economic health of the community. For example, some Iowa towns have been considering financing a meat packing plant as a community project. The purpose of the project is to increase employment, thus, creating increased demand for the other business establishments in the town. Consequently, a somewhat different decision problem is provided. The location of the plant is determined; it will be located in or near the town. The question then is what size of plant can operate at a reasonable profit at this site? Data provided by the information system could be used to provide an answer to this question.

The location of competing plants and the prospective supply of slaughter livestock in the area may be such as to rule out any profitable operation in the town. Thus, the community could be saved from a disastrous financial burden. On the other hand, a plant of some size may be profitable, and the operation of such a plant could greatly add to the vitality of the local economy by providing jobs for workers displaced from agricultural occupations. The community would share in the indirect benefits of the information system in that a better investment decision would be made.

The decision model in relation to the information system

The investment decision model presented earlier can serve as a framework for the analysis of alternative investment projects. The purpose of the information system is to provide inputs into the investment analysis of meat packing firms and prospective entrants into the industry. Thus, the decision model and the information system are intimately related; this also provides the link between industry-wide trends and firm-level planning. A firm's decision to build a meat packing plant would be based in part on the data obtained from the information system, and the operation of the plant would, in turn, affect the information system.

The decision model also provides a means for determining the functions of the information system. If the decision model is used to analyze alternative investment projects, then the information required

for investment planning is specified, at least partially, by the data requirements of the model. Thus, the decision model in effect specifies different types of information which could be generated by the information system. The kinds of information actually included in the information system would be determined by means of the cost-benefit analysis described earlier.

This provides a focus for future research in the area of investment planning. On the one hand, research would be conducted to determine better methods of investment analysis; this would involve the development of models which could be used by investment analysts to evaluate alternatives. On the other hand, research to improve the information system would be carried on simultaneously. As better decision models are developed, different informational inputs will be required. This, in turn, will affect the value of different types of information and call for a revision of the information system. Also, the usefulness of a decision model will depend upon the data generated by the information system.

This study has attempted to show the relationship between a public information system and investment planning in the meat packing industry. The central idea of this approach, a public information system to provide informational inputs for private investment planning, could be applied to other industries.

SUMMARY

This study is concerned with the informational inputs to investment decision making in the meat packing industry. An information system operated by a governmental agency or a meat packing trade agency is proposed. The function of the information system would be to provide certain types of information which would be useful in the investment planning procedures of meat packing firms and prospective entrants into the meat packing industry. The techniques for projecting slaughter livestock supplies are discussed, and are applied to a six-state region.

A brief description of the meat packing industry is followed by a general discussion of investment planning techniques. The informational needs for investment planning in the meat packing industry are delineated. It is determined that the location of slaughter livestock production and the spatial aspects of slaughter livestock marketing channels are two of the most important considerations in deciding upon the scale and location of new meat packing facilities. Since meat packing plants involve large commitments of funds in fixed plant and equipment, estimates of slaughter livestock production and marketing patterns in future years, as well as the present, are important informational inputs into the investment planning procedures.

The production of slaughter livestock in 53 substate regions in the Upper Midwest States (Wisconsin, Minnesota, Iowa, North Dakota,

South Dakota, and Nebraska) is estimated for a historical base period, 1959-61, and projected to 1975. The estimates of slaughter cattle and hog production are divided into two components: sales to terminal markets, and the residual which is called the "available supply" of the region. In addition, the salable receipts of slaughter cattle and hogs at the six Upper Midwest terminal markets are estimated for recent years and projected to 1975.

Production in 1975 is estimated in three steps: (1) national production is projected to 1975, (2) the share of national production of each of the Upper Midwest States is projected, and (3) the production of each state is allocated among the substate regions. National slaughter livestock production in 1975 is based on projections of national consumption, exports, and imports of meat. Meat consumption projections from existing statistical demand studies are used, while exports and imports are assumed to grow at the same rate as the domestic non-military consumption of meat.

A homothetic model is used to allocate national production to the individual states. U. S. Department of Agriculture livestock marketings data is used to estimate the model. The results show that all the Upper Midwest States, except Wisconsin, would increase their share of the production of slaughter cattle between the 1959-61 base period and 1975. Only two states, North Dakota and South Dakota, would increase their shares of slaughter calf production, while only South Dakota

would increase its share of slaughter hog production. All six states except Wisconsin and Nebraska would increase their share of slaughter sheep and lamb production.

A homothetic model is used, also, to allocate the 1975 state production estimates to the 53 substate regions. Data reported by the Livestock and Crop Reporting Service of the various states is used to estimate the model.

The historical trend in salable receipts of slaughter cattle and hogs at Upper Midwest terminal markets as a proportion of total cattle and hog marketings in the Upper Midwest Region is used to project terminal consignments to 1975. U. S. Department of Agriculture marketings data and a survey of livestock marketing in 1956 in the North Central States are used to establish the historical trend. The percent of slaughter cattle sold at terminals is expected to decline, while the percent of slaughter hogs sold at terminals is expected to remain unchanged.

The projected sales to terminals from each state are allocated to the substate regions according to their distance from the nearest terminal market. Those regions closer to a terminal are expected to consign a higher percentage of their total production to terminal markets. Data from the North Central Region marketing survey are used in estimating these allocation coefficients.

Salable receipts at the individual terminal markets in 1975 are, in turn, a function of sales to terminals from the surrounding pro-

duction regions. The terminal market receipts are expected to increase at the same rate as the terminal consignments from the surrounding regions. All six of the Upper Midwest terminals are expected to increase their receipts of both slaughter cattle and slaughter hogs. The Omaha market is expected to have the highest receipts of slaughter cattle, and the South St. Paul market is expected to have the highest slaughter hog receipts.

The interstate flows of cattle and hogs as they move from the point of production to slaughter are analyzed, and the levels of slaughter in the substate regions in the base period are estimated. Net outshipments of slaughter cattle and hogs in each of the Upper Midwest States are divided into three components: (1) the difference between the available supply in the interior and interior slaughter, (2) the difference between salable receipts of slaughter livestock and slaughter at the terminal market, and (3) the difference between the sales from the interior at all terminal markets and salable receipts of slaughter livestock at the state's terminal market. This identity, along with the projections of production and marketing patterns, provides the basis for estimating interior slaughter and terminal slaughter of cattle and hogs in each of the six states. The growth in slaughter between 1959-61 and 1975 is used to project investment in meat packing facilities.

Slaughter at the terminal markets in 1975 is assumed to be related to the salable receipts of slaughter livestock at the terminals. Slaughter in the interior markets is estimated as being equal to the available supply plus the spill-over from the terminal markets. According to the projections, the most rapidly increasing component of slaughter in the Upper Midwest Region is the interior slaughter of cattle which is projected to increase 138 percent between 1959-61 and 1975. This is due to the rapid increase in slaughter cattle production, the relative decline of sales to terminals, and the increased number of cattle moving from the terminal to the interior for slaughter. All states show large increases in interior cattle slaughter and varying amounts of increase in terminal cattle slaughter. Both interior and terminal hog slaughter are expected to decrease substantially in Wisconsin. The other states exhibit increases in both components of hog slaughter.

Investment in new livestock slaughter plants to handle the projected increases in slaughter is estimated. Between 1959-61 and 1975 it is estimated that $78 million will be invested in new cattle slaughter plants and $51 million will be invested in new hog slaughter plants in the Upper Midwest Region. It is estimated that a total of $51 million will be invested in cattle and hog slaughter plants in Iowa.

A normative decision model for investment planning in the meat packing industry is presented. The cash flows associated with meat packing plants are analyzed by components such as meat sales, cost of

livestock, and procurement costs, as well as in-plant costs. These components are, in turn, functionally related to other variables such as livestock supplies. The model can be used to analyze alternative sites and sizes of plants.

The proposed information system is described and the feasibility of implementing the system is discussed. The purpose of the information system is to provide periodically revised information which is needed for investment planning in the meat packing industry. A benefit-cost criterion is specified for deciding what types of information to include in the system. The nature of the benefits accruing to individual investors is discussed. Finally, the relationship between the public information system and private investment planning is described. It is noted that this relationship provides a framework for further research on the information needs for investment decision making in meat packing and other industries.

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