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NUMBER, SIZE, AND LOCATION OF BEEF SLAUGHTER PLANTS IN MICHIGAN

By

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ABSTRACT

NUMBER, SIZE, AND LOCATION OF BEEF SLAUGHTER PLANTS IN MICHIGAN

By

John M. Huie

Michigan's beef industry is faced with changing economic and institutional forces which suggest a major adjustment in the number, size and location of beef slaughter plants if Michigan plants are to remain nationally competitive. Existing plants are small compared to plants in major competing areas and compared to potential economies of scale indicated by past studies. Recent national trends indicate major cost advantages to locating slaughter plants in cattle producing areas, while Michigan plants are now concentrated in urban areas.

The purpose of this study was to provide information to Michigan beef slaughterers that will assist them in long-run planning of plant facilities; and to aid development groups that seek information on their relative competitive position in specific industries. More specifically the objectives were:

(1) To review trends and recent developments relating to the number, size and location of beef slaughter plants in the United States, East North Central region and Michigan.

(2) To estimate the number, size and location of plants in Michigan that will minimize the total cost of cattle assembly, in-plant processing and meat distribution for projected 1980 cattle production and beef consumption.

Some of the major concepts of location theory as well as recent trends and developments in the beef slaughter industry were reviewed. Cattle marketing and beef consumption projections to 1980 were made for the area covered by this study. Transportation cost functions for live cattle and dressed beef were estimated. The long-run total cost function for cattle slaughtering in Michigan, was derived by synthesizing costs for five different plants with rated capacities ranging from 20 to 120 head per hour.

Based on the synthesized cost of in-plant slaughter plant operations significant economies of scale are possible in Michigan. The average cost per head declined from $11.34 for the 20 head per hour plant to $8.85 for the 120 head per hour plant. Although economies existed for all categories of cost, reduced labor costs accounted for 60 percent of the economies to size.

Using the slaughter cost function, and the cattle and beef transportation functions, two models were used to estimate the number, size and location of plants that minimized transportation and slaughter costs for the projected 1980 levels of cattle marketings and beef consumption.

Using Stollsteimer's procedure for estimating the number, size and location of plants, four plants located at Alma, Sandusky, Sturgis and Adrian, Michigan, were indicated in order to minimize total cattle assembly and slaughter costs. Using a linear programming transhipment model which estimated the number, size and location of plants that minimize cattle assembly, slaughtering and beef distribution costs four plants located at Alma, Sandusky, Lansing and Adrian were specified.

Use of the two models made it possible to estimate the effect of adding beef distribution costs to the results obtained from the Stollsteimer model. Although the transhipment solution indicated that shifting a plant from Sturgis to Lansing would reduce costs over the Stollsteimer solution the cost reduction of $64,000 was less than 0.3 percent of the system's total cost of $25.5 million.

Based on the program used for the Stollsteimer solution, 35 different locational configurations of four plants were within 5 percent of the least cost solution. This indicated the small change in assembly costs incurred by changing the location of 4 plants among 15 potential sites selected for inclusion in the program. Of the 15 potential sites only two, Detroit and Jackson did not appear in any of the 35 locational patterns.

The study provided a useful indication of probable future adjustments in Michigan's beef slaughter industry. It suggests the likelihood of fewer and larger firms located closer to major production areas. However, the results were not sufficiently comprehensive to provide all the information needed for specific plant investment decisions. For example, the influence of existing plants in Michigan, interregional factors affecting plant location, seasonal variations in cattle supplies, as well as availability and cost of inputs at specific locations were neglected. Nevertheless the results were meaningful and provided a useful addition to the information required for sound, long-run investment decisions.

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Chapter 1

OBJECTIVES AND THEORETICAL CONSIDERATIONS

Introduction

Michigan's beef industry is entering a period in its history when major adjustments in the number, size and location of beef slaughter plants are likely to take place. New transportation technology, changes in marketing channels, improved technology in slaughter plant operations, and new institutional requirements suggest these adjustments will be necessary if Michigan plants are to remain nationally competitive.

Michigan's present beef slaughter plants are small compared to plants in major competing regions. Also, previous economies to size studies suggest that major reductions in slaughter costs are possible by increasing size, and shifting to new technologies.[1]

Michigan's beef slaughter plants are currently concentrated in the Detroit, Flint-Saginaw, and Grand Rapids-Muskegon areas. This locational pattern evolved during a

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[1]Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962).

period when location in major population centers was important, and buying of livestock by inspection was necessary. In the case of Detroit, the terminal market once provided convenient access to a large supply of livestock and proximity to the municipal market. Comparisons of livestock and meat transfer costs and recent trends in location of slaughter plants suggest that location in cattle producing areas now provides a cost advantage.

Objectives

As suggested above, Michigan's beef slaughter industry is being exposed to strong economic pressures to adjust the number, size and location of plants if the industry is to remain viable in the national market. With this situation facing Michigan's beef slaughter industry, it is the objective of this study to provide information, that will be helpful to industry personnel who must make long-run investment decisions in plants and equipment. The study should also be useful to state, area, county and municipal development groups, who seek information on their relative competitive position for industrial development in specific industries.

More specifically the objectives are:

(1) To review trends and recent developments relating to the number, size and location of beef slaughter plants in the United States, East North Central region and Michigan.

(2) To estimate the number, size and location of beef slaughter plants in Michigan that will minimize the total cost of cattle assembly, in-plant processing and meat distribution for projected 1980 cattle production and beef consumption.

Although not specific objectives within themselves, several major estimates are necessary for the attainment of the second objective. These include (1) an estimate of the long-run cost curves for beef slaughtering in Michigan: (2) estimates of transportation cost functions for live cattle and carcass beef: (3) projections to 1980 of cattle marketings and beef consumption by geographic subdivisions of the study area.

Procedures

The procedures outlined here are used in the study to attain the indicated objectives. No detailed discussion of the procedures seems necessary at this point as this is accomplished in the development of the study. This outline is provided to help the reader understand the total framework within which the thesis is developed and the procedures that are necessary to attain the stated objectives.

(1) Review of the major concepts of location theory.

(2) Review of the major trends and recent developments in the beef slaughter industry.

(3) Projections to 1980 of cattle marketings and beef consumption by geographic divisions of the study area.

(4) Estimation of transportation costs for live cattle and carcass beef.

(5) Estimation of long-run cost curves for beef slaughtering in Michigan.

(6) Selection and use of models to estimate the number, size and location of beef slaughter plants that will minimize the combined cost of cattle assembly, slaughtering, and meat distribution.

Major Location Theories

A brief review of some of the important location theories is included to provide an understanding of the present state of theory in this area but more important, as an aid in understanding the rationale behind the models used in attaining the objectives of this study.

Greenhut classifies major location theories into three categories that serve as a useful framework within which to discuss the development of location theory. These categories are: (1) least-cost location theories, (2) market area theories, and (3) interdependence theories.[1]

Least-cost Location Theories: The common element of theories in this group, as the name implies, is their concentration on the location of firms at sites where the firm's cost of production is minimized. They generally assume a completely elastic demand function that is not affected by

[1] Melvin L. Greenhut, Plant Location in Theory and in Practice: The Economics of Space, (Chapel Hill: University of North Carolina Press, 1956), pp. 1-100.

their location decision. Other key assumptions vary depending on the specific theory under consideration.

One of the earliest attempts to incorporate a theory of location into the general framework of economics, and probably the most famous location theory, is the theory of Johann Heindrich von Thunen.[1] Von Thunen was primarily interested in developing a theory for the location of agricultural production, however, the concepts included in his framework have been widely used in explaining the location of industrial activity as well. Von Thunen assumed an isolated state with a completely homogeneous land surface and a single consuming center. The consuming center, also the center for manufacturing activity, supplies the outlying areas with manufactured goods in exchange for agricultural produce and raw materials.

Price differences among locations were explained by differences in transfer costs; this difference being exactly equal to cost of transferring a good between locations. Agrilcultural prices tended to be higher near the center, while prices of manufactured goods increased as distance from the center increased. The locational advantage of land near the market center gave rise to increased land rents. This meant that the production of high value crops or products with extremely high transfer costs would tend to be produced near

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[1]Johann Heindrich von Thunen, Der Isolierte Staat in Beziechung auf Landwirtschaft und Nationalokonomie (3rd ed.; Berlin: Schumacher-Zardilin, 1875).

the center while products that used land less intensively or could be transferred inexpensively would tend to be located in more remote areas.

Another important contribution to least-cost location theories was made by Alfred Weber.[1] Weber starts with a given type of firm and obtains the appropriate location for its production. His theory is less restrictive than is von Thunen's in that it assumes uneven deposits of raw materials and allows more than one consuming center. Three factors, transportation, labor, and agglomerating tendencies, are important in Weber's theory. According to this theory, differences in the cost of production are important primarily in determining the appropriate production region. Weber defines production costs to include raw material costs, including assembly of raw materials, labor costs in processing and distribution costs. Agglomerating factors (discussed later) become important in determining a specific location within the region.

Under Weber's theory, if transfer costs are considered the only significant factor influencing plant location, then the location that minimizes the total assembly and distribution costs becomes the site selected. The least-cost site is a function of the product being produced, the factors of production and the effect of the processing activity on the factors. Those materials that lose weight during processing

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[1] C.J. Friedrich, Alfred Weber's Theory of the Location of Industries, (Chicago: University of Chicago Press, 1928).

tend to pull the site toward production areas. A weight gaining process, on the other hand, tends to favor locations nearer consumers.

Weber, however, realized that for many production processes factors other than transfer costs were also important. Specifically, he considered differences in labor costs including both wage and productivity differentials. Differences in labor costs among alternative sites must be compared with differences in transfer costs. The objective function, thus, becomes one of minimizing the total cost of labor as well as assembly costs, including raw material prices, and distribution costs.

In the final selection process Weber included a third factor, agglomerating forces. These he defined as forces that tend to produce "an 'advantage' or a cheapening of production or marketing which results from the fact that production is carried on to some considerable extent at one place."[1] Included are such factors as improved market outlets, economies to size, or the importance of proximity to service industries. He also recognized the existence of high rents in central markets as being a deglomerating force. That is, a force encouraging decentralization of production.

Based on this analysis, Weber divided industries into three categories; those oriented to transportation, those oriented to labor, and third, but much less important, those

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[1] Ibid., p. 126.

oriented to agglomeration. This latter group becomes important when little difference in transfer or labor costs occur among alternative sites.

Edgar M. Hoover is also a major contributor to least-cost location theories.[1] His major contribution has been the inclusion of a wide variety of factors that influence plant locations. Although he suggests the desirability of considering demand conditions as well as cost factors, his work is discussed here because most of it has been within the framework of cost analysis. In addition to the factors considered by Weber, Hoover's inclusion of institutional factors, climate, property taxes, and a much deeper analysis of other costs have improved greatly our understanding of location factors. His major thesis is very similar to Weber's, that is, the location decision is primarily a problem of substitution among costs. The major difference is Hoover's inclusion of a wider variety of costs.

Market Area Theories: A critical assumption underlying the least-cost location theories is that the firm faces a completely elastic demand curve that is unaffected by the firm's location decision. The "market area" approach points out that demand functions vary among geographic areas and that sellers must consider these differences in their location plans. These theories suggest that sellers will locate so as to control a specific segment of the market --

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[1] Edgar M. Hoover, The Location of Economic Activity, (New York: McGraw-Hill, 1948).

separated from competition primarily by transfer costs. This approach stresses the importance of selecting the maximum profit location rather than the least-cost location.

Associated with its emphasis on demand conditions, this approach considers monopolistic effects of plant locations. Selection of plant sites must, according to this school, consider the possibility that certain locations can provide a firm sufficient control over a larger enough market to overcome the slightly higher costs associated with that location.

Losch's theory is one of the best known theories of this type and will be discussed as an example.[1] By assuming a given location of production, uniform population density, and a uniform terrain, Losch concludes that an equilibrium pattern of hexagonal market areas will develop with one plant located at the center of each area. The hexagonal pattern arises from the overlapping of curcular market areas of competing firms. Under perfect competition, each plant's average cost is identical, and due to his assumption of a uniform terrain and population density, distribution costs for all firms are equal. Thus, the competing firms' market areas are all of equal size.

The shape and relative size of the market area can easily be modified to account for changes in assumptions

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[1] August Losch, <u>The Economics of Location</u>, trans. by William H. Woglom and Wolfgang F. Stolper (New Haven: Yale University Press, 1964).

regarding population distribution, uniformity of the terrain, or by including a particular pattern of transportation arteries. French, for example, has shown that with a rectangular grid system of roads -- a system occurring in most of the midwestern region of the United States -- a square market area tilted 45 degrees to the road network provides the area shape that minimizes distribution costs.[1] Likewise, if one were to assume different production costs by competing firms, the market areas for the higher cost forms would be reduced in size while those of the lower cost firms would be expanded.

Interdependence Theories: The interdependent approach to the theory of plant location is similar in many respects to the market area theories. It differs primarily in that it assumes freely movable locations and seeks to find reasons for particular locations rather than building a system of locations that meets certain assumptions. This approach stresses the importance of factors that attract and/or repel a firm from the location of competing firms. That is, the factors that cause dispersion or concentration of firms are emphasized. The interdependence approach permits the possibility of competing firms being attracted to the same location, whereas, the market area approach does not permit this possibility. Such factors as concentration of markets,

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[1]Benjamin C. French, "Some Considerations in Estimating Assembly Cost Functions for Agricultural Processing Operations," Journal of Farm Economics, Vol. 42 (No. 4), pp. 771-772.

the need for special service facilities, low freight rates, the impact of time-of-delivery on sales, or attempts to gain market advantage as seen in Hotellings's model, may encourage the concentration of competing firms.

Hotellings' model is an example of forces that attract firms to the same location.[1] Although he considers several situations, one will suffice for illustrative purposes. He argues that if two firms are competing for a given market area, and both are mobile geographically, they will each be drawn toward the other in an attempt to expand the market area over which they have a competitive advantage. The advantage arises from lower transportation costs. Consider the line in Figure 1.1 as a market area with firms A and B each making location decisions within the market. Suppose also that a and b are the present market areas held by firms A and B respectively. Since it is assumed that each firm's unit cost of transferring products are equal, A will have an incentive to relocate as near to B as possible in order to expand his market area. Likewise, B will have an incentive to move as near to A as possible. Thus, they will both have an incentive to locate near the center of the market. Hotellings also shows that total transportation costs for the two firms are minimized by locating at the center of two equal size market areas, points x and y. This latter configuration approaches Losch's market area location pattern.

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[1]Harold Hotellings, "Stability in Competition," The Economic Journal, Vol. 39, pp. 41-57.

Figure 1.1. Hotellings' Market Area Model

Factors discussed under the least-cost and market area theories of location are those generally recognized as being important in the geographic dispersion of firms. The interdependence theories, however, suggest that firms tend to concentrate in certain locations if, by doing so, their costs are reduced by more than the increase in assembly and distribution costs resulting from the location, or if their market area is increased sufficiently to compensate for the increased costs.

Summary

Objectives: Michigan's beef slaughter plants are being exposed to economic pressures that suggest a trend toward fewer, larger and likely relocated plants in Michigan. It is the objective of this thesis to provide data that will be useful to industry personnel who must make long-run investment decisions, and to state, area and municipal development groups that seek information on their relative competitive position in specific industries. The specific objectives are: (1) To review trends and recent developments relating to the number, size and location of beef slaughter plants in the United States, East North Central region and in Michigan, and (2) To estimate the number, size and location of beef slaughter plants in Michigan that will minimize the total cost of cattle assembly, in-plant processing and meat distribution for projected 1980 cattle production and beef consumption.

Location Theories: Three categories of location theory are discussed in this chapter, with emphasis placed on the differences in the three approaches. These are: (1) least-cost theories, (2) market-area theories, (3) interdependence theories. All three groups have made significant contributions to our understanding of the location of economic activity. Considerations pointed out by each group are important in location decisions and should be a part of the general theory of location. Practically, however, the importance of a limited number of factors in the location of specific firms may be of such overriding importance that other less critical factors may be eliminated from detailed consideration.

In essence, the theories suggest that firms attempt to locate in such a manner that profits are maximized. In the case of least-cost theories demand conditions are not considered important, except as proximity to the market is concerned. In the latter two cases, market area theories and interdependence theories, conditions underlying both supply and demand become explicitly important.

The necessity of considering a wide variety of factors on both the supply and demand sides in the development of a general theory of location is important. However, in an empirical study of a given industry certain factors may be so important relative to others that useful inferences may be developed by focusing only on a limited number of factors. In beef slaughtering differences in transportation costs among locations is sufficiently critical to warrant concentration on this aspect, as a first step in providing needed information for location decisions.

In the following chapters recent trends in beef slaughtering will be discussed, and projections of livestock supply and beef demand will be provided. Estimates of livestock and beef transportation functions and slaughter costs will be made. Finally, these data will be used in models to estimate the number, size and location of beef slaughter plants that will minimize the total cost of livestock assembly, slaughtering and beef distribution.

Chapter 2

TRENDS AND RECENT DEVELOPMENTS IN THE BEEF SLAUGHTER INDUSTRY

Introduction

It is the purpose of this chapter to provide greater understanding of important trends and recent developments affecting the beef slaughter industry. This is necessary in order to understand the reasoning behind some of the assumptions that are incorporated into the models to be used in determining the number, size and location of beef slaughter plants in Michigan. It is not the intent of this chapter to provide a comprehensive review of changes or new developments in the industry but to provide a brief review of some of the more important aspects of the economic environment in which firms will be making plant investment decisions. Because of the limited geographic scope of this study, national trends will be supplmented, when data permits, by East North Central regional trends and trends for the state of Michigan.

<u>Volume of Commercial Slaughter</u>[1]

The volume of commercial cattle slaughter in the U.S. has increased substantially in recent years. Between 1950 and 1966 the annual number of cattle slaughtered nationally increased from 17,901,000 to 33,727,000, an increase of 88 percent (Table 2.1). However, growth during this period was not continuous. A marked increase occurred between 1950 and 1954 when total commercial slaughter increased by almost 40 percent (18 to 25 million head). A net decline of 6 percent during the '54-'58 period was followed by a 40 percent increase over the next ten years, two-thirds of which occurred during the 1962-66 period.

While the volume of cattle slaughter has been increasing nationally at a rather rapid pace the same has not been true for all regions.[2] Between 1950 and 1962 the New England

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[1]As used here, commercial slaughter refers to slaughter by federally inspected plants and other plants slaughtering a volume of 300,000 pounds live weight or more annually.

[2]States composing each region are as follows:
New England - Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut.
Middle Atlantic - New York, New Jersey, Delaware, Maryland and Pennsylvania.
South Atlantic - West Virginia, Virginia, North Carolina, South Carolina, Georgia and Florida.
East North Central - Wisconsin, Michigan, Illinois, Indiana and Ohio.
Southeast - Kentucky, Tennessee, Mississippi and Alabama.
West North Central - North Dakota, South Dakota, Minnesota, Nebraska, Iowa, Kansas and Missouri.
South Central - Oklahoma, Texas, Arkansas and Louisiana.
Mountain - Idaho, Montana, Wyoming, Nevada, Utah, Colorado, Arizona and New Mexico.
Pacific - Alaska, Washington, Oregon, California and Hawaii.

Table 2.1. Commercial Cattle Slaughter, Michigan, Nine Regions and United States, 1950, 1954, 1958, 1962, 1966.

Item and Year	Michigan[1]	REGIONS[2] New England	Mid-Atlantic	South Atlantic	South East	East North Central	West North Central	South Central	Mountain	West Coast	United States
Number Slaughtered[3] (1,000)											
1950	629	331	1529	781	705	4455	5797	1441	874	1987	17,901
1954	807	305	2046	1391	1130	5629	7667	2468	1411	2971	25,017
1958	712	258	1922	1184	1131	5232	7642	1928	1526	2732	23,555
1962	714	230	1965	1197	1152	4724	9342	2146	2037	3289	26,083
1966[4]	704	207	1765	1428	1510	5512	13020	3272	3000	4013	33,727
Percent of U.S. Slaughter											
1950	3.5	1.8	8.5	4.4	3.9	24.9	32.4	8.0	4.9	11.1	100.0
1954	3.2	1.2	8.2	5.6	4.5	22.5	30.6	9.9	5.6	11.9	100.0
1958	3.0	1.1	8.2	5.0	4.8	22.2	32.4	8.2	6.5	11.6	100.0
1962	2.7	0.9	7.5	4.6	4.4	18.1	35.8	8.2	7.8	12.6	100.0
1966	2.1	0.6	5.2	4.2	4.5	16.3	38.6	9.7	8.9	11.9	100.0
Percent Change											
1950-54	28.3	- 7.9	33.8	78.1	60.3	26.4	32.3	71.3	61.4	49.5	39.8
1954-58	-11.8	-15.4	- 6.1	-14.9	0.1	- 7.1	- 0.3	-21.9	8.2	- 8.1	- 5.8
1958-62	0.3	-10.9	2.2	1.1	1.9	- 9.7	22.2	11.3	33.5	20.4	10.7
1962-66	- 1.4	- 9.9	-10.2	19.3	31.1	16.7	39.4	52.5	47.3	22.0	29.3
1950-66	11.9	-37.5	15.4	82.8	114.2	23.7	124.6	127.1	243.2	102.0	88.4

[1] Michigan Crop Reporting Service, Michigan Agricultural Statistics (Lansing: Michigan Department of Agriculture and U.S.D.A. Statistical Reporting Service Cooperating, 1951, 1955, 1959, 1963, 1957).

[2] See footnote, page 16, for states in each region.

[3] Willis E. Anthony, Structural Changes in the Federally Inspected Livestock Slaughter

Table 2.1. (Continued)

Industry 1950-1962, Agricultural Economics Report No. 83, (Washington: U.S. Department of Agriculture, 1966), p. 31.

[4]United States Department of Agriculture, Statistical Reporting Service, Livestock and Meat Statistics, Supplement for 1966 to Statistical Bulletin No. 333, (Washington: U.S. Department of Agriculture, 1967), p. 65. 1966 data not comparable with former years due to inclusion of certain slaughtering in commercial plants for farmers as part of commercial meat production beginning January 1, 1966.

region exhibited absolute declines in volume of slaughter. Since 1962, the Middle Atlantic region has also declined in absolute volume of slaughter. The East North Central region showed slight gains in volume of cattle slaughter, increasing from 4.5 million to 5.5 million head for an increase of 24 percent. The increase was not sufficient, however, to maintain the region's 1950 share of national slaughter. The region's percent of national slaughter continuously declined from 25 percent in 1950 to 16 percent in 1966 (Table 2.1).

Of the total national increase in volume of cattle slaughter between 1950 and 1966, three regions; West North Central, South Central, and Mountain; accounted for 71 percent, with the West North Central region alone accounting for 46 percent, of the national increase.

Michigan's volume of cattle slaughter showed a substantial gain between 1950 and 1954, increasing from 629,000 head to 807,000 head, an increase of 28.3 percent. Since 1954, however, the reverse has been true. Between 1954 and 1959, a decline of 11.8 percent occurred. Between 1959 and 1962, slaughter volume was relatively stable, but declined 1.4 percent between 1962 and 1966. The overall change between 1950 and 1966 amounted to a net increase of 11.9 percent.

In spite of the increase in volume slaughtered, Michigan's share of national slaughter has continuously declined throughout the 16 year period to a low of 2.1 percent in 1966.

The trends in volume of slaughter by regions of the United States point toward a shift in cattle slaughter away from major consumption centers and from the historical location near major terminal markets. Slaughter is declining in absolute terms in the New England and Middle Atlantic areas and in relative terms in the East North Central region. A relative decline since 1962 in the West Coast region has also occurred. The major production areas of the West North Central, Mountain and South Central regions, have been increasing both in absolute and relative terms. The shift of slaughter to cattle production regions indicated by this data suggests that if this trend continues in the long run, the volume of regional or state slaughter will, to a considerable degree, be dependent on production of cattle for slaughter from within the area.

Number of Slaughter Plants

The Statistical Reporting Service estimates indicate a decline in the number of slaughter plants.[1] According to their figures, the number of commercial slaughter plants, have been declining at an increasing rate (Table 2.2). Between 1950 and 1955, a net decline of 21 plants was estimated for the United States. This increased to a decline of 73 plants between '55 and '60 and to 187 between '60 and '65. The same trend appeared in the East North Central region

[1]United States, Department of Agriculture, Statistical Reporting Service, Number of Livestock Slaughter Plants, March 1, 1965, SRS - 8, (Washington: U.S. Government Printing Office, 1965), p. 1.

Table 2.2. Number of Slaughter Plants, Michigan, East North Central, West North Central Regions and United States, 1950, 1955, 1960, 1965.

Year and Plant Class	Michigan	East North Central	West North Central	North Central	United States
	Number of Plants				
1950:					
Federally Inspected	----	96	86	182	441
Other Commercial	----	704	227	931	2,797
1955:					
Federally Inspected	----	96	86	182	455
Other Commercial	----	678	204	882	2,762
1960:					
Federally Inspected	4[1]	107	108	215	530
Other Commercial	190[1]	615	204	819	2,614
1965:[1]					
Federally Inspected	5	108	125	233	570
Other Commercial	169	549	243	792	2,387

[1]United States, Department of Agriculture, Statistical Reporting Service, Number of Livestock Slaughter Plants, March 1, 1965, SRS - 8, (Washington: U.S. Government Printing Office, 1965), p. 5.

Source: Except where noted, Willie E. Anthony, Structural Changes in the Federally Inspected Livestock Slaughter Industry 1950-1962, Agricultural Economics Report No. 83, (Washington: U.S. Department of Agriculture, 1966), p. 61.

which showed declines of 26, 52, and 65 for the three periods respectively. Michigan data for 1960 and 1965 also indicated a down turn in number of slaughter plants. The net decline was from 194 in 1960 to 174 in 1965.

A significant trend also shown by data in Table 2.2 is the increase in the number of federally inspected plants regardless of the region concerned. The national totals show a net increase of 129 federally inspected plants. Increased emphasis on interstate shipment of meat as opposed to livestock shipment has undoubtedly contributed to the increasing number of federally inspected plants as has the tendency for state meat inspection laws to more nearly conform to federal standards. Recent legislative action which requires state laws to conform to federal standards will likely increase further the interest in federal as opposed to state inspection. The influence of these institutional changes will be discussed in more detail later.

For a closer look at Michigan's beef slaughter industry, data were obtained from the Michigan Department of Agriculture and from the Consumer and Marketing Service, U.S.D.A., on the number of head slaughtered by species from all plants in the state (Table 2.3). Unfortunately, only data for 1967 were available so no trends could be developed.

In 1967 there were a total of 202 state or federally inspected plants in Michigan that slaughtered cattle and/or calves. Of these, 198 slaughtered cattle, with 32 slaughtering cattle only, and three slaughtering calves only. A total

Table 2.3. Number of Plants, Number of Head Slaughtered and Volume of Carcass Beef and Veal Slaughtered by Size of Plant, Michigan, 1967.

Item	No. of Heads Slaughtered in Thousands								
	<.26	.26-.75	.76-1.5	1.6-3.0	3.1-6.25	6.26-15	16-25	26-50	Total
Cattle									
No. of plants[1]	45	68	23	25	13	12	5	7	198
Plants as % of total[2]	22.73	34.34	11.62	12.63	6.57	6.06	2.53	3.54	100.00
No. of head slaughtered	5250	31477	25704	52041	52766	106676	99197	231182	604293
Head as % of total[3]	0.87	5.21	4.25	8.61	8.73	17.65	16.42	38.26	100.00
Average no. of head slaughtered per plant[4]	117	463	1118	2082	4059	8890	19839	33026	3052
Volume slaughtered[5]	3151	18893	15428	31236	31671	64028	59539	138758	362703
Average volume slaughtered per plant[6]	70	278	671	1249	2436	5336	11908	19823	1832
Calves									
No. of plants	110[a]	6[b]	----	----	----	----	----	5[c]	121
Plants as % of total	90.91	4.96	----	----	----	----	----	4.13	100.00
No. of head slaughtered	2118	1915	----	----	----	----	----	165304	169337
Head as % of total	1.25	1.13	----	----	----	----	----	97.62	100.00
Average no. of head slaughtered per plant	19	319	----	----	----	----	----	33061	1399

Table 2.3. (Continued)

Item	No. of Head Slaughtered in Thousands <.26	.26-.75	.76-1.5	1.6-3.0	3.1-6.25	6.26-15	16-25	26-50	Total
Volume slaughtered[7]	181	163	----	----	----	----	----	14092	14436
Average volume slaughtered per plant	2	27	----	----	----	----	----	2818	119
Cattle and/or Calves									
No. of plants[8]	48	64	24	24	13	12	6	11	202
Plants as % of total	24.24	32.32	12.12	12.12	6.57	6.06	3.03	3.54	100.00
No. of head slaughtered	5527	30917	26884	51344	53373	110878	112423	382284	773630
Head as % of total	0.71	4.00	3.48	6.64	6.90	14.33	14.53	49.41	100.00
Average no. of head slaughtered per plant	115	483	1120	2139	4106	9240	18737	34753	3830
Cattle Only									
No. of plants	10[d]	----	----	7[e]	----	5	4	6	32
Plants as % of total	31.25	----	----	21.88	----	15.62	12.50	18.75	100.00
No. of head slaughtered	1391	----	----	19719	----	43968	83604	195273	343955
Head as % of total	0.40	----	----	5.73	----	12.78	24.30	56.77	100.00
Average no. of head slaughtered per plant	139	----	----	2817	----	8794	20901	32546	10749

Table 2.3. (Continued)

Item	No. of Head Slaughtered in Thousands								
	<.25	.26-.75	.76-1.5	1.5-3.0	3.1-6.25	6.26-1.5	16-25	26-50	Total
Volume slaughtered	835	----	----	11836	----	26390	50180	117205	206445
Average volume slaughtered per plant	84	----	----	1691	----	5278	12545	19534	6452

[1]Number of plants that reported slaughtering cattle in 1967.

[2]Number of plants in each size class as a percent of total number of plants reporting.

[3]Number of head slaughtered in each size class as a percent of the total number of cattle slaughtered.

[4]Number of head slaughtered in each size class divided by number of plants in that size class.

[5]Number of head slaughtered times average live weight of cattle slaughtered in Michigan in 1966 (1053 pounds) times an assumed dressing, percent of 57. Volume expressed in 1,000's of pounds of carcass weight.

[6]Volume slaughtered in each size class divided by the number of plants in that size class.

[7]Number of head slaughtered in each size class times average weight of calves sold in Michigan in 1966 (155 pounds) times an assumed dressing percent of 55. Volume expressed in 1,000's of pounds carcass weight.

[8]Number of plants reporting slaughtering cattle and/or calves in 1967.

[a]Includes plants slaughtering less than 200 head of calves.

[b]Includes plants slaughtering from 200 to 750 head of calves.

[c]Includes one plant slaughtering less than 6,250 head of calves.

[d]Includes plants reporting slaughtering less than 750 head of cattle.

Table 2.3. (Continued)

[e]Includes plants reporting slaughtering from 750 to 6,250 head of cattle.

Source: Calculated from unpublished data supplied by the Michigan Department of Agriculture, Meat Inspection Division and U.S. Department of Agriculture Consumer and Marketing Service. Data excluded 37,263 head of cattle and 26,007 head of calves slaughtered in Detroit slaughterhouses during January and February, 1967.

of 641,556 head of cattle and 195,344 calves were reported slaughtered during the year for an estimated volume of 385,068,000 pounds of carcass beef and 16,653,000 pounds of veal.

The number of plants shown in this data is larger than previous data due to the inclusion of plants slaughtering less than 300,000 pounds live weight. All plants slaughtering less than approximately 285 head of cattle annually would not be classified as commercial slaughter plants and would not be included in former data.

The geographic distribution of state licensed slaughter plants and federally inspected plants is shown in Figure 2.1. These include plants slaughtering all species of livestock, except horses, under state inspection as well as plants not yet under state inspection. The concentration of plants in the Detroit area is obvious with 53 plants in a four county area (Macomb, Oakland, Washtenaw and Wayne). Other concentrations, though not as pronounced, occur in the Saginaw-Genessee county area which has 17 plants and in the four county area of Muskegon, Ottawa, Kent, and Allegan with 29 plants. Although not shown, the concentration of volume would be substantially greater due to the larger average size of plants in these areas.

The location of Michigan slaughter plants strongly suggests their orientation toward the population centers of the state. Detroit has long been a center for slaughter activity. Plants were originally attracted to Detroit by

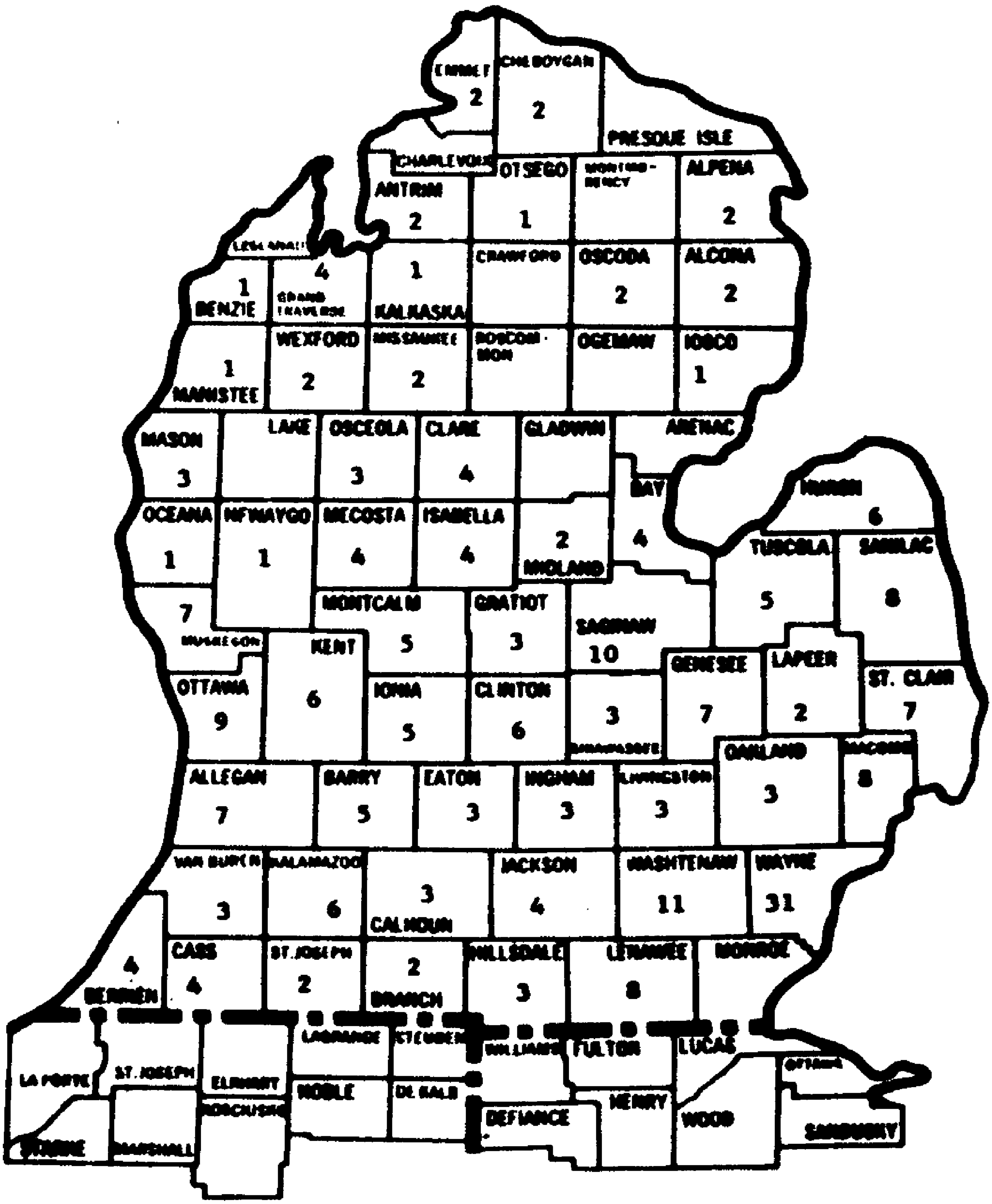

Figure 2.1. Location of Licensed Slaughter Plants, Michigan 1967.

both the population and the relatively large terminal market which served as a major source of livestock.

Size Distribution of Slaughter Plants

According to Anthony,[1] of the 491 federally inspected cattle-slaughter plants in the U.S. in 1962, 26 percent (128 plants) slaughtered 50,000 head or more; another 26 percent slaughtered between 25,000 and 50,000 head. In 1950 only 16.5 percent of the federally inspected plants were slaughtering in excess of 50,000 head, while only 19.4 percent slaughtered between 25,000 and 50,000 head. Forty-one plants slaughtered less than 12,500 head. On the average, plants in 1950 slaughtered 31,804 head compared to 41,172 in 1962. Between 1950 and 1962 there was a net decline of 29 plants slaughtering less than 25,000 head and a net increase of 108 plants slaughtering over 25,000 head. Although these figures tend to indicate an increase in the average size of cattle slaughter plants, one should be cautious in making this interpretation. Year to year shifts in the average percent of capacity at which existing plants operate may contribute to the difference. However, it does not seem likely that a difference of 10,000 head on the average or an increase of 30 percent can all be attributed to differences in the degree to which plants are operating at capacity.

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[1]Willis E. Anthony, Structural Changes in the Federally Inspected Livestock Slaughter Industry 1950-1962, Agricultural Economics Report No. 83, (Washington: U.S. Department of Agriculture, 1966), p. 63.

Based on data in Table 2.4, the average number of cattle slaughtered by the 198 plants that slaughtered cattle in Michigan was only 3,052 head. This average reflects the large number of plants that reported slaughtering less than 750 head. The four largest cattle slaughter plants in the state had an average slaughter of 37,905 head in 1967, while the next six largest plants averaged 24,497 head per plant. Of these ten larger plants, eight were specialized cattle slaughtering plants and slaughtered an average of 29,898 head per year.

Table 2.4. Average Volume of Cattle Slaughtered per Plant in Federally Inspected Plants, East North Central and West North Central Regions and United States, 1950, 1954, 1958, 1962.

Year	East North Central	West North Central	United States
		Number of Head	
1950	37,846	67,056	31,804
1954	44,808	83,027	42,457
1958	39,296	80,791	38,520
1962	35,660	81,581	41,172

Source: Willis E. Anthony, Structural Changes in the Federally Inspected Livestock Slaughter Industry 1950-1962, Agricultural Economics Report No. 83, (Washington: U.S. Department of Agriculture, 1966), p. 62.

One of the major interests in the average size of plants relates to the degree to which plants are realizing economies of size that exist in cattle slaughtering. If estimates made by previous studies hold under Michigan conditions, significant economies are possible beyond the average sizes now existing in Michigan.[1] Without significant increases in the total volume of slaughter, increasing plant sizes will require a drastic reduction in the number of plants. This trend is already underway.

Concentration of Slaughter Plants

Concentration, as used here, refers to the proportion of total slaughter accounted for by a specified number of firms. In 1950, the four largest cattle slaughtering firms in the U.S. accounted for 51 percent of the U.S. cattle slaughter. The ten largest accounted for 60 percent (Table 2.5). These percentages have been rapidly declining since 1950 and by 1962 the four largest had less than 30 percent of total slaughter, while the ten largest had 40 percent. For the East North Central region, the four largest and ten largest accounted for 50 and 68 percent respectively in 1950. By 1962 the percentages had declined to 30 and 47, slightly higher than for the U.S.

In Michigan, the four largest firms (assuming no firm owns more than one plant) slaughtered approximately 25.1 percent of the state's cattle slaughter and the ten largest, 49.4 percent in 1966. These percentages are slightly lower than regional or U.S. estimates for the four plant and

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[1] Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 102.

Table 2.5. Percent of Cattle Slaughtered by Four Largest and Ten Largest Firms, Michigan, East North Central, West North Central and United States, 1950, 1954, 1958, 1962.

Number of Firms and Year	Michigan[1]	East North Central	West North Central	United States
	Percent			
Four Largest				
1950	----	50.2	64.6	51.5
1954	----	48.7	58.6	45.2
1958	----	40.4	51.2	35.7
1962	25.1	29.8	45.6	29.5
Ten Largest				
1950	----	67.7	82.5	60.2
1954	----	66.1	77.1	55.2
1958	----	58.4	70.4	46.2
1962	49.4	46.7	63.0	39.9

[1]Calculated from unpublished data supplied by Michigan Department of Agriculture, Animal Health Division.

Source: Except where noted, Willis E. Anthony, Structural Changes in the Federally Inspected Livestock Slaughter Industry 1950-1962, Agricultural Economics Report No. 83, (Washington: U.S. Department of Agriculture, 1966), p. 38-40.

higher for ten plant concentration for 1962.

Anthony presents a distribution of the number of firms by size class for 1950, 1954, 1958, and 1962. In summing up this distribution he states, "The size distribution of FI (Federally Inspected) cattle slaughter firms has changed between 1950 and 1962 ....The most notable characteristic of change is the rising peak near the center of the distribution. At the same time, there has been little change in numbers of very small or very large firms. The declining concentration is due to relatively more slaughter by medium size firms."[1]

Several factors are believed to have contributed to the decline in the share of the market held by the largest firms. First, consumer acceptance of federal grades as a standard of quality for fresh beef has reduced the ability of the large national packers to differentiate their products. This has made entry of new firms easier and increased the ability of other firms to compete for markets. Second, transportation rate changes and changes in livestock marketing channels, especially the reduced importance of terminal markets and the increased importance of direct purchasing have improved the locational advantage of packers located in major production areas. Generally, lower wage rates in production regions have also been suggested as a factor

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[1]Willis E. Anthony, Structural Changes in the Federally Inspected Livestock Slaughter Industry 1950-1962, Agricultural Economics Report No. 83, (Washington: U.S. Department of Agriculture, 1966), p. 6.

Table 2.6. Horizontal Slaughter Plant Specialization: Percent of Federally Inspected Plants Slaughtering Given Combinations of Livestock Species, Michigan, 1966, East North Central Region, United States, 1950, 1954, 1958, 1962.

Area and Year	Cattle	Calves	Sheep	Hogs	Cattle Calves Sheep Hogs	Cattle Sheep Hogs
Michigan[1]						
1966	11.9	-	-	5.1	50.3	17.0
East North Central						
1950	11.3	1.0	-	12.4	28.9	-
1954	14.6	-	1.0	12.5	22.9	-
1958	22.0	2.6	0.9	11.0	21.1	-
1962	25.0	0.9	1.8	17.9	12.5	2.7
United States						
1950	7.4	0.4	-	8.1	38.3	0.7
1954	13.4	0.4	0.4	8.6	29.9	1.3
1958	19.0	0.8	0.2	8.4	24.9	1.6
1962	22.4	0.5	0.5	10.6	14.8	3.9

contributing to the ability of plants in production regions to compete with larger packers.

Horizontal Plant Specialization

Horizontal specialization, defined as the degree to which plants specialize in the slaughtering of single species of livestock, has been increasing in the United States, as well as in most regions of the nation. In 1950, only 16 percent of the nation's federally inspected slaughter plants slaughtered only one species. By 1962, this had increased to 34 percent. During the same period the proportion of plants slaughtering four species declined from 38 to 15 percent (Table 2.6).

The East North Central region showed a similar but even more rapid trend toward specialization. In 1962, 46 percent of the plants slaughtered only one species, while only 12 percent slaughtered four species. Almost three-fourths slaughtered less than three species.

Michigan appears to be lagging behind both the U.S. and the region, however, the data presented in Table 2.6, are not strictly comparable. Michigan data in this table are not restricted to federally inspected plants. When all plants slaughtering 300 head of livestock or more are considered, only 17 percent limited their slaughtering to one species, while 76 percent slaughtered three or more species (Table 2.6). Of the six federally inspected plants in the state in 1967, five slaughtered only one species.

Table 2.6. (Continued)

	Cattle Calves Sheep	Cattle Calves Hogs	Cattle Calves	Cattle Hogs	Other 2-Species	No. of Species Slaughtered			
						1	2	3	4
Michigan[1]									
1966	4.5	4.0	2.8	0.6	4.0	17.0	7.3	25.4	50.3
East North Central									
1950	11.3	11.3	17.5	2.1	4.1	24.7	23.7	22.7	28.9
1954	12.5	11.5	18.7	5.2	1.0	28.1	25.0	24.0	22.9
1958	10.1	9.2	15.6	3.7	3.7	36.7	22.9	19.3	21.1
1962	8.9	3.6	17.0	6.2	3.6	45.5	26.8	15.2	12.5
United States									
1950	14.9	12.0	10.7	4.6	2.8	16.0	17.7	28.0	38.3
1954	13.8	11.7	14.2	5.2	1.3	22.8	20.5	26.9	29.8
1958	13.5	9.4	13.7	6.7	2.0	28.4	21.9	24.9	24.9
1962	12.5	7.4	13.6	9.2	4.6	34.0	27.2	24.0	14.8

[1] Calculated from: Unpublished data provided by Animal Health Division, Michigan Department of Agriculture. Based on 177 plants that slaughtered 300 or more head of livestock.

Source: Except where noted, computed from: Willis E. Anthony, Structural Changes in the Federally Inspected Livestock Slaughter Industry 1950-1962, Agricultural Economics Report No. 83, (Washington: U.S. Department of Agriculture, 1966), pp. 68-9.

Specialization in cattle slaughtering has been the major factor in the national, regional and state trends toward horizontal specialization. At the national level, 127 or 66 percent of the 193 single species plants were cattle slaughtering plants. At the regional level, 55 percent were cattle plants. In Michigan 21 out of 30, or 70 percent of the single species plants were specialized in cattle slaughtering (Table 2.6).

Patterns of Entry and Exit

Entry and exit of firms into cattle slaughtering in the United States has been relatively active in recent years. Over two-thirds of the firms operating in 1950 discontinued federally inspected slaughter operations by 1962. On the other hand, over half of the firms with federally inspected plants in 1962 began slaughtering under federal inspection after 1950.[1]

The East North Central region had an exit ratio of 0.43 and an entry ratio of 0.54.[2] This exit ratio is higher and the entry ratio about the same as the national ratios.

One should be reminded that these ratios apply only to the federally inspected plants, and as such do not include the bulk of the firms or plants in the industry. In terms

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[1] *Ibid.*, p. 6.

[2] Exit ratio is a ratio of the number discontinuing operation during a given period to the total number operating at the beginning of the period. Entry ratio is a ratio of the number entering during a given period to the total number operating at the end of the period.

of the volume of slaughter, however, the federal plants represented about 78 percent of the commercial livestock slaughter in 1962, and this has been gradually increasing. It is also possible that these figures are biased by the continued operation of slaughter firms as nonfederally inspected firms or to the entry of firms as federally inspected firms that were previously a part of the commercial slaughter industry. The degree to which this affects the ratios is indeterminant. Even with these weaknesses in the data they seem sufficient to indicate a considerable turn over of firms during the 1950 to 1962 period.

New Legislation Affecting Beef Slaughtering

Although there are many laws and regulations that affect the beef slaughter industry, two recently enacted laws are of particular significance to the future adjustments that are likely to take place in the number and size of beef slaughter plants in Michigan.

The first of these, Act 280 of the Public Acts of 1965, known as the Statewide Meat Inspection Act, was enacted by the Michigan legislature in 1965 and became effective January 1, 1966. It requires that, "no person shall establish, conduct, maintain or operate, a slaughterhouse or edible rendering establishment without a license from the department."[1]

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[1]Michigan Department of Agriculture, Meat Inspection Laws Act 280 of 1965 as Amended Regulation No. 148 (Lansing: Michigan Department of Agriculture), 1967, p. 2.

It further states that the Michigan Department of Agriculture, "...shall provide for the anti-mortem inspection of all meat animals slaughtered in any slaughterhouse or edible rendering establishment, excepting those meat animals slaughtered under the direct supervision of the United States Department of Agriculture, before they are slaughtered."[1] The Michigan Department of Agriculture must also provide for post-mortem inspection of all meat animals except those slaughtered under federal inspection. The law further requires slaughter establishments to provide adequate facilities, including office space and janitorial service for the state inspectors. The facilities in which slaughtering takes place, including all equipment, must also meet certain conditions to guarantee a sanitary and healthful slaughtering operation.

The second act, Public Law 90-201, a federal act, was passed in December, 1967, and is known as the Wholesome Meat Act. Although this act covers a wider variety of items, including packaging and labeling, the major section of the act that is of special interest here pertains to the requirement concerning compulsory meat inspection of virtually all meat that enters commercial trade. The act provides for a federal-state cooperative arrangement to strengthen state meat inspection programs. Under this feature of the act, states may obtain financial assistance up to half the cost

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[1] Ibid., p. 2.

of the state program, as well as technical assistance to improve their programs. It also authorizes the Secretary of Agriculture to provide immediate inspection to any plant, even if it sells only to intrastate markets, if the plant is believed to be a health hazard and the state fails to inspect it. The act also provides a two year period -- to December 15, 1969 -- in which states must set up state inspection programs equivalent to the federal program or the federal government will assume the inspection responsibility of all plants.[1]

In effect, this law requires all slaughtering operations to meet federal requirements. Thus, it is expected that many of the larger commercial plants that are not now federally inspected will seek to obtain federal inspection. Many will be faced with a decision to either update their present facilities or completely rebuild. Those who choose the latter, will no doubt, also be considering the possibility of relocating. The smaller slaughter firms may be discouraged to the point that they will not continue to operate. Other firms that have slaughter operations only as a part of their total business may be encouraged to discontinue slaughter operations.

Differences in requirements between the federally

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[1]U.S. Congress, House, An Act to Clarify and Otherwise Amend the Meat Inspection Act to Provide for Cooperation with Appropriate State Agencies with Respect to State Meat Inspection Programs, and for other Purposes, H.R. 12144, 90th Congress, 1967, p. 12.

inspected and state inspected or non-inspected plants have generally provided a cost advantage to the state and non-inspected plants. This advantage helped to overcome some of the cost advantages gained by the generally larger federally inspected plants due to economies of size. This new act however has the potential of eliminating much of this. However, according to Abel P. Davis, vice-president of the American Meat Institute as reported in the National Provisions, "the thing he (the meat packer) is more fearful of is lack of uniformity of costs."[1] Their concern seems to be in the implementation of the act. Davis is reported to have suggested that the most important thing facing the USDA now is how to get the regulation interpreted the same way by all inspectors in all plants.[2]

Others have been especially concerned with the ability of small packers to get the financing needed to make the necessary changes in plants and equipment. A resolution has been introduced by Senators Alan Bible and John Sparkman calling upon the Small Business Administration to make a study of the needs for capital by meat processors and packers to meet the requirements of the Act.[3]

It would seem that the effect of these two laws on Michigan's slaughter industry will be to speed up the

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[1]"Changing Role of Vets in Meat Inspection is Explored," The National Provisioner, June 29, 1968, p. 20.

[2]Ibid., p. 20.

[3]Ibid., p. 7.

reduction in the number of firms and an increase in the size of firms. Also, some relocation of firms is likely to take place as well as the emergence of new firms better able to meet the new requirements.

<u>Summary</u>

This chapter has briefly outlined some of the major trends and recent developments that will have a bearing on the number, size, and location of beef slaughter plants in Michigan. Total volume of cattle slaughtering is increasing rapidly on a national basis, but Michigan has been continually reducing its share of national slaughter.

The number of commercial slaughter plants has been declining in the United States as well as in Michigan. Major reductions at the national level have been in plants slaughtering less than 25,000 head. However, medium size firms have been a major factor in the growth in slaughter while the top ten firms have reduced their share of the market.

The geographic distribution of slaughter nationally over time shows a trend toward location in production areas while in Michigan, slaughter plants tend to be located in major urban areas.

Horizontal specialization toward single species plants is increasing rapidly with specialized cattle slaughtering plants being the major single species plants. However, most Michigan plants are still highly diversified.

Available data suggest that entry and exit into the industry has been relatively active since 1950.

Necessary adjustments to new legislation suggests an increase in the rate of growth of federally inspected plants, an increase in specialized slaughtering as processors discontinue slaughter operations, and an increased rate of adjustments toward location in production areas both at the national and state level.

Chapter 3

CATTLE AND BEEF PROJECTIONS, ESTIMATES OF TRANSPORTATION FUNCTIONS, SELECTION OF PLANT SITES AND OUT-OF-AREA SUPPLY POINTS

Introduction

The purpose of this chapter is to present the procedures used and the estimates obtained for: 1) Projected volume of cattle marketed by production areas in 1980, 2) projected beef consumption by areas to 1980, 3) transportation rates for live cattle, 4) transportation costs for carcass beef, 5) selection of plant sites, and 6) selection of out-of-area supply points.

Before developing these estimates the area to be included in the study area should be identified. The geographic interest of the study is the state of Michigan. However since the Upper Penninsula is not an important source of livestock supply to Michigan plants it was not included in the study area. On the other hand, the importance of the Northern Indiana and Ohio counties as potential suppliers of livestock to Michigan plants warranted their inclusion in the study. The Indiana and Ohio counties included in the study were arbitrarily limited to the most northern eighteen counties east of Porter county, Indiana. Also, by including these out-of-state counties, Michigan's southern border counties were not penalized as heavily as would have been the case had they been on the margin of the potential supply area. Counties on the margin of the supply area will normally be omitted from least cost transportation solutions. In the same way the Indiana and Ohio counties are likely to be omitted. Figure 3.1 outlines the geographic area of the study.

Cattle Marketing Projections

Number of cattle marketed. In early 1964 Michigan State University's College of Agriculture, undertook an intensive, multi-disciplinary study of rural Michigan. The study concentrated on the projection of potentials for rural areas of the state to 1980. Aspects of the state's agricultural production, processing, and marketing activities were considered. Since these projections are available, they are used as a basis for the Michigan projections.[1]

Since previous state projections for Michigan are used for this study, the major issue pertaining to production of cattle for slaughter in Michigan is one of allocating the projected state cattle marketings to each production area. For the Indiana and Ohio counties a different approach is necessary. The basic cattle production area used in both cases is the county, since county data are readily available.

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[1] Michigan State University, Project '80 Rural Michigan Now and in 1980 -- Highlights and Summary of Project '80, Michigan State University Agricultural Experiment Station and Cooperative Extension Service, Research Report No. 37 (East Lansing: Michigan State University, 1966).

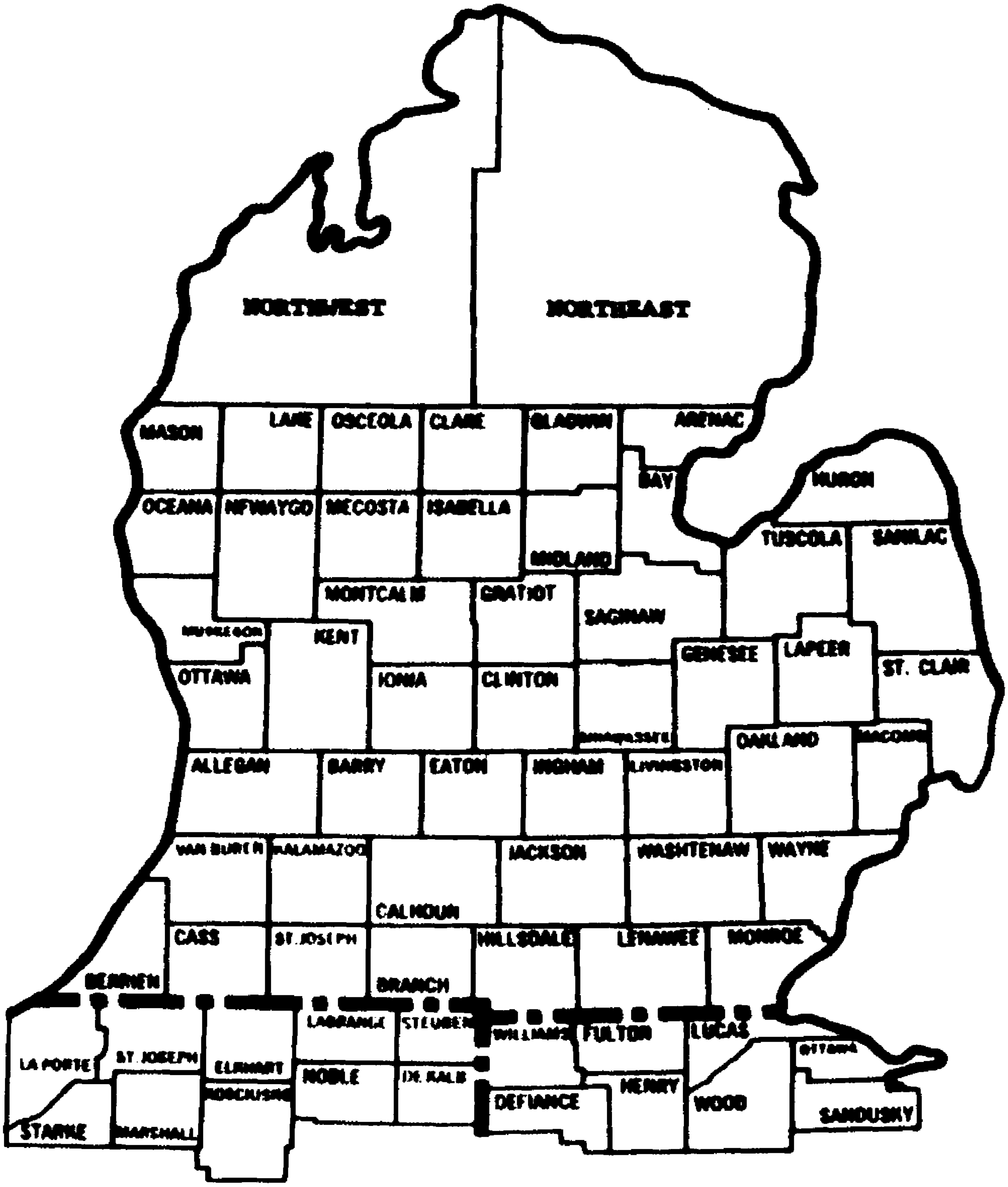

Figure 3.1. Outline of Production Areas in Study.

There are two exceptions, however. The Northwest and Northeast crop reporting districts of the state are each considered as an area. Cattle production in many of these counties is so small that individual county data are not available. Production areas are outlined in Figure 3.1.

Several alternative methods for projecting county and district sales for Michigan areas were considered. One possibility considered was calculating for each area (county or district) the average annual percentage change in the number of cattle (except calves) sold between 1954 and 1964 using U.S. Census of Agriculture data. According to previous estimates, these two years are peak years in the cattle cycle. By using '54 and '64 data, the influence of the cycle would be minimized. Applying these percentage changes to the county's or district's 1964 sales and multiplying by the number of years to be projected would yield a first approximation of the area's projected sales. In order to assure the sum of the individual projections would agree with the Project '80 state projection, each individual area's projection would need to be multiplied by a ratio of the state projection to the sum of the individual county or district projections.

This procedure has at least two weaknesses. First, it has the potential of overestimating the increases or decreases of counties with small absolute numbers, since small absolute changes yield larger percentage changes. Second, in counties that have heavy dairy populations, the decline in dairy cow numbers reduces the source of supply of dairy steers and would tend to cause this procedure to overestimate the future volume of cattle sold from the county.

A second alternative considered was to base projections on the trends in the number of dairy and beef cows on farms. Estimates of calf crop, death losses, replacement rates, the number of calves sold or fed out, could be made and the results projected. However, this procedure does not account for movements of calves and yearlings between counties, during the growing and fattening states of production. Estimates on the inter-county movement of calves for fattening are not possible with available data and therefore make this procedure infeasible.

The final procedure considered, and used, was to calculate each county's or district's cattle sales as a percentage of the state's sales for 1949, 1954, 1959, and 1964 using census of agriculture estimates. These estimates were then used to project the area's percent of state sales to 1980 by simple linear regression procedures. This procedure minimizes the importance of the absolute number involved in the first procedure and eliminated the need to estimate intercounty movements of calves for feeding that the second procedure required. It does not overcome the potential tendency for overestimating the volume of cattle available from areas with declining dairy populations. The lack of a strong concentration of counties with declining dairy populations in any one area of the state will help to minimize the consequences of overestimating future sales in these counties. Also, there is reason to expect that some of the resources released from dairy production will be transferred to beef cattle and thus provide a compensating trend.

Maish and Hoglund made a comparative budget study of beef cow herds in Michigan.[1] One of the budget comparisons made was between a 50-cow beef herd and a 22-cow dairy enterprise in Southern Michigan. The budgets were developed to simulate the normal resource combinations found on many small dairy farms in the area. Net incomes were $96 to $1314 less on the beef herd operation depending on the efficiency and management assumptions made. The authors point out, however, that if off-farm employment becomes a possibility with the shift to beef production net incomes to the farm family may be substantially higher. At $20 per day only 5 to 66 days of off-farm employment is necessary to equal the loss in farm income by the shift from dairy to beef.

To obtain projections of cattle marketings for the ten counties in northern Indiana and eight in northern Ohio that are included in this study a linear peojection of the 1949, 1954, 1959 and 1964 trend in number of cattle (except calves) sold from each county from U.S. Census of Agriculture data was made.

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[1]L.J. Maish and C.R. Hoglund, The Economics of Beef Cow Herds in Michigan, Michigan State University Agricultural Experiment Station Research Report No. 58 (East Lansing: Michigan State University, 1966), p. 2.

Since neither procedure used to project cattle marketings took into account trends in urbanization, it seemed necessary to determine if population pressures would require adjustments in cattle projections in some of the urban counties. Fifteen of the counties with major urban centers were individually checked to determine if the projected populations for these areas and the projected cattle production appeared inconsistent. Based on the information available, there did not appear to be sufficient inconsistencies to make adjustments in the cattle projections.

In 1960, population per square mile exceeded 500 persons in four counties; Wayne, Macomb, Oakland, and Genessee. Three of these sold a smaller percentage of the state's cattle sales in 1964 than in 1959 and are projected to continue to decline both on a percentage basis and in absolute number. Since Genessee's cattle sales increased during the 1959-64 period, population pressure did not appear sufficient to greatly influence the rate of growth in number of cattle marketed. However, due to the decline between 1949 and 1959, the county's cattle sales projections indicate a continued growth in absolute numbers but a slower rate than the state average. Thus, as a percent of state sales, they are expected to decline.

Population projections to 1980 indicate only to other counties in the state are expected to approach the density of Genessee county by 1980.[1] These two are Ingham (Lansing) and Kent (Grand Rapids). Population per square mile in these two counties are projected to approach 549 and 594 respectively compared to Genessee's 1960 density of 583 per square mile. Cattle projections indicate that Kent county is expected to reduce its share of the state's cattle marketing from 1.96 percent or 10,400 head in 1960 to 1.05 percent or 8,900 head in 1980. Ingham county, however, is projected to increase its share from 2.47 percent or 13,100 in 1960 to 3.34 percent of 28,400 by 1980. Although Ingham county's projection is admittedly a substantial increase, it was not believed to be sufficiently unrealistic to warrant an adjustment which would, of necessity, be based on little more than an arbitrary decision to reduce the projection by some percentage factor.

As a result of this modest check, no adjustments were made in the cattle projections to account for population pressures. It appeared, from the data available, that in areas where population pressures were expected to be heavy between now and 1980, pressures were already sufficient to have influenced past trends and therefore influence the linear projections. Obviously, this does not prevent the possibility of population pressures being sufficient to reduce the rate of growth below the linear projections used

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[1]Michigan State University, Project '80 Rural Michigan Now and in 1980 -- Highlights and Summary of Project '80, Michigan State University Agricultural Experiment Station and Cooperative Extension Service, Research Report No. 37 (East Lansing: Michigan State University, 1966), p. 75.

but they did not appear to be sufficient to reverse the directions of the cattle marketing projections in any of the urban counties.

Trends for each production area and projections to 1980, are presented in Table 3.1.

Type of Cattle Marketed: Dairy cattle have been an important source of cattle for Michigan slaughter plants. The number of dairy cows on farms declined from 715 thousand head in 1960 to 519 thousand in 1968 -- a decline of 196 thousand or 27 percent. This decline is not a new trend but does appear to be accelerating. Numbers declined by 3 percent in 1964, 6 percent in 1965, 8 percent in 1966 and 7 percent in 1967.[1]

During the 1963 to 1967 period, the number of beef cows two years old or over averaged only 129 thousand or 20 percent of the number of milk cows. However, the number increased up to 1966 when an all-time high of 136 thousand head were estimated to be on Michigan farms. Since 1966, a decline of 20 thousand head has occurred.[2] It seems likely that part of this decline is explained by a downturn in the cattle cycle that, according to one estimate was at a high in terms of number of cattle on farms January 1, 1965.[3] The

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[1]Michigan Crop Reporting Service, Michigan Agricultural Statistics (Lansing, Michigan Department of Agriculture and Statistical Reporting Service, U.S.D.A. Cooperating, 1967), p. 42.

[2]Ibid., p. 42.

[3]Robert L. Rizek, "The Cattle Cycle," Livestock and Meat Statistics, United States Department of Agriculture, Economic Research Service, LMS No. 148 (Washington: U.S. Government Printing Office, March 1966), p. 26.

Table 3.1. Number of Cattle Sold by Areas, and Percent of State Sales, 1949, 1954, 1959, and 1964 and Projection to 1980.[1]

Area	1949		1954		1959		1964		1980[2]	
	Number (thous)	% of state	Number (thous)	% of state	Number (thous)	% of state	Number (thous)	% of state	Number (thous)	% of state
Michigan	318.6	100.00	384.2	100.00	402.3	100.00	530.3	100.00	850.0	100.00
Districts										
Upper Penninsula	15.8	4.96	16.0	4.16	13.4	3.33	14.8	2.79	4.3	0.51
Northwest	17.7	5.55	18.6	4.84	15.1	3.75	18.1	3.41	8.6	1.01
Northeast	18.1	5.68	20.8	5.41	16.2	4.03	22.1	4.17	18.4	2.16
West Central	13.2	4.14	14.6	3.80	12.5	3.11	16.0	3.02	14.4	1.70
Central	40.1	12.59	48.0	12.49	45.2	11.24	67.5	12.73	101.1	11.89
East Central	41.5	13.03	51.2	13.33	53.1	13.20	77.3	14.58	132.3	15.57
Southwest	38.2	11.99	48.9	12.73	46.7	11.61	60.8	11.47	91.3	10.74
Southern	69.0	21.66	83.4	21.71	101.4	25.21	130.5	24.61	245.3	28.86
Southeast	65.0	20.40	82.7	21.53	98.7	24.53	123.2	23.23	234.5	27.59
Counties										
West Central										
Lake	1.2	0.38	1.0	0.26	0.7	0.19	0.7	0.13	0.0[a]	0.00[a]
Mason	2.5	0.78	3.1	0.81	2.3	0.57	3.8	0.72	4.5	0.53
Muskegon	1.9	0.60	2.6	0.68	2.7	0.67	3.0	0.57	5.0	0.58
Newaygo	4.4	1.38	4.6	1.20	3.4	0.85	4.9	0.92	2.6	0.31
Oceana	3.2	1.00	3.3	0.86	3.4	0.85	3.6	0.68	3.5	0.41
Central										
Clare	6.1	1.91	6.6	1.72	4.2	1.04	4.5	0.85	0.0[a]	0.00[a]
Gladwin	4.1	1.29	4.4	1.15	2.5	0.62	5.7	1.07	4.2	0.50
Gratiot	8.0	2.51	9.7	2.52	11.1	2.76	15.8	2.99	29.3	3.45
Isabella	6.2	1.95	8.8	2.29	8.7	2.16	17.1	3.22	34.5	4.06
Mecosta	3.4	1.07	4.5	1.17	4.4	1.09	5.2	0.98	7.8	0.92
Midland	2.3	0.72	2.8	0.73	3.2	0.80	5.2	0.98	10.1	1.19
Montcalm	5.3	1.66	6.7	1.74	6.8	1.69	8.7	1.64	13.9	1.63
Osceola	4.7	1.48	4.5	1.17	4.3	1.07	5.3	1.00	4.1	0.49

Table 3.1. (Continued)

Area	1949		1954		1959		1964		1980[2]	
	Number (thous)	% of state	Number (thous)	% of state	Number (thous)	% of state	Number (thous)	% of state	Number (thous)	% of state
East Central										
Arenac	2.1	0.66	2.5	0.65	3.1	0.77	3.4	0.67	6.4	0.76
Bay	3.1	0.97	2.6	0.68	4.6	1.14	4.3	0.81	7.6	0.89
Huron	11.8	3.70	15.8	4.11	17.0	4.23	28.8	5.43	57.4	6.76
Saginaw	6.3	1.98	8.0	2.08	6.5	1.62	9.4	1.77	11.7	1.37
Sanilac	12.3	3.86	14.2	3.70	14.8	3.68	21.3	4.02	34.2	4.02
Tuscola	5.9	1.85	8.1	2.11	7.1	1.76	10.1	1.90	15.4	1.82
Southwest										
Allegan	7.5	2.35	10.0	2.60	8.8	2.19	12.8	2.41	19.4	2.28
Berrien	3.2	1.00	5.0	1.30	3.7	0.92	5.3	1.00	7.5	0.88
Cass	3.7	1.16	4.9	1.28	6.3	1.57	7.5	1.41	15.5	1.82
Kalamazoo	5.8	1.82	7.5	1.95	9.4	2.34	10.9	2.06	21.6	2.54
Kent	8.3	2.61	8.9	2.32	7.2	1.79	10.4	1.96	9.0	1.05
Ottawa	5.4	1.69	6.6	1.72	6.7	1.67	7.9	1.49	11.5	1.35
Van Buren	4.3	1.35	6.0	1.56	4.6	1.14	6.0	1.13	6.9	0.81
South										
Barry	4.4	1.38	5.8	1.51	8.5	2.11	9.3	1.75	20.9	2.46
Branch	5.8	1.82	6.5	1.69	7.9	1.96	9.6	1.81	16.4	1.93
Calhoun	8.3	2.61	11.2	2.92	9.5	2.36	15.2	2.87	23.7	2.79
Clinton	6.3	1.98	7.6	1.98	9.9	2.46	16.3	3.07	34.5	4.06
Eaton	7.2	2.26	7.8	2.03	9.1	2.26	12.4	2.34	20.7	2.43
Hillsdale	7.2	2.26	7.2	1.87	8.2	2.04	10.8	2.04	15.6	1.83
Ingham	6.2	1.95	7.9	2.06	11.2	2.78	13.1	2.47	28.4	3.34
Ionia	8.0	2.51	9.2	2.39	12.5	3.11	16.6	3.13	33.5	3.95
Jackson	7.3	2.29	7.8	2.03	12.3	3.06	10.2	1.92	19.5	2.29
St. Joseph	4.0	1.26	5.9	1.54	5.1	1.27	9.6	1.81	17.8	2.09
Shiawassee	4.3	1.35	6.5	1.69	7.2	1.79	7.4	1.40	14.2	1.67

Table 3.1 (Continued)

Area	1949		1954		1959		1964		1980[2]	
	Number (thous)	% of state	Number (thous)	% of state	Number (thous)	% of state	Number (thous)	% of state	Number (thous)	% of state
Southeast										
Genessee	5.7	1.79	6.8	1.78	6.6	1.64	9.8	1.85	15.2	1.78
Lapeer	7.6	2.39	8.8	2.29	10.6	2.63	11.8	2.23	19.7	2.32
Lenawee	13.0	4.08	21.0	5.47	30.0	7.46	38.7	7.30	96.2	11.32
Livingston	4.0	1.26	6.5	1.69	7.6	1.89	9.2	1.73	20.1	2.37
Macomb	4.5	1.41	4.7	1.22	4.5	1.12	4.1	0.77	1.9	0.22
Monroe	5.8	1.82	6.0	1.56	8.3	2.06	12.0	2.26	23.3	2.74
Oakland	6.2	1.96	7.7	2.00	4.7	1.17	6.1	1.15	1.0	0.11
St. Clair	7.1	2.23	8.5	2.21	10.1	2.51	13.6	2.56	25.1	2.96
Washtenaw	9.7	3.04	11.3	2.94	15.0	3.73	16.8	3.17	31.9	3.75
Wayne	1.4	0.44	1.4	0.36	1.3	0.32	1.1	0.21	0.0[b]	0.00[b]
Indiana[3]										
Dekalb	4.3		5.1		7.1		6.3		9.4	
Elkhart	7.2		9.6		12.1		13.1		19.6	
Kosciusko	11.7		14.4		19.0		21.7		32.3	
LaGrange	5.5		7.3		13.7		13.7		24.0	
LaPorte	6.9		9.2		11.8		12.5		18.8	
Marshall	7.7		9.0		9.3		13.9		18.5	
Noble	6.2		8.8		8.6		10.8		14.7	
St. Joseph	4.2		6.8		9.6		8.2		13.9	
Starke	2.6		3.3		2.1		2.1		1.4	
Steuben	4.7		5.2		6.5		6.4		8.6	
Ohio[3]										
Defiance	3.5		4.2		5.7		6.5		9.8	
Fulton	14.4		26.7		42.6		49.7		88.1	
Henry	7.6		9.9		10.4		15.0		20.9	
Lucas	2.2		3.8		4.6		3.3		5.4	
Ottawa	2.4		2.9		4.4		3.9		6.2	

Table 3.1. (Continued)

Area	1949 Number (thous)	1949 % of state	1954 Number (thous)	1954 % of state	1959 Number (thous)	1959 % of state	1964 Number (thous)	1964 % of state	1980[2] Number (thous)	1980[2] % of state
Ohio (con't.)										
Sandusky	5.8		9.9		14.1		12.0		20.7	
Williams	6.6		7.8		10.7		15.8		23.9	
Wood	11.6		18.0		24.4		24.3		39.6	
GRAND TOTAL[4]	433.7		546.1		619.0		769.5		1226.2	

[1]Source: United States Department of Commerce, or Bureau of the Census, United States Census of Agirculture -- Michigan, 1949, 1954, 1959, 1964.

[2]Michigan production based on a linear projection of each area's production expressed as a percentage of the state's production. Projected percentages were then multiplied by the 850,000 head state projection from Michigan State University, Project '80 Rural Michigan Now and in 1980 -- Livestock and Meat, Michigan Agricultural Experiment Station and Cooperative Extension Service Research Report No. 50, East Lansing: Michigan State University, 1966, p. 3.

[a]Projections indicated a negative figure and was thus set equal to zero.

[b]Projections indicated less than .005 percent and less than .5 thousand.

[3]Indiana and Ohio production based on a linear projection of each area's 1949-1964 production as reported by U.S. Bureau of Census, United States Census of Agriculture for the respective states.

[4]Excludes Michigan's Upper Peninsula, columns may not add to total due to rounding.

increase since 1950 has been considerable. The number of beef cows on Michigan farms in 1950 was only 39 thousand, compared to 166 thousand in 1967.[1]

Regression analysis of these two opposing trends, using data for the years 1950 to 1967 indicate an average annual decline in dairy cow numbers of over 11,500 and an annual increase in beef cow numbers of approximately 2,600.

These trends are reflected in the Project '80 projections for beef[2] and dairy cows[3] on farms. In order to estimate their influence on the production of cattle for slaughter the following assumptions were made:

1) The number of calves weaned will be 85 percent of the number of cows on farms for both dairy and beef herds.
2) A replacement rate of 25 percent for dairy herds and 20 percent for beef breeding stock.
3) All dairy steers will be fed.
4) All dairy heifers not used for replacements will be sold for veal.

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[1]Michigan Department of Agriculture, Crop Reporting Service, and U.S. Department of Agriculture, Statistical Reporting Service, Michigan Agricultural Statistics, Lansing: Michigan Department of Agriculture, 1951, p. 28 and 1967, p. 42.

[2]Michigan State University, Project '80 Rural Michigan Now and in 1980 -- Livestock and Meat, Michigan State University Agricultural Experiment Station and Cooperative Extension Service, Research Report No. 50 (East Lansing: Michigan State University 1966), p. 3.

[3]Michigan State University, Project '80 Rural Michigan Now and in 1980 -- The Dairy Industry, Michigan State University Agricultural Experiment Station and Cooperative Extension Service, Research Report No. 45 (East Lansing: Michigan State University, 1966), p. 4.

5) All beef steers and heifers, not used for replacements will be fed.

6) Project '80 projections of 350,000 head of beef cows and 450,000 head of dairy cows on farms January 1, 1980.

7) A linear projection of inshipments of feeder cattle based on the 1950 to 1966 period.

8) Project '80 projections of 850,000 head marketed in 1980.

Using these assumptions, projections to 1980 of the number and percent of cattle by type were made and are summarized in Table 3.2.

These totals in table 3.2 are comparable to the estimates of 650 thousand fed plus nonfed steers and heifers and the 200 thousand cows and bulls which appear in Project '80.[1]

The significance of these estimates is the projected increase in the volume of fed cattle available for slaughter in Michigan and the corresponding decline in the importance of nonfed cattle.

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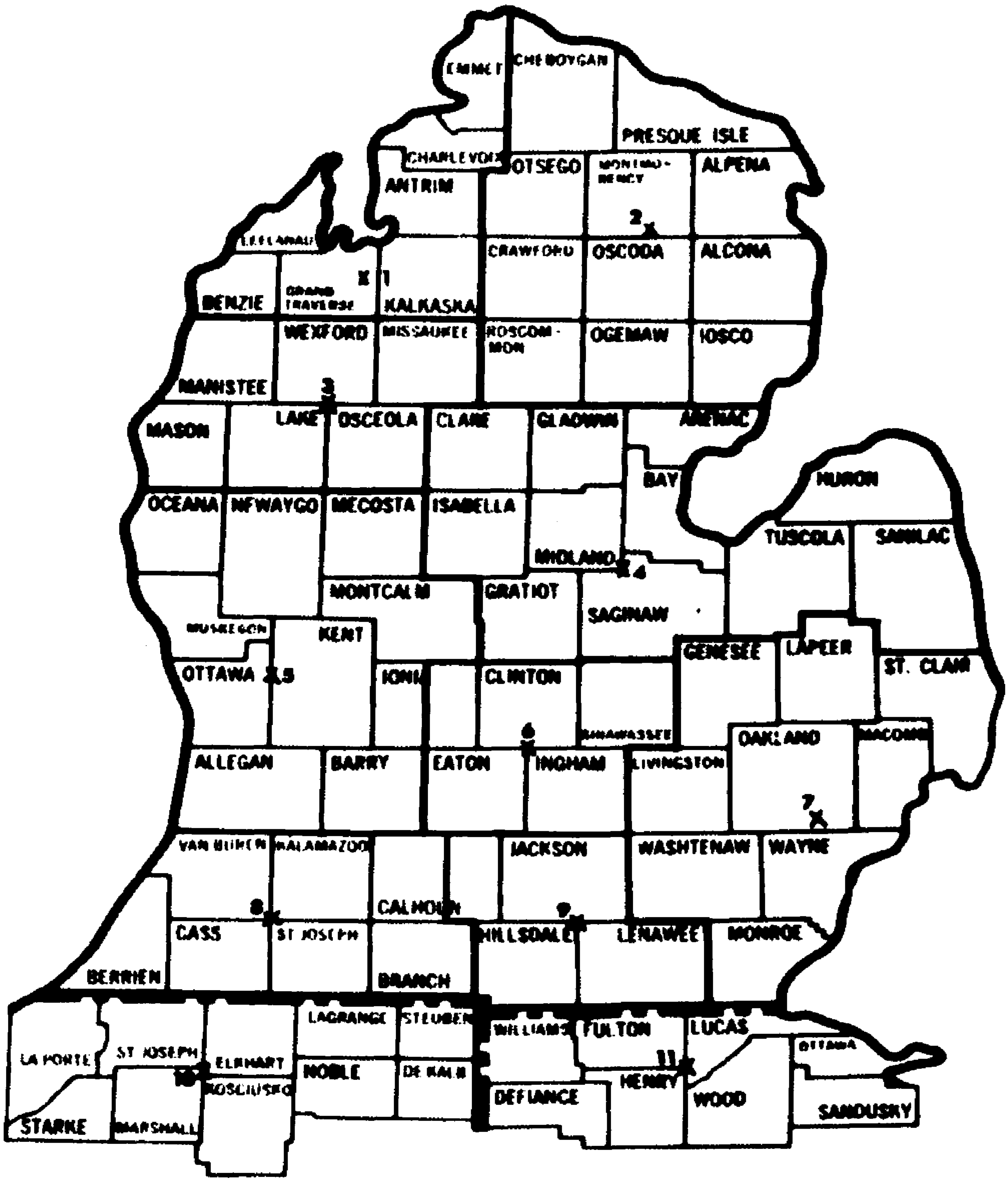
[1]Michigan State University, Project '80 Rural Michigan Now and in 1980 -- Livestock and Meat, Michigan State University Agricultural Experiment Station and Cooperative Extension Service, Research Report No. 50 (East Lansing: Michigan State University 1966), p. 3.

Table 3.2. Projections of Number and Percent of Cattle Marketed by Type, Michigan, 1980.

Type	Number	Percent
Total all cattle	850,000	100
Total fed cattle	655,000	77
Instate production	519,000	61
Beef steers and heifers	289,000	34
Dairy steers	230,000	27
Inshipment of feeder cattle	136,000	16
Total non fed cattle	195,000	23
Cull dairy animals	119,000	14
Cull beef animals	76,000	9

Beef Consumption Projections

The first step in projecting beef consumption by areas was to specify points to be used as beef receiving points in the transportation estimates. Two interrelated considerations were important. Since it is assumed that the packing plants will not be breaking carcasses but shipping carcass beef, the receiving points were selected to be representative of regional wholesale distributing points. This reduces the number of beef receiving points one need consider. This reasoning is tied to the idea of regional or urban areas that serve as a hub for retail and wholesale trade (i.e., the concept of trade centers). In the final selection of consumption centers, eleven were chosen and are shown in Figure 3.2.



KEY

1. Traverse City
2. Alpena
3. Cadillac
4. Saginaw
5. Grand Rapids
6. Lansing
7. Detroit
8. Kalamazoo
9. Jackson
10. South Bend
11. Toledo

Figure 3.2. Outline of Beef Consumption Areas in Study.

The projection of consumption for each area in Michigan was developed from population and per capita consumption projections from Project '80 reports.[1] Table 3.2 presents this data. It should be noted that these projections do not take into account differences in consumption among areas due to differences in income, place of residence, nationality and other factors that may influence consumption.

For counties in Northern Indiana and Ohio that are included in the study, the following procedures were used. First, state population projections were obtained from current population reports of the United States Bureau of the Census. Second, the percent of the state's population residing in each county for the four census years, 1930, 1940, 1950, and 1960 were calculated. A linear regression equation for each county was calculated and the percentage projected to 1980. These percentages were then multiplied by the projected state population. Finally, the same per capita consumption as used in Michigan was applied to the population projections. Consumption estimates for each area are presented in Table 3.2.

Estimation of Transportation Costs

An important part of the models used to estimate the number, size and location of beef slaughter plants in this

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[1] Michigan State University, Project '80 Rural Michigan Now and in 1980 -- Highlights and Summary of Project '80, Michigan State University Agricultural Experiment Station and Cooperative Extension Service, Research Report No. 37 (East Lansing: Michigan State University, 1966), p. 75-6.

study is the transportation rates applicable to live cattle and carcass beef. Cattle must be assembled from the production areas for slaughter and carcasses distributed to the consumption regions for breaking and distribution.

Estimation of Highway Distances: In estimating transportation costs between production areas, plant sites, and consumption centers, one must determine the distances between production areas and plant sites and between plant sites and consumption areas. With 65 production areas, 15 potential plant sites and 11 consumption areas, this involves determining a total of 1140 distances. Although it would be possible to estimate these distances directly from a state highway map a different approach was taken.

Heifner and Greig,[1] had previously selected 435 points in Southern Michigan and estimated the relationship between highway mileage and air distances, and highway mileage and a rectangular coordinate system of point identification. Air mileage and rectangular distances proved to be equally satisfactory in predicting highway mileage for Michigan. Since one of the computer routines used later had already been programmed for use of rectangular distances, this method was selected.

Using a common point of origin due west of the southwest corner of the state, east-west and north-south

[1]Unpublished material made available by Richard G. Heifner and W.S. Greig, Assistant and Associate Professors, Agricultural Economics Department, Michigan State University, respectively.

Table 3.3. Projected Human Population and Consumption of Beef by Areas, 1980.

Area	Projected Population[1] (number)	Projected Beef Consumption[2]		
		Steer & Heifer[3] (100 pounds)	Cow & Bull[4] (100 pounds)	Total[5] (100 pounds)
1. Traverse City	93,900	89,205	23,475	112,680
2. Alpena	143,000	135,850	35,750	171,600
3. Cadillac	79,800	75,810	19,950	95,760
4. Bay City	686,400	652,080	171,600	823,680
5. Grand Rapids	1,028,900	977,455	257,225	1,234,680
6. Lansing	526,700	500,365	131,675	632,040
7. Detroit	6,253,400	5,940,730	1,563,350	7,504,080
8. Kalamazoo	718,100	682,195	179,525	861,720
9. Jackson	372,000	353,400	93,000	446,400
10. South Bend	782,100	742,995	195,525	938,520
11. Toledo	894,000	849,300	223,500	1,072,800
TOTAL	11,578,300	10,999,385	2,894,575	13,893,960

[1]Michigan projections from: Michigan State University, Project '80 Rural Michigan Now and in 1980 -- Highlights and Summary of Project '80, Michigan State University Agricultural Experiment Station and Cooperative Extension Service, Research Report No. 37 (East Lansing: Michigan State University, 1966), p. 75. See text for South Bend and Toledo projection procedures.

[2]Ibid., p. 76.

[3]Based on an estimated per capita consumption of 95 pounds.

[4]Based on an estimated per capita consumption of 25 pounds.

[5]Based on an estimated per capita consumption of 120 pounds.

coordinates were measured on a map to the nearest millimeter and a conversion factor of 1.071 miles per millimeter used to estimate distances between points.

Cattle Transportation Rate Function: The cattle transportation rate function, as well as the beef transportation cost function discussed in the next section are based on current transportation technology. To the extent that new technology lowers these rates a given plant can assemble livestock from and distribute beef to larger areas without increasing total costs. This will tend to increase the size of plants and may have significant influence of the interregional distribution of slaughtering. At least two possibilities for decreasing costs appear to be worth mentioning. First, there seems to be some likelyhood that a second trailer behind a tractor-trailer rig may become legal in many states. Secondly, significant reductions in air freight rates appear to be a matter of time. However, the inability of making realistic estimates of these costs with present information made it necessary to restrict transportation estimates to present technology.

To estimate the cost of transporting cattle, interviews to obtain actual rates were conducted with "for hire" truckers in Michigan. A list of truckers was obtained from the Michigan department of Agriculture. In order to help assure that truckers who moved a significant volume of livestock were contacted, only those who had three or more trucks licensed were contacted. Also, because of the concentration of livestock in the lower peninsula and the relatively small volume of livestock that are transported from the Upper Peninsula to markets in the lower Peninsula, truckers from the U.P. were not contacted. Finally, since the list of truckers included auction markets and local sales yards, these were eliminated from consideration. The rationale was that livestock hauling is a sideline business with many of these firms and that much of it was for service of their regular customers rather than being an important part of their business activity. This elimination process left a list of thirty-eight truckers.

Rates were obtained through telephone interviews with 32 of these truckers. Rates for both straight trucks and semi-trailer trucks were recorded. An estimate of the size of truck was obtained by asking the number of 1100 pound steers that make up a full load. In most cases, weight capacity and/or length of bed was also obtained.

Although the desired rate structure for our purposes was on a hundred weight basis no attempt to force this on the truckers was made. In many cases the rates used were on a loaded mile basis. When this was the normal method of quoting rates they were recorded and later converted to a hundredweight basis. Also, for those who normally charged on a hundredweight basis, no forced step function was imposed. The interviewee was free to establish the bounds of each step.

The rates quoted on a loaded mile basis were converted to a rate per hundred pounds by dividing the rate per loaded mile by the capacity of the truck, measured in hundred weights, and multiplying by the median distance of 25 mile steps (12.5, 37.5, etc.).

In a few cases, usually for short distances, rates were quoted on either a per load or per head basis. In these instances, the weight per head was assumed to be 1100 pounds and the capacity weight of the truck or the number of head making up a full load times 1100 pounds per head was used in estimating costs per hundredweight.

Before running the regression analysis, the mean rate for each step was calculated and plotted against the median value of each step. This was accomplished to obtain some idea of the relationship that existed so that an appropriate functional form could be selected for the regression analysis. Based on this plot, a linear function was chosen.

For use in this study, distances of less than 20 to 30 miles are unimportant since one of the assumptions of the models used is that costs for assembly of cattle within a production region does not vary between regions, and are therefore set equal to zero. Since the rates for semi-trailer trucks were lower for all distances above approximately 28 miles, only this rate function was used in estimating transportation costs.

The two regression equations obtained from the regression analysis were:

For straight trucks: $Y = 6.92332 + .29122X \quad \bar{R}^2 = .8078$
$\qquad\qquad (2.28342) \quad (.01671)$

For semi-trucks: $Y = 9.81571 + .18571X \quad \bar{R}^2 = .8449$
$\qquad\qquad (1.21093) \quad (.00717)$

Where Y = cost in cents per hundred pounds live weight

X = one-way mileage

() = standard errors of the coefficients

By dividing the equation through by the dressing percentage they can be converted to rates on a carcass weight equivalent. Assuming a dressing percentage of 57 these equations become:

For straight trucks: $Y = 12.15098 + .51091X$

For semi-trucks: $Y = 17.22054 + .32581X$

Where Y = cost in cents per hundred pounds carcass weight equivalent

X = one-way mileage

It should be pointed out explicitly that the above cost does not include an estimate of the costs due to shrinkage of animal tissue, bruising or other damage to the livestock during transit. For the distances included in this study, tissue shrinkage was not felt to be a major cost item and loss due to bruising or other damage is difficult to estimate and is thought to be more of a function of the loading and unloading facilities and care taken during the loading and unloading process than of distance traveled. Nevertheless it should be recognized that these costs are real and that adding these costs would increase the value of the intercept in the linear function, if not the slope.

Thus, the transportation cost function used may be assumed to be a slight underestimate of the transfer cost function.

Beef Transportation Cost Function: A different approach was taken in estimating the meat transportation function. Since most of the carcass beef is transported by packer-owned and operated truck fleets, a cost function seemed more appropriate. In a recent study by Kerchner the cost of transporting packaged milk by truck was estimated by synthesizing the cost of operating a tractor-trailer unit with a payload capacity of 35,000 pounds of milk.[1] It was assumed that the primary use of a large refrigerated semi-trailer for hauling packaged milk would be to haul milk from a processing plant to a central distribution center.[2] Likewise, in this study it is assumed that meat will be delivered from the plant to primary distribution centers, such as district warehouses. It is further assumed that only carcass beef -- sides and quarters -- would be hauled. All breaking is assumed to be accomplished by the wholesaler or retailer.

Size of truck and refrigeration requirements in this study were judged to be similar enough to the equipment normally used to haul meat so that, with minor adjustments, cost estimates were believed to be appropriate for meat

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[1]Orval Kerchner, Costs of Transporting Bulk and Packaged Milk by Truck, United States Department of Agriculture, Marketing Research Report No. 791 (Washington: U.S. Government Printing Office, 1967), p. 14.

[2]Ibid., p. 1.

hauling. An adjustment for weight of load seemed necessary. Johnson reported that the actual weight of beef carcasses hauled in refrigerated trailers with a 36,000 pound capacity ranged from 28,439 pounds to 32,024 pounds with an average weight of 30,041 pounds.[1] Based on this study it was assumed that the weight of meat hauled by this size truck would average 30,000 pounds.

Kerchner estimated costs per hundredweight for distances ranging from 5 miles to 1600 miles.[2] For our purposes, distances up to 205 miles were used. Although a few potential distances for meat transportation in this study would be beyond this distance, Kerchaner's next step was 400 miles and involved the use of two drivers which seemed unnecessary for distances involved in this study.

Kerchner's estimated costs per hundredweight were multiplied by a factor of 1.1667 (35,000 ÷ 30,000) to account for differences in average weight per load and a least squares regression analysis used to estimate the cost-distance relationships. The following equation was obtained:

$$\underset{(.2548)}{Y = 7.0799} + \underset{(.0023)}{.1813X} \qquad \bar{R}^2 = .9979$$

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[1]H.D. Johnson, R.F. Guilfoy, and R.W. Penney, _Transportation of Hanging Beef by Refrigerated Rail Cars and Piggyback Trailers_, United States Department of Agriculture, Marketing Research Report No. 485 (Washington: U.S. Government Printing Office, 1961), p. 22.

[2]Orval Kerchner, _Costs of Transporting Bulk and Packaged Milk by Truck_, United States Department of Agriculture Marketing Research Report No. 791 (Washington: U.S. Government Printing Office, 1967), p. 18.

Where Y = cents per hundredweight of beef

X = one-way mileage

() = standard errors of the coefficients

Selection of Plant Sites

Several factors were considered in the selection of potential plant sites for inclusion in the models. The distribution of sited throughout the middle and southern portion of Michigan should be sufficient to include all major beef producing areas and major consumption areas. The three present major beef slaughtering areas of the state should be included to determine if they are represented in the final solution. The distribution of sites should also be sufficiently widespread to be sure that no marginal sites appear in the final solution. However, as indicated by French, a square market area tilted 45 degrees with the plant located in the center of the square minimizes the distribution (assembly) costs of a plant, given the rectangular road system which exists in Michigan.[1] This being true, some potential sites on the borders of the area included in this study can be eliminated without fear of eliminating a potentially lower cost site. Because of their importance as consumption centers, two sites, Detroit, Michigan and Toledo, Ohio, both border sites, were included.

It should be stressed, at this point, that the plant

[1]Benjamin C. French, "Some Considerations in Estimating Assembly Costs Functions for Agricultural Processing Operations," Journal of Farm Economics, Vol. 42 (No. 4, 1960), p. 771.

sites selected are not the only acceptable sites available but are chosen to be representative of an area surrounding the specified location. In most cases the sites included are sufficiently close so that each site represents a relatively small area, see Figure 3.3. Differences in wage rates, availability of land, zoning regulations, availability and rates for water, electricity, and other utilities are considerations that must be evaluated in determining specific site selections within the area. The detailed study required for this is considered to be beyond the bounds of this study.

The models and estimating procedures used in this study are sufficiently precise to indicate the areas in the state where slaughter activity should be concentrated, given the objective function of cost minimization, but are not sufficiently precise to differentiate accurately between sites located within a given area.

Selection of Out-of-Area Supply Point

For this study it is assumed that the volume of slaughter in Michigan in 1980 will be a function of Michigan's production of cattle for slaughter. Therefore, all inshipments into Michigan to meet the projected excess demand for meat will be in the form of carcass beef.

Trends developed in Chapter II provide the rationale for this assumption. The major argument against this assumption is the seasonal variability of livestock marketing.

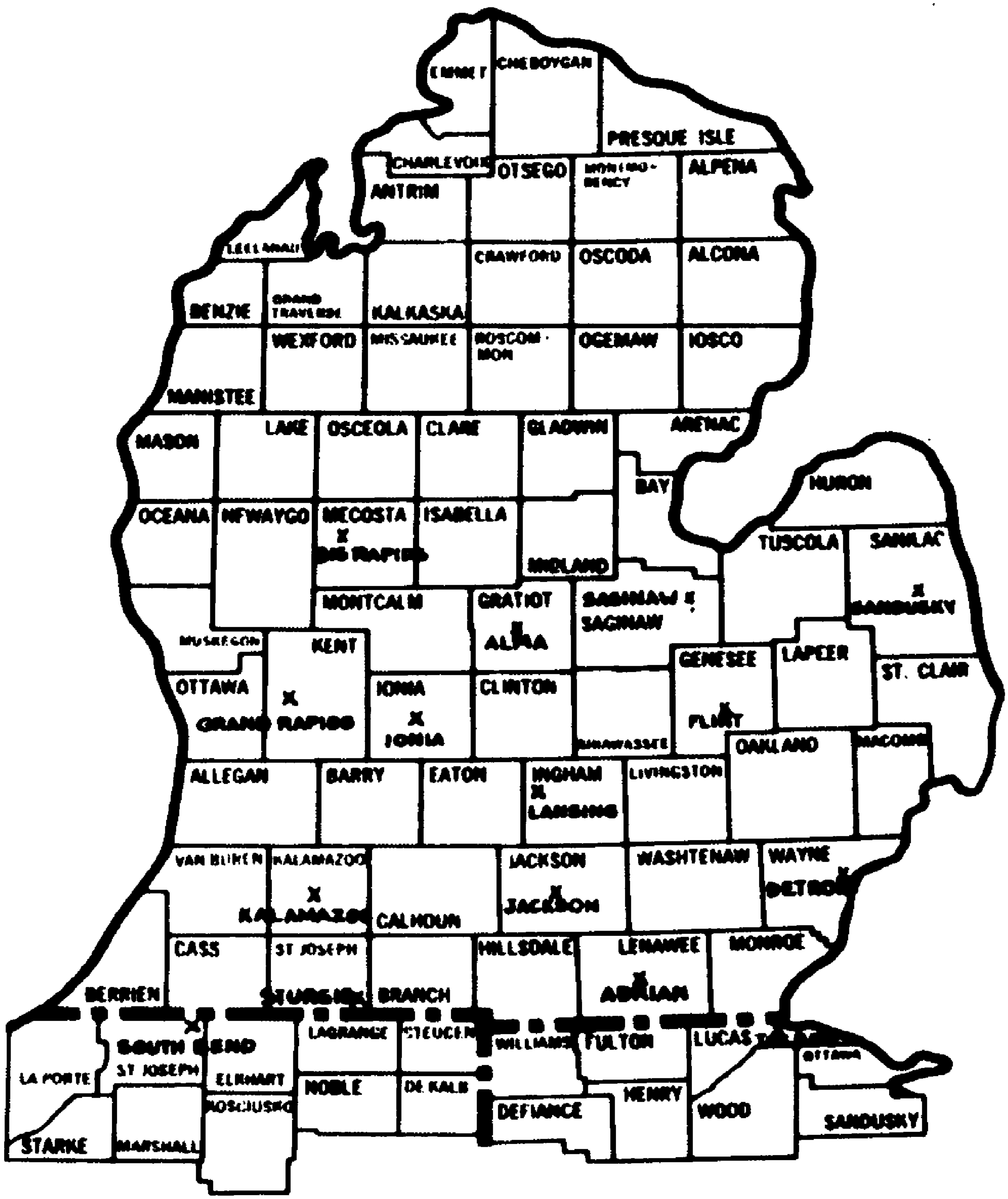

Figure 3.3. Potential Plant Sites in Study.

This variability is likely to force slaughter plants to import some livestock during months when Michigan marketings are low.

In the development of the transhipment model it is necessary that total supply be equal to or greater than total demand. Since Michigan's projected production plus the production of the 18 out-of-state counties, will supply only 53 percent of the projected demand, it is necessary to select out-of-state areas from which the projected inshipments will originate.

Since no estimates are presently available of the volume of inshipments of meat from various out-of-state points a different method of determining these points was necessary. Fortunately, a previous study provides a basis for selection. Crom presented a simulated interregional model of the cattle-meat economy using projected 1975 production and demand conditions. Assuming slaughter capacity in each region was fully utilized his base solution minimized livestock and meat transportation and slaughter labor costs. He also developed solutions involving various changes in the transportation rate structure, distribution of production and consumption, and absences of slaughter capacity restrictions.

The solution obtained by removal of slaughter capacity restriction is of special interest here because this solution provides the possibility of shifting slaughter capacity to minimize the combined transportation of livestock and meat, and slaughter labor costs. This solution provided a savings of $36.75 million or 17 percent in transportation costs over the base solution. An increase in labor costs of $1.8 million resulted in a net savings of $35 million annually.[1] In this solution, only one interregional shipment of live cattle occurred. Thus, the solution amounted to the assumption of all cattle being slaughtered in the region where they were produced. Under this solution, all of the Michigan inshipment was beef and all originated in Iowa. Based on these results, it was assumed for this study that all out-of-area shipments of beef originated in Iowa.

Summary

This chapter presents the methods used for estimating most of the data used in later chapters to obtain the number, size and location of beef slaughter plants within the study area that minimized the combined costs of slaughtering, and transporting live cattle and carcass beef. Projections of cattle marketings to 1980 indicate a total of 1.2 million head of cattle in the study area. Estimates of cattle marketings by areas for 1980 are presented in Table 3.1. Beef consumption projections totaled 1.4 billion pounds in 1980. Projections of beef consumption by areas were presented in Table 3.2.

The estimated transportation rate for live cattle was:

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[1]Richard Crom, Simulated Interregional Models of the Livestock-Meat Industry, United States Department of Agriculture, Agricultural Economics Report No. 117 (Washington: U.S. Government Printing Office, 1967), p. 30.

$Y = 9.81571 + .18571\ X$

Where Y = cost in cents per hundred pounds live weight

X = one-way mileage

The estimated cost of transporting carcass beef was:

$Y = 4.0355 + .1033X$

Where Y = cost in cents per hundred pounds live weight

X = one-way mileage.

The selection of plant sites for inclusion in later estimates and sources of inshipment of carcass beef to meet the excess demand within the study area are also presented.

Chapter 4

LONG-RUN COST FUNCTION FOR CATTLE SLAUGHTERING

Introduction

The objective of this chapter is to develop a long-run in-plant cost function for specialized cattle slaughtering in Michigan. Two alternative approaches to obtain long-run estimates of in-plant costs are generally recognized. Statistical analysis of accounting data obtained from firms operating at various rates of output has been used.[1] A second approach involves the synthesizing of input-output relationships of plants designed for various levels of output.[2] This approach involves a stage by stage study of the physical input requirements for various rates of output. Finally, the aggregation of stages and the application of appropriate factor costs leads to the least cost combination of stages for a given rate of output. In the aggregation of stages the problem of harmonizing stages to minimize overcapacity of each stage and thus minimized cost for the whole operation becomes an important consideration.

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[1] R.E. Schneidau and J. Havlicek, Jr., Labor Productivity in Selected Indiana Meat Packing Plants, Research Bulletin No. 769 (Lafayette: Purdue Agricultural Experiment Station, Nov. 1963).

[2] Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962).

A statistical analysis of accounting data often obtains results at relatively lower costs, especially in cases where no recent economic-engineering data has been previously developed for use in the second approach. However, several limitations to this approach should be pointed out. First, accounting data often is not easily adapted to cost analysis, and may give rise to data inaccuracy.[1] A second problem associated with this method is the selection of the appropriate functional form for use in the regression analysis. Without prior knowledge of the "true" function a bias is likely created by this technique.[2] A true function, as used here, refers to the function from which the data is generated. It has been suggested that, "the usual statistical tests of reliability and of correlation are of very limited usefulness in judging the significance of results as estimates of underlying relationships."[3] This, the authors point out is due primarily to the intercorrelation of the independent variables of capacity and volume of output.[4]

In recent years, the use of the synthetic approach has

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[1]B.C. French, L.L. Sammet, and R.G. Bressler, "Economic Efficiency in Plant Operations with Special Reference to Marketing of California Pears," Hilgardia, Vol. 24, No. 19, (Berkeley: California Agricultural Experiment Station, July 1956), p. 580-1.

[2]John F. Stollsteimer, R.G. Bressler, Jr., and J.N. Boles, "Cost Functions from Cross Sectional Data - Fact or Fantasy," Agricultural Economics Research, Vol. 13 (Washington: U.S. Department of Agriculture), p. 86.

[3]Ibid., p. 89.

[4]Ibid., p. 86.

been increasingly used. According to Black, "The synthetic method of cost analysis permits more accurate research determination of the economies-of-scale curve than is possible by any other method."[1] However, Black also points out four limitations: (1) it does not permit a statistical test of the reliability of the results, (2) it does not overcome the arbitrary allocation of joint and overhead costs, (3) differences in managerial ability are not accounted for, (4) the necessity of making an arbitrary assumption regarding the time dimension of plant operations, i.e., hours per day, days per week, etc., and (5) the possibility of neglecting coordination among stages.[2] It has also been suggested that this approach is unable to detect diseconomies of size or external economies.[3]

However, since the economic-engineering approach is generally recognized to be a more accurate method of estimating economies of size in plant operations and since a recent economic-engineering study by Logan and King is available for use as a basic guide in developing physical input-output requirements, this approach is used in this study.[4]

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[1] Guy Black, "Synthetic Method of Cost Analysis in Agricultural Marketing Firms," Journal of Farm Economics, Vol. 37 (1955), p. 276.

[2] Ibid., p. 275-77.

[3] Robert Newell Wisner, Estimated Optimum Interregional Competition and Location Patterns in the Southern Cattle Slaughtering Industry in 1975 (unpublished Ph.D. Dissertation, University of Tennessee, 1967), p. 85.

[4] Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962).

The general estimating procedure used was to adapt Logan's and King's estimates by making adjustments in their data to reflect current conditions for Michigan. Adjustments in the data are designed to reflect differences due to geographic and time changes. Specific sources of data and estimating procedures used are discussed in the process of reporting the results obtained.

Estimation of Slaughter Cost Function

Present technilogies in specialized beef cattle slaughtering include three basic types of kill floor operations. These are: (1) bed-type systems where carcasses are moved manually along overhead rails and lowered onto a craddle (two parallel bars that hold the carcass on its back about six inches off the floor) or to pritch plates (large metal plates in the floor) for part of the dressing operation; (2) intermittent on-the-rail systems in which the carcass remains on the rail throughout the operation and is moved from one operating station to the next by means of an intermittently operated drive, and (3) continuous on-the-rail systems which, as the name implies, utilizes a continuous rather than intermittent drive rail. For a more detailed discussion of these systems, the reader is referred to Logan and King,[1] and Wisner.[2]

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[1]Ibid., p. 22-6.

[2]Robert Newell Wisner, Estimated Optimum Interregional Competition and Location Patterns in the Southern Cattle Slaughtering Industry in 1975 (unpublished Ph.D. Dissertation, University of Tennessee, 1967), p. 98-9.

Cost estimates in this study will be limited to on-the-rail systems. According to estimates by Logan and King, it appears reasonable to assume, although no direct comparisons were made, that for rates of output in excess of 60 head per hour continuous on-the-rail systems provide significant cost advantages over other systems.[1] Discussions with equipment manufacturers confirm these findings. Also, it was learned through discussion with industry personnel that almost all new plants are utilizing on-the-rail systems. As pointed out by Logan and King, the factors considered in their study were limited to costs and did not include worker satisfaction or quality of product. Worker satisfaction is likely to be in favor of the on-the-rail system since it eliminates almost all bending and stretching.[2] At the same time it should be recognized that for the two smaller size plants considered in this study, conventional bed-type plants may offer cost advantages over the intermittent on-the-rail systems estimated. Also, through discussions with industry personnel it was discovered that there is disagreement on the relative efficiency of intermittent and continuous systems at these levels of output. This being the case, cost estimates for the smaller plants may be somewhat overstated.

Before proceeding to the estimates it should be made explicit that all cost estimates reflect current conditions.

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[1]Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 102.

[2]Ibid., p. 104.

No attempt was made to project changes in technology, its influence on costs, or to interject into the estimating procedure expected changes in factor costs.

In the following discussion of estimating procedures and presentation of cost estimates, costs are broken down into the following categories: labor; equipment; building, corrals and parking area; land; utilities; interest; property taxes; insurance; and miscellaneous supplies and services.

Labor: Except for the cost of livestock labor represents the largest single expense item in most beef slaughter plants. Some studies have estimated labor costs to be in excess of 60 percent of the total annual operating costs excluding the cost of cattle.[1] Because of its importance, it is desirable to estimate this cost as closely as possible. Relatively small changes in hourly wages can have a relatively large influence on the firm's labor costs. In addition to hourly wages, vacation and holiday pay, as well as fringe benefits must be estimated. Although all costs should be estimated as closely as feasible, one needs to keep in mind one of the weaknesses of the economic-engineering study. That is, the influence of managerial skills on costs cannot be evaluated directly and thus all costs must reflect costs at an assumed level of management. Management

[1] John R. Franzmann and B.T. Kuntz, Economies of Size in Southwestern Beef Slaughter Plants, Bulletin No. B-648, (Stillwater: Oklahoma Agricultural Experiment Station and U.S.D.A. Cooperating, April, 1966), p. 23.

of the firm is likely to also have a significant influence on labor productivity and thus the actual labor costs of the operation.

Labor requirements, as was true of most plant requirements, were taken from Logan and King.[1] Wages covered by union contracts were estimated with the direct assistance of Michigan labor union representatives,[2] while non-union wages were adjusted for time and geographic differences from Logan and King.[3]

Unionized labor wages for Michigan were applied to each operation specified by Logan and King. Since Michigan currently has only one plant that has an on-the-rail system, it was necessary for union representatives to apply wage rates to each operation based on this one plant plus indirect experience with this type of system and on their experience with bed-type plants. Although considerable differences in operations and skill requirements are involved between the two systems, the estimates provided appear to be reasonable and are the best currently available. Table 4.1 gives a summary of labor requirements and costs. Detail data are presented in Appendix Tables 1, 2 and 3.

Once wage rates were obtained, annual labor costs had

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[1]Samuel H. Logan and Gordon A. King. Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 123-7.

[2]Amalgamated Meat Cutters and Butcher Workmen of North America Local 630, Detroit, Michigan.

[3]Logan and King, p. 127.

Table 4.1. Number of Workers, Annual Labor Cost Per Worker and Total Yearly Labor Cost by Size of Plant, Michigan, 1968.

No. of Workers	Annual Labor Cost Per Worker: Wages	Vacation Pay	Sick Leave	Health & Welfare	Pensions & Retirement	Total	Total Yearly Labor Cost
				20 Head Per Hour Plant			
9	$5,200	200	80	$120	$208	5,808	52,272
4	5,616	216	86	120	208	6,246	24,984
1	6,656	256	102	120	208	7,342	7,342
1	6,760	260	104	120	208	7,452	7,452
1	6,864	264	106	120	208	7,562	7,562
1	6,900	-	-	-	-	6,900	6,900
10	9,485	365	146	120	208	10,324	103,240
1	10,000	-	-	-	-	10,000	10,000
1	12,100	-	-	-	-	10,000	12,100
3	13,800	-	-	-	-	13,000	41,400
1	23,300	-	-	-	-	23,300	23,300
33	-	-	-	-	-	-	296,552
				40 Head Per Hour Plant			
21	5,200	200	80	120	208	5,808	121,968
8	5,616	216	86	120	208	6,246	49,968
1	6,656	256	102	120	208	7,342	7,342
2	6,760	260	104	120	208	7,452	14,904
1	6,900	-	-	-	-	6,900	6,900
1	7,280	280	112	120	208	8,000	8,000
1	8,600	-	-	-	-	8,600	8,600
1	10,000	-	-	-	-	10,000	10,000
17	10,026	386	154	120	208	10,894	185,198
1	12,100	-	-	-	-	12,100	12,100
6	13,800	-	-	-	-	13,800	82,800
2	16,000	-	-	-	-	16,000	32,000
1	25,800	-	-	-	-	25,800	25,800
63	-	-	-	-	-	-	565,580

Table 4.1. (Continued)

No. of Workers	Annual Labor Cost Per Worker: Wages	Vacation Pay	Sick Leave	Health & Welfare	Pensions & Retirement	Total	Total Yearly Labor Cost
			60 Head Per Hour Plant				
28	5,200	200	80	120	208	5,808	162,624
11	5,616	216	86	120	208	6,246	68,706
1	6,656	256	102	120	208	7,342	7,342
2	6,760	260	104	120	208	7,452	14,904
3	6,900	-	-	-	-	6,900	6,900
1	7,280	280	112	120	208	8,000	8,000
1	8,600	-	-	-	-	8,600	8,600
1	10,000	-	-	-	-	10,000	10,000
24	10,650	410	164	120	208	11,552	277,248
1	12,100	-	-	-	-	12,100	12,100
11	13,800	-	-	-	-	13,800	151,800
2	17,300	-	-	-	-	17,300	34,600
2	19,000	-	-	-	-	19,000	38,000
1	28,300	-	-	-	-	28,300	28,300
89	-	-	-	-	-	-	829,124
			75 Head Per Hour Plant				
35	5,200	200	80	120	208	5,808	203,280
11	5,616	216	86	120	208	6,246	68,707
1	6,656	256	102	120	208	7,342	7,342
3	6,760	260	104	120	208	7,452	22,356
3	6,900	-	-	-	-	6,900	20,700
1	7,280	280	112	120	208	8,000	8,000
1	8,600	-	-	-	-	8,600	8,600
1	10,000	-	-	-	-	10,000	10,000
27	11,835	455	182	120	208	12,800	345,600
1	12,100	-	-	-	-	12,100	12,100
12	13,800	-	-	-	-	13,800	165,600
2	17,300	-	-	-	-	17,300	34,600

Table 4.1. (Continued)

No. of Workers	Annual Labor Cost Per Worker: Wages	Vacation Pay	Sick Leave	Health & Welfare	Pensions & Retirement	Total	Total Yearly Labor Cost
	75 Head Per Hour Plant (Con't)						
2	19,000	-	-	-	-	19,000	38,000
1	28,300	-	-	-	-	28,300	28,300
101	-	-	-	-	-	-	973,184
	120 Head Per Hour Plant						
51	5,200	200	80	120	208	5,808	296,208
16	5,616	216	86	120	208	6,246	99,936
1	6,656	256	102	120	208	7,342	7,342
5	6,760	260	104	120	208	7,452	37,260
4	6,900	-	-	-	-	6,900	6,900
1	7,280	280	112	120	208	8,000	8,000
3	8,600	-	-	-	-	8,600	25,800
2	10,000	-	-	-	-	10,000	20,000
44	11,627	447	179	120	208	12,581	553,564
2	12,100	-	-	-	-	12,100	24,200
18	13,800	-	-	-	-	13,800	248,400
2	19,000	-	-	-	-	19,000	38,000
2	21,000	-	-	-	-	21,000	42,000
1	30,800	-	-	-	-	30,800	30,800
152	-	-	-	-	-	-	1,438,410

Source: See Appendix Tables 1 through 4.

to be synthesized. For operations paid on an hourly basis, it was assumed that employees were paid for 260 eight-hour days including vacations, holidays, and sick leave, or 2080 hours per year. For those paid on a per head basis, the rated hourly output of the plant was assumed. This was divided by the number of piece rate workers to obtain the output per hour per worker. This rate ranged from 2.3 to almost 2.8 head per employee, generally increasing with the size of plant. This is consistent with the rule of thumb used by unions in setting piece rate wages. They assume an output of approximately two head per man up to about ten-piece rate workers and then about 2.5 head per man for larger plants.[1] The output per hour per worker was then multiplied by the rate per head, the 2080 hours of operation, and the number of workers per opeation to obtain the annual wage cost for each operation. In cases where one worker handled more than one operation, the wage for the higher paying operation was used.

Estimates of annual labor costs for salaried personnel are difficult to estimate with any degree of precision. Variations will occur depending on the structure of the firm's ownership. Where managers are also owners of the plant, extreme variations in the methods of allocating returns above all other costs to the managers are likely to to occur. In some cases, supervisory personnel may be

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[1]Obtained in informal discussion with union representatives.

allowed to share in the profits of the firm as an incentive; in others only a standard salary will be paid.

Logan and King based their estimates on accounting records from firms surveyed in California.[1] In adjusting these costs to account for geographic and time differences, the average hourly wages paid production and nonsupervisory personnel in manufacturing establishments published by the U.S. Department of Labor was used.[2]

The following formula was used to make the necessary adjustment:

$$W_D = W_{LA}\ [1 + (.248 \times .509)]\ [1.18]$$

or

$$W_D = 1.33\ W_{LA}$$

where:

W_D = Detroit wage in 1968

W_{LA} = Los Angeles wage in 1961

.248 = The percent (expressed as a decimal) increase in average hourly wages for all manufacturing industries in Los Angeles between April 1961[3] and April 1968[4]

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[1]Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 50.

[2]U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings (Washington: U.S. Government Printing Office, June 1961), Vol. 7, No. 12, p. 94.

[3]Ibid., June 1961, p. 39.

[4]Ibid., June 1968, p. 94.

.509 = The ratio of the percent change in average wages between April, 1961[1] and April, 1968[2] in the meat packing industry in the U.S. to the percent change in average wages for all manufacturing for the same period.[3,4]

1.18 = The ratio of average Detroit wages in all manufacturing industries in April 1968[5] to the average Los Angeles wages for the same industries.[6]

For labor requirements and salaries applied to each size plant see Appendix Table 4.

In addition to wages, labor costs include costs for vacation pay, sick leave, group health and welfare plans, and pensions and retirement funds for labor covered by union contracts. It is assumed that any employer costs associated with these items for salaried employees are included in their salary. Social security, taxes and unemployment insurance are included in miscellaneous supplies and services. Guidelines for estimating these costs were obtained from a union contract.[7] According to union representatives, these items are standard across all contracts in Michigan.

Vacation time varies with the length of employment as follows:

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[1] Ibid., June 1961, p. 33.

[2] Ibid., June 1968, p. 82-3.

[3] Ibid., June 1961, p. 30.

[4] Ibid., June 1968, p. 78.

[5] Ibid., June 1968, p. 95.

[6] Ibid., June 1968, p. 94.

[7] Amalgamated Meat Cutters and Butcher-Workmen of North America, 1967-1970 Agreement Great Markwesten Packing Company with Amalgamated Meat Cutters and Butcher-Workmen of North America Local 630 AFL - C.I.O., pp. 13-21.

One year or more of service - 40 hours (1 week)

Three years or more of service - 80 hours (2 weeks)

Ten years or more of service - 120 hours (3 weeks)

Fifteen years or more of service - 160 hours (4 weeks)[1]

Two weeks of paid vacation per employee per year was used in this study.

Each employee received 32 hours (4 days) sick leave per year with pay at the regular hourly rate. This leave is cumulative at its entirety and upon completion of the contract period must be paid for by the employer.[2]

Employer contributions to the Union's group health and welfare fund is $120 per employee per year.[3]

For the pension and retirement fund, the employer must contribute a total of $208 per employee per year effective June 1, 1968.[4]

For a detailed breakdown of total labor requirements and cost per plant by operation, see Appendix Tables 1, 2, 3 and 4. Data in Table 4.1 summarizes these costs for each size plant.

Equipment: Equipment requirements for each synthesized plant are specified in the Logan and King study.[5] However,

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[1] *Ibid*., p. 15.

[2] *Ibid*., p. 13.

[3] *Ibid*., p. 19.

[4] *Ibid*., p. 21.

[5] Samuel H. Logan and Gordon A. King, *Economies of Scale in Beef Slaughter Plants*, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 129-30.

at the request of the manufacturers, only total equipment costs are published.[1] Contacts with manufacturers indicated that no major changes in technology since 1961, had occured, thus no changes in equipment requirements were made. Recent equipment cost estimates from a manufacturer were obtained from Purdue University.[2] The costs obtained were total costs by size of plant for kill floor, refrigeration, and office equipment. The prices quoted were f.o.b. Chicago prices and excluded taxes and installation costs.

Through contacts with industry personnel involved in the contracting of equipment installation, an "average" figure used in estimating installation costs of 30 to 33 percent of the equipment cost was obtained. The larger percentage was used in this study. To the f.o.b. Chicago equipment prices a 4 percent Michigan sales tax was also added. No attempt was made to estimate freight costs due to the minor significance of this cost relative to the total costs of the equipment. Total investments in equipment, including tax and installation may be found in Table 4.2.

In order to estimate the annual cost of equipment, it would be desirable to estimate the average salvage value and average length of life for each piece of equipment. The salvage value could then be deducted from the purchase price

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[1] _Ibid_., p. 72.

[2] Through correspondence with Mr. Terry Roe, Graduate Assistant, Agricultural Economics Department, Purdue University, West Lafayette, Indiana.

Table 4.2. Total and Annual Equipment Costs by Size of Plant, Michigan, 1968.

Plant Size in No. of head per hour	Cost of Equipment (dollars)	Salvage Value (dollars)	Balance for Depre- ciation (dollars)	Average Length of Life (years)	Annual Depre- ciation (dollars)
20	112,600	8,600	107,500	12.5	8,600
40	167,900	13,000	160,200	12.0	13,400
60	268,800	20,700	256,300	12.3	20,800
75	308,400	23,700	294,100	12.3	23,900
120	480,800	37,000	458,500	12.8	35,820

Source: Cost of Equipment - Allbright-Nell Co., Chicago, Illinois. Includes f.o.b. plant price plus installation cost estimated to be 33 percent of kill floor and refrigeration equipment cost for each plant. Installation estimation procedure obtained from Omaha Manufacturing and Engineering Company, Omaha, Nebraska.

Salvage Value - 10 percent of equipment cost, excluding installation cost and sales tax.

Balance for Depreciation - Cost of equipment plus 4 percent sales tax, plus installation cost minus salvage value.

Average Length of Life - Calculated from Logan and King, see text for procedure.

Annual Depreciation - Balance for depreciation divided by average length of life.

All figures rounded to nearest $100.

of the equipment and the remaining depreciable balance depreciated over the life of the equipment.

Due to the lack of detailed cost data on each piece of equipment, this approach was not possible. Again, the work of Logan and King was relied upon. The annual depreciation for equipment reported by Logan and King for each plant was divided into the total balance to be depreciated.[1] This yielded an "average" length of life for the equipment specified for each plant. Also, for each size plant, the salvage value was assumed to be 10 percent of the equipment cost excluding installation cost.

Using these two sets of figures - average length of life for the equipment and salvage value - annual depreciation costs for equipment for each plant was estimated. Estimates are recorded in Table 4.2.

Building, Corrals and Parking Area: California building cost data from Logan and King[2] was adjusted to Michigan prices in 1968 by using data from Architectural Record.[3] Historical building costs for all building types are compared over time for 21 major cities in the United States including Detroit and Los Angeles. Each city's index is based

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[1]Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 72.

[2]Ibid., p. 75.

[3]W.F. Dodge, Cooperation, "Building Cost Indexes and Indications," Architectural Record, Vol. 143, pt. 1 (March 1968), p. 89.

on 1941 averages for that city, so direct comparisons of costs among cities based on the cost indexes are not possible. However, beginning in March, 1963, a cost differential which can be used to compare costs between cities is published.

Logan and King estimated building costs from a published meat industry report (source not given) and verified these costs for the Los Angeles area through discussions with architects and industrial engineers in the Los Angeles area.[1] In order to adjust these costs to current prices, they were multiplied by 113 percent, the increase suggested by the Los Angeles indexes published in Architectural Record.[2] Secondly, costs were adjusted to Detroit prices by multiplying current Los Angeles costs by 111 percent, based on cost differentials for March, 1968 from Architectural Record.[3]

Building and corral requirements and costs, including a 5 percent architectural fee, are presented in Table 4.3.

Although Logan and King did not include parking area requirements in their cost estimates, they are estimated for this study. For details on space requirements for

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[1]Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 59.

[2]W.F. Dodge, Cooperation, Building Cost Indexes and Indications," Architectural Record, Vol. 143, pt. 1 (March 1968), p. 89.

[3]Ibid.

Table 4.3. Building, Corral and Parking Area Requirements and Costs by Size of Plant, Michigan, 1968.

Plant Size in No. of head per hour	Building Requirement (sq.ft.)	Corrals (sq.ft.)	Corral Gates (No.)	Length of Fencing (feet)	Parking Requirement (sq.ft.)	Total Cost[1] (dollars)	Depreciation per year[2] (dollars)
20	10,111	9,313	34	1,107	12,580	243,000	9,720
40	19,367	17,813	68	2,037	23,800	380,000	15,200
60	27,295	26,313	102	2,977	33,320	549,000	21,960
75	31,591	32,813	128	3,687	37,740	644,000	25,760
120	46,852	51,913	204	5,777	56,780	978,000	39,120

[1] See text for procedures on cost estimates. Total cost excludes land costs which are included in another section. Cost rounded to nearest $1,000.

[2] Depreciation assumes a 25 year life and zero salvage value. Total cost divided by 25 years.

Source: All requirements taken from Samuel H. Logan and Gordon A. King. Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), pp. 62-4.

parking the reader is referred to the next section on land. Total parking area requirement are listed in Table 4.3 for completeness.

An estimated cost of 32 cents per square foot of paving was obtained from contractors in Lansing, Michigan. Total costs for parking are included in the total cost figure by size of plant in Table 4.3.

The annual costs for improvements were estimated by assuming a 25 year life (a figure commonly used in the industry), a straight line depreciation policy, and zero salvage value.[1] Annual depreciation costs may be found in Table 4.3.

Land: Land requirements were estimated by adding together building, corrals and parking area requirements, and are listed in Table 4.4. Building and corral requirements were taken from Logan and King.[2] Parking area requirements were estimated by assuming a parking space for each employee plus 10 percent for visitors and business associates. Requirements per space were based on 9 by 18 foot spaces and 24 foot roadways. In addition to the roadway between parking lanes, a 24 by 60 foot roadway for every 20 parking spaces was added for access roads. The resulting 342 square feet per space was rounded to 340 square feet.

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[1]Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 74.

[2]Ibid., p. 67.

Table 4.4. Land Requirements and Costs by Size of Plant, Michigan, 1968.

Plant size in No. of head per hour	Land Requirements				Land Cost	
	Building Area	Corral Area	Parking Area	Total Land Area	Per sq.ft.	Total
	------------sq. feet------------				---dollars---	
20	10,111	9,313	12,580	32,004	.60	19,202
40	19,367	17,813	23,800	60,980	.60	36,588
60	27,295	26,313	33,320	86,928	.55	47,810
75	31,591	32,813	37,740	102,144	.55	56,179
120	46,852	51,913	56,780	155,545	.50	77,772

Source: Building and corral requirements from Smauel H. Logan and Gordon A. King. Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 67.
Parking area requirements based on space for 110 percent of the number of employees and 340 square feet per space.
Costs per square foot estimated from discussions with Ingham County, Michigan tax equilization director.

Land costs were estimated from information obtained from the Ingham County, Michigan tax equilization director. Land was assumed to be industrial land adjacent to a major urban area (Detroit excluded) with all utilities provided to the site. Minimum highway frontage and no rail siding requirements were also assumed. Based on this description, a range of 35 to 60 cents per square foot was obtained. One of the major variables in the cost was the size of the tract, with small tracts commanding a higher price. For this reason, the cost per square foot was assumed to vary from 50 to 60 cents per square foot depending on size. This variation, although admittedly arbitrary, appeared to be more realistic than a constant cost figure. Land cost estimates may be found in Table 4.4.

Utilities: Annual utility requirements were assumed to be the same as reported by Logan and King.[1] These are reported in Table 4.5 through 4.8.

Cost estimates, reported in Tables 4.5 through 4.8, were calculated from rate schedules obtained from a major Michigan utility company or from the city of Lansing. The rate schedules used are included as footnotes to the tables and will not be repeated in the text.

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[1]Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), pp. 80-88.

Table 4.5. Annual Electrical Requirements and Costs by Size Plant, Michigan, 1968.

Plant size in head per hour	Yearly Electrical Requirements	Average Monthly Electrical Requirements	Billing Demand per Month	Monthly Demand Charge	Monthly Energy Charge	Total Monthly Electrical Cost	Total Yearly Electrical Cost
	----------kwh----------		kw	----------dollars----------			
20	741,118	61,760	247	505	631	1,136	13,632
40	1,325,052	110,421	442	823	1,069	1,895	22,840
60	1,908,987	159,082	636	1,107	1,507	2,614	31,368
75	2,344,991	195,416	782	1,319	1,827	3,146	37,752
120	3,660,790	305,066	1,220	1,954	2,842	4,796	57,552

Source: Electrical requirements obtained from Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 84.
Billing demand estimated to be 4 k.w. for every 1,000 kwh, from Logan and King, Economies of Scale in Beef Slaughter Plants, p. 83.
Electrical rates obtained from Consumers Power Company, Jackson Michigan. Commercial and Industrial Primary Service Contract D was used. Rates were effective on or after April 27, 1967.

The following rate schedule was applied:

Demand charge:

- 2.55 per kw for the first 100 kw of billing demand
- 1.70 per kw for the next 300 kw of billing demand
- 1.45 per kw for the next 1600 kw of billing demand
- 1.30 per kw for the next 18,000 kw of billing demand
- 1.20 per kw for all over 20,000 kw of billing demand

Energy charge:

- 1.05¢ per kwh for the first 50,000 kwh
- .90¢ per kwh for the next 180 kwh per kw of billing demand
- .75¢ per kwh for the next 1,000,000 kwh's
- .68¢ per kwh for the next 1,500,000 kwh's
- .60¢ per kwh for the excess

Table 4.6. Annual Water Requirements and Water and Sewage Costs by Size of Plant, Michigan, 1968.

Plant size in head per hour	Water Requirements: Monthly (100 cu.ft.)	Water Requirements: Annually (100 cu.ft.)	Monthly water costs: Gross (dollars)	Monthly water costs: Net (dollars)	Annual Net Water costs (dollars)	Annual Net Sewage costs (dollars)
20	1,140	13,684	186	167	2,004	1,503
40	2,281	27,367	369	332	3,984	2,988
60	3,421	41,051	551	496	5,952	4,464
75	4,272	51,268	688	619	7,428	5,571
120	6,842	82,102	1,099	989	11,868	8,901

Source: Water requirements from Samuel H. Logan and Gordon A. King, *Economies of Scale in Beef Slaughter Plants*, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 85.
Requirements are 36.2 cubic feet per head slaughtered.
Rates obtained from Board of Water and Light, Lansing, Michigan. Rates effective December 1, 1960. Rates obtained were as follows:

40 cents per 100 cu.ft. for the first 500 cu.ft. used per month.
20 cents per 100 cu.ft. for the next 4500 cu.ft. used per month.
16 cents per 100 cu.ft. for all over 5,000 cu.ft. used per month.

A minimum charge of $1.00 per month plus the above demand charge is included in the monthly gross cost. Net cost equals 90 percent of gross.
Annual requirements and costs are 12 times the monthly costs.

Sewage costs were obtained from *Article II, Rates and Charges for City Services Sec. 27-33*, City of Lansing, Michigan. The rate is 75 percent of the net water bill.

Table 4.7. Annual Natural Gas Requirements and Costs by Size of Plant, Michigan, 1968.

Plant size in head per hour	Monthly Gas Requirements (cu. ft.)	Costs: Monthly (dollars)	Costs: Annual (dollars)
20	222,600	178	2,136
40	342,720	271	3,252
60	443,520	349	4,188
75	524,160	411	4,932
120	806,400	629	7,548

Source: Requirements from Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 88.
Rates from Consumers Power Company, General Commercial and Industrial Service (open order rate "B"). This rate was specified as follows:
Commodity Charge:
$2.00 per month which shall include 300 cu. ft.
15.30¢ per 100 cu.ft. for the next 1,700 cu.ft.
10.50¢ per 100 cu.ft. for the next 10,000 cu.ft.
7.73¢ per 100 cu.ft. for all over 12,000 cu.ft.

Table 4.8. Total Utility Costs by Size of Plant, Michigan, 1968.

Plant size in head per hour	Electricity	Water	Sewage	Natural Gas	Total
20	13,632	2,004	1,503	2,136	19,275
40	22,740	3,984	2,988	3,252	32,964
60	31,368	5,952	4,464	4,188	45,972
75	37,752	7,428	5,571	4,932	55,683
120	57,552	11,868	8,901	7,548	85,869

Source: From Tables 4.5 through 4.7.

<u>Interest</u>: Interest on investments in land, buildings, and other improvements, and equipment represents an important cost to firms even if internal sources of financing are used due to the interest foregone on the money invested. For this study, an annual rate of interest of 6 percent was used. This rate was applied to the initial investment in land and to the total salvage value of the equipment. For investments in depreciable items including buildings, other improvements, and depreciable balance of equipment, the average outstanding value of the property was assumed to be half of the depreciable balance and was used as the base to which the interest rate was applied. Annual interest costs are found in Table 4.9.

<u>Property Taxes</u>: Taxes on land, improvements, inventory and equipment in Michigan are established by school districts and vary considerably among districts. From discussions with Ingham county's tax equilization director, a rate of $43 per $1000 of assessed value was used. Assessed value was set at 50 percent of the current market price.

For land and salvage value of equipment, both nondepreciable items, the full tax rate was applied to 50 percent of the initial cost of the items. However, for depreciable improvements and depreciable balance of equipment, the above tax rate was applied to half the average outstanding non-depreciated value. Assuming a straight line depreciating policy, this means the tax rate was applied to 25 percent of the depreciable balance. This procedure yields an

Table 4.9. Interest on Investments by Size of Plant, Michigan, 1968.

Plant Size in No. of Head per Hr.	Average Investments Improvements	Average Investments Equipment	Land	Salvage Value of Equipment	Average Total Investment[1]	Interest on Investments per Year[1]
20	121,500	53,750	19,202	8,600	203,100	12,200
40	190,000	80,000	36,588	13,000	319,700	19,200
60	274,500	120,150	47,810	20,700	471,200	28,300
75	322,000	147,050	56,179	23,700	548,900	32,900
120	489,000	229,250	77,772	37,000	833,000	50,000

[1]Rounded to nearest $100.

Source: Improvements - 50 percent of total cost from Table 4.3.
Equipment - 50 percent of depreciable balance from Table 4.2.
Land - Total land cost from Table 4.4.
Salvage value - Table 4.2.
Average Total Investment - sum of columns 1-4.
Interest on Investment - 6 percent of average total investment.

estimate of the average tax paid on depreciable improvements and equipment. An estimate of taxes on inventories was not inlcuded.

The yearly tax cost based on these assumptions and rates is given in Table 4.10.

Insurance: Insurance on buildings, equipment and inventory of cattle and beef are normally carried by most packing plants. An attempt was made to obtain an estimate of this cost from a major insurance company in Michigan. Building and equipment investments and inventory estimates by size of plant were furnished to the company and they agreed to furnish the estimates. However, even after follow-ups were made, no estimates were obtained. Since the cost of this item in other studies has been less than half of one percent of the total, it was decided to increase the cost estimates from Logan and King by an arbitrary 20 percent. This is to reflect increases in building and equipment costs and probably increase in rates since 1961. It should be noted that the rates used by Logan and King do not include insurance on inventory. The costs used by size of plant are as follows:

Plant Size in head per hour	Total Annual Insurance Cost
20	$1818
40	2738
60	4150
75	4826
120	7205

Table 4.10. Property Tax Costs by Size of Plant, Michigan, 1968.

Plant size in No. of head per hour	Assessed Land Value	Average Assessed Improvement Value	Assessed Salvage Value	Average Assessed Equipment Value	Total Assessed Value[1]	Annual Tax Cost[2]
20	9,601	60,750	4,300	26,875	101,500	4,364
40	18,294	95,000	6,500	40,005	159,800	6,871
60	23,905	137,250	10,350	64,075	235,600	10,131
75	28,080	161,000	11,850	73,525	274,500	11,804
120	38,886	244,500	18,500	114,625	416,500	17,910

[1]Rounded to the nearest $100.

[2]Tax rate is $43 per $1000 assessed value.

Source: Assessed land value - 50 percent of total from Table 4.4.
Assessed improvement value - 25 percent of total cost from Table 4.3, i.e., 50 percent of half the depreciable balance.
Assessed salvage value - 50 percent of salvage value of equipment from Table 4.2.
Assessed equipment value - 25 percent of balance for depreciation.
Total assess value - sum of col. 2-5.

Miscellaneous Supplies and Services:[1] This category of costs includes eight sub-groups that together make up a significant portion of the total cost of operating a beef slaughter plant. Considerable variability in most of these costs would be expected among firms. Nevertheless, the importance of the costs make it necessary to include them in the totals.

A brief discussion of each cost included in this category follows.

Repair and Maintenance includes both fixed and variable costs for repair and maintenance to all buildings and equipment. As used here, the fixed component refers to costs that would be incurred even if the plant were not operating. Variable costs refers to costs that result from use of the facilities and vary with the intensity of use. No attempt is made to estimate these separately. According to Logan and King "...the plant is generally operating at some level the year around and the firm has little means of estimating how much of the expense results because of the time factor and how much results from the wear and use factor.[2]

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[1]Future institutional requirements may force firms to install anti-pollution devices to reduce air pollution. Also in many areas waste disposal requirements for large plants may require plant investments in disposal systems which would likely increase costs for larger firms with requirements that exceed the capacity of local municipalities. This potential cost is not estimated in this study.

[2]Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 89.

Killing and supply costs include items related to the killing operation itself. Such things as shrouds, soap, shroud pins, neck skewers, shroud laundry, ink, and towels are included. Logan and King, suggest that the relatively low coefficient of determination obtained in their estimate of this item is due to the lack of standard accounting procedures in defining killing costs.[1]

Office costs include dues and subscriptions to magazines and, trade journals, miscellaneous supplies such as pencils, tags, postage, auditing, and credit expenses, and service to office machines. Investment in office equipment is included in equipment cost estimates.

Social security, unemployment insurance and state licenses represent another sub-group in this category of costs.[2] The present rate of employer contribution to social security is 4.4 percent of an employee's wages up to a maximum of $4800. The maximum contribution of $211 was applied to the total number of workers employed by each plant.[3]

The unemployment insurance in Michigan varies among firms depending on their historical record of employment, and past contributions. The more stable their employment record, the lower the rate. The contribution rate ranges

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[1]Ibid., p. 93.

[2]Workmen's compensation insurance of approximately 5 percent of a firm's annual payroll was not included in the estimates.

[3]This estimate has now increased to 4.8 percent of the first $7800; an increase of $163 per employee.

from 0.0 percent to 4.6 percent for 1964 and subsequent years.[1]

In the absence of information pertaining specifically to the experience of present meat slaughtering firms in Michigan, the maximum rate applicable to new employers was used in this study. According to the Michigan Employment Security Commission, "A newly liable employer --- pays contributions at a rate which cannot exceed 2.7 percent for the first four years."[2] Also, the rate applies only to the first $3600 in wages paid to each employee during a calendar year.[3] Thus, for this study, $97 (2.7 percent of $3600) per employee was used.

In addition to the above items, the state of Michigan requires all slaughter plants to pay a license based on their volume of operation. Currently, any plant slaughtering over 10,000 animals per year must pay a flat fee of $1,000 per year.

<u>Telephone</u> expenses are self explanatory. For a firm of this type, they often represent a significant cost item and will vary with the size of the firm's supply and market area, as well as volume of slaughter. A linear function regressed against yearly slaughter was estimated by Logan and King, (see Table 4.11).

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[1]Michigan Employment Security Commission, <u>Employer's Handbook</u>, (Lansing: Michigan Department of Labor, 1967), p. 12.

[2]<u>Ibid</u>., p. 13.

[3]<u>Ibid</u>., p. 9.

Table 4.11. Estimating Functions and Cost Estimates for Miscellaneous Supplies and Services, Michigan, 1968.

	Logan and King Estimates[1]			Michigan Estimates[2]	
Dependent variable	r	Constant term	Regression[3] coefficient	Constant term	Regression[3] coefficient
Repair and Maintenance	-		.339	0	.356
Killing supplies	.505	$7,010	.114	7,361	.120
Office supplies	.883	$3,561	.049	3,740	.051
Taxes and Licenses	.987	$2,084	.299	1,000	308[4]
Telephone	.9412	$1,126	.269	1,126	.269
Delivery and Selling	.781	$8,032	.212	8,435	.223
Feed	-		.100	0	.100
Buying	-		.050	0	.052

[1] Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 90.

[2] Except where noted obtained by multiplying Logan's and King's estimates by 1.05 which represents the increase in prices of industrial commodities based on the average wholesale price indexes for 1961 and 1967, U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Price Indexes (Washington: U.S. Government Printing Office, September 1962, Jan. 1968).

[3] Regression coefficients are dollars per head of annual slaughter except where noted.

[4] Social security unemployment insurance and state license. Regression coefficient is per employee.

Delivery and selling costs are limited to supplies such as twine, butcher paper, tags, ink, and laundry of drivers' coats. Truck transfer costs and labor costs for sellers are estimated elsewhere.

Feed costs for animals in the holding pens were estimated from plants that did not have cattle feeding operations.

Buying costs include all nonsalary buying costs. One would expect a large variability of this factor for plants of the same size due to differences in the geographic area of their supply, the mix of marketing outlets used, the variability of seasonal supply in the vicinity of the plant, and many other factors. Also, data on these buying cost items are not easily obtained. The average cost for the observations obtained were used by Logan and King (see Tables 4.11 and 4.12).

Each of the above eight cost items were considered separately in deciding how to adjust the costs for current Michigan conditions. It was decided that an appropriate procedure would be to inflate California's estimates by using the average annual 1961[1] and 1967[2] wholesale price index for industrial commodities. However, three items were not adjusted by this procedure, for these the following procedures were used.

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[1]U.S. Department of Labor, Bureau of Labor Statistics, Wholesale Price Indexes (Washington: U.S. Government Printing Office, Sept. 1962), p. 4.

[2]Ibid., Jan. 1968, p. 5.

Table 4.12. Estimated Costs for Miscellaneous Supplies and Services by Size of Plant, Michigan, 1968.

Plant size in No. of head per hour	Repair and Mainten-ance	Killing Supplies	Office Supplies	Soc. Sec. Unemploy-ment and License	Telephone	Delivery and Selling	Feed	Buying
	dollars							
20	13,457	11,897	5,668	11,164	11,294	16,864	3,780	1,966
40	26,914	16,433	7,596	20,712	21,462	25,284	7,560	3,931
60	40,370	20,969	9,523	27,412	31,631	33,723	11,340	5,897
75	50,418	24,356	10,963	31,108	39,223	40,017	14,162	7,364
120	80,741	34,577	15,307	46,816	62,135	59,011	22,680	11,794

Source: See text for procedures and Table 4.11 for estimating equations.

For telephone service, the same cost figure was used. It was assumed that although rates may have changed significantly, any rate difference for long distance calls would be overshadowed by differences in distances of calls, and number of calls made between firms. Since no procedure for estimating these latter disturbances in the estimating procedure seemed feasible, no change was made in telephone costs.

Feed costs for animals in holding pens represent a very small part of the total cost of operation, accounting for less than 7 percent of the miscellaneous supplies and services category. Thus, no attempt to estimate these costs directly was made. Feed prices exhibit considerable geographic and seasonal variability as well as variability among years. Finally, since Logan and King did not present sufficient detail to estimate the type of feed generally used in California, or more importantly, the prices used, it is impossible to adjust differences in this cost item. As a result of these factors, feed costs were assumed to be identical to Logan and King's estimate (see Tables 4.11 and 4.12).

The third item in this category adjusted separately was costs for taxes and licenses. In this study only social security and unemployment taxes and state licenses, were included. State laws that imposed state taxes also make the taxing of slaughter plants by local governmental units illegal. This does not, of course, pertain to property taxes covered elsewhere.

Data in Table 4.11 summarizes the stimating equations used. Total cost estimates for all eight items by size of plant are listed in Table 4.12.

Total Cost: Total and average annual costs by size of plant are presented in Table 4.13. Economies of size are significant throughout the range of plant sizes considered. Average costs declined from $11.34 per head in the smallest plant to $8.85 per head in the largest plant. Savings in labor costs were the most significant cost item contributing to lower costs as plant size increased. Labor costs declined from $7.84 per head in the smallest to $6.34 per head in the largest plant. The reduction of $1.50 in labor costs per head accounted for 60 percent of the total reduction of $2.49 per head as the size of plant increased from 60 to 120 head per hour. No category of costs showed dis-economies to size within the range studied.

Labor accounted for about 70 percent of total annual costs (Table 4.13). The variation was from a low of 69 percent for the smallest plant to 73 percent for the 60 head per hour plant. Labor costs for the largest plant accounted for 72 percent of the total. These are slightly higher than those presented in Logan and King. Their percentages ranged from 67 to 70 percent.[1] This difference reflects

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[1]Samuel H. Logan and Gordon A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 102.

Table 4.13. Total Annual Cost, Cost per Head and Cost as a Percent of Total Cost for Beef Slaughter Plant Operations by Type of Cost and by Size of Plant, Michigan, 1968.

Plant Size in Head Per Hour	Labor	Depreciation Improve-ments	Depreciation Equip-ment	Interest	Property tax	Utilities	Insurance	Misc. Supplies & Serv.	Total Annual Cost
				Cost in Dollars					
20	296,552	9,720	8,600	12,200	4,364	19,275	1,818	76,090	428,649
40	565,580	15,200	13,400	19,200	6,871	39,964	2,738	129,892	785,845
60	829,124	21,960	20,800	28,300	10,131	45,972	4,150	180,865	1,141,197
75	973,184	25,760	23,900	32,900	11,804	55,683	4,826	217,611	1,345,668
120	1,438,410	39,120	35,820	50,000	17,910	85,869	7,205	333,061	2,007,395
				Cost per Head in Dollars					
20	7.84	0.26	0.23	0.32	0.12	0.51	0.05	2.01	11.34
40	7.48	0.20	0.18	0.25	0.09	0.44	0.04	1.72	10.40
60	7.31	0.19	0.18	0.25	0.09	0.41	0.04	1.59	10.06
75	6.87	0.18	0.17	0.23	0.08	0.39	0.03	1.54	9.49
120	6.34	0.17	0.16	0.22	0.08	0.38	0.03	1.47	8,85
				Cost as a Percent of Total					
20	69.18	2.27	2.01	2.85	1.02	4.50	0.42	17.75	100.00
40	71.97	1.93	1.72	2.44	0.87	4.20	0.35	16.53	100.00
60	72.65	1.92	1.82	2.48	0.89	4.03	0.36	15.85	100.00
75	72.32	1.91	1.78	2.45	0.88	4.14	0.36	16.17	100.00
120	71.66	1.95	1.78	2.49	0.89	4.28	0.34	16.60	100.00

Source: Property Tax: Table 4.10.
Utilities: Table 4.8.
Insurance: Page 103.
Misc. Supplies & Services: Table 4.12.

Property Tax: Table 4-10.
Utilities: Table 4-8.
Insurance: Page 106.
Misc. Supplies & Services: Table 4-12.

the relatively greater increase in labor costs compared to other items since the Logan and King study was completed.

The following total cost function was obtained through linear regression analysis of the cost data:

$$Y = \$153{,}895 + \$8.2982X$$
$$(37{,}530) \quad (.2774)$$

where:

Y = total annual costs

and X = number of head slaughtered annually

() = standard error of the coefficients

$\bar{R}^2 = .9955$

In order to evaluate the above estimating equation it was used to estimate the expected cost in Michigan plants that had been previously studied by Wissman.[1]

Wissman estimated the total in-plant cost of slaughtering beef for three plants varying in size from an annual slaughter of 13,232 to 34,380. Assuming 2080 hours of operation per year, as was the case in the estimates presented in this study, the three plants had an average output of 6.4, 11.1 and 16.6 head per hour. Although these plants are all smaller than the synthesized plant sizes used in this study and all the cost data in Wissman's study are for 1963-64, the comparison has some usefulness in evaluating the estimates obtained in this study. Estimates using the two

[1]Donald J. Wissman, Comparative Costs of Slaughtering Cattle in Michigan Packing Plants, Agric. Econ. Report No. 10 (East Lansing: Department of Agricultural Economics, Michigan State University, May 1965), p. 28.

studies for each plant are as follows:

Annual Slaughter in No. of Head	Average Cost Per Head	
	Wissman	From Above Equations
13,232	$15.40	$19.93
23,080	14.47	14.97
34,380	12.19	12.77

Based on these comparisons it would seem that for extremely small plants the estimating equation will likely overestimate actual costs. However, for the larger plants the equation does appear to provide reasonable estimates. If we were to inflate Wissman's estimates to account for an inflated price level then our estimates would be lower than Wissman's. Some of this difference would be expected due to difference in the technology of existing as opposed to the synthesized plants. Also the synthesized plant data assumes a constant rate of output while actual plant operation data reflects increased costs associated with operating plants at varying levels of output.

Although other cost comparisons with studies conducted in other areas could be made, a detailed analysis of factor costs used in those studies is required to make any meaningful comparisons. Wage rate differences are especially important in making interregional cost comparisons. For example, Logan and King[1] estimates for the 120 head per hour plant was $7.28 per head compared to $8.85 per head for the estimates given in this report. The difference is due to

[1]Samuel H. Logan, Economies of Scale in Cattle Slaughtering Plants, Report prepared for the National Commission on Food Marketing, December 1965, p. 9.

differences in input prices used since the same level of technology is assumed. A study by Franzmann and Kuntz in 1965 reported per head slaughtering costs in Oklahoma ranging from $6.74 to $7.23.[1] In their study wage rates increased with the size of firm. This resulted in diseconomies beyond a 60 head per hour plant. The generally lower wage rates in Oklahoma in 1965 compared to the wages used in this study account for most of the difference in slaughter costs. Labor cost per head in Oklahoma ranged from about $2.25 to $2.75 less than the Michigan costs used in this study.

Based on these cost comparisons it was concluded that cost function derived in this study was realistic and adequate for the purposes of this analysis. However, the estimates are biased downward slightly by the omission of workmen's compensation and the low rate assigned to social security payments.

Summary

This chapter presents the requirements and cost of slaughtering beef in Michigan for five different plant sizes. The presentation is divided into the following major cost categories: (1) labor, (2) equipment, (3) buildings, corrals and parking area, (4) land, (5) utilities, (6)

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[1] John R. Franzmann and B.T. Kuntz, Economies of Size in Southwestern Beef Slaughter Plants, Bulletin No. B-648 (Stillwater: Oklahoma Agricultural Experiment Station and USDA cooperating, April, 1966), p. 24.

interest, (7) property tax, and (8) miscellaneous supplies and services.

Economies of size were found in all cost categories with labor accounting for 60 percent of the $2.49 per head reduction in costs as the size of plant increased from 20 to 120 head per hour.

The total cost function obtained from fitting a linear equation was: $Y = \$153,895 + 8.2982X$, where Y is the total annual cost and X is the number of head slaughtered annually. This equation was then used to estimate average costs for Michigan plants on which estimates from accounting data had previously been made. Although differences in time, plant size, and technology limited their usefulness, the comparisons made tended to support the estimates of this study.

Chapter 5

NUMBER, SIZE AND LOCATION OF BEEF SLAUGHTER PLANTS

Introduction

The purpose of this chapter is to present the transportation models used and the results obtained in determining the number, size and location of beef slaughter plants that minimizes the combined cost of livestock assembly, slaughter of cattle and distribution of beef to consuming areas. Data presented in chapter three and four were used in the development of the results obtained.

Two models were selected for use in estimating the number, size and location of plants. Two were used in order to make comparisons between the results obtained. Due to the estimating procedures used it cannot be shown mathematically that the result obtained in either case actually is the least cost solution. To the extent that the models supported each other added reliance on the estimates was provided. Secondly, differences in the models made it possible to get some idea of the influence of beef shipments on the location of plants. The first model considers only cattle shipments and slaughter costs while the second also includes beef shipments. Finally, results from the first model made it possible to make certain assumptions regarding cattle shipments in the second model which significantly reduced the size of the problem.

Stollsteimer Procedure

The Model: The initial model used in estimating the number, size and location of beef slaughter plants in Michigan employs a procedure proposed by Stollsteimer. The objective function in this model, as used in this study, is that of minimizing the combined cost of cattle assembly and slaughter, assuming economies of scale exist and that slaughter costs do not vary among plant locations. This corresponds to Stollsteimer's Case I.[1]

Mathematically, the model can be stated as follows:[2]

Minimize:

$$\underset{(JL_k)}{TC} = \sum_{j=1}^{J} P_j X_j \Big| L_k + \sum_{i=1}^{I} \sum_{j=1}^{J} X_{ij} C_{ij} \Big| L_k$$

(Total cost = processing cost + assembly cost) with respect to plant numbers ($j \leq L$) and locational pattern $L_k = 1 \; . \; . \; . \; (^L J)$.

Subject to:

$$\sum_{j=1}^{J} X_{ij} = X_i$$

(Sum of shipments from i to j = quantity of raw material available at i)

[1]John F. Stollsteimer, "A Working Model for Plant Numbers and Locations," Journal of Farm Economics, Vol. 45 (August, 1963), p. 633.

[2]Ibid., p. 632-3.

$$\sum_{i=1}^{I} X_{ij} = X_j$$

(Sum of shipments to j = quantity of raw material processed at plant j)

$$\sum_{i=1}^{I} \sum_{j=1}^{J} X_{ij} = X$$

(Total shipments of cattle = total quantity of cattle, produced and processed)

where:

T_C = total processing and assembly cost

P_j = unit processing cost in plant j (j=1 ....J¯L) located at L_j

X_i = quantity of cattle shipped from origin i to plant j located at L_j

C_{ij}= unit cost of shipping cattle from i to j located with respect to L_j

L_k = one locational pattern for J plants among the $\binom{L}{J}$ possible combinations of locations for J plants given L possible locations

L_j = a specific location for an individual plant (j = 1 ... J)

Following Stollsteimer

> "The problem of minimizing (the objective function) with respect to plant numbers (J) and locational pattern (L_k) can then be accomplished in two steps. The first step is to obtain a transfer-cost function that has been minimized with respect to plant locations with varying numbers of plants, J."[1]

This can be stated mathematically as follows:

$$\overline{TTC} \Big|_{J = L_k} \text{Min}_{(X_i')} \overline{C_{ij}} \Big| L_k$$

[1]John F. Stollsteimer, "A Working Model for Plant Numbers and Locations," Journal of Farm Economics, Vol. 45 (August, 1963), p. 634.

where:

$\overline{TTC}$ = total transfer cost minimized with respect to plant locations for each value of J = 1 ... L

(X_i') = a (1 x I) vector where entries, X_i, represent the quantities of raw material produced at each of the I origins, and

$\overline{C_{ij}}|L_k$ = a vector where entries C_{ij} represent minimized unit transfer costs between each origin and a specified set of locations, L_k, for J plants.[1]

The second step is to add the processing cost to the minimized transfer cost function for each value of J (the number of plants). Under the assumptions of constant marginal processing cost in any given plant, equal plant costs at all locations, and a positive intercept in the plant-cost function, the total cost of processing a given quantity of cattle will increase by an amount equal to the intercept value of the plant cost function with each increase in plant numbers.

The number of plants that minimize the combined transfer cost and processing cost then depends on the relative slope of the two functions. In order for the total cost to decrease with an increase in the number of plants, the increase in processing costs must be less than the decrease in transportation costs.[2]

The amount processed in each plant is determined entirely by transportation costs since total processing cost is unaffected by the allocation of cattle among plants.

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[1] Ibid.

[2] Ibid., p. 638.

This result is due to the assumption of a linear total cost function and the associated constant marginal cost.

Empirical Results: Data in Table 5.1 summarizes the results of the Stollsteimer procedure for one to five plants. As plant numbers increased livestock assembly cost decreased at a decreasing rate. Increasing the number of plants from 1 to 2 resulted in a decline of almost $639,000. This compares with a decline of less than $84,000 when plant numbers increased from four to five plants. Since total processing costs increased by almost $154,000 with each increase in plant numbers, total costs declined to $13,097,708 as plant numbers increased up to four plants. The minimum cost location for five plants resulted in an increase in total costs of over $70,000. Although not shown in Table 5.1 total costs continued to increase at an increasing rate as plant numbers increased beyond five plants. As plant numbers increased to six, seven and eight plants total costs increased by an additional $80,603, $100,101 and $103,453 respectively.

The least cost location for one plant was Jackson, Michigan. This solution resulted in a total processing cost of $10,300,000 and an assembly cost of $3,500,000 for a total cost of $13,800,000.

The two plant solutions resulted in plant locations at Alma and Adrian, Michigan and a reduction in total costs of $485,000 over the one plant solution. In this solution, 503,000 head of cattle were allocated to the Alma plant and 723,000 to the Adrian plant (Table 5.1).

Table 5.1. Estimated Livestock Assembly and Processing Costs for Beef Slaughtering by Number of Plants with Specified Locations, Stollsteimer Procedure.

No. of Plants and Least-Cost Locations	Livestock Assembly Cost		No. of head processed	Annual processing cost[2]	Increase in processing cost	Change in Total Cost
	Total cost	Decrease in cost[1]				
1-Plant						
Jackson	$3,519,666	-	1,226,155	$10,328,774	-	-
2-Plants						
Alma	2,880,682	$638,984	502,996	4,327,856	$153,895	$-485,089
Adrian	-	-	723,159	6,154,813	-	-
3-Plants						
Saginaw	2,522,795	357,887	424,422	3,675,833	153,895	-203,992
Adrian	-	-	449,735	3,885,886	-	-
Sturgis	-	-	351,998	3,074,845	-	-
4 Plants						
Alma	2,307,217	215,578	295,613	2,606,951	153,895	- 61,683
Sandusky	-	-	169,932	1,564,025	-	-
Adrian	-	-	449,735	3,885,885	-	-
Sturgis	-	-	310,875	2,733,598	-	-
5 Plants						
Alma	2,223,655	83,562	167,272	1,541,952	153,895	+ 70,333
Sandusky	-	-	169,932	1,564,025	-	-
Ionia	-	-	242,352	2,164,980	-	-
Adrian	-	-	455,726	3,935,600	-	-
South Bend	-	-	190,873	1,737,997	-	-

[1]Decrease in assembly cost compared to the previous number of plants.

[2]Based on total processing cost function of y =$153,895 + $8.2982 where y = total annual processing cost and x = number of head slaughtered annually.

When three plants were considered, Adrian remained in the solution. Alma was dropped from the solution while Sturgis and Saginaw were added. This provided two plants in the extreme southern portion of Michigan and one in the middle eastern section of the Lower Peninsula. Allocation of cattle among plants were as follows: Saginaw - 424,000; Adrian - 450,000; and Sturgis - 352,000 (Table 5.1).

For the solution that minimized total costs (four plants) Saginaw was replaced by a plant at Alma and one at Sandusky. The two southern plants from the three plant solution (Adrian and Sturgis) remained in the solution. Cattle were allocated to these plants as follows: Alma - 296,000; Sandusky - 170,000; Adrian - 450,000 and Sturgis - 311,000. The cattle shipment patterns are shown for this solution in Figure 5.1.

In the program used with this model, the total assembly cost for all alternative configurations of plant locations that had an assembly cost of less than five percent more than the least cost solution was also obtained. As the number of plants being considered increased, the number of possible combinations of plant locations for a given number of plants increased rapidly. As a result, the number of possible configurations of plant locations within 5 percent of the least cost solution also increased. The alternative configurations of plant locations and the cost differences are summarized in Table 5.2.

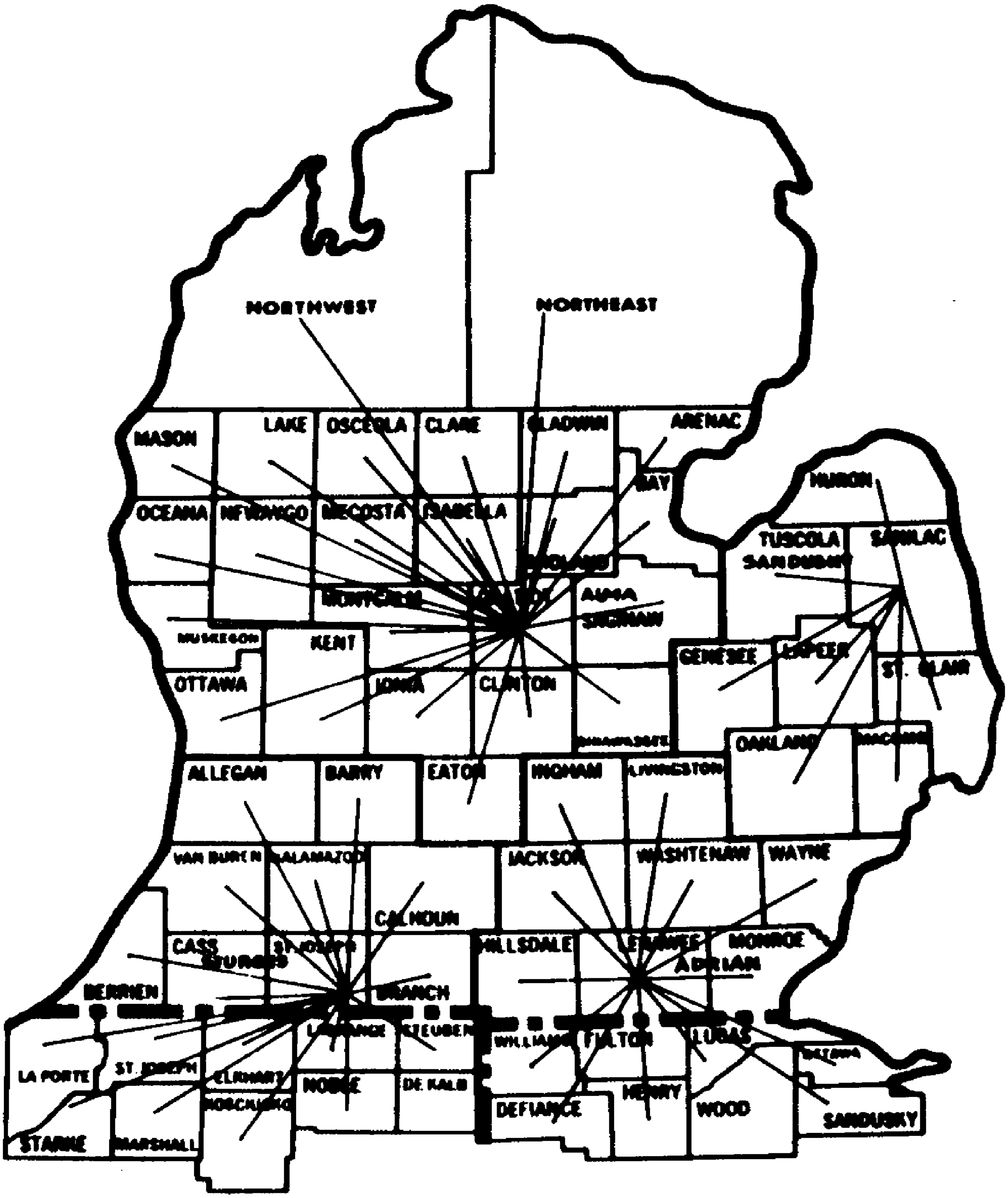

Figure 5.1. Cattle Shipment Pattern for Stollsteimer Procedure.

Table 5.2. Estimated Assembly Costs for Livestock by Number of Plants at Alternative Locations, and Differences in Assembly Costs by Location, Stollsteimer Procedure.

No. of Plants & Alternative Locations	Increased Assembly Cost	Increased Assembly Cost Over Least Cost Location	
		Actual	Percent
1-Plant			
Jackson	$3,519,666	-	0.00
Adrian	3,598,207	$ 78,541	2.23
Lansing	3,643,163	123,497	3.51
Ionia	3,920,076	400,410	11.38
Flint	4,090,944	571,278	16.23
Alma	4,133,620	613,954	17.44
Saginaw	4,256,387	736,721	20.93
2-Plants			
Alma-Adrian	2,880,682	-	0.00
Saginaw-Adrian	2,900,613	19,931	0.69
Flint-Adrian	2,967,261	86,579	3.01
Ionia-Adrian	2,967,598	86,916	3.02
Saginaw-Sturgis	2,980,390	99,708	3.46
Lansing-Adrian	2,982,421	101,739	3.53
Alma-Sturgis	3,011,459	130,777	4.54
Flint-Sturgis	3,016,103	135,421	4.70
3-Plants			
Saginaw-Adrian-Sturgis	2,522,795	-	0.00
Saginaw-Kalamazoo-Adrian	2,530,380	7,585	0.30
Alma-Adrian-Sturgis	2,530,760	7,965	0.32
Alma-Adrian-South Bend	2,555,702	32,907	1.30
Saginaw-Adrian-South Bend	2,558,717	35,922	1.42
Alma-Kalamazoo-Adrian	2,564,505	41,710	1.65
Flint-Kalamazoo-Adrian	2,592,175	69,380	2.75
Flint-Adrian-Sturgis	2,593,723	70,928	2.81
Sandusky-Ionia-Adrian	2,614,853	92,058	3.65
Sandusky-Kalamazoo-Adrian	2,619,082	96,287	3.82
Flint-Adrian-South Bend	2,621,092	98,297	3.90
Saginaw-Sturgis-Toledo	2,630,450	107,655	4.27
Sandusky-Adrian-Sturgis	2,639,327	116,532	4.62
Alma-Sturgis-Toledo	2,641,757	118,962	4.72
Saginaw-Kalamazoo-Toledo	2,644,082	121,287	4.81
Saginaw-Ionia-Adrian	2,646,359	123,564	4.90
4-Plants[1]			
Alma-Sandusky-Adrian-Sturgis	2,307,217	-	0.00
Sandusky-Ionia-Adrian-So. Bend	2,311,955	4,738	0.21
Sandusky-Ionia-Adrian-Sturgis	2,312,072	4,855	0.21
Alma-Sandusky-Adrian-So. Bend	2,332,159	24,942	1.08
Alma-Sandusky-Kalamazoo-Adrian	2,340,961	33,745	1.46

Table 5.2. (Continued)

No. of Plants & Alternative Locations	Estimated Assembly Cost	Increased Assembly Cost Over Least Cost Location	
		Actual	Percent
Saginaw-Ionia-Adrian-So. Bend	2,343,461	36,244	1.57
Saginaw-Ionia-Adrian-Sturgis	2,343,578	36,361	1.58
Ionia-Flint-Adrian-So. Bend	2,358,152	50,935	2.21
Ionia-Flint-Adrian-Sturgis	2,358,269	51,052	2.21
Ionia-Sandusky-Adrian-Kalamazoo	2,366,409	59,192	2.57
Lansing-Sandusky-Adrian-Sturgis	2,368,114	60,897	2.64
Alma-Flint-Adrian-Sturgis	2,368,742	61,526	2.67
Sandusky-Lansing-Adrian-So. Bend	2,371,755	64,538	2.80

[1]A total of 35 configuration appeared within 5 percent of least cost location pattern. Only those within 3 percent are listed.

When only one plant was being considered, plant locations at Adrian and Lansing resulted in an increase in assembly costs of 2.23 and 3.51 percent respectively. The two-plant solution indicated eight different patterns of plant locations were within 5 percent of the least cost solution. Sixteen different location patterns were within 5 percent of the least cost solution for three plants, while 35 were within this margin when four plants were considered.

It is significant to note that Detroit was the only site that did not appear in any of these solutions. It is also interesting that while Jackson was the least cost location for a single plant it did not reappear in any of the other location patterns up through four plants.

In the location patterns for four plants (the least cost number according to this model) only Detroit and Jackson among the fifteen plant sited did not enter any of the location patterns. Big Rapids and Toledo entered only twice, both in combinations exceeding 104.5 percent of the least cost solution. On the other hand, Adrian appeared in the first 31 of the 35 combinations ranked in ascending order by cost.

The relatively large number of location patterns that are within a relatively small margin of the least cost pattern is a result of the relatively short distances between sites compared to the total distance traveled in the assemblying of cattle. Thus, if factor prices are expected to vary considerably among sites, then an evaluation of these differences is likely to be important in determining the location pattern that will minimize total costs. Due to the importance of labor costs in processing, differences in wage rates would be the most likely factor to cause sufficient differences among sites to affect the location pattern obtained.

Transhipment Model

The Model: The Stollsteimer procedure just discussed does not include the possibility of meat shipment costs influencing the least cost location for slaughtering cattle. The cost functions obtained in chapter 2 suggest that meat shipment is less important. However, in order to determine its influence on the locational pattern of slaughter plants it was included in this model. Thus, the objective function becomes one of minimizing the total cost of cattle assembly, slaughter, and meat distribution.

Several variations of similar methods of handling the transhipment problem have been used. They can, for the most part, be classified as either modifications of transportation models or linear programming models. A modification of a transportation model was applied to cattle slaughtering by Logan and King[1] and further modified by

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[1]Samuel H. Logan and Gordon A. King, "Size and Location Factors Affecting California's Beef Slaughtering Plants," Hilgardia, Vol. 36, No. 4, (Berkeley: University of California Agricultural Experiment Station, Dec. 1964).

Hurt and Tramel.[1] Logan and King also have a discussion of the linear programming model.[2]

In transportation models one must specify "n" number of surplus producing regions and "m" number of deficit regions. The quantity supplied in each surplus region and the quantity demanded in each deficit region must also be specified. Finally, the model requires that total demand and supply must be equal. The problem then becomes one of determining the shipment pattern that minimizes the total transport cost. Orden has shown that a modification of this model may be used for problems involving transhipment.[3] (That is, shipment from one or more points to a central point or points for later shipment to final destinations). In effect, these modifications make it possible for shipments to go by any sequence of points rather than being limited to shipments from designated surplus to predetermined deficit regions. Each production and consumption region becomes a possible transhipment region.

Logan and King used these modifications and specified each transhipment point as a potential processing location. Per unit slaughter costs were then added to the cattle

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[1] Verner Hurt and Thomas Tramel, "Alternative Formulations of the Transhipment Model," Journal of Farm Economics, Vol. 47, No. 5 (August, 1965), 763-73.

[2] Samuel H. Logan and Gordon A. King, "Size and Location Factors Affecting California's Beef Slaughtering Plants," Hilgardia, Vol. 36, No. 4, (Berkeley: University of California Agricultural Experiment Station, Dec. 1964), p. 149.

[3] A. Orden, "The Transhipment Problem," Management Science, Vol. 2 (April, 1956), 277-85.

transport cost.[1]

The major advantage of the approach is that it permits an approximation of the number, size and location of plants that minimizes the objective function with much less computer storage capacity than is required by the linear programming models.[2] Since this method is not followed in this study, the reader is referred to the references cited for a more detailed discussion.

In the linear programming approach to the transhipment problem the objective function remains one of minimizing the combined costs of live cattle shipments, slaughter and meat shipments.[3] The model has the following restrictions:

(1) a production balance - live animal shipments must be equal to or less than the total volume supplied in each region,

(2) a processing balance - the meat equivalents of livestock shipped to each processing plant must be equal to the sum of meat shipments from each plant,

(3) a consumption balance - the volume of meat shipped to each consumption region must be equal to or greater than the demand in each consumption region, and

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[1]Samuel H. Logan and Gordon A. King, "Size and Location Factors Affecting California's Beef Slaughtering Plants," Hilgardia, Vol. 36, No. 4, (Berkeley: University of California Agricultural Experiment Station, Dec. 1964), p. 151.

[2]Verner Hurt and Thomas Tramel, "Alternative Formulations of the Transhipment Model," Journal of Farm Economics, Vol. 47, No. 5 (August, 1965), p. 773.

[3]Logan and King, Factors Affecting Slaughter Plants, p. 149.

(4) the volume of all cattle and meat shipments and slaughter must be non-negative.

Given the above objective function, the restrictions, the supplies of animals and quantity of meat consumed in each region, the transportation cost function for meat and livestock and the unit cost of slaughtering in each region (assuming initially no economies of scale) one can estimate the number and location of plants and the volume of slaughter in each plant required to assemble slaughter and distribute the given supply at the least total cost.

In a model of this type where each region becomes a supply region, a potential slaughtering region and a consumption region, the model evolves into an extremely large problem. In our case, for example, with 65 livestock supply regions, the model would require 195 equations (three for each region) and 8450 activities (4225 for meat shipments, 65 for slaughter and 4160 for cattle shipments). For most computer programs, this becomes prohibitive.

To modify the above model for use in this study the supply areas, potential processing points and consumption regions were individually defined (see Chapter 2). The result was to maintain 65 cattle supply regions but to reduce the number of processing regions to 16 (15 within the study region and one outside plant location to supply the excess demand) and the consumption regions to 11. This reduced the problem to 92 equations and 1167 activities (975 for cattle shipments, 16 for slaughter and 176 for meat shipments). This still exceeded the capacity of the available program. However, when economies of size are included in the model, an iterative process is required which makes it possible to eliminate some of the activities. The process involved will become clear after the following discussion relative to the inclusion of economies of size in the model.

The process used to include economies of size in the linear programming model is discussed by Logan and King.[1] The approach involves assigning a low unit processing cost to each region based on a large volume of processing. This processing cost is added to the constant term in the transportation cost function of either cattle shipments or meat shipments. The identical processing cost in the initial cost matrix for all regions assures that each potential processing region is considered in the first iteration. The program is run to determine the volume of processing at each processing location under these conditions. The first iteration essentially minimizes the transportation cost, since processing costs are equal at all sites.

The actual cost of slaughtering the volume assigned to each processing location based on the economies of size curve is compared with the cost assigned in the initial cost matrix and, where necessary, adjustments in the costs are made. The problem is then rerun using the adjusted

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[1]Samuel H. Logan and Gordon A. King, "Size and Location Factors Affecting California's Beef Slaughtering Plants," Hilgardia, Vol. 36, No. 4, (Berkeley: University of California Agricultural Experiment Station, Dec. 1964), p. 150.

processing costs. Finally, the results of the second, third, and other iterations are examined and cost adjustments made where necessary until costs begin to increase or until no change in the number and location of plants occurs. Regions where no processing takes place in a particular iteration are removed from the program.

Logan and King point out one difficulty in this procedure. When all supply regions are also potential processing regions the slaughtering cost in each region is based on the supply in that region plus the shipment of livestock to that region indicated by the initial or later iterations of the program. The possibility of combining the supply of several small regions at a central location to increase the volume and reduce slaughter cost is likely to be overlooked. In these cases Logan and King suggest that a budgeting procedure may be used to estimate the feasibility of a larger plant at some central location.[1]

This problem, though not eliminated, is minimized in this study since production regions are already "combined" into 15 potential processing sites. This procedure is feasible when studies are available to indicate the extent of economies of size and thus provide an idea of the number of plants that are likely to be indicated in the final solution. However, the problem of selecting sites to represent processing regions and the possibility that excluded sites would further reduce the total cost is injected by this

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[1] Ibid., p. 150-1.

procedure. The degree to which this becomes a problem increases with the distance between processing locations. Considerations inlcuded in the selection of sites are discussed in Chapter 2.

As mentioned earlier, the problem as initially set up involved 1167 activities which exceeded the limit of 999 imposed by the program used. However, the iterative procedure discussed in relation to incorporating economies to size into the model provides a means of eliminating many of the activities from each run without fear of eliminating shipments that would reduce the total cost in a particular iteration. To do so, it is necessary to have some idea of the maximum shipment cost for a given number of plants.

In the solutions obtained from the Stollsteimer model the unit cost of shipping cattle from each production region within the supply area of each plant was obtained. It was thus assumed, a priori, for the initial run of the transhipment model that no shipping cost for live cattle that exceeded the highest cost for the location of six plants would be included in the cattle transportation cost matrix. Two exceptions were made. The Northwest and Northeast production regions were not subject to this limitation since it would have necessitated a plant in one of the northern locations to handle their production. Since a total of fifteen plant locations were being considered and slaughter costs were the same at all locations this appeared to be a "safe" method of eliminating a relatively large number of activities. As the iterative process proceeded the elimination of processing locations obtained from former iterations reduced the number of activities to a manageable size.

The linear programming model used in this study can be specified mathematically up to the point where iteration for inclusion of economies of size are required. It is as follows:

Minimize:

$$\sum_{i}\sum_{j} T_{ij}L_{ij} + \sum_{j} HS_j + \sum_{j}\sum_{k} T_{jk}X_{jk}$$

(cattle shipment + slaughter + meat shipment)

Subject to:

Production balance:

$$\sum_{i} L_{ij} \leq S_i \quad \text{for all } i$$

Processing balance:

$$\sum_{i} \alpha L_{ij} = \Sigma_k X_{jk} \qquad \text{for all } j$$

Consumption balance:

$$\sum_{j} X_{jk} \geq D_k \qquad \text{for all } k$$

and

$$L_{ij} \geq 0,\ X_{jk} \geq 0 \qquad \text{for all } i,\ j \text{ and } k$$

Where:

X_{jk} = meat shipment from region j to region k

L_{ij} = live animal shipment from region i to region j

S_j = slaughter in region j

T_{jk} = meat transfer cost from region j to region k

T_{ij} = cattle transfer cost from region i to region j

H_j = slaughter cost per head in region j

α = constant dressing percentage

S_i = supply of slaughter cattle in region i

D_k = demand for meat in region k

i = refers to 65 production regions

j = refers to 16 processing locations

k = refers to 11 consumption regions

Empirical Results: Following the iterative procedure discussed in the previous section, a total of five iterations were necessary before no change in the number or location of plants occurred. Information on the number of plants, volume of processing and the beef shipment patterns for each iteration is summarized in Table 5.3. The discussion which follows is primarily directed toward the final solution obtained, the cost reduction compared to earlier iterations and some comparisons with the Stollsteimer results.

Data in Table 5.4 summarizes the cost of the second through the fifth iterations of the program. Costs for the first iteration were meaningless due to the arbitrarily low processing costs inlcuded for each site. As expected, the first iteration allocated some slaughter to each potential processing location. This, in essence, minimized the total transportation cost for cattle and beef since processing costs did not differ among sites. An adjustment of processing costs based on the volume allocated to each site in the first iteration resulted in no processing in five of the

Table 5.3. Beef Shipment Patterns by Iteration, Transhipment Model.

(Million Pounds of Beef Shipped Expressed in Live Weight Equivalents)

Processing Plant Location	Consumption Regions: Traverse City	Alpena	Cadillac	Bay City	Detroit	Lansing	Grand Rapids	Jackson	Kalamazoo	South Bend	Toledo	Total
First Iteration												
Big Rapids			16.8000				16.4609					33.2609
Alma				66.7879								66.7879
Saginaw				77.7172								77.7172
Sandusky					96.4774							96.4774
Flint					76.4965							76.4965
Grand Rapids							69.1873					69.1873
Ionia							49.9349					49.9349
Lansing						110.8061						110.8061
Detroit					36.6075							36.6075
Jackson								20.4877				20.4877
Adrian								57.8386			188.2104	246.0490
Kalamazoo									54.9561			54.9561
Sturgis									96.2122	21.4768		117.6890
South Bend										134.2866		134.2866
Toledo					100.3215							100.3215
Out-of-Area 1/	19.2686	30.1052			1006.6036		81.0273			8.8893		1145.8938
Second Iteration												
Alma				96.8931								96.8931
Saginaw		30.1052		47.6120								77.7172
Sandusky					126.9310							126.9310
Grand Rapids	19.2686		16.8000				1.8817					37.9501
Flint					36.7618							36.7618
Lansing					61.4718	110.8061						172.3559
Adrian					626.8232							626.8232
South Bend								44.2978	11.0391			55.3369
Sturgis								36.0285				36.0285
Toledo					28.3637							28.3637
Out-of-Area					630.1730		216.7287		140.1292	166.6525	188.2104	1145.8938
Third Iteration												
Alma				128.2378								128.2378
Saginaw		30.1052		16.2673								46.3725
Lansing					98.1260	110.8061						209.0081
Adrian					745.5637							765.5637
Sandusky					161.9593							161.9593
Out-of-Area	19.2686		16.8000		310.8575		216.6106	78.3263	151.1683	166.6526	188.2104	1145.8938
Fourth Iteration												
Alma	.0051	30.1052		144.5051								174.6154
Sandusky					160.7169							160.7169
Lansing					108.3606	110.8061						219.2265
Adrian					728.5066							728.5066
Out-of-Area	19.2633		16.8000		310.8626		216.6106	78.3263	151.1683	166.6525	188.2104	1145.8938
Fifth Iteration												
Alma	6.7627	30.1052		144.5051								181.3730
Sandusky					161.9593							161.9593
Lansing					108.3606	110.8061						219.2265
Adrian					728.5066							728.5066
Out-of-Area	12.5057		16.8000		317.6202		216.6106	78.3263	151.1683	166.6525	188.2104	1145.8938
TOTAL	19.2686	30.1052	16.8000	144.5051	1316.5065	110.8061	216.6106	78.3263	151.1683	166.6525	188.2104	2437.0352

1/ Out of area plants are represented by shipments from Des Moines, Iowa.

Table 5.4. Cost of Cattle Assembly, Slaughtering and Meat Distribution, by Program Iteration. Transhipment Model.

Costs	Second Iteration	Third Iteration	Fourth Iteration	Fifth Iteration
Intra-area Costs				
Livestock Assembly Cost	$2,288,390	$2,557,093	$2,567,266	$2,565,382
Slaughtering Cost[1]	11,708,232	10,948,108	10,808,191	10,790,053
Meat Distribution Cost	1,337,443	1,445,547	1,456,903	1,459,059
Total	$15,334,065	$14,950,748	$14,832,360	$14,814,494
Inter-area Costs				
Meat Distribution Cost	10,782,391	10,702,210	10,702,207	10,669,421
Total Cost	$26,116,456	$25,642,958	$25,534,567	$25,513,915

[1]Slaughtering costs have been adjusted based on the number of plants and the volume of slaughter at each plant in the solution of each iteration as opposed to the unit costs actually included in the iteration. Costs therefore represent the cost of the solution to each iteration.

fifteen sites in the second iteration (see Table 5.3). Total costs, based on the solution of the second iteration and with processing costs adjusted to the number of plants indicated by the solution, was $26,116,000 (Table 5.4). The final iteration yielded a total cost of $25,514,000, a reduction of $602,000 or 2.3 percent. Intra-area costs (total costs less cost of out-of-area beef shipments to consumption regions) declined by $519,000 or a decline of 3.4 percent. As expected, as plant numbers declined assembly and distribution costs increased while slaughter costs decreased.

The final solution is summarized by data in Table 5.5 and Figures 5.2 and 5.3. The volume of slaughter at the four plants and the pattern of beef shipments to consumption regions can be seen in Table 5.5. The four plant sites remaining in the final solution were Alma, Sandusky, Lansing, and Adrian. Converted to number of head, assuming an average weight of 1053 pounds per head, the annual slaughter volume for each plant was approximately as follows:

Alma	172,000	head
Sandusky	154,000	head
Lansing	208,000	head
Adrian	692,000	head
Total	1,226,000	head

When compared with the results of the previous model, Lansing replaced Sturgis as a plant location. Two factors are responsible for the shift. First the inclusion of beef

Table 5.5. Number, Size and Location of Plants and Beef Shipment Patterns, Transhipment Model.

Consumption Region	Plant Location				Out of Area	Total
	Alma	Sandusky	Lansing	Adrian		
	----------million pounds live weight equivalents-------------					
Traverse City	6.7626				12.5057	19.2684
Alpena	30.1052					30.1052
Cadillac					16.8000	16.8000
Bay City	144.5051					144.5051
Detroit		161.9593	108.3404	728.5846	371.6202	1370.5045
Lansing			110.8841			110.8841
Grand Rapids					216.6104	216.6104
Jackson					78.3263	78.3263
Kalamazoo					151.1683	151.1683
South Bend					164.6525	164.6525
Toledo					188.2104	188.2104
Total	181.3730	161.9593	219.2245	728.5846	1145.8938	2437.0352

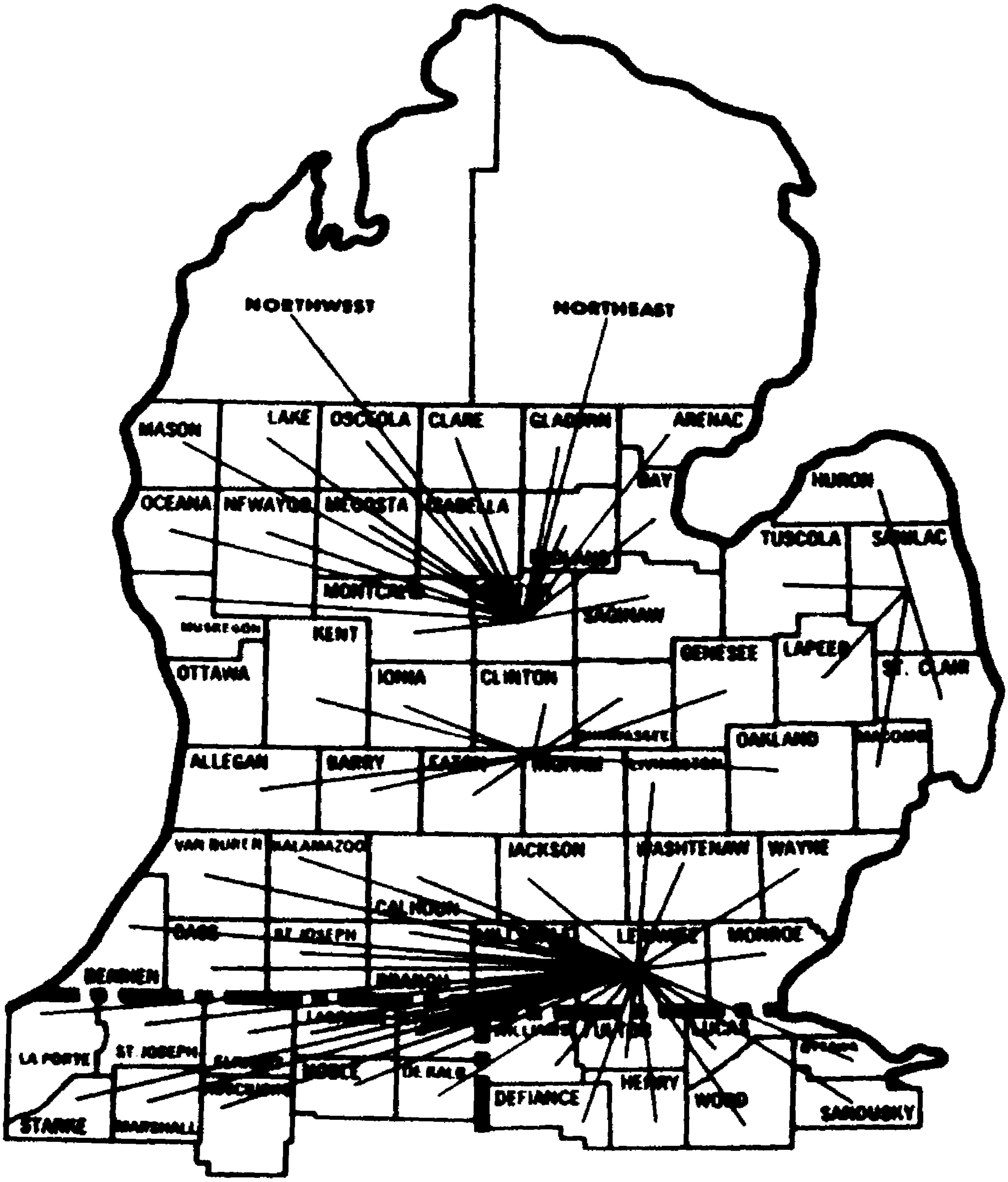

Figure 5.2. Cattle Shipment Patterns for Transhipment Model.

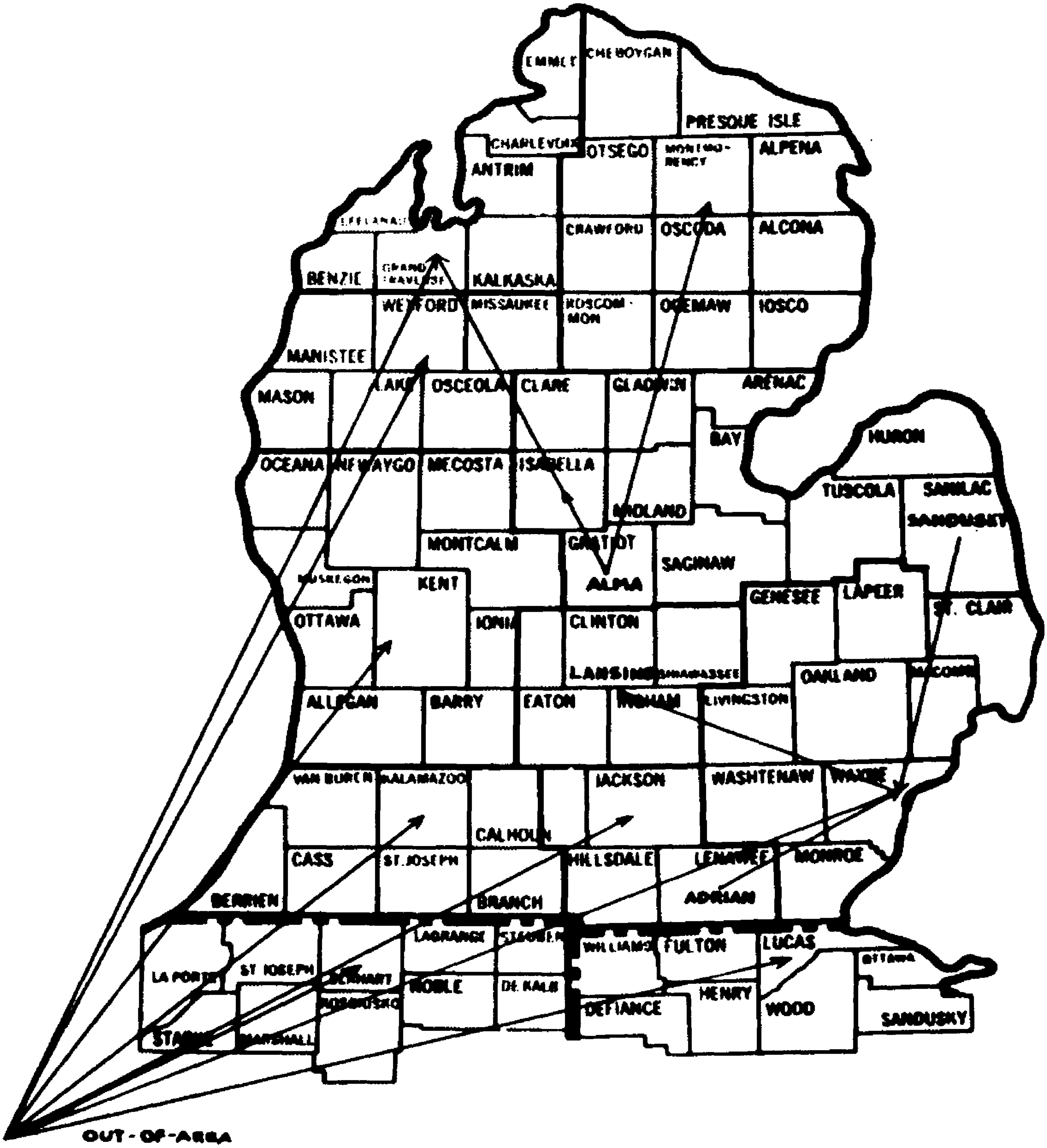

Figure 5.3. Beef Shipment Patterns for Transhipment Model.

distribution costs within the study area and second the influence of inter-area shipment of beef from a southwesterly direction. The concentration of population north and east of Sturgis was sufficient, when combined with the lower cost of meat inshipment to the southwest, to shift the location of this plant.

Cattle supply areas were generally consistent with expectations, given the plant locations and volumes slaughtered at each plant (see Figure 5.2).

As was true in the previous model, the least cost solution resulted in the allocation of an extremely large volume of slaughter at Adrian. The 692,000 head to be slaughtered is over three times the size of the largest plant considered in the synthesis of costs in the previous chapter. The result is due to the assumption that the linear total cost function obtained is representative for all plant sizes.

It should be pointed out that, based on the cost function used, the major economies of size are obtained by the largest synthesized plant. The per head slaughtering cost curve is asymptotic to a value of $8.30 which is only 55 cents below the per head slaughtering cost of the largest plant considered. However, of major concern here is the possibility of significant diseconomies when annual slaughter volume approaches 700,000 head. No synthesized cost data is now available for plants of this size in the study area. Thus, of necessity, it was assumed that the cost function obtained was applicable.

It is also worth noting that even when the number of plants increases the volume of cattle allocated to the Adrian plant remains much higher than the largest synthesized plant. The second iteration of the transhipment model allocated production to ten plants. An annual volume of 595,000 head was to be slaughtered at Adrian. If diseconomies at extremely large plants do in fact exist then some difference in plant locations and plant sizes would be expected. Although the exact influence cannot be estimated from the above data without changes in the models used it seems likely that additional plants would be suggested in the Adrian area including south and east of Adrian. Some shifting of other plant locations might also be expected.

Since one cannot show mathematically that the solution obtained is a true optimum, several alternative solutions were rerun after the above solution was obtained. In these iterations only assembly and distribution costs were considered. This was done because the allocation of cattle between plants does not affect the total cost of the solution.

The same number and location of plants as obtained remained the least costly. However, there was a shift of production from Adrian to Lansing of approximately 96 million pounds of live cattle. The second least costly solution shifted the Lansing plant to Kalamazoo. This increased transportation costs by $43,368. A shift in plant locations to the locations suggested by the Stollsteimer procedure resulted in an increase of $64,000 over the least costly solution. This change involved a shift of one plant from Lansing to Sturgis.

Using the transhipment model the least costly location of three plants increased transportation costs by $361,200 while the least costly five plant solution showed a decline in costs of only $2,024. When the increase in processing costs due to the additional plant are considered the four plant solution remained the least costly by about $152,000.

Summary

This chapter presented two models, the estimating procedures used, and the empirical results obtained in estimating the number, size and location of beef slaughter plants that met the objective function of each model.

The first model employed the Stollsteimer procedure for estimating the number, size and location of plants that minimizes the total assembly plus slaughtering cost, assuming economies of size exist. The results of this model indicate that four plants located at Adrian, Sturgis, Alma and Sandusky meet the minimum cost objective. Total cost was $13,098,000. However, a total of 35 other configurations of four plant locations were within 5 percent of the minimum cost configuration. Also, the location of five plants, one at Alma, Sandusky, Ionia, Adrian, and South Bend resulted in a cost increase of only $70,000, while reducing plant numbers to three (Saginaw, Adrian, and Sturgis) increased costs by only $62,000.

The second model used had as the objective function minimization of assembly, slaughtering and meat distribution. This model not only included meat distribution within the study area but also inshipment of beef to meet the excess demand in the area. The final estimate obtained indicated four plants located at Adrian, Lansing, Alma and Sandusky. The primary difference compared to the previous model was the replacement of the Sturgis plant by one in Lansing. Total costs were $25,514,000 of which $10,699,000 were for inshipment of beef from outside the study area. Intra-area costs were $14,814,000. Total transportation costs were increased by $64,000 when the transportation costs of the four plant solution of the Stollsteimer model were estimated using the transhipment program.

Chapter 6

SUMMARY, IMPLICATIONS, LIMITATIONS AND NEEDED RESEARCH

Summary

Introduction: Michigan's beef slaughter industry is faced with economic and institutional pressures which are increasing to a point where major adjustments in the number, size and location of beef slaughter plants are likely to be required if Michigan firms are to remain competitive. Present firms are small compared to firms in major competing areas. Existing firms tend to be located in major urban areas, while recent trends in beef slaughter location and transportation costs suggest that location near cattle supplies can reduce costs significantly. Also, new meat inspection legislation will require considerable investment in many existing plants if they are to remain in operation.

Objectives: The purpose of this study is to provide information that will be useful to industry personnel who must make adjustment decisions; and to state, area and local development groups who seek information on their relative competitive position for industrial development in specific industries. More specifically the objectives were:

(1) To review the trends and recent developments relative to the number, size and location of beef slaughter

plants in the United States, East North Central region and Michigan.

(2) To estimate the number, size and location of beef slaughter plants that will minimize the total cost of cattle assembly, in-plant processing and meat distribution for projected 1980 cattle production and beef consumption.

Three major tasks were involved in the process of obtaining the second objective. These were: (1) to estimate the long-run total cost curve for beef slaughtering in Michigan; (2) to obtain estimates of transfer cost functions for live cattle and carcass beef; and (3) to project to 1980 cattle marketings and beef consumption by geographic subdivisions of the study area.

The procedures used in the attainment of these objectives can be divided into six relatively distinct steps. These were:

(1) A review of the major concepts of location theory

(2) A review of the major trends and recent developments in the beef slaughter industry

(3) Projections to 1980 of cattle marketings and beef consumption by geographic areas

(4) Estimation of transportation rates for live cattle and carcass beef

(5) Estimation of the long-run total cost curve for beef slaughtering in Michigan

(6) Selection and use of models to specify the number, size and location of beef slaughter plants that will

minimize the combined cost of cattle assembly, slaughtering and meat distribution.

The following summary follows the procedural steps outlined above.

Location Theories: Major location theories can be meaningfully categorized into three groups: (1) least-cost location theories, (2) market area theories, and (3) interdependence theories. The least-cost theories concentrate on the cost of production. They generally assume that the firms demand function is perfectly elastic and unaffected by the firms' location decision. Early theories in this group were relatively restrictive in terms of the costs included as well as the nature of the geography being considered. For example, Von Thunen assumed an isolated state with a completely homogeneous land surface and a single consuming center.[1] Weber, however, included more than one consuming center and uneven deposits of raw materials.[2] Transportation, labor and agglomerating tendencies are the three most important location factors in Weber's theory. Finally, Hoover emphasized the importance of a wide variety of factors which affect costs including climate, property taxes and institutional factors.[3]

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[1] Johann Heindrich Von Thunen, Der Isolierte Staat in Beziechung auf Landwirtschaft und Nationalokonomie (3rd ed.; Berlin: Schumacher Zardilin, 1875).

[2] C.J. Friedrich, Alfred Weber's Theory of the Location of Industries, (Chicago: University of Chicago Press, 1962).

[3] E.M. Hoover, The Location of Economic Activity, (New York: McGraw-Hill, 1948).

The market area and interdependence theories differ from the first due mainly to their inclusion of demand factors. They stress the importance of location at points which maximize profits rather than minimize costs. The possibility of affecting the level and elasticity of the firms demand function is an integral part of these theories. The interdependence theories differ from the market area theories in that they admit the possibility of firms being attracted to the same location where as the market area theories do not.

Although it would be appropriate to consider all cost differences and differences in demand conditions that may exist among sites, it was not felt to be an empirically realistic approach for this study. Locational advantages were determined solely on the basis of differences in transportation costs, given the distribution of cattle and consumption of beef.

Major Trends and Developments in Beef Slaughter Industry: An analysis of major trends in beef slaughtering indicated that although the total volume of cattle slaughtered annually is increasing nationally, Michigan is not maintaining its share of the national volume. The number of slaughter plants have been declining both nationally and in Michigan. Nationally major reductions have been in plants slaughtering less than 25,000 head annually.

Over time the geographic distribution of slaughter plants nationally shows a trend toward location in major production areas, while in Michigan plants are highly concentrated in major urban areas.

Other major developments influencing the future of Michigan's beef slaughter industry include the trend toward single species plants, relatively active entry and exit of firms into the industry and new neat inspection legislation that requires all plants to meet the minimum requirements of the federal meat inspection laws.

Cattle Marketing Projections: Previous cattle projections to 1980 for Michigan were used as a basis for the individual production projections within the state. For each production area cattle marketings as a percent of the state's marketings for 1949, 1954, 1959, and 1964 as reported by the U.S. Census of Agriculture were regressed over time to obtain a projection of each area's share of total marketings in 1980. These percentages were then multiplied by the projected state total. Production in each of the eighteen counties in northern Indiana and Ohio which were included in the study was projected by linear regression based on U.S. Census of Agriculture data for 1949, 1954, 1959, and 1964. This approach was selected since no state projections for thses states were available. The total projected volume of cattle marketed in the study area was 1,226,000 head, 850,000 of which was in Michigan.

Beef Consumption Projections: Estimates of beef consumption were based on previous projections of per capita consumption and population for the study area. A per capita consumption of 120 pounds and a total population of 11,578,300 was used. This yielded an estimated consumption of 1,389.4 million pounds of beef.

Cattle Transportation Function: A sample of 32 commercial livestock truckers were interviewed by phone to obtain transportation rates for live cattle. Rates on both straight and semi-trucks were obtained. Since rates for semi-trucks were less for all distances over about 28 miles, only the semi-truck rates were used. The rate function obtained through regression analysis was:

$$Y = \underset{(1.21093)}{9.81571} + \underset{(.00717)}{.18571}X \qquad \bar{R}^2 = .8449$$

where Y = cost in cents per hundred pounds live weight

X = one-way distance

() = standard error of the coefficients

Beef Transportation Function: Since most packing companies own their truck fleets for meat deliveries a cost function was used rather than a rate function. A recent study conducted by the U.S.D.A. reported operating cost of a refrigerated tractor-trailer unit. Since the truck sizes and refrigeration requirements were judged to be very similar, costs from the previous study were adjusted for difference in weight and applied to this study. The regression equation obtained was:

$$Y = \underset{(.2548)}{7.0799} + \underset{(.0023)}{.1813}X \qquad \bar{R}^2 = .9979$$

where Y = cents per hundred weight of beef

X = one-way distance

() = standard error of the coefficients

Long-run Total Cost for Beef Slaughtering: A modified economic engineering approach to cost estimates were taken in estimating the long-run total cost for beef slaughtering in Michigan. Physical input-output requirements for five on-the-rail plants with hourly capacities of 20, 40, 60, 75, and 120 head per hour were obtained from a recent California study. Factor input prices were estimated for present supply-demand conditions in Michigan. No attempt was made to adjust prices among locations within the study area but rather to obtain a representative price for each input. By synthesizing the total costs for each input and summing these, an estimate of the total cost of operating each plant at its rated output was obtained. These five cost figures were then regressed on annual output and the following total cost function obtained:

$$Y = \underset{(37,530)}{153,895} + \underset{(.2774)}{8.2982}X \qquad \bar{R}^2 = .9955$$

where Y = total annual cost in dollars

X = number of head slaughtered annually

() = standard error of the coefficients

Costs per head ranged from a high of $11.34 for the smallest to a low of $8.85 for the largest plant. The cost per head based on the above total cost function has a minimum value of approximately $8.30 per head as reflected by the second coefficient in the function. Savings in labor costs were the major contribution to the lower per unit cost as size increased. They declined from $7.84 to $6.34 or by $1.50 per head as plant capacity increased from 20 to 120 head per hour.

Model Results: Two models were established as a basis for estimating the number, size and location of beef slaughter plants. The first model had as its objective function the minimization of cattle assembly and slaughter costs with no consideration for meat distribution or inshipment of meat from outside the study area. The second model included these two latter factors.

Before the models were developed, 15 potential plant sites were selected for inclusion in the models. Consideration of local conditions were not included because it was believed that these conditions were subject to change and that potential sites should not be eliminated from consideration based on existing situations.

The estimating procedure for the first model followed that suggested by Stollsteimer. The solution which minimized the total assembly and slaughtering cost resulted in the location of a plant at the following locations with the indicated annual volume of slaughter:

Alma	- 295,613 head
Sandusky	- 169,932 head
Adrian	- 449,735 head
Sturgis	- 310,875 head

Total costs for this solution was $13,098,000, of this $10,790,000 was slaughter cost and $2,307,000 was for assembly of livestock.

It is significant that 35 different configurations of four plant sites resulted in assembly costs within 5 percent of the least cost locations indicated above. Also the least cost three plant solution resulted in an increase of only $62,000 or 0.4 percent in total costs while the five plant solution increased total costs by $70,000 or 0.5 percent. Thus, although the four plants at the above locations resulted in the least cost, numerous alternatives are very near the least cost solution. This suggests that factors not included here would likely affect total costs more than the small differences in costs indicated between these alternatives (see Table 5.2).

The second model, a transhipment model, was estimated through an iterative, linear programming procedure similar to the process used by Logan and King in connection with a transportation model.[1] The final solution of this model also indicated that four plants minimized total costs. Three of the plants were at the same locations as indicated by the previous model, while Lansing replaced Sturgis as a plant site. The sites in the final solution and annual volume slaughtered were as follows:

Alma	-	172,000 head
Sandusky	-	154,000 head
Lansing	-	208,000 head
Adrian	-	692,000 head

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[1]Samuel H. Logan and Grodon A. King, "Size and Location Factors Affecting California's Beef Slaughtering Plants," Hilgardia, Vol. 36 (December 1964).

Minimized total costs for this model was $25,514,000. Of this, $10,699,000 represented the cost of shipping meat from outside the area. Intra-area costs were $14,814,000.

It is important to point out that in both models the volume of cattle slaughtered at some locations exceeded the largest size plant in the cost estimates. This was especially true in the transhipment model. However, since no other data was available it was assumed that the cost function obtained was applicable. In the transhipment model the volume of cattle allocated to the Adrian plant remained extremely high even when a larger number of plants were located so as to minimize costs. An annual volume of 595,000 head was shipped to the Adrian plant in the results of the second iteration of the transhipment model. This iteration minimized costs with ten plants.

If significant diseconomies exist in slaughter costs above the plant sizes studied then more than one plant in the Adrian area, separated so as to minimize the transportation cost would be suggested.

Implications

The overall purpose of this study was to provide information to Michigan beef slaughterers that will assist them in long-run planning of plant facilities and to assist development groups that seek information on their relative competitive position in specific industries.

In view of the economic and institutional forces affecting the competitive position of Michigan's beef slaughter industry, many of the present firm's owners and managers are or soon will be faced with new investment decisions. Where major investments are necessary to up date plants to meet new legislative requirements an alternative that will often be considered is the construction of a completely new plant. When this becomes a feasible alternative to existing firms, the possibility of relocation will also be a consideration. The data presented here provides valuable information on volume-cost relationships in slaughter plant operations under Michigan conditions, cattle transportation costs, beef delivery costs, projections of cattle supply and beef consumption and an indication of the areas of the state where location will minimize the transportation costs.

With respect to the transportation minimization aspect, one must remember that it does so only if other plants are located at the specified sites and at the specified volumes of production. This seriously reduces the direct application of the results of the transportation models to an individual firm's location decision. However, in a competitive system it does indicate the direction toward which plant locations are likely to evolve. To the extent that the models developed do reflect the combined decisions of firms over time, they provide a glimpse of some of the important competitive relationships that firms will face in the future.

Based on the estimates of economies to size, large plants are able to produce at significantly lower costs than are smaller plants. Critical to the validity of this conclusion is the assumption that factor costs, especially wage rates, are the same for all plants and that management is able to attain the potential economies suggested by the data. In practice one of the cost advantages of small plants in the past has been their ability to obtain labor at rates significantly below rates paid by larger plants.

Lower wages coupled with the potential for small plants to meet the demand of specialized markets may be sufficient to keep some small plants in operation. However, this potential should be studied carefully by the individual plant management before making long run decisions.

The cost data presented is valuable not only in making plant size and location decisions but also in comparing the cost of present operations against those presented here. If care is taken to assure that cost data on existing operations provide comparable cost estimates the total cost estimates of this study can be used to evaluate the efficiency of present operation. In making such comparisons a detailed analysis of the individual cost items should be made in order to remove the influence due to factor price differences.

Although a detailed study of factor prices at specific locations considered is needed, the cost data presented will be useful to firms making cost comparisons between Michigan and other potential slaughtering locations. In making these comparisons the time at which factor prices, especially labor, are obtained is important since absolute costs per unit are trending upward.

Subject to some important limitations discussed later, state-wide industrial development groups are here provided with data that suggests the general areas of the state where new or expanding beef slaughter operations should be encouraged. It is the interest of state-wide development groups to aid industry in making the necessary adjustments to remain viable and competitive. Possibly even more important than location, the data suggests that a few large firms would result in the least total use of the state's resources. Thus, unless special conditions not reflected by the models in this study prevail the construction of new small high cost plants should be discouraged.

Local development groups are interested in developing the resources of their local area. The data here provides an indication of the general areas of the state where beef slaughtering has a competitive advantage given the limitations of the factors considered. In general, areas not indicated in the solutions obtained by this study or adjacent to these areas should be extremely cautious before encouraging or supporting the development of beef slaughtering in their area. (This in effect eliminates only the northern part of the lower peninsula.) Here it should be reemphasized that the locations specified in the study are intended to be representative of an area not a specific location. Special input cost advantages, especially for labor, access to a specific market or other conditions can change the results obtained, but the reasons should be studied carefully before investments are made.

For those locations in or near an area specified by the study, a competitive advantage appears to exist, providing the input prices used are representative, the physical requirements of the plant are available, and the projections of cattle supplies and beef demands are realized. For these areas a detail study of the local input prices would be valuable. Also the effect of existing plants on the competitive position of a new plant should be evaluated. This would show a strengthening or weakening of the area's advantage depending on the results of the study. As a part of this detail cost study, the actual availability of utilities, adequate transportation access, and zoning restrictions would need to be considered. If not available, consideration should be given to the feasibility of providing the needed services in the event a plant location became a possibility.

Limitations and Needed Research

Several limitations of this study have been suggested throughout its development, however, it was felt that these should be reemphasized and some suggested research to overcome these limitations should be indicated.

Individual research projects are always limited by the abilities of existing procedures and the capability of the analyst to incorporate all the needed variables. In this study the procedures focused on an estimate of the number, size and location of beef slaughter plants that would minimize total assembly, slaughter and distribution costs of the projected 1980 cattle production in the study area. No consideration was given to the influence of existing plants, to the costs involved in making the changes indicated by the models, or to the savings that would occur over the present situation by shifting to the new organization. Additional work to estimate the effect of existing plants on the solutions would be an important addition to the results of this study and should, in the author's opinion, be placed high on the list of priorities for future research relating to livestock marketing.

Another important limitation of this study is the omission of the influence of seasonal variations in the marketing of cattle in the area. Estimates were based only on the total volume of annual slaughter. This would suggest that over and under capacity will exist during some periods as supply fluctuates. An estimate of the short run cost curve would help identify the influence of variations in output on per unit slaughter costs. An analysis of the cattle procurement practices and problems of existing firms including the location and volume of inshipments by time periods within the year would supplement the analysis presented as well as make it possible to estimate the influence of cattle as well as meat inshipments on the number, size and location of plants.

The results obtained were based on projections of cattle production and beef consumption by geographic subdivisions of the study area. The nature of the analysis used suggests a long-run equilibrium condition and as such would be based on expected supply and demand conditions. Imperfect foresight of these conditions is a limitation but one which cannot be easily overcome. The procedures used for making the projections suggest a continuation of past trends in each area. These trend- were based on a limited number of observations. Although it is not expected that significant shifts would occur more detailed information on past trends for each area would improve the projections obtained and increase the reliability of the results.

Present programs and computer capacity made it necessary to limit the number of supply, processing and consumption regions. This means that either the total geographic area considered must be restricted, as was the case in this study, or the individual sub-areas must be relatively large as is the case in most national models. When an area smaller than the nation is considered, problems arise in determining the exact geographic area to be included. This decision can, in and of itself, influence the results, especially if plant locations result near the border of the area being studied. For instance it seems quite clear that the inclusion of parts of Indiana and Ohio in the present study resulted in the selection of different plant sites in Michigan that would have been selected if the Indiana and Ohio counties had been excluded.

One alternative would be the inclusion of Indiana, Ohio, Illinois and Michigan into a four state regional model. This would not eliminate the influence of the selection of the study area boundaries on the results but would help minimize the influence of this decision on the location of plants in or near Michigan. It would, however, increase the size of the supply and consumption areas that would have to be included and thus reduce the precision with which transportation costs could be measured.

Cost data in this study is believed to be the best available without extremely detailed evaluation of each item considered. Due to the importance of labor costs, which represent about 70 percent of the total costs, additional work to verify the estimates obtained here would be worthshile. Although the estimates used here were obtained from union contracts or direct estimates from union representatives the limited experience of local union officials with on-the-rail plants suggest that some variation from the costs used might be expected from either wage rate differences or due to differences in productivity.

The results of the models used indicated the establishment of some plants considerably larger than those considered in the cost data. This suggests a need to verify the assumption that the total cost function used is representative for larger firms. During early work on this project an attempt was made to obtain input-output data on a larger plant but it was not available at that time.

Actual transportation rates between points often differ depending on the volume of traffic, the possibility of backhauling and other factors. These differences were not considered in this study but could have an influence on plant locations. A study which would reveal the extent and nature of these differences would make it possible to include them in future studies.

Finally, additional work might be done on developing procedures which would make it possible to include into the models differences in demand and supply functions among geographic regions within the area.

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APPENDICES

Appendix Table 1. Synthesized Kill Crew and Annual Cost, 20 and 40 Head Per Hour Plant, Michigan, 1968.

Operation	Wage Rate: Wage	Wage Rate: Unit	Output Per Hour in Number of Head: 20 — No. of Workers	20 — Yearly Wage[1]	40 — No. of Workers	40 — Yearly Wage[1]
Kill, remove head, and wash head						
Drive, pen, knock	$2.50	hour	.67		1.00	5,200
Shackle, hoist stick, scalp head	2.05	head	.67	14,685[a]	2.00	20,052
Tag, cut off head, dehorn, wash head	2.50	hour	.67		1.00	5,200
Remove hide, eviscerate, split and scribe						
skin leg, punch, gam, saw off, skin gam and punch, rip and point tail	2.05	head	.50		1.00	10,026
Transfer from bleeding to skinning rail, remove udder or pizzle, mark aitch bone	2.05	head	.50	9,485	1.00	10,026
Skin leg and saw off, split aitch bone	2.05	head	.50	9,485	1.00	
Drop bung	2.05	head	.50			10,026
Turn round and flank both sides to naval	2.05	head	.50		1.00	10,026
Skin fell, rump and pull tail	2.05	head	.50	9,485	1.00	10,026

Appendix Table 1. (Continued)

Operation	Wage Rate: Wage	Wage Rate: Unit	Output Per Hour in Number of Head: 20 No. of Workers	20 Yearly Wage[1]	40 No. of Workers	40 Yearly Wage[1]
Skin and remove front feet, raise and tie weasand, clean neck both sides	$2.05	head	.50		1.00	10,026
Mark and saw brisket, rim over right and left brisket	2.05	head	.50	9,485	1.00	10,026
Turn shank, clean rosette, mark neck and drop hide	2.05	head	1.00	9,485	2.00	20,052
Skin sides, high and low back	2.05	head	1.00	9,485	3.00	30,078
Transfer to flat rail	2.50	hour	.50	9,485	.25	10,026
Eviscerate (Paunch trunk 20-40)	2.05	head	1.00	9,485	1.00	10,026
Split	2.05	head	.50	-	.75	-
Trim bruises	2.05	head	.50	9,485	1.00	10,026
Remove passed viscera	2.50	hour	1.00	5,200	1.00	5,200
Scribe and trim neck	2.50	hour	.50	-	1.00	5,200
Carcass finishing						
Scale	2.50	hour	.50	5,200	1.00	5,200
High and low wash	2.50	hour	1.00	5,200	2.00	10,400
High and low shroud	2.90	hour	.50	-	2.00	10,400
Others						
Utility and relief	2.50	hour	1.00	5,200	1.00	5,200
Tripe work-up	2.50	hour	1.00	5,200	2.00	10,400

Appendix Table 1. (Continued)

Operation	Wage Rate: Wage	Wage Rate: Unit	Output Per Hour in Number of Head: 20: No. of Workers	20: Yearly Wage[1]	40: No. of Workers	40: Yearly Wage[1]
Offal work-up	$2.50	hour	.50	$ 6,760	1.00	$5,200
Head work-up	3.25	hour	.50		2.00	13,520
TOTAL	-	-	17.00	132,810	32.00	251,562

[1] Yearly wages are computed by assuming 2,080 hours per year (260 days at 8 hours each) including 8 holidays for wages given on a per-hour basis. For the piece rate workers the rated output of the plant per hour is assumed and divided by the number of piece rate workers required to arrive at an hourly output per worker. This was then multiplied by the wage rate and the number of workers required for each operation.

[a] One worker at $2.05/head and one at $2.50/hour.

Source: Requirements taken from Samuel H. Logan and Gordon A. King, <u>Economies of Scale in Slaughter Plants</u>, Giannini Foundation Research Report No. 260, Berkeley: California Agricultural Experiment Station, 1962, p. 123-27.

Appendix Table 2. Synthesized Kill Crew and Annual Cost, 60, 75 and 120 Head Per Hour Plants, Michigan, 1968.

Operation	Wage Rate: Wage	Wage Rate: Unit	60: No. of Workers	60: Yearly Wage	75: No. of Workers	75: Yearly Wage	120: No. of Workers	120: Yearly Wage
			Output Per Hour in N-mber of Head					
Kill, remove head, and work head								
Drive, pen cattle and knock	$2.50	hour	1.00	$5,200	2.00	$10,400	3.00	$15,600
Shackle, hoist, stick scalp, head	2.05	head	3.00	31,950	3.00	35,505	5.00	58,135
Tag, cut off, dehorn and wash head	2.50	hour	1.00	5,200	2.00	10,400	3.00	15,600
Remove head, eviscerate, split and scribe								
Skin legs, punch gams, rip and point tail	2.05	head	2.00	21,300	2.00	23,670	4.00	46,508
Transfer from bleeding conveyor to skinning conveyor	2.50	hour	1.00	5,200	1.00	5,200	2.00	10,400
Remove, shackle, skin legs, cut off	2.05	head	1.00	10,650	2.00	23,670	3.00	34,881
Remove udder or pizzle, mark aitch bone	2.05	head	.50	10,650	1.00	11,835	1.00	11,627
Drop bung	2.05	head	1.00	10,650	1.00	11,835	2.00	23,254
Split aitch bone	2.05	head	.50	-	1.00	11,835	1.00	11,627
Turn round and flank both sides to naval	2.05	head	2.00	21,300	2.00	23,670	3.00	34,881
Skin fell, rump both sides, pull tail	2.05	head	2.00	21,300	2.00	23,670	3.00	34,881
Skin, remove front feet, raise and tie weasand	2.05	head	2.00	21,300	1.50	35,505	3.00	34,881
Open and turn shanks, clean necks	2.05	head	1.00	10,650	1.50		2.00	23,254

Appendix Table 2. (Continued)

Operation	Wage Rate		Output Per Hour in Number of Head					
			60		75		120	
	Wage	Unit	No. of Workers	Yearly Wages	No. of Workers	Yearly Wages	No. of Workers	Yearly Wages
Mark and saw brisket	$2.05	head	.50	$10,650	1.00	$11,835	1.00	$11,627
Rim over brisket, both sides	2.05	head	.50		1.00	11,835	2.00	23,254
Skin rosettes and neck	2.05	head	2.00	21,300	2.00	23,670	3.00	34,881
Low back	2.05	head	1.00	10,650	1.00	11,835	2.00	23,254
High back	2.05	head	1.00	10,650	1.00	11,835	2.00	23,254
Eviscerate	2.05	head	2.00	21,300	2.00	23,670	3.00	34,881
Saw rump and loin, backs and chuck	2.05	head	1.00	10,650	1.00	11,835	2.00	23,254
Scribe and trim bruises	2.05	head	1.00	10,650	1.00	11,835	2.00	23,254
Carcass finishing								
Scale and tag	2.50	hour	2.00	10,400	2.00	10,400	2.00	10,400
High and low wash	2.50	hour	2.00	10,400	3.00	15,600	4.00	20,800
High and low shroud	2.40	hour	2.00	10,400	2.00	10,400	4.00	20,800
Other								
Utility and relief	2.50	hour	2.00	10,400	2.00	10,400	4.00	20,800
Remove passed viscera	2.50	hour	2.00	10,400	2.00	10,400	2.00	10,400
Operate hide puller	2.50	hour	1.00	5,200	1.00	5,200	1.00	5,200
Head work-up	3.25	hour	2.00	13,520	3.00	20,280	5.00	33,800
Tripe work-up	2.50	hour	3.00	15,600	4.00	20,800	7.00	36,400
Offal work-up	2.50	hour	1.00	5,200	2.00	10,400	2.00	10,400
TOTAL	-	-	44.00	$362,720	53.00	$459,425	83.00	$722,188

Source: Requirements taken from Samuel H. Logan and Gordon A. King, Economies of Scale in Slaughter Plants, Giannini Foundation Research Report No. 260, Berkeley: California Agricultural Experiment Station, 1962, p. 123-27.

Appendix Table 3. Synthesized Crew Sizes and Annual Wages for Specified Operations, by Size of Plant, Michigan, 1968.

		Output Per Hour in Number of Head									
		20		40		60		75		120	
Operation	Hourly Wage	No. of Workers	Annual Wages	No. of Workers	Annual Wages	No. of Workers	Annual Wages	No. of Workers	Annual Wages	No. of Workers	Annual Wages
Cooler	2.70	4	$22,464	5	$28,080	8	$44,936	8	$44,936	12	$67,404
Dock											
Foreman	3.20	1	6,650	1	6,656	1	6,656	1	6,656	1	6,656
Order clerk	2.70	-	-	2	11,232	2	11,232	2	11,232	2	11,232
Checkers	2.70	-	-	1	5,616	1	5,616	1	5,616	2	11,232
Maintenance											
Foreman	3.50	-	-	1	7,280	1	7,280	1	7,280	1	7,280
Gang leader	3.30	1	6,864	-	-	-	-	-	-	-	-
Workers	2.50	1	5,200	4	20,800	5	26,000	6	31,200	9	41,800
Yardmen	2.50	1	5,200	2	10,400	2	10,400	2	10,400	3	15,600
Clean-up	2.50	1	5,200	2	10,400	3	15,600	4	20,800	5	26,000
TOTAL	-	9	$51,584	18	$100,464	23	$127,720	25	$138,120	35	$187,204

[1]Annual wages based on number of workers times 2080 hours per year (260 days at 8 hours per day) times hourly wages.

Source: Requirements taken from Samuel H. Logan and Gordon A King, Economies of Scale in Slaughter Plants, Giannini Foundation Research Report No. 260, Berkeley: California Agricultural Experiment Station, 1962, p. 39.
Hourly wages synthesized from unpublished data obtained from Amalgamated Butchers and Meat Cutters of North America, Local 630, Detroit, Michigan.

Appendix Table 4. Annual Wages and Number of Salaried Personnel by Size of Plant, Michigan, 1968.

Operation	Annual Cost Per Worker	No. of Workers and Annual Cost by Plant Size in Head Per Hour				
		20	40	60	75	120
Office						
Switchboard	$ 6,900	-[a]	1	1	1	1
Payroll, acct. payable	10,000	1	1	1	1	2
General	8,600	-	1	1	1	3
Credit manager, livestock payable	12,000	-	1	1	1	2
General ledger, office manager	13,800	-	1	1	1	2
Phone, billing and posting	6,900	1	-	2	2	3
General ledger, credit, acct. payable	12,100	1	-	-	-	-
Buying and Selling						
Buyers	13,800	1	2	5	5	7
Sellers	13,800	2	3	5	6	9
Management						
General manager[1]	23,300	1	1	1	1	1
Senior buyer[2]	16,000	-	1	1	1	1
Sales manager[2]	16,000	-	1	1	1	1
Plant superintendent[3]	17,300	-	-	1	1	1
Asst. Plant Superintendent[4]	17,300	-	-	1	1	1
Total Annual Cost	-	$93,700	$178,200	$314,400	$314,400	$453,500

Appendix Table 4. (Continued)

[a]Dashes indicate the position is not utilized as specified.

[1]Salary rate is assumed to increase with size of plant as follows: 20 head, $23,300; 40 head, $25,800; 60 and 75 head, $28,300; 120 head, $30,800.

[2]Salary rate is assumed to increasd with size of plant as follows: 40 head, $16,000; 60 and 75 head, $19,000; 120 head, $21,000.

[3]Salary rate is assumed to increase with size of plant as follows: 60 and 75 head, $17,300; 120 head, $19,000.

[4]Salary rate is assumed to increase with size of plant as follows: 60 and 75 head, $17,300; 120 head, $19,000.

Source: Requirements taken from: Samuel H. Logan and Gordon A. King, Economies of Scale in Slaughter Plants, Giannini Foundation Research Report No. 260, Berkeley: California Agricultural Experiment Station, 1962, p. 127. For cost estimate procedure, see text.