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Estimated optimum interregional competition and location patterns in the southern cattle slaughtering industry in 1975

Robert Newell Wisner

To the Graduate Council:

I am submitting herewith a dissertation written by Robert Newell Wisner entitled "Estimated optimum interregional competition and location patterns in the southern cattle slaughtering industry in 1975." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

Irving Dubov, Major Professor

We have read this dissertation and recommend its acceptance:

Joe A. Martin, Hans E. Jensen, Merton B. Badenhop

Accepted for the Council:

Carolyn R. Hodges

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(Original signatures are on file with official student records.)

January 7, 1967

To the Graduate Council:

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and recommend its acceptance:

Joe A. Martin

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Graduate Studies and Research

ESTIMATED OPTIMUM INTERREGIONAL COMPETITION AND LOCATION PATTERNS IN THE SOUTHERN CATTLE SLAUGHTERING INDUSTRY IN 1975

A Dissertation

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Doctor of Philosophy

---

by

Robert Newell Wisner

March 1967

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CHAPTER I

DEFINITION OF THE PROBLEM AND OBJECTIVES OF THE STUDY

Information about the approximate size and general direction of future changes in the interregional patterns of marketing activities for a given industry is needed for decision-making in respect to resource allocation and capital budgeting at the farm level. This information also is needed to guide decisions affecting the location of processing facilities, their expansion, and the adoption of new processing and distribution technology. The study reported here was undertaken to provide a subset of such information. It was concerned with estimating the effects of technological changes in cattle slaughtering and interregional transportation, as well as increases in population and per capita income, on the optimum locations and volumes of cattle slaughtering in various areas of the South.[1] An additional objective was to estimate the effects of these developments on optimum interarea movement patterns of slaughter cattle and beef. This information should provide estimates of the changing comparative advantages of the areas in cattle slaughtering.

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[1]The South, as defined here, includes the following states: Virginia, West Virginia, North Carolina, South Carolina, Georgia, Alabama, Florida, Mississippi, Louisiana, Arkansas, Oklahoma, Tennessee, and Kentucky. The areas used in this study are specified in Chapter III.

I. FACTORS AFFECTING FUTURE INTERREGIONAL COMPETITION PATTERNS IN CATTLE SLAUGHTERING

Technological Changes in Transportation and Slaughtering

One major change in transportation technology, currently under way, is the National System of Interstate and Defense Highways, commonly called the Interstate System. This system was created by the Federal-Aid Highway Act of 1944, and was expanded by the Federal-Aid Highway Act of 1956. The total mileage of the Interstate System, as specified by the 1956 Amendment, is forty-one thousand miles.[2] When completed in 1972, the system is expected to carry more than 20 percent of all United States traffic. It will connect and serve 92 percent of all cities of over fifty thousand population and many smaller cities and towns.[3] A map of the planned Interstate Highway network is shown in Figure 1.

As McLeary has pointed out, economic effects associated with highway construction or improvement projects may be separated into two broad categories: (1) expenditure effects and (2) location effects.[4] The former involves its impact on aggregate effective demand. The

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[2]United States Department of Commerce, Bureau of Public Roads, Highway Progress, 1964: Annual Report of the Bureau of Public Roads, Fiscal Year 1964 (Washington: Government Printing Office, 1964), p. 14.

[3]U. S. Department of Commerce, Bureau of Public Roads 6-10, Quarterly Report of the Federal-Aid Highway Program (Washington: Government Printing Office, February 1965), p. 1.

[4]J. W. McLeary, "Optimum Interregional Shipments of Beef, Pork, Broilers and Eggs, and the Predicted Effects of the Interstate Highway System on the Equilibrium Movement Patterns of These Commodities" (unpublished Ph. D. dissertation, The University of Tennessee, Knoxville, 1965), p. 3.

PLANNED ROUTES OF
THE NATIONAL SYSTEM OF INTERSTATE AND DEFENSE HIGHWAYS

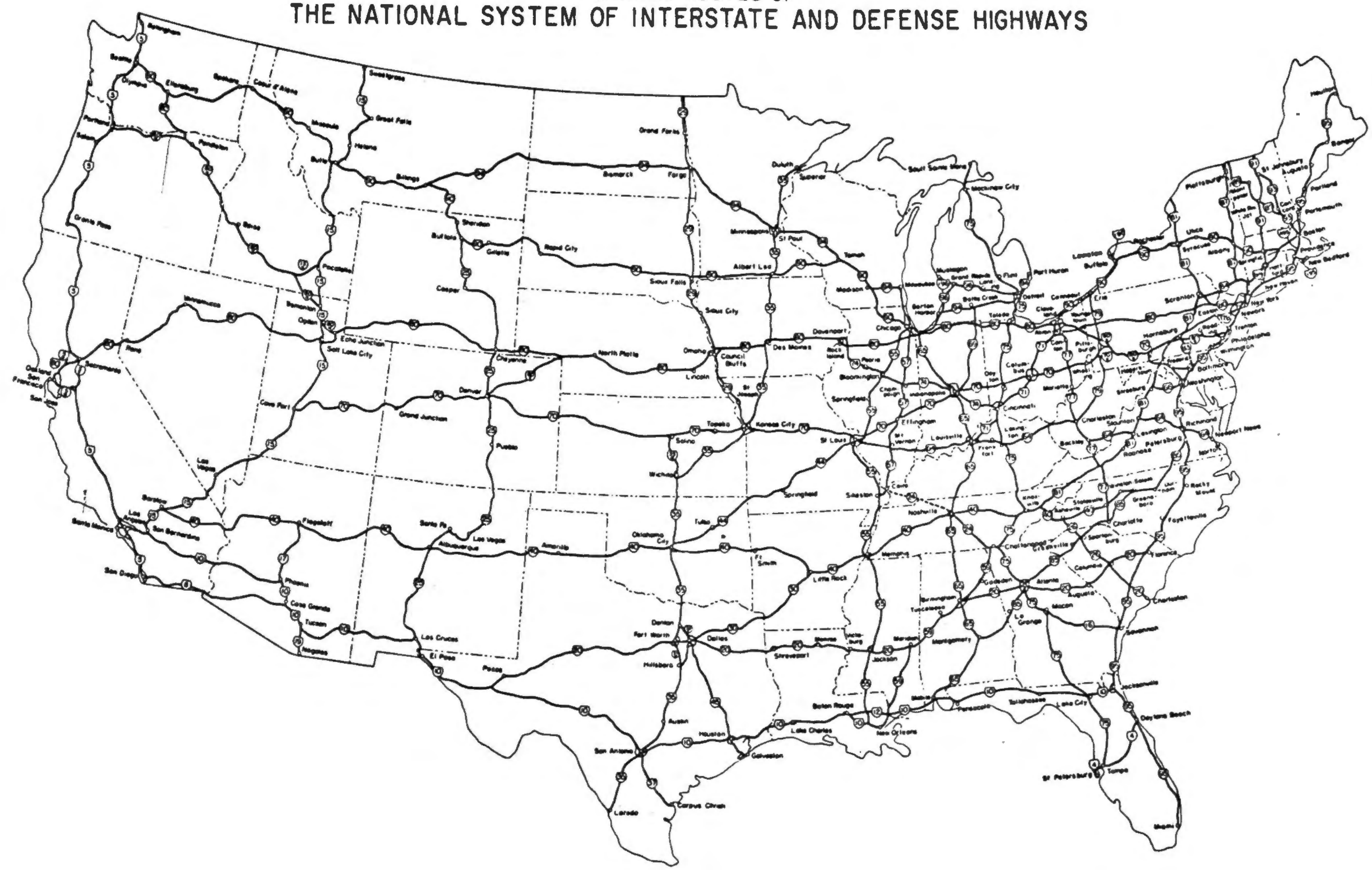

Figure 1. The planned network of interstate and defense highways.

Source: United States Department of Commercie, Bureau of Public Roads, <u>Interstate System Route Log and Finder List</u> (Washington: Government Printing Office, 1963), p. 1.

latter involves the impact on comparative advantage relations among areas. The present study was concerned with the Interstate System from a locational (or comparative advantage) point of view rather than from the expenditure-effect standpoint. It was assumed that locational effects would be registered primarily through changes in relative interregional transportation costs. While community attitudes and cultural patterns also can influence the locational advantages of a given area, the net effect of possible changes in these factors was assumed to be random.[5]

Turning next to technological changes in cattle slaughtering, presently available slaughter-plant technology includes (1) bed-type and (2) on-the-rail systems. Basically, the bed-type system requires that carcasses, suspended from a rail, be moved manually along the rail, and removed from the rail for performance of major slaughtering operations. In contrast, on-the-rail systems contain a power driven unit that moves the carcass along the rail, and slaughtering operations are performed while the carcass is suspended from the rail.[6] As a result, this latter system permits increased mechanization and job specialization, thus leading to larger possible plant capacities and economics of scale. Although data are not available concerning the distribution of present

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[5]For a discussion of methods for quantifying such effects, see Walter Isard, Methods of Regional Analysis: An Introduction to Regional Science (New York: John Wiley and Sons, Inc., 1960), pp. 281-293.

[6]S. H. Logan and G. A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962), p. 21.

slaughtering facilities by these two different systems, the data in Table I suggest that existing Federally Inspected cattle slaughtering plants in the South may be generally too small to utilize on-the-rail systems economically. This observation, which will be considered in more detail in Chapter V, is based on Logan and King's study of economies of scale in slaughter plants.[7] It also should be noted that data in Table I may suggest a trend toward larger slaughter plants in the South Atlantic and Southeast regions.

Historical Changes in the Location of Cattle Slaughtering

During the late 19th and early 20th centuries, the development of railroads encouraged a centralized livestock marketing system in the United States. Slaughtering facilities tended to locate adjacent to large terminal markets in the North Central and Northeast Regions. Then, in the late 1920's and early 1930'2, improved highway systems, truck transportation, and dissemination of market news through radio broadcasting started a decentralization movement in the livestock marketing system.[8]

In the 1950's, completion of the unionization of meat packing workers,[9] the development of on-the-rail slaughtering technology, and

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[7] Ibid., pp. 101-104. Logan and King's study indicated that on-the-rail systems become economical at approximately 140,000 head per year, using California wage rates.

[8] Stewart H. Fowler, The Marketing of Livestock and Meat (Danville: The Interstate Printers and Publishers, Inc., 1957), pp. 194-198.

[9] David Brody, The Butcher Workmen (Cambridge: Harvard University Press, 1964), p. 241.

TABLE I

AVERAGE NUMBER OF HEAD OF CATTLE SLAUGHTERED ANNUALLY PER PLANT IN FEDERALLY INSPECTED PLANTS IN THE SOUTH, 1950, 1954, 1958, AND 1962[a]

Year	South Atlantic[b]	Southeast[c]	South Central[d]
1950	11,797	20,792	28,430
1954	24,354	36,465	54,407
1958	16,873	32,019	28,024
1962	22,730	30,992	29,024

[a]Source: Willis E. Anthony, Structural Changes in the Federally Inspected Livestock Slaughter Industry, 1950-62, Agricultural Economic Report No. 83, Economic Research Service, U. S. Department of Agriculture (Washington: Government Printing Office, Revised February 1966), p. 62.

[b]Consists of West Virginia, Virginia, North Carolina, South Carolina, Georgia, and Florida.

[c]Consists of Kentucky, Tennessee, Mississippi, and Alabama.

[d]Consists of Texas, Oklahoma, Arkansas, and Louisiana.

the shift in the balance of market power away from meat packers toward retailers probably encouraged further shifts in the location of the slaughtering industry.[10] By 1960, these and other factors affecting meatpacking profits had forced all of the large national meatpacking firms to reduce or close down operations in their Chicago plants.[11]

Technological developments in slaughtering, combined with transportation cost reductions from the Interstate Highway System, rising per capita income levels, and growth of population centers in the South, may set the stage for further shifts in the location and concentration of the cattle slaughtering industry. Isard suggested that where only changing transportation costs are considered, the general effect may be as follows:

> Suppose an advance in the state of transport technology pushes the supply curve of transport inputs to the right and results in a lower price. From the viewpoint of industrial production there will be both a scale and a substitution effect. Historically we find that reduced transport rates have tended (1) to transform a scattered, ubiquitous pattern of production into an increasingly concentrated one, and (2) to effect progressive differentiation and selection between sites with superior and inferior resources and trade routes.[12]

In conjunction with these observations and a possible trend toward larger cattle slaughtering plants in parts of the South, two other aspects

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[10]Dale E. Butz and George L. Baker, Jr., The Changing Structure of the Meat Economy (Norwood: Plimpton Press, 1960), pp. 58-66.

[11]Brody, op. cit., p. 242.

[12]Walter Isard, Location and Space-Economy (New York: John Wiley and Sons, Inc., 1956), p. 87.

of the Southern cattle slaughtering industry should be pointed out. These include changes in the number of slaughter plants by states and changes in the number of specialized cattle slaughtering plants in the South. Data concerning these changes are presented in Table II. Numbers of specialized cattle slaughtering plants increased in North Carolina, Georgia, Mississippi, Louisiana, Oklahoma, Kentucky, and Tennessee over the period, 1960-1965. In total, the number of specialized cattle slaughtering plants in the South increased from 65 to 1960 to 74 in 1965.

II. OBJECTIVES

This study was directed toward estimating the effects of changes in demand levels for beef, transportation costs, and slaughter plant technology on the levels of cattle slaughtering in various areas of the South. Specifically, the objectives were (1) to estimate the optimum locations and volumes of cattle slaughtering within a set of areas in the South, using estimated 1975 supply, demand, transportation, and slaughtering cost data, (2) to estimate the resulting interarea movements of slaughter cattle and beef, and (3) to estimate the impact of seasonal variations in slaughtering rates on the factors considered under (1) and (2). The optimum pattern is defined here as the location and interregional shipment patterns that minimize combined total costs of transporting and slaughtering given quantities of cattle, and distributing the resulting beef to meet a set of given area demands.

TABLE II

NUMBER OF SLAUGHTERING ESTABLISHMENTS AND SPECIALIZED CATTLE SLAUGHTERING PLANTS IN THE SOUTH, BY STATES, MARCH 1960 AND 1965[a]

State	Total Slaughter Establishments		Specialized Cattle and Calf Slaughter Plants	
	1960	1965	1960	1965
Virginia	42	39	2	1
West Virginia	38	32	7	4
North Carolina	87	80	4	6
South Carolina	50	41	1	1
Georgia	99	94	--	2
Alabama	56	46	2	1
Florida	54	49	17	11
Mississippi	33	33	4	6
Louisiana	82	70	7	9
Arkansas	55	52	5	5
Oklahoma	65	74	9	16
Kentucky	48	40	3	6
Tennessee	72	61	4	6
Southern Region	781	711	65	74
48 States	3,144	2,957	513	523

[a]Source: U. S. Department of Agriculture, Statistical Reporting Service, "Number of Livestock Slaughter Plants March 1, 1965" (Washington: Government Printing Office, June 1965), pp. 5-7.

III. HYPOTHESES EXAMINED

To facilitate the analysis, two general hypotheses were developed and were specified as follows:

1. The factors noted above concerning changing marketing and distribution technology and changing demand levels for beef will not encourage geographic concentration in the cattle slaughtering industry of the South.

2. These developments will not affect the comparative advantages of the three areas, East Tennessee, Middle Tennessee, and West Tennessee, in cattle slaughtering.

As a basis for comparison of estimated results, the 1965 location pattern for livestock slaughtering plants in the United States is shown by the maps in Figures 2 and 3. Estimated 1962 levels of commercial cattle slaughtering, on an equivalent retail poundage basis, for the three areas of Tennessee were as follows:[13]

Area	Hundredweight Slaughtered Beef Equivalent Units
East Tennessee	787,420
Middle Tennessee	653,760
West Tennessee	498,530

IV. SOME REQUIRED ASSUMPTIONS

In carrying out this study, specialized cattle slaughtering plants were assumed to be economically justified. However, the question

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[13]Liveweight data were obtained from J. C. Purcell, Trend In Production, Marketings, Slaughter, and Consumption of Livestock and Meats In the South, forthcoming Southern Cooperative Series Bulletin. These data were converted to beef equivalent units by using the beef yield coefficient for the South that is developed in Chapter III below.

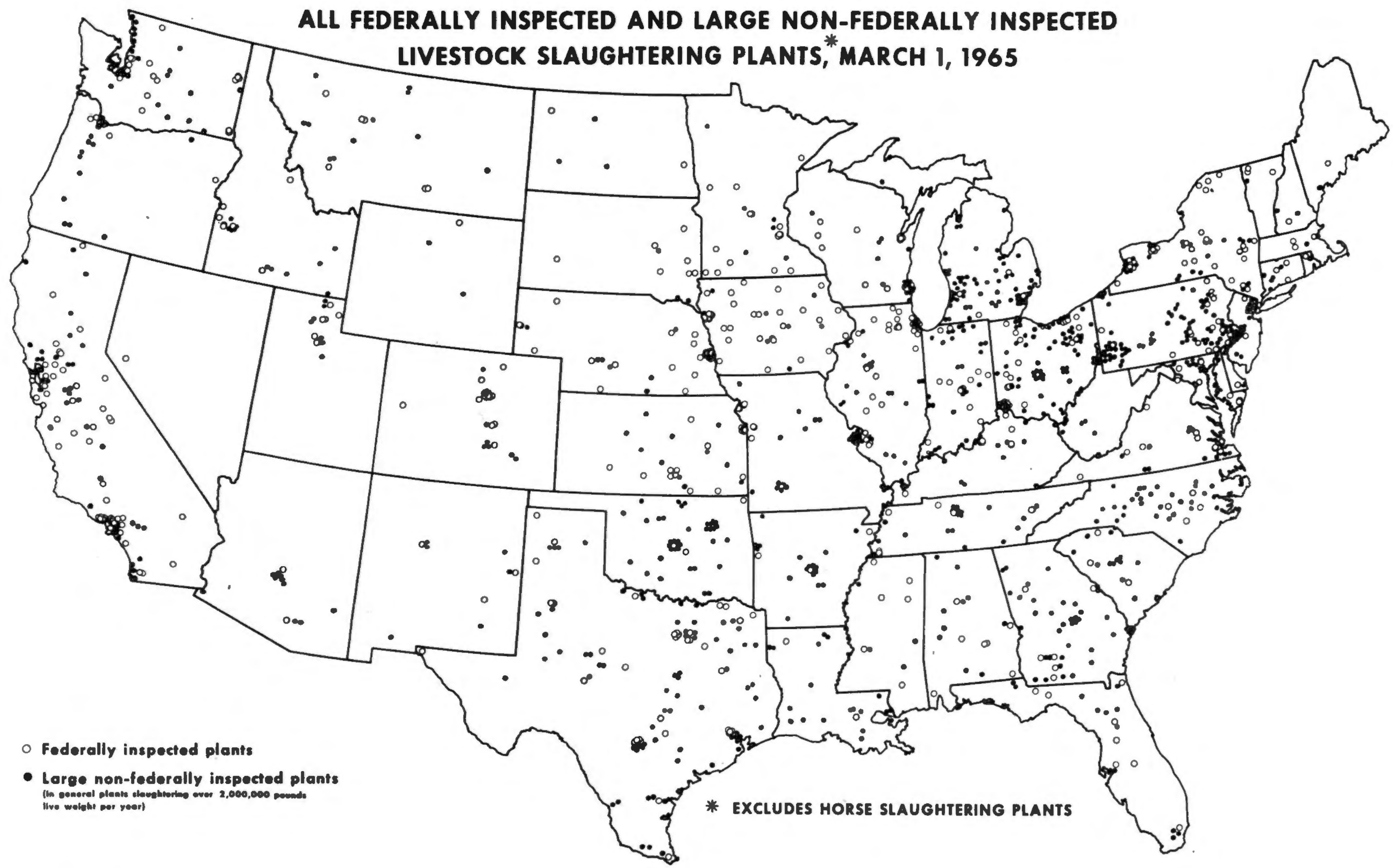

Figure 2. Locations of federally inspected and large non-federally inspected slaughter plants, March 1, 1965.

Source: U. S. Department of Agriculture, Statistical Reporting Service, "Number of Livestock Slaughter Plants March 1, 1965" (Washington: Government Printing Office, June 1965), p. 4.

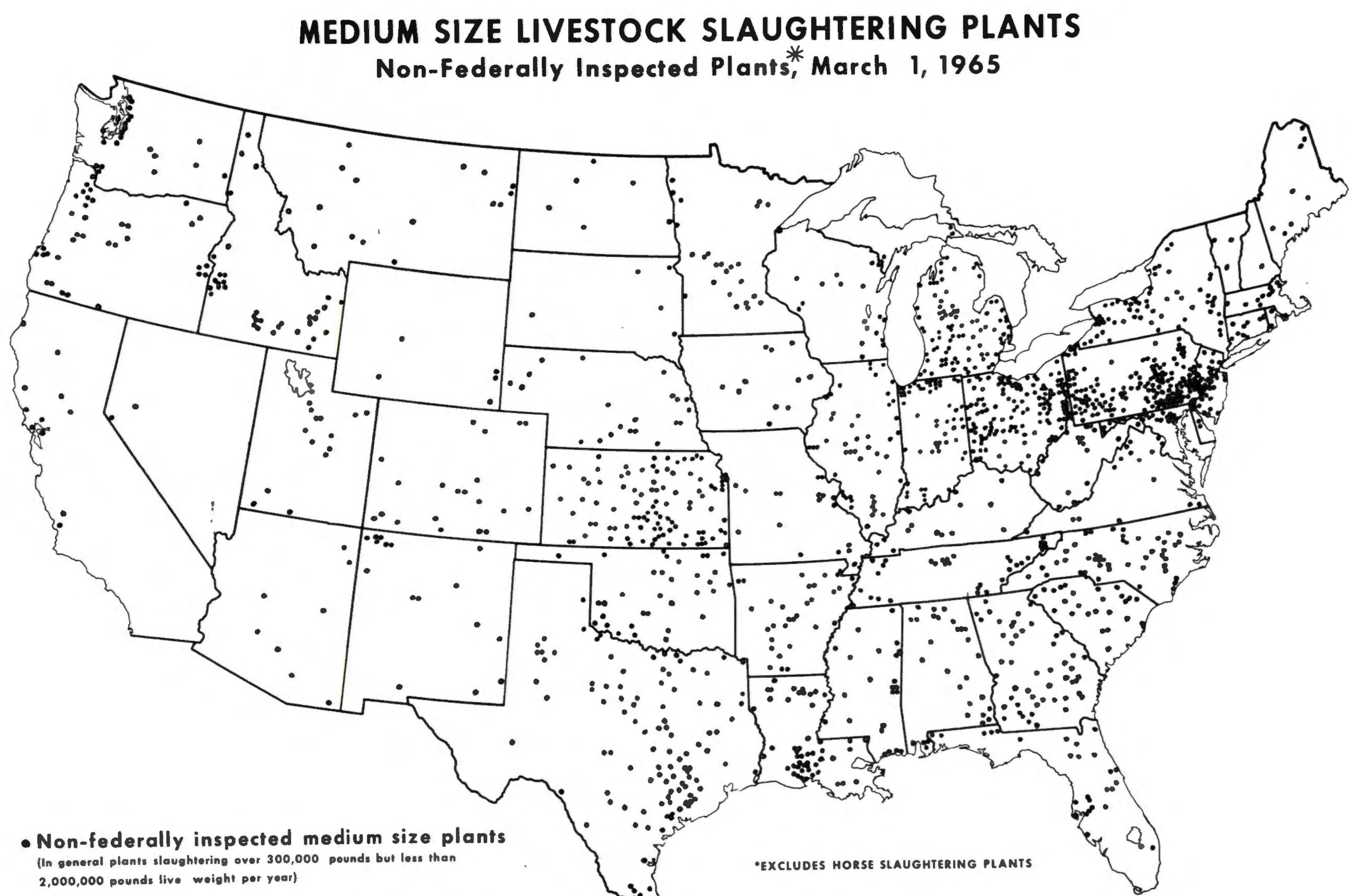

Figure 3. Locations of medium size slaughter plants, March 1, 1965.

Source: U. S. Department of Agriculture, Statistical Reporting Service, "Number of Livestock Slaughter Plants March 1, 1965" (Washington: Government Printing Office, June 1965), p. 14.

arises as to whether week-to-week, seasonal, and cyclical variations in cattle supplies, coupled with a unionized labor force and pressure for a relatively constant level of employment within plants might encourage diversified slaughtering operations.[14] To keep the labor force fully utilized, hogs might be slaughtered during periods of low cattle supplies. In considering this question, indexes of monthly cattle and hog slaughtering in the South were constructed, based on the years 1959 to 1964, by computing twelve-month moving averages.[15] These indexes are shown in Figure 4; they indicate some possibility for utilizing plants and labor force for hog slaughter during the months, December through April.

In addition, it was assumed that the locations of livestock auctions within given areas do not have economically significant effects on slaughtering location among areas. Along with this, all processing of beef is assumed to be done in specialized meat processing plants, by-products of slaughtering plants are assumed to be rendered in specialized rendering plants, and the value of inedible by-products

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[14]S. K. Seaver, The Effect of Variability in the Supply of Eggs Upon Wholesale Marketing Costs, Bulletin 331 (Storrs, Connecticut: Storrs Agricultural Experiment Station, April 1957), p. 33, suggests these factors have contributed to the increase in integration throughout the economy. To overcome seasonal supply problems, firms add other lines to keep labor and plants fully employed.

[15]The procedure used here for constructing moving averages and seasonal indexes is described in F. E. Croxton and D. J. Cowden, Applied General Statistics (New York: Prentice Hall, Inc., 1939), pp. 471-484.

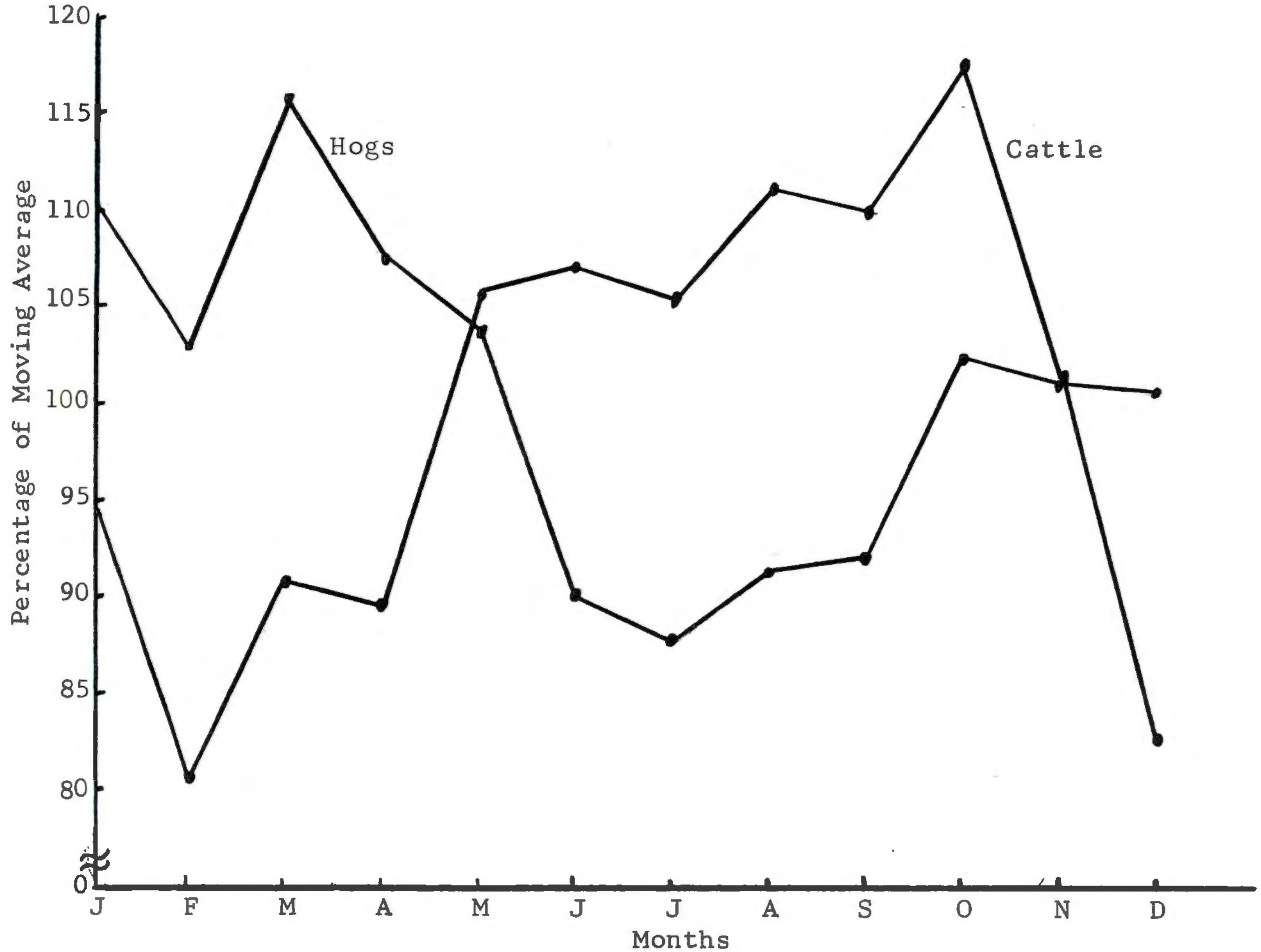

Figure 4. Cattle and hog slaughter in the South, as percentages of centered twelve-month moving averages, based on 1959-1964 data.

is assumed to equal handling costs. The location of specialized processing and rendering activities is assumed not to have economically significant effects on the location of cattle slaughtering among areas. Finally, for the analytical model, pure competition is assumed to exist in the cattle slaughtering industry. These assumptions are maintained throughout the study. Other required assumptions will be specified in the appropriate sections.

V. PROCEDURE

The procedure outlined below, and which provides the sequence for following chapters, was required to attain the indicated objectives:

1. An appropriate theoretical and analytical framework was specified for estimating optimum interarea flows of slaughter of cattle and beef, and area slaughtering volumes.

2. An appropriate set of geographical areas was specified, and interarea transportation cost matrices for cattle and beef were estimated.

3. Area quantities of beef demanded and supplied in 1975 were estimated.

4. Cattle slaughtering cost functions were estimated and were adjusted for variations in labor costs among areas.

5. The optimum interarea flow patterns for cattle and beef, and area slaughter volumes under 1975 supply and demand conditions were estimated, assuming no seasonal variation in slaughtering rates.

6. The optimum flow patterns and slaughter volumes were estimated with seasonal variations in slaughtering rates introduced into the analytical framework.

CHAPTER II

REVIEW OF INTERREGIONAL COMPETITION AND LOCATION THEORY, AND SPECIFICATION OF THE ANALYTICAL MODEL

Spatial models can be defined broadly as economic models in which the geographical location of production or marketing activities, and/or geographical flows of the products involved are unknowns to be estimated. As Seaver has pointed out, these models are based on a mixture of both interregional trade theory and location theory.[1] The purpose of this chapter is to trace briefly the evolution of these two subject areas, and to use this review as a background for specifying an appropriate model to attain the objectives of the study.

I. DEVELOPMENT OF INTERREGIONAL TRADE AND LOCATION THEORY[2]

Concern with understanding interregional and international trade is traceable at least as far back as the work of Adam Smith. In his concern with welfare goals, Smith examined the effects of specialization on real per capita national income. In so doing, he developed

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[1]S. K. Seaver, "Spatial Research--Measurement for What?", Journal of Farm Economics, 46(5):1365, December 1964.

[2]In developing this section the author drew on Willard F. Williams, "Interregional Competition--The Relevant Theory"; and R. J. Amick, "A Review of Research in Interregional Competition," Workshop on Interregional Competition (Stillwater: Oklahoma State University, 1966), pp. 1-37 and 51-85, respectively.

the concept of absolute advantage, pertaining to international trade. Smith suggested:

> What is prudence in the conduct of every private family, can scarce be folly in that of a great kingdom. If a foreign country can supply us with a commodity cheaper than we ourselves can make it, better buy it of them with some part of the produce of our own industry, employed in a way in which we have some advantage.[3]

Later, Ricardo provided an explanation of which commodities will be produced and which goods will be purchased in international trade.[4] To do this, he developed the principle of Comparative Advantage, which states: Each area tends to produce those commodities for which its ratio of advantage is greatest as compared with other areas, or its ratio of disadvantage is least.[5]

Von Thunen, writing in 1826, became interested in the influence of transportation costs on the location of agricultural production.[6] He began his analysis by assuming the existence of a plain of homogeneous fertility, containing a single market center. Under these conditions, production locations were distinguished only by differences in the cost of transporting the crop to market. Von Thunen concluded that different types of agriculture would be located in concentric rings around the market center in order of decreasing intensiveness of cultivation, the

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[3]Adam Smith, An Inquiry Into the Nature and Causes of the Wealth of Nations (New York: The Modern Library, 1937), p. 424.

[4]David Ricardo, The Principles of Political Economy and Taxation (London: J. M. Dent and Sons, Ltd., 1948), pp. 77-93.

[5]Ronald L. Mighell and John D. Black, Interregional Competition in Agriculture (Cambridge: Harvard University Press, 1951), p. 17.

[6]Von Thunen, Der Isolierte Staat in Beziehung Auf Landwirtschraft und Nationalokonomie (Hamburg: 1826).

only exceptions being cases of bulky or perishable crops.[7] Concentrated and durable products would be drawn from more remote points, while bulky and perishable goods would be produced near the central city.[8]

Weber, examining the problem of industry location, found that optimum location, given discrete market and raw product supply points, was determined by the weight of materials and products to be transported and by the location of materials and skilled labor.[9] His analysis was oriented toward mathematically determining the geographic point at which the sums of the costs of transporting the raw materials to the factory, and of the finished product to the consuming center, are at a minimum. In addition, Weber examined factors contributing to agglomeration. This he defined as "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. . . ."[10] In other words, according to Weber one type of agglomeration occurs when several plants exist at a given geographic location. Factors that encourage this kind of agglomeration include such things as the existence of specialized auxiliary industries, skilled labor supplies, and marketing advantages.

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[7]Amick, _op. cit._, p. 2, citing Von Thunen.

[8]Richard King and William R. Henry, "Transportation Models in Studies of Interregional Competition," _Journal of Farm Economics_, 41(5): 998, December 1959, citing Von Thunen.

[9]Alfred Weber, _Theory of the Location of Industries_, translated with an introduction and notes by Carl J. Friedrich (Chicago: The University of Chicago Press, 1929).

[10]_Ibid._, p. 126.

The last of these might result from the development of a large enough demand for raw materials to encourage an efficient raw product supply industry.[11]

One other outstanding development in location theory is found in the work of Losch. By assuming the location of production is given, and that population density and terrain are uniform, Losch concluded that an equilibrium pattern of market areas similar to that shown in Figure 5 will develop.[12] One plant is located at the center of each hexagon-shaped market area. These results can be modified theoretically by relaxing the assumptions of uniform population density and terrain, and by introducing a grid system of road networks. Relaxation of these and other assumptions leads to the irregularly shaped market areas encountered in the real world.

Losch's theory is particulary important from the standpoint of being a structure within which market area boundaries are determined endogeneously. However, the results depend on the particular spatial pricing system that is assumed, and serious problems are involved in specifying this when monopolistic and oligopolistic aspects

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[11] Ibid., pp. 127-130.

[12] August Losch, The Economics of Location, translated from the second revised edition by William H. Woglom with the assistance of Wolfgang F. Stolper (New Haven: Yale University Press, 1964), pp. 101-114.

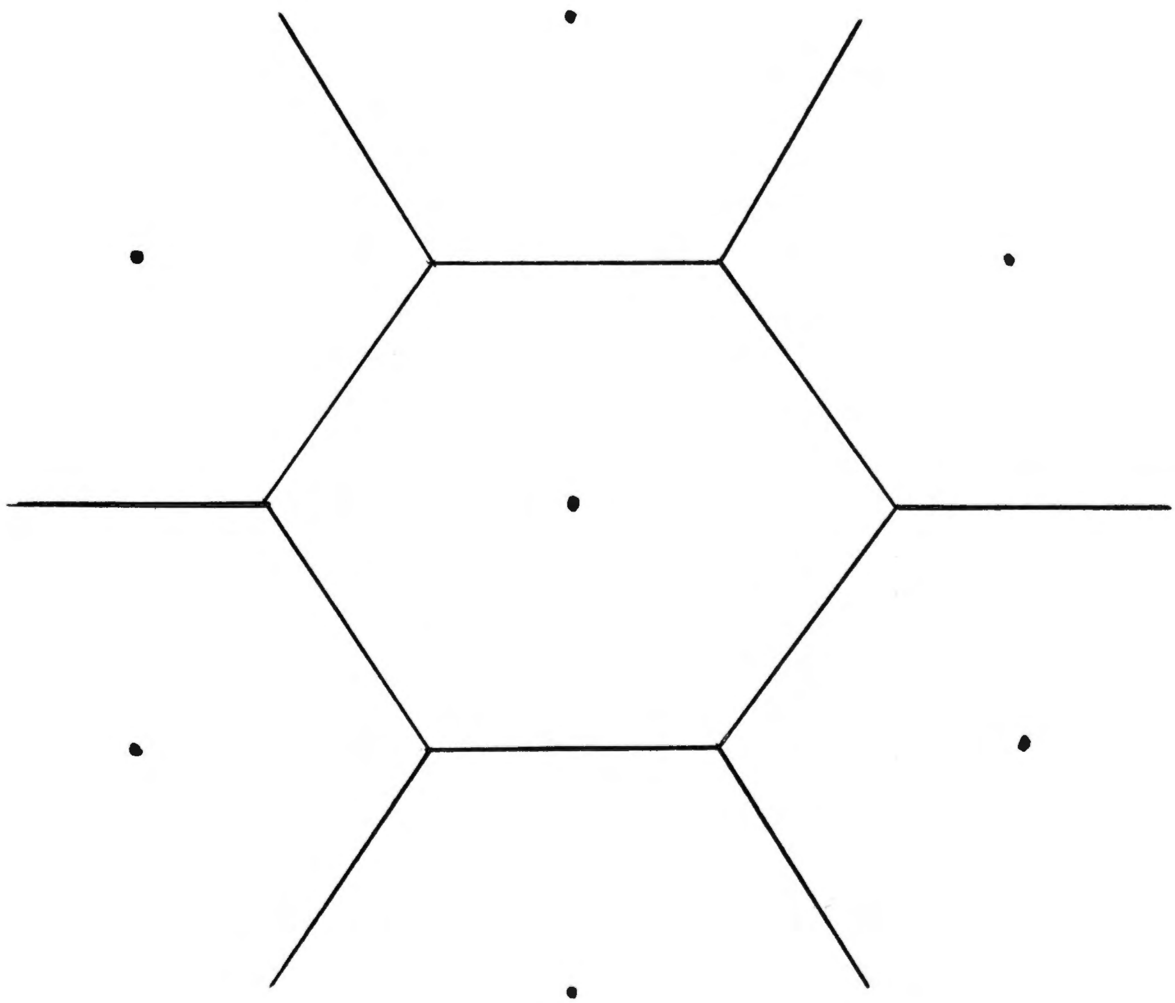

Figure 5. Equilibrium pattern of market areas.

Source: August Losch, The Economics of Location, translated from the second revised edition by William H. Woglom with the assistance of Wolfgang F. Stolper (New Haven: Yale University Press, 1964), p. 117.

of the location dimension are recognized.[13]

In 1935, in his Interregional and International Trade,[14] Ohlin made one of the first serious attempts to integrade trade and location theories. Ohlin employed a mutual interdependence theory of pricing, which was intended to determine simultaneously prices, markets, location of industry, commerce, agriculture, and the spatial distribution of factors and commodities.[15] He began by developing an international trade theory in which interregional costs of transporting commodities are assumed to be zero. Ohlin defined a region as the area within which there is perfect mobility of factors; between regions, factors were assumed perfectly immobile. Later, he introduced transfer costs for interregional commodity movements, as well as interregional factor movements and local differences in factor supplies. However, Isard notes that Ohlin was unable to incorporate intra-region location aspects into his general equilibrium framework.[16] In spite of this, Ohlin's work continues to be the main foundation for modern interregional competition theory.

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[13]Problems resulting from imperfect competition are discussed in Walter Isard, Location and Space-Economy (New York: John Wiley and Sons, Inc., 1956), pp. 158-171; Lester V. Manderscheid, "Equilibrium in Spatial Markets--A Comment," Journal of Farm Economics, 45(2):449-452, May 1963; and R. G. Bressler, Jr., "Pricing Raw Product in Complex Milk Markets," Agricultural Economics Research, 10(4):113-130, October 1958.

[14]Bertil Ohlin, Interregional and International Trade (Cambridge: Harvard University Press, 1935).

[15]Isard, op. cit., pp. 50-54, citing Ohlin.

[16]Ibid., pp. 50-54.

This brief summary does not do justice to authors of various trade and location theories. However, it is useful as an inventory of the current state of interregional trade theory, which is summarized in Figure 6 for the two region, single commodity case. The diagrams are drawn under the assumptions of perfect competition within each region, and immobility of factors and consuming units between regions. Without trade, the price in region 2 would be OS, while the price in region 1 would be PR. The interregional price differential would exceed the interregional transportation cost differential, T_{12}, by the amount RS. For this reason, interregional trade would occur.

An equilibrium trade pattern is determined by the intersection of the two excess supply curves, EX_1 and EX_2. These curves represent the horizontal distance between their respective supply and demand curves. Under the equilibrium pattern, region 1 ships OS''' units to region 2, and the price in region 1 is lower than the price in region 2 by the amount of the interregional transportation cost. It can be seen that anything affecting (1) regional supplies of the final product, (2) regional demands for the final product, or (3) transportation costs will affect interregional production, consumption, and shipment patterns.

Three assumptions behind these diagrams should be brought to attention since they limit the validity of the equilibrium results. First, all interregional shipments are assumed to move from a single point in one region to a single point in the other region. Second, the efficiency of the spatial location pattern within each region may affect its corresponding excess supply function. However, factors affecting the interregional competitive position of a region are assumed not to affect the intra-regional location pattern. Third, regional boundaries are taken as given and are determined outside the model. Problems stemming from use of these assumptions should increase as regional sizes increase.

II. APPLIED INTERREGIONAL TRADE AND LOCATION MODELS

Figure 6 illustrates the analytical basis for several recent applications of interregional trade and location models to agriculture. This section will begin with a brief description of models in which the only variables to be estimated are interregional commodity flows. Later, the assumptions underlying these models will be relaxed, thus leading to models in which regional production, consumption, market or supply area boundaries, or the locations of intermediate activities are determined.

Transportation Models

The transportation model is an interregional trade model that requires the assumptions of given and fixed quantities of the product demanded and supplied at specific points within each of a group of regions.[17] In terms of Figure 6, excess supply functions are perfectly inelastic. A set of transportation costs for each possible combination

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[17]King and Henry, op. cit., pp. 998-999.

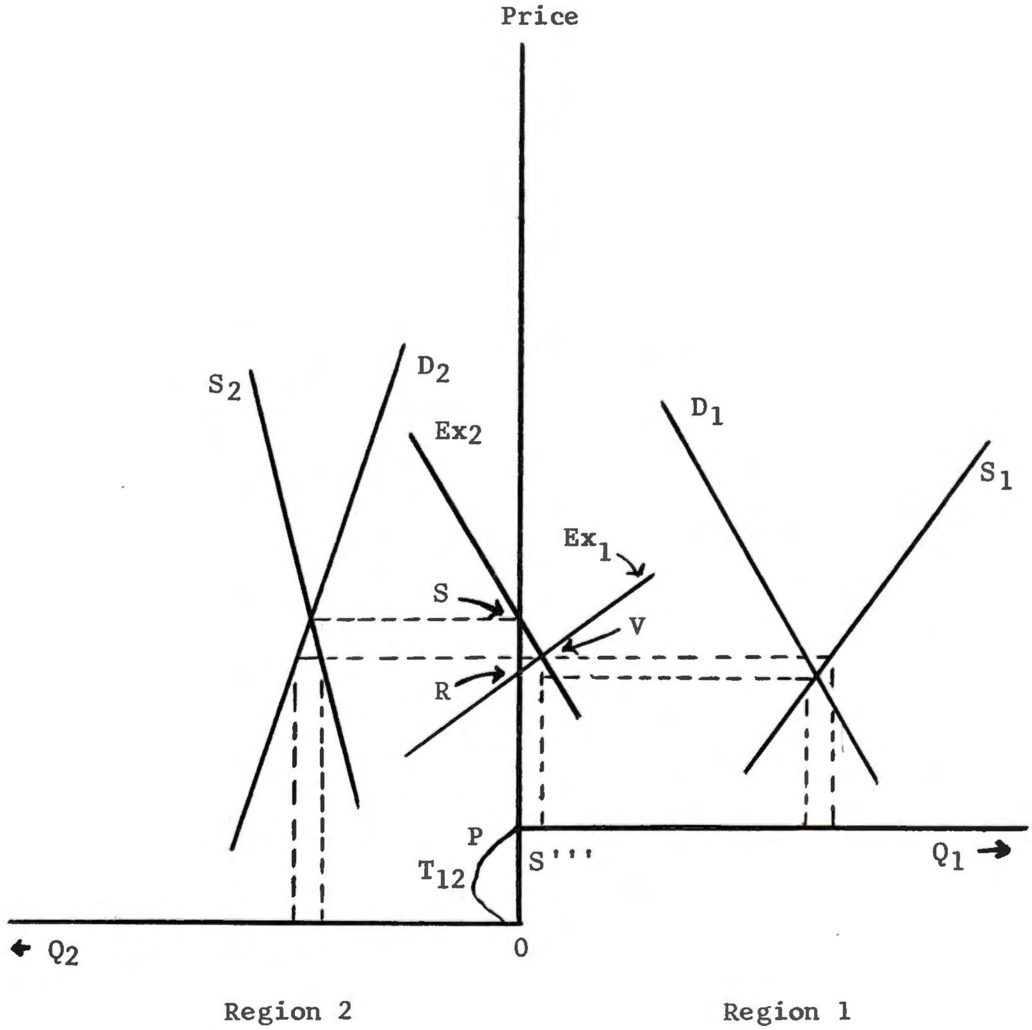

Figure 6. Equilibrium for the two-region, single commodity case.

of origin-destination shipments is specified, and the model is used to obtain the least-cost pattern of shipments from surplus to deficit producing regions.[18]

Because of the assumptions of perfectly inelastic supplies and demands, the transportation model does not permit changes in quantities supplied or demanded to alter interregional flows. Accordingly, the basic model appears best suited for determining efficient interregional shipping patterns, for evaluating the impact of changed transportation costs on efficient shipping patterns, and for single-firm production and distribution problems. In addition, it is an important part of more complex interregional models.

Bawden warned that care must be exercised in using the transportation model to estimate efficient industry shipping patterns. A difference between the actual shipping pattern and the model solution could reflect not only an inefficient market, but also an incorrect model and inaccurate data. Also, he cautions that for predictive purposes, the model estimates only the efficient shipping pattern. Due to market imperfections, the predictions may not be very accurate.[19] To reduce difficulties such as these and increase the usefulness of estimated results, more complex interregional models have been developed by relaxing various assumptions behind the transportation model.

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[18] For an historical sketch and a discussion of alternative computational procedures, see G. Hadley, Linear Programming (Reading, Massachusetts: Addison-Wesley Publishing Co., Inc., 1962), pp. 20-21 and 273-318.

[19] D. Lee Bawden, "An Evaluation of Alternative Spatial Models," Journal of Farm Economics, 46(5):1375-1376, December 1964.

Transhipment Models

In 1956 Orden demonstrated that the basic transportation model may be modified to permit shipments of a commodity to be made by any sequence of points, rather than just from surplus regions directly to deficit regions.[20] One origin is permitted to ship to another origin, rather than to destinations only. Kriebel, in 1961, indicated that, in effect, the transhipment model permits the location of an intermediate activity to become a variable in the model.[21] Logan and King, using Kriebel's formulation, applied the transhipment model to cattle slaughter plant location in California. In this situation live animals may be shipped from each origin to several possible slaughtering points, from which meat is shipped to demand centers.[22]

Computationally, transhipment problems can be solved using either linear programming or a conventional transportation program. The latter provides a computational advantage since less computer capacity is required. However, the problem has recently been formulated as a linear programming problem and applied to a spatial analysis of livestock

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[20] A. Orden, "The Transhipment Problem," Management Science, 2(3): 277-285, April 1956.

[21] Charles H. Kriebel, "Warehousing with Transhipment Under Seasonal Demand," Journal of Regional Science, 3(1):57-59, Summer 1961.

[22] Gordon A. King and Samuel H. Logan, "Optimum Location, Number and Size of Processing Plants with Raw Product and Final Product Shipments," Journal of Farm Economics, 46(1):94-108, February 1964.

slaughter, and the interregional flows and pricing of meat.[23]

One possible future extension of the transhipment model might be noted here. Wagener has developed a method of solving the transportation problem by operating on the cost matrix one column at a time. His method permits part of the cost matrix to be stored externally on magnetic tape during computation, thus allowing very large problems to be solved on relatively small computers.[24] Wagener's computational procedure, employed in transhipment location problems, could permit use of a larger number of areas in the model than are possible under alternative solution procedures. This might reduce problems from using a single shipping point per area, as well as the problem of intra-area location patterns. However, at the same time it would increase the problems of obtaining required data.

One other extension of transhipment models should be noted. Hurt and Tramel have suggested they can be applied to multiproduct problems.[25] Using cattle as an example, a multiproduct model might

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[23]The model is presented in G. G. Judge, J. Havlicek, Jr. and R. L. Rizek, "An Interregional Model--Its Formulation and Application to the Livestock Industry," Agricultural Economics Research, 17(1):1-9, January 1965; and R. L. Rizek, G. G. Judge and J. Havlicek, Jr., Spatial Structure of the Livestock Economy, III. Joint Spatial Analysis of Regional Slaughter and the Flows and Pricing of Livestock and Meat, North Central Regional Bulletin No. 163 (South Dakota Bulletin 522) (Brookings: South Dakota Agricultural Experiment Station, October 1965).

[24]Ulrich A. Wagener, "A New Method of Solving the Transportation Problem," Operational Research Quarterly, 16(4):453-469, December 1965.

[25]Verner G. Hurt and Thomas E. Tramel, "Alternative Formulations of the Transhipment Problem," Journal of Farm Economics, 47(3):763-773, August 1965.

have some potential for handling regional variations in grade composition of cattle supplies. Provided regional supply and demand data could be obtained, each grade might be treated as a single product. However, since the transhipment model requires the assumptions of fixed quantities supplied and demanded, the optimum solution would not endogeneously determine regional adjustments in grade composition of the cattle supplies.

Models Determining Market Areas Endogeneously

A model theoretically similar to the one suggested by Losch[26] has been applied by Cobia and Babb to the problem of minimizing combined average processing and distribution costs for milk processing plants under the following assumptions:[27]

1. Sales density is uniform through a given plant's sales area.
2. All customers are charged a uniform price regardless of distance from the plant.
3. Distance is the only barrier to sales area expansion.
4. Transportation method and topography are uniform.
5. Raw milk costs are constant.

These assumptions provide continuous and differentiable cost functions, so that optimum sales area radius and plant volume can be

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[26] Losch, *loc. cit.*

[27] D. W. Cobia and E. M. Babb, "An Application of Equilibrium Size of Plant Analysis to Fluid Milk Processing and Distribution," *Journal of Farm Economics*, 46(1):109-116, February 1964.

estimated by calculus. The optimum solution gives a circular sales area around the plant.

A more realistic formulation of this type of model might include competing plants as barriers to sales area expansion. In addition, similar models suggested by Olson[28] and Williamson[29] have considered assembly costs. Such models also might be expanded to include non-uniform sales and production density. However, mathematically these modifications may be difficult to handle.

Stollsteimer Plant Location Models

As an alternative to continuous market-supply area models, Stollsteimer has developed a point-trading approach to plant location.[30] His procedure begins with a given number of raw material production areas, possible plant location sites, and quantities of raw material in each area. In addition, a transportation cost matrix containing the unit cost of shipping from each raw material origin to each potential plant location is required. From these data, a transportation cost function is obtained that is minimized with respect to plant location for each possible number of plants. The resulting transportation cost function

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[28] Fred L. Olson, "Location Theory as Applied to Milk Processing Plants," Journal of Farm Economics, 41(5):1546-1556, December 1959.

[29] J. C. Williamson, Jr., "The Equilibrium Size of Marketing Plants in a Spatial Market," Journal of Farm Economics, 44(4):953-967, November 1962.

[30] John F. Stollsteimer, "A Working Model for Plant Numbers and Locations," Journal of Farm Economics, 45(3):631-645, August 1963.

will resemble that shown in Figure 7.[31] The minimum cost number of plants and location pattern are determined from Figure 8, where total processing cost and minimized total transportation costs are combined. In this example, the optimum solution would be two plants.[32]

Stollsteimer models can be modified to consider minimized distribution costs, given a set of fixed demands at various locations. In addition, they can be modified to solve plant location problems in which both assembly and distribution costs are considered, provided the assumption is made that assembly costs should be minimized prior to minimizing total distribution costs.[33]

Models such as these appear well suited for solving individual firm location problems. However, for each possible number of plants, there are $\binom{L}{J}$ location patterns that must be evaluated to obtain the minimized total transportation cost function, where L represents the number of possible plant sites and J represents the number of plants considered.[34] For this reason, Stollsteimer models appear applicable mainly to situations where a relatively small number of possible plant location sites exist.

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[31]John F. Stollsteimer, "Fixed Production--Fixed Consumption Models with Processing Introduced," Interregional Competition Research Methods, Richard A. King, editor (Raleigh: Agricultural Policy Institute, 1965), pp. 40-43.

[32]Ibid., pp. 43-44.

[33]Ibid., pp. 39-40.

[34]Ibid., pp. 40-43.

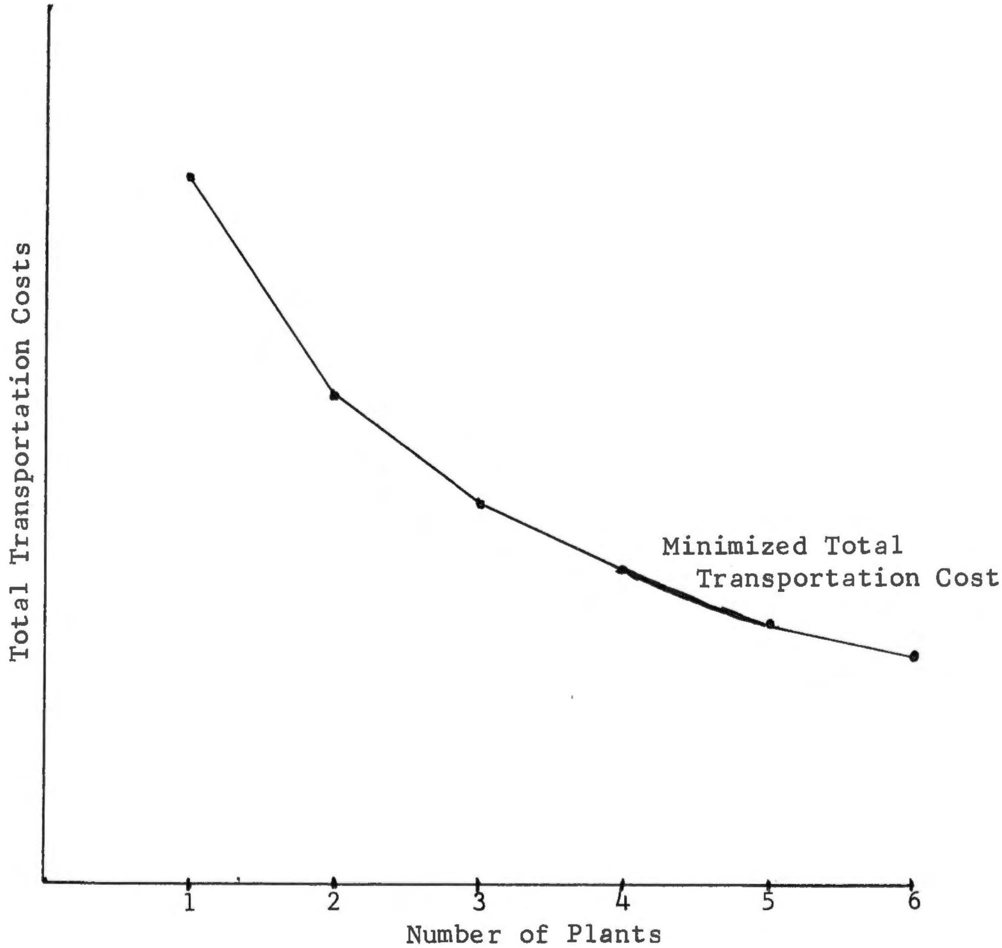

Figure 7. Minimized total transportation cost, Stollsteimer model.

Source: John F. Stollsteimer, "Fixed Production--Fixed Consumption Models with Processing Introduced," _Interregional Competition Research Methods_, Richard A. King, editor (Raleigh: Agricultural Policy Institute, 1965), p. 43.

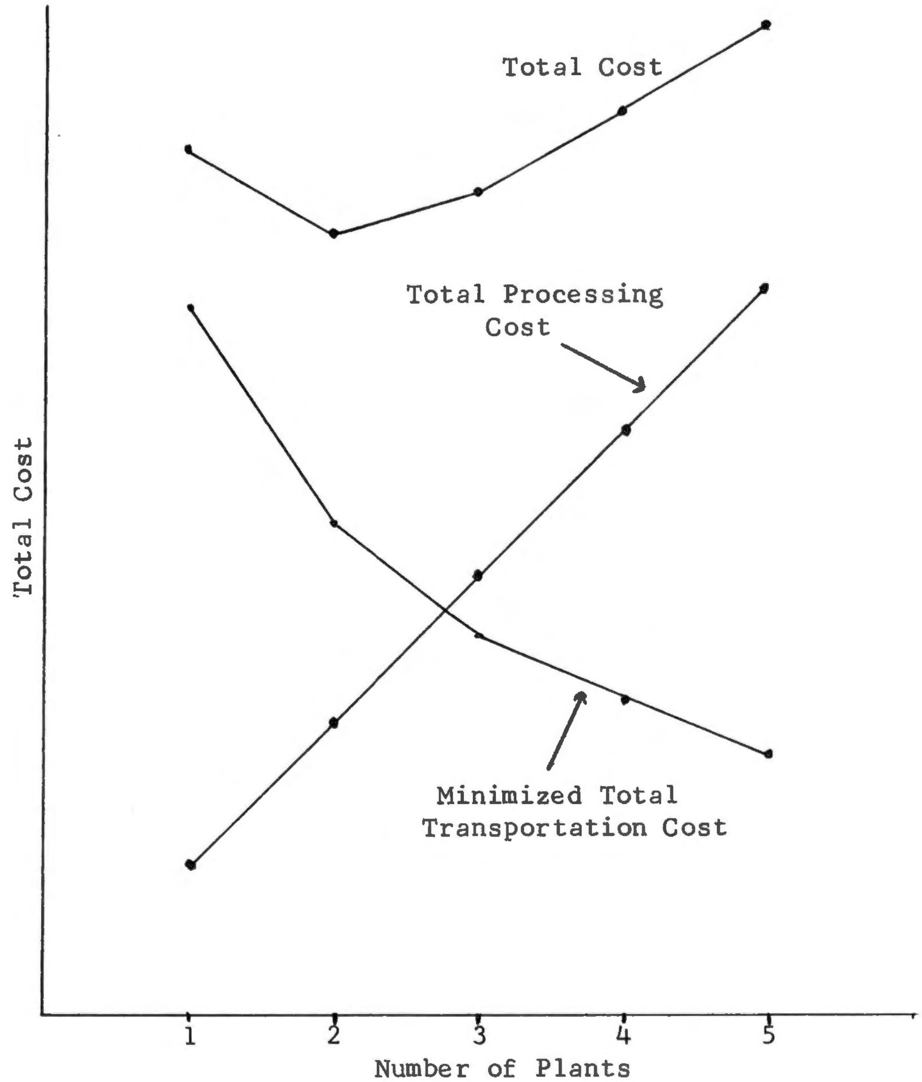

Figure 8. Optimum number of plants, Stollsteimer model.

Source: John F. Stollsteimer, "Fixed Production--Fixed Consumption Models with Processing Introduced," Interregional Competition Research Methods, Richard A. King, editor (Raleigh: Agricultural Policy Institute, 1965), p. 44.

Spatial Equilibrium Models

Turning again to the conceptual framework of Figure 6, page 24, another class of spatial models derived directly from this framework has been called the spatial equilibrium model. The spatial equilibrium problem was formulated by Enke[35] and Samuelson,[36] and in the mid-1950's was applied to the feed-livestock sector of the economy by Fox and Taeuber.[37] The basic model requires the assumption that the regional pattern of prices and flows of the commodity are determined under perfect competition. In addition, regional supplies are taken as predetermined, and all regional demand functions are assumed to be linear.

In determining the equilibrium solution, aggregate production is set equal to aggregate consumption, and a base region is selected. By summing the regional demand functions and inserting the value for aggregate consumption, the price is estimated for the base region. Next, an initial approximate set of regional price differentials expressing the difference between price in the i^{th} region and price in the base region is obtained. Initial approximations can be estimated by classifying

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[35] S. Enke, "Equilibrium Among Spatially Separated Markets: Solution by Electric Analogue," Econometrica, 29(1):40-47, January 1951.

[36] P. A. Samuelson, "Spatial Price Equilibrium and Linear Programming," American Economic Review, 43(3):283-303, June 1952.

[37] Karl A. Fox, "A Spatial Equilibrium Model of the Livestock-Feed Economy in the United States," Econometrica, 21(4):547-566, October 1953; and Karl A. Fox and Richard C. Taeuber, "Spatial Equilibrium Models of the Livestock-Feed Economy," American Economic Review, 45(4):584-608, September 1955.

each region as either surplus or deficit for the commodity in question, and by using the following rules:[38]

1. If one region ships to another, prices must differ by the known unit transportation cost between the regions.

2. If two surplus regions ship to the same deficit region, the difference between prices in the surplus regions will equal the difference between their unit transportation costs to the deficit region.

The initial set of regional price differentials obtained in this manner is next used to estimate the quantity of surplus or deficit for each region. This can be done by inserting prices into regional demand functions. Surpluses are then allocated to deficit regions, using the linear programming solution to the transportation problem. The dual solution in this step provides a set of regional price differentials consistent with the interregional shipment pattern.[39]

The next step in the solution procedure is to determine whether the set of price differentials generated by the dual solution agrees with the initial approximate set. If the two sets are different, the process of determining equilibrium prices and flows is repeated, using the new price differentials obtained from the dual solution. Thus, an

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[38]G. G. Judge and T. D. Wallace, Spatial Price Equilibrium Analyses of the Livestock Economy, I. Methodological Development and Annual Spatial Analyses of the Beef Marketing Sector, Technical Bulletin TB-78 (Stillwater: Oklahoma Agricultural Experiment Station, June 1959), p. 14.

[39]*Ibid*., pp. 15-16.

iterative process is used to arrive at a final equilibrium.[40]

Several variations of the spatial equilibrium formulation have been used in empirical applications. Judge and Wallace's studies of pork and beef illustrate spatial equilibrium models employing demand functions and perfectly inelastic supply functions.[41] Snodgrass and French, in a study of the dairy industry, used a model containing production and transportation cost data to minimize combined transportation and production costs in meeting fixed regional demands.[42] A third approach, used by Fox and Taeuber, considered a joint equilibrium for one intermediate product (feed) and one final product (livestock). For each region, functions were specified for the demand and supply of livestock and the demand for feed; feed supplies were considered predetermined. The solution procedure required two linear programming formulations, one for feed and one for livestock.[43]

A fourth formulation of the spatial equilibrium procedure, by King and Schrader, considered the optimum location of cattle feeding, given regional quantities of feed concentrates, roughages and feeder

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[40] *Ibid*., pp. 9-14.

[41] Judge and Wallace, *op. cit*.; and Judge and Wallace, *Spatial Price Equilibrium Analyses of the Livestock Economy, III. Spatial Price Equilibrium Models of the Pork Marketing System,* Technical Bulletin TB-81 (Stillwater: Oklahoma Agricultural Experiment Station, January 1960).

[42] Milton M. Snodgrass and Charles E. French, *Linear Programming Approach to the Study of Interregional Competition in Dairying*, Bulletin 637 (Lafayette: Purdue Agricultural Experiment Station, May 1958).

[43] Fox and Taeuber, *loc. cit*.

cattle, and demand functions for beef. King and Schrader's model also contained nine possible feeding activities, none of which included economies of scale. Their equilibrium solutions generated (1) the locations of cattle feeding, (2) the types of feeding in each region, (3) interregional feed shipments, (4) interregional feeder cattle shipments, (5) interregional beef shipments, and (6) regional beef consumption levels.[44]

Reactive Programming Models

Seale and Tramel have developed a computational procedure called reactive programming that can be used to incorporate less than perfectly inelastic supply and demand functions into spatial analyses simultaneously.[45] Basically, the procedure begins with a definition of the equilibrium conditions that are obtained when net returns to each of several spatially separated shippers are maximized, under specified forms of competition. Each supply point is considered a shipper, and by evaluating the demand function in each possible outlet, a series of gross prices is established for each producer. Transportation charges are deducted from gross prices to obtain a series of net prices, and supplies are allocated to the outlets which offer the highest net prices.

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[44]G. A. King and L. F. Schrader, "Regional Location of Cattle Feeding--A Spatial Equilibrium Analysis," Hilgardia, 34(10):331-416, July 1963.

[45]Thomas E. Tramel and A. D. Seale, Jr., "Reactive Programming of Supply and Demand Relations--Applications to Fresh Vegetables," Journal of Farm Economics, 41(5):1012-1022, December 1959.

This process is performed through a series of iterations, with each shipper making the most profitable allocation possible. The equilibrium solution has been obtained when it is not profitable for any shipper to reallocate its supplies among outlets.[46]

Tramel and Seale have suggested several variations of the model that might be utilized in empirical applications.[47] As one possible case, reactive programming can be used to obtain estimated regional quantities consumed and optimum interregional shipments, assuming perfectly inelastic supplies, but less than perfectly inelastic demands.[48] The procedure also can be used to estimate optimum regional production and interregional shipments, assuming perfectly inelastic demands, but less than perfectly inelastic supplies. As a third formulation, reactive programming can be used to estimate regional quantities produced and consumed, assuming both supplies and demands are less than perfectly inelastic. In addition to these types of problems, the procedure can be used for market structures other than perfect competition, and slopes

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[46]Thomas E. Tramel and A. D. Seale, Jr., "Reactive Programming--Recent Developments," in Interregional Competition Research Methods, op. cit., pp. 59-68.

[47]A. D. Seale, Jr. and Thomas E. Tramel, "Reactive Programming Models," in Interregional Competition Research Methods, pp. 47-58.

[48]One recent application of this type of model is presented in J. W. McLeary, "Optimum Interregional Shipments of Beef, Pork, Broilers and Eggs, and the Predicted Effects of the Interstate Highway System on the Equilibrium Movement Patterns of These Commodities" (unpublished Ph. D. dissertation, The University of Tennessee, Knoxville, 1965).

of supply and demand functions can be permitted to vary among regions.[49]

One type of problem for which the reactive programming approach has encountered difficulties is analysis of the equilibrium location of an intermediate activity. Although Miller and King have developed a reactive programming location model, its usefulness appears limited at present. The maximum size of problem it will handle is seven origins, six plants, and three destinations, on the IBM 1620 computer.[50] Finally, it should be noted Miller and King point out that it has not yet been shown mathematically why reactive programming must converge to an equilibrium, although all applications to date have done so.[51]

III. THE ANALYTICAL MODEL

The preceding review is intended to describe briefly the most common types of location and interregional models employed in agricultural marketing research. Some of the more important kinds of economic relationships these models necessarily exclude are reflected in assumptions about price elasticities of supply and demand, and the kinds of competition involved. Others are reflected in assumptions that the location of intermediate activities is given, and that unit costs of

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[49]Seale and Tramel, "Reactive Programming Models," *op. cit.*, pp. 53, 57.

[50]B. R. Miller and R. A. King, *Models for Measuring the Impact of Technological Change on the Location of Marketing Facilities*, A. E. Information Series No. 115 (Raleigh: North Carolina Agricultural Experiment Station, September 1964), pp. 57-60.

[51]*Ibid.*, p. 88.

performing intermediate activities are not a function of volume processed. In their present state, these models are unable to handle effectively simultaneous analysis of supply and demand relationships, and the location of an intermediate activity for which unit costs vary with volume.

Given the objectives of the study, attention was thus focused on selection of a partial equilibrium model that could be used to estimate optimum location of an intermediate activity when unit costs vary with volume. The model selected to meet these specifications was a linear programming formulation containing a single raw product, a single final product, and one intermediate activity.[52]

Temporal Assumptions

One of the first questions to be resolved in specifying the analytical model was that of the appropriate temporal assumptions. An important element that required consideration here was the cyclical behavior of cattle production, since the optimum spatial patterns of both cattle slaughtering, and interregional shipments of cattle and beef may vary considerably, depending on what point in the cattle cycle is selected for analysis. While other points in the cycle could have been selected, the present study considered only average cyclical conditions, inasmuch as computer time required to analyze other phases of the cycle would have been prohibitive.

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[52]The solution procedure for this type of problem is presented in Hadley, *op. cit.*, pp. 71-168.

It was assumed the cyclical pattern of cattle supplies estimated by Purcell[53] for the United States as a whole will continue through the next decade. Accordingly, average cyclical conditions in cattle production should occur from approximately mid-1975 to mid-1976. These estimates are based on an interval of approximately nine years' duration from average cyclical conditions on the upturn phase to average cyclical conditions on the next upturn, and approximately four years from the average cyclical point on the upturn to the corresponding point on the downturn.

While making the assumption that this cyclical pattern will continue, several structural changes that have occurred in the cattle industry during the past decade should be noted. These developments, all of which influence the behavior of the cattle cycle, include:[54]

1. The increased movement of cattle through feedlots and the increasing separation of this part of the beef industry from the production of feeder animals.

2. The declining proportion of dairy animals in the total cattle and calf inventory.

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[53]Joseph C. Purcell, Livestock Prices and Meat Supplies, Trends and Interrelationships, 1950-1959, Technical Bulletin N. S. 24 (Experiment: Georgia Agricultural Experiment Station, May 1961), p. 20.

[54]Robert L. Rizek, "The Cattle Cycle," Livestock and Meat Situation LMS-148, Economic Research Service, U. S. Department of Agriculture (Washington: Government Printing Office, March 1966), p. 26.

3. Continued dispersion of slaughter cattle production throughout the nation, thus minimizing the risk of forced liquidations due to weather.

For the analysis, it was assumed these factors may affect the amplitude, but not the length of the cattle cycle.[55]

Assuming a nine-year cyclical pattern, the year 1975 was selected as the appropriate date for projection of the variables to be studied. This date also provided an advantage from the standpoint of data availability, since state population estimates were available from the United States Census Bureau for July 1, 1975.[56] In addition, income estimates for 1975 by states have been published by the National Planning Association.[57]

Along with consideration of average cyclical conditions, an estimate of effects of seasonal variations in cattle supplies and beef demands on interregional competition patterns was desired. In the absence of information for projecting future seasonal patterns, the assumption was made that 1962 seasonal patterns of cattle marketings for slaughter, and beef demands would remain constant.

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[55]Shepherd has noted also a long-term shortening of the cattle cycle, due to the fact that beef cattle are being sold for slaughter now at a younger age than they were several decades ago. See Geoffrey S. Shepherd, Agricultural Price Analysis (fifth edition, Ames: Iowa State University Press, 1963), pp. 42-43.

[56]U. S. Census Bureau, Current Population Reports, Series P-25, No. 301 (Washington: Government Printing Office, February 26, 1965).

[57]National Planning Association, State Projections to 1975: A Quantitative Analysis of Economic and Demographic Changes, Regional Economic Projection Series--Report No. 65-II (Washington: National Planning Association, October 1965), p. 7.

Formal Statement of the Model

The general concern of this study was with long-run normative estimates of the volume of cattle slaughtering in each of a set of areas in the South[58] and the accompanying interarea distribution patterns for cattle and beef, given projected future levels of cattle marketings for slaughter and estimated future area demands for beef. The normative concept used was that of marketing efficiency, suggested by Bressler.[59] Using this concept, attention was focused on the cost-minimizing spatial pattern of cattle slaughtering volumes, interarea cattle shipments, and interarea beef shipments. Specifically, a linear programming interregional competition model containing a single raw product (cattle), a single final product (dressed beef), and one intermediate activity (slaughtering) was used.

Notation for the formal statement of the model is as follows:

T_{ij} = cattle transportation cost per unit of beef equivalent, from area i to area j

T'_{ij} = meat transportation cost per unit, from area i to area j

C_i = cattle slaughtering cost per unit of beef equivalent for area i

S_i = volume of cattle slaughtering in area i, in units of beef equivalent

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[58] The areas used are specified in Chapter III.

[59] Raymond G. Bressler, Jr., "Efficiency in the Production of Marketing Services," Economic Efficiency Series Paper No. 6, Social Science Research Council Project in Agricultural Economics (Chicago: University of Chicago, Summer 1950), pp. 1-4.

L_i = quantity of slaughter cattle available in area i, in units of beef equivalent

D_i = quantity of beef demanded in area i

X_{ij} = cattle shipments from area i to area j in units of beef equivalent

X'_{ij} = beef shipments from area i to area j.

The objective was to minimize:[60]

$$F = \sum_{i=1}^{I} \sum_{j=1}^{J} T_{ij} X_{ij} + \sum_{i=1}^{I} \sum_{j=1}^{J} T'_{ij} X'_{ij} + \sum_{i=1}^{I} C_i S_i . \quad (1)$$

Subject to the following constraints:

$$S_i - \sum_{j=1}^{J} (X'_{ij} - X'_{ji}) = D_i \qquad (i = 1, 2, \ldots, I) \qquad (2)$$

For each area, the quantity of beef slaughtered minus net outshipments of beef equals the quantity of beef demanded in that area.

$$S_i + \sum_{j=i}^{J} (X_{ij} - X_{ji}) = L_i \qquad (i = 1, 2, \ldots, I) \qquad (3)$$

For each area, the quantity of beef slaughtered plus net outshipments of cattle, in units of beef equivalent, equals the quantity of slaughter cattle available in the area, in units of beef equivalent.

$$X_{ij}, X'_{ij}, S_i \geqslant 0 \qquad (i = 1, 2, \ldots, I; j = 1, 2, \ldots, J) \qquad (4)$$

All slaughtering volumes, and interarea shipments of cattle and dressed beef are non-negative.

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[60]A similar model is presented in Rizek, Judge and Havlicek, op. cit., pp. 6-9.

The programming tableau for a three-region example is shown in Figure 9. In the tableau, the U_{id} may be interpreted as the value of dressed beef in area i; the U_{iL} may be interpreted as the value of cattle in the i^{th} area before slaughter. These coefficients are obtained from solution of the dual problem, which can be stated as follows:

$$\text{Maximize } G = \sum_{i=1}^{I} D_i U_{id} - \sum_{i=1}^{I} L_i U_{iL} \quad .$$

Subject to:

$$U_{jL} - U_{iL} \leqslant T_{ij} \quad (j = 1, 2, \ldots, J; \; i = 1, 2, \ldots, I) \; i \neq j$$

$$U_{id} - U_{iL} \leqslant C_i \quad (i = 1, 2, \ldots, I)$$

$$U_{jd} - U_{id} \leqslant T'_{ij} \quad (j = 1, 2, \ldots, J; \; i = 1, 2, \ldots, I) \; i \neq j$$

$$U_{id}, U_{iL} \geqslant 0 \quad (i = 1, \ldots, I)$$

where

U_{id} = the value of dressed beef in area i

U_{iL} = the value of cattle in area i, before slaughter.

The dual formulation can be interpreted as the problem of maximizing net returns to livestock producers and slaughter plant owners, subject to the specified constraints.

Procedure for Handling Slaughtering Costs That Vary With Volume

To take account of the effect of slaughtering costs that vary with volume slaughtered, the procedure developed by King and Logan was

Internal Prices	Regional Constants	Meat Shipments						Cattle Shipments						Slaughter		
		T'_{12} X'_{12}	T'_{13} X'_{13}	T'_{21} X'_{21}	T'_{23} X'_{23}	T'_{31} X'_{31}	T'_{32} X'_{32}	T_{12} X_{12}	T_{13} X_{13}	T_{21} X_{21}	T_{23} X_{23}	T_{31} X_{31}	T_{32} X_{32}	C_1 S_1	C_2 S_2	C_3 S_3
U_{1d}	D_1	-1	-1	1		1								1		
U_{2d}	D_2	1		-1	-1		1								1	
U_{3d}	D_3		1		1	-1	-1									1
U_{1L}	L_1							1	1	-1		-1		1		
U_{2L}	L_2							-1		1	1		-1		1	
U_{3L}	L_3								-1		-1	1	1			1

Figure 9. Programming tableau for the single product, three-region case.

employed.[61] The procedure involved initially setting all slaughtering costs at the lowest point on an estimated long-run average cost curve, and solving the model using these cost figures. The initial solution was examined and slaughtering costs were corrected for levels of slaughtering volume indicated in the solution. Then, using the corrected slaughtering costs, the model was solved again. Thus, by a series of iterations, processing costs, as affected by varying plant operating volumes, were introduced. Although this procedure lacked mathematical rigor, it provided an approximate estimate of the effects of slaughtering economies of scale on the optimum spatial slaughtering and distribution patterns.

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[61] S. H. Logan and G. A. King, "Size and Location Factors Affecting California's Beef Slaughtering Plants," Hilgardia, 36(4):173-180, December 1964.

CHAPTER III

AREA DELINEATIONS, SUPPLY AND DEMAND CENTERS, AND TRANSPORTATION COST ESTIMATES

The preceding chapter indicated that important requirements of an applied interregional competition model include specification of an appropriate set of geographic areas, selection of area supply and demand centers, and estimation of interregional transportation cost matrics for the commodities involved. This chapter considers the relevant criteria for choosing area boundaries and trading centers, and indicates the set of areas and centers selected for use in this study. In addition, it describes the derivation of cattle and beef transportation costs under conventional and Interstate highway systems.

I. AREA DELINEATION

Ideally, delineation of production and consumption areas in an interregional competition study would be determined endogeneously, within a framework such as Losch's theory of equilibrium market area patterns.[1] However, in view of the difficulties involved in applying that type of analytical framework, a more realistic criterion for area specification is homogeneity with respect to production and consumption characteristics.

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[1]August Losch, The Economics of Location, translated from the Second Revised Edition by William H. Woglom with the assistance of Wolfgang F. Stolper (New Haven: Yale University Press, 1964).

But even when using the homogeneity criterion, two important constraints are involved; both availability of data and capacity of computational facilities must be considered. For this study, the computational capacity constraint created a practical upper limit of thirty-three areas that could be considered in the model.

Since the main concern of the study was an analysis of the location and interregional competition pattern for cattle slaughtering within the South under projected conditions, the Southern region was divided into twenty-seven areas. The areas used were based on area boundaries set up under the former Southern Regional Livestock Marketing Project SM-23, and were intended to represent relatively homogeneous cattle production conditions. Their use in the analytical model permitted utilization of data generated under Project SM-23.[2]

In addition, the remainder of the continental United States was divided into six areas. Computer capacity limited the extent to which homogeneity of cattle production and beef consumption could be considered in making these delineations. Also, since data for non-South areas were not available for geographical units smaller than states, areas boundaries were restricted to state boundaries. Areas used for both South and non-South regions are indicated by the map in Figure 10.

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[2]In the present study, the South initially was divided into thirty-seven areas. However, because computational difficulties arose in using a linear program of this size, the number of areas in the South was reduced to twenty-seven. Areas 3, 6, 10, 16, 17, 20, 21, and 27, in Figure 10 below, represent combinations of some of the original thirty-seven areas. These area combinations were used because preliminary analysis using thirty-seven areas in the South indicated that at least one of the sub-areas in each combination would not contain a slaughtering activity.

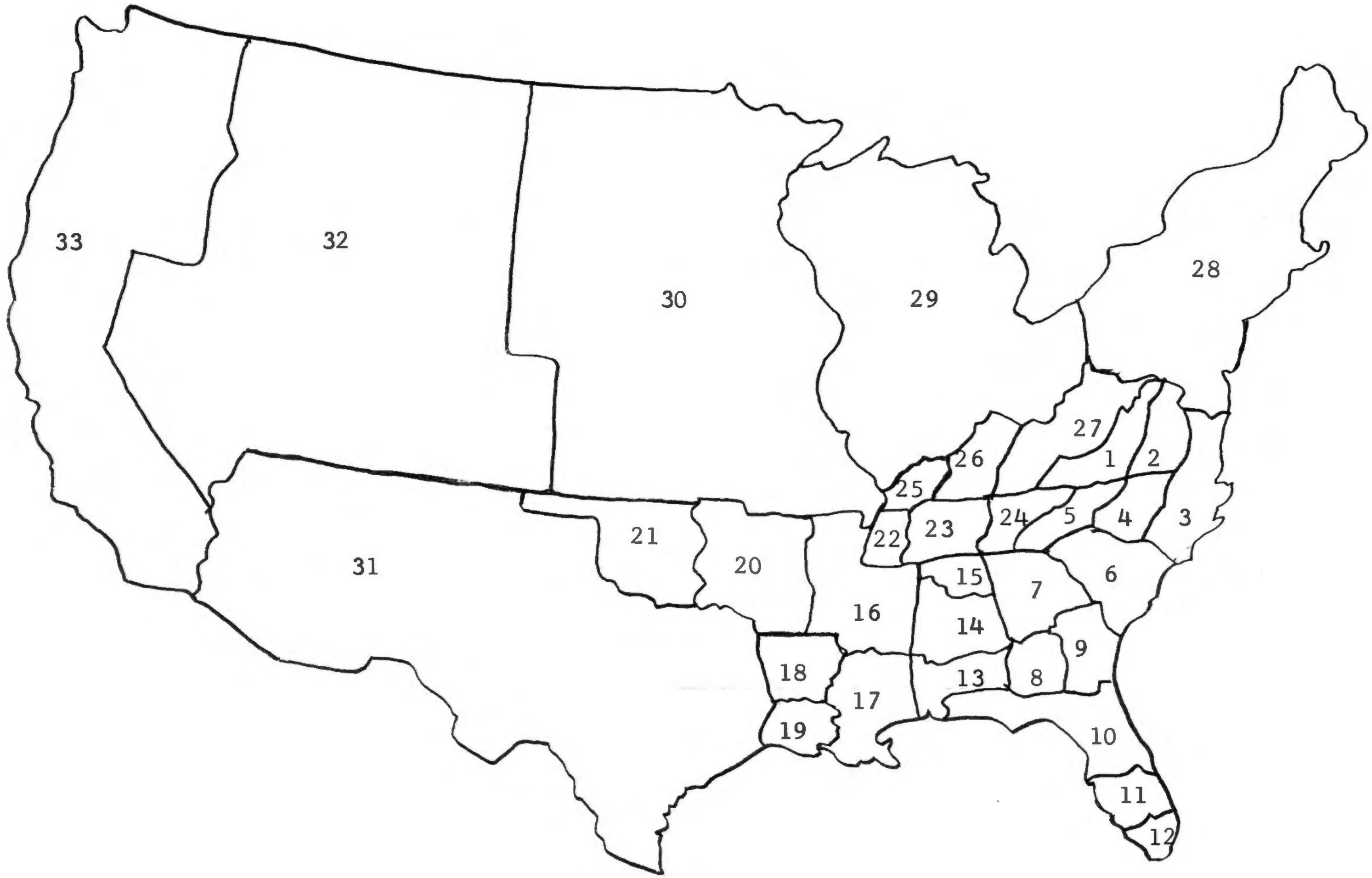

Figure 10. Areas used in the analytical model.

II. AREA SUPPLY AND DEMAND CENTERS

The analytical model required selection of a set of supply and demand centers, between which interregional shipments would be made, for each of the thirty-three areas. In making the selection, primary emphasis was given to selecting a city as close as possible to the approximate geographical center of the area. However, the additional constraint was imposed that the center should, if possible, contain either a population of more than 25,000 or be the location of a medium or large slaughtering plant in 1965.[3] It was assumed that a city of this size would be able to provide the utilities and labor supply required by a cattle slaughtering plant. Demand and supply centers selected for the analysis are presented in Table III.

III. ESTIMATED TRANSPORTATION COSTS FOR CATTLE AND BEEF

Previous studies have indicated the relative importance of truck transportation in transfer of cattle. Newberg reported that 99.3 percent of the cattle and calves sold by farmers in the East North Central Region and 97.3 percent in the West North Central Region were shipped by truck.[4] Roberts and Grover estimated that 72 percent

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[3]Large plants are those slaughtering over 2,000,000 pounds liveweight per year; medium size plants slaughter 300,000 to 2,000,000 pounds liveweight per year.

[4]R. R. Newberg, Livestock Marketing in the North Central Region. I. Where Farmers and Ranchers Buy and Sell, Research Bulletin 846 (Wooster: Ohio Agricultural Experiment Station, 1956), pp. 75-80.

TABLE III

AREA SUPPLY AND DEMAND CENTERS USED IN THE ANALYTICAL MODEL

Area	Center	Area	Center
1	Roanoke	18	Monroe
2	Richmond	19	Lake Charles
3	Wilson, North Carolina	20	Fort Smith, Arkansas
4	Greensboro	21	Oklahoma City
5	Ahseville	22	Memphis
6	Orangeburg	23	Nashville
7	Atlanta	24	Knoxville
8	Albany	25	Owensboro
9	Savannah	26	Louisville
10	Tallahassee	27	Charleston, West Virginia
11	Lakeland	28	Harrisburg, Pennsylvania
12	Miami	29	Indianapolis, Indiana
13	Mobile	30	Des Moines, Iowa
14	Birmingham	31	Lubbock, Texas
15	Huntsville	32	Salt Lake City, Utah
16	Greenville, Mississippi	33	Fresno, California
17	Baton Rouge, Louisiana		

of the cattle shipped within Utah were transported by truck.[5] In the Southern Region, Johnson estimated that practically all livestock sold by producers were transported to market by truck. This observation covered all livestock movements from farmers to first hand receivers, including auctions, local dealers, terminal markets, packing plants, and other farmers.[6] Because of the overwhelming importance of shipments by this mode of transport, cattle transportation cost estimates used here included only truck rates.

While data are not available concerning the relative importance of truck transportation in dressed beef shipments, only truck rates were used to estimate beef transfer costs. As a justification for this, truck traffic in farm products, particularly perishable ones, has increased substantially over the period 1947-1964. Although the rate of increase is not available by commodity groups, truck carriers increased their share of all intercity freight from 10 percent to 24 percent over this period, while the share transported by railroads dropped from 65 percent to 43 percent.[7] Completion of the Interstate Highway System should encourage further shifts from rail to truck transportation.

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[5] N. K. Roberts and L. H. Grover, Transporting Utah Cattle by Truck, Bulletin 417 (Logan: Utah Agricultural Experiment Station, November 1959), pp. 3-5.

[6] Jack D. Johnson, Livestock Marketing in the Southern Region, Southern Cooperative Series Bulletin 26 (Knoxville: Tennessee Agricultural Experiment Station, July 1952), p. 91.

[7] Economic Research Service, U. S. Department of Agriculture, Marketing and Transportation Situation, MTS-157 (Washington: Government Printing Office, May 1965), p. 1.

Since estimates of transportation costs under the completed Interstate System were needed for the analysis, three types of data were required. These included (1) highway mileages between each possible set of shipping centers, (2) cost functions expressing cost per hundredweight of shipping cattle and dressed beef as a function of highway mileage for conventional highways, and (3) estimates of the reduction in transportation costs per hundresweight mile that will result from the completed Interstate System.

Mileages and Transportation Costs Under Conventional Highway Systems

Highway mileages between each pair of supply and demand centers were obtained from the Rand-McNally highway mileage guide.[8] These data were used in estimating cattle and dressed beef transfer costs, under the assumption that highway mileages between shipping centers will not be altered by the Interstate System.[9]

Functions expressing cost per hundredweight of shipping cattle as a function of distance, between five major rate territories shown in Figure 11, were estimated by regression analysis of data obtained from

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[8]Rand-McNally and Company, Standard Highway Mileage Guide (Chicago, New York, Washington, San Francisco: Rand-McNally and Company, 1951).

[9]See J. W. McLeary, "Optimum Interregional Shipments of Beef, Pork, Broilers and Eggs, and the Predicted Effects of the Interstate Highway System on the Equilibrium Movement Patterns of These Commodities" (unpublished Ph. D. dissertation, The University of Tennessee, Knoxville, 1965), pp. 39-40. McLeary found, in a statistical analysis of 170 routes, that Interstate Mileage was not significantly different from conventional highway mileage at the 95 percent level of probability.

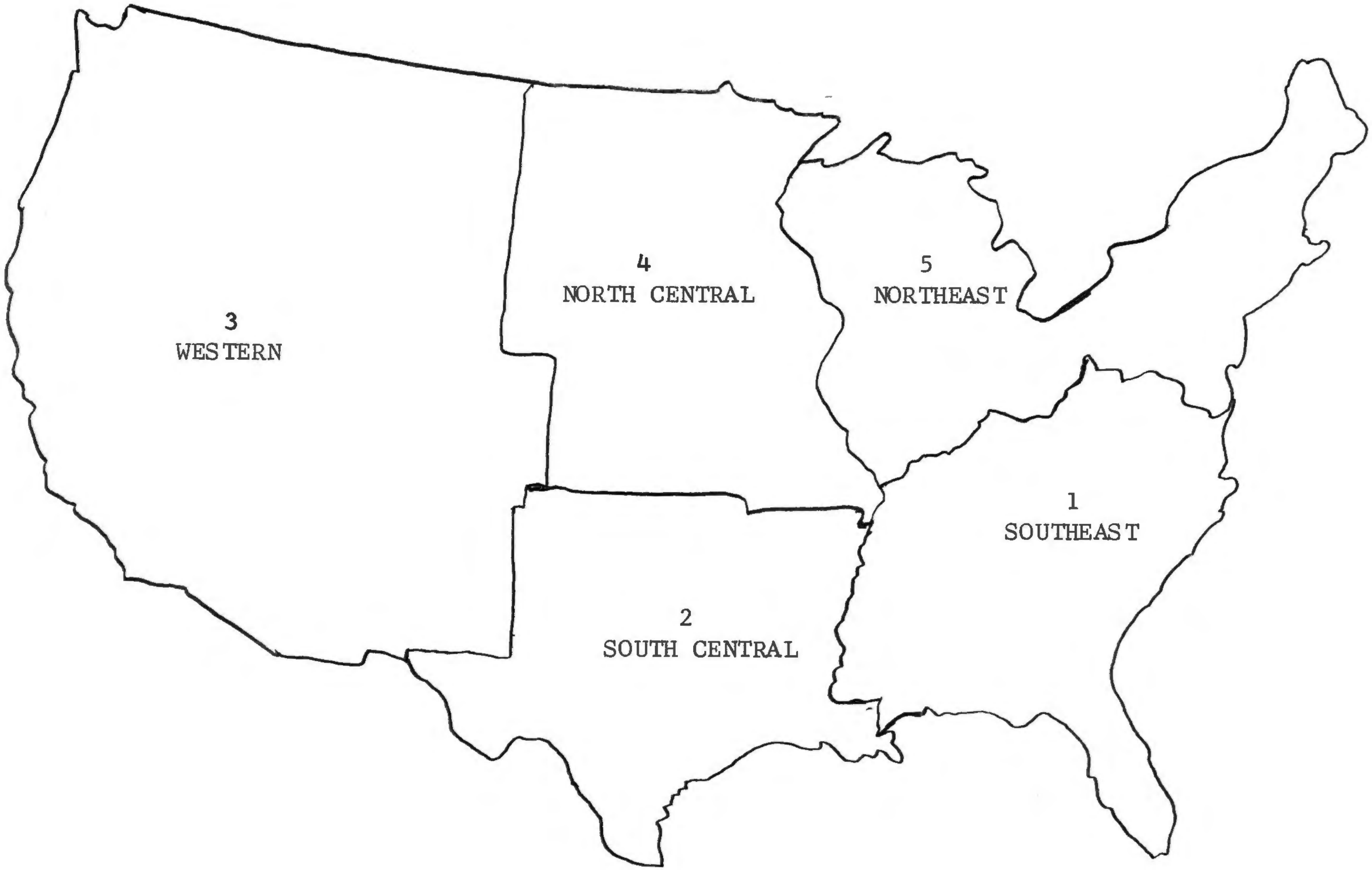

Figure 11. Rate territories used in estimating cattle transportation costs.

surveys of truckers and dealers in each area. Sources of the cost functions used and functional forms that were applied to various origin-destination combinations are shown in Table IV. In cases where sufficient data were not available to obtain functions for given route combinations, functions for the reverse directions were used. To estimate dressed beef transportation costs under the conventional highway system, a linear functional form was used. This equation was estimated by McLeary from tariff schedules published by the Interstate Commerce Commission.[10]

In order to transform cattle transportation cost functions into the form required by the analytical model, they were converted to transfer costs per hundredweight of beef equivalent. Previous studies, suggesting a lower average grade composition for slaughter cattle in the South than in other areas, implied that the conversion process should reflect regional carcass yield differences.[11] To incorporate these findings into the analysis, the dressing percentage for areas in the South was estimated from data developed in previous Southern livestock

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[10]Ibid., pp. 34-39. The tariffs were Southern Motor Carrier Rate Conference, 169-K (Edible Goods), MF-ICC, 1337; 169-K Supplement e, effective March 24, 1965; and 8-E (South-East Commodities), MF-ICC, 1317.

[11]Based on R. G. Stout and R. J. Freund, Marketing Cattle and Calves Through Southern Auctions--Analysis of Factors Contributing to Price Variation, Southern Cooperative Series Bulletin No. 54 (Knoxville: Tennessee Agricultural Experiment Station, June 1958), p. 4; R. G. Stout, Marketing Cattle and Calves Through Southern Auctions--Characteristics of Animals and Types of Buyers, Southern Cooperative Series Bulletin No. 48 (Knoxville: Tennessee Agricultural Experiment Station, February 1957), p. 21; and Economic Research Service, U. S. Department of Agriculture, Livestock and Meat Statistics for 1961, Statistical Bulletin No. 230 (Washington: Government Printing Office, June 1962), pp. 57-59.

TABLE IV

FUNCTIONAL FORMS OF CATTLE TRANSPORTATION COST EQUATIONS[a]

Equation Form:[b] $y = a + bX + c\sqrt{X}$		Equation Form:[c] $y = a + bX$	
Origin	Destination	Origin	Destination
Non-South Regions	Non-South Regions		
Southeast	Western	All other origin-destination combinations	
South Central	Northeast		

[a]In these equations, y denotes cost per hundredweight and x denotes miles from origin to destination.

[b]Functions used between these areas were computed from data published in J. D. Goodwin, Optimum Distribution Patterns of Feeder Cattle From the Southeast, Southern Cooperative Series Bulletin No. 101 (Knoxville: Tennessee Agricultural Experiment Station, October 1965), pp. 35-44 and pp. 68-71. Goodwin obtained the functions from W. R. Maki, Iowa State University.

[c]Functions used between these areas were obtained from personal communication of the author with L. D. Malphrus, Clemson University.

marketing studies,[12] while the United States average dressing percentage was used for areas outside the South.[13] Both figures include 3.7 percent for edible by-producets,[14] and 2.24 percent shrinkage.[15] For areas in the South, the average yield was estimated to be 49.86 pounds of beef per hundredweight of cattle; for the remaining areas, the yield figure was 58.96 pounds.

Two general limitations of these yield estimates might be noted. First, in the absence of information for projecting future regional differences in the quality of slaughter cattle supplies, quality differences were assumed to remain constant. However, possible future changes in feeding rates within the South could reduce the average grade differential. Second, the shrinkage figure is an average for 26 lots of beef cattle shipped 35 miles and over, and does not reflect a large number of factors influencing shrinkage. Some of the more important of these

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[12]Stout and Freund, *ibid*., p. 4; and Stout, *ibid*., p. 21.

[13]Economic Research Service, U. S. Department of Agriculture, *Livestock and Meat Statistics, 1962*, Statistical Bulletin No. 333 (Washington: Government Printing Office, 1963), p. 158.

[14]Based on S. H. Logan and G. A. King, "Size and Location Factors Affecting California's Beef Slaughtering Plants," *Hilgardia*, 36(4):156, December 1964, citing Henry W. Vaughn, *Types and Classes of Livestock* (Columbus: Long's College Book Store, 1951).

[15]G. F. Hennings and P. R. Thomas, *Some of the Factors Influencing the Shrinkage of Livestock From Farm to the First Market*, Research Bulletin 925 (Wooster: Ohio Experiment Station, October 1962), p. 6.

include time in transit, distance, temperature, type of driving during transit, and amount of fill.[16] Since these factors were not considered, the figure used here is only an approximate one.

Estimated Reduction in Transportation Costs From the Completed Interstate Highway System

In a study made for the Bookings Institution, Friedlaender estimated fixed and variable costs per vehicle mile at the beginning of construction on the Interstate System and under the completed system.[17] These costs were presented separately for various classes of vehicles. Fixed costs included depreciation, insurance, and overhead, while variable costs included maintenance, tires and tubes fuel, oil, and the driver's time. Friedlaender estimated that important reductions in fixed costs will result from lower insurance rates and lower average fixed costs per mile due to fuller utilization of the trucks over the course of a year. The latter reduction results from increased average speeds made possible by the Interstate System. In the variable cost group, fuel was the primary element that Friedlaender estimated would be affected by the Interstate System.[18]

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[16] Ibid., pp. 3-4.

[17] Ann Fetter Friedlaender, The Interstate Highway System, A Study in Public Investment (Amsterdam: North-Holland Publishing Company, 1965), pp. 37-45, and 139-167.

[18] Ibid., pp. 37-45, 164.

To obtain estimates of cost functions under the completed Interstate Highway System, the following procedure was used. First, since interarea shipments were the main concern in this study, it was assumed the relevant truck combination for long distance transporting would be medium size combinations.[19] In Friedlaender's study the average payload of these combinations was 42,000 pounds.[20]

For this truck size, the ratios shown in column 3 of Table V were computed for rural highway systems and urban systems, using data from Friedlaender's analysis.[21] These ratios represent the proportion that the relevant Interstate System cost component is of the conventional highway system cost component. Next, an average ratio, weighted according to vehicle miles traveled on urban and rural systems, was computed separately for fixed and for variable costs. The appropriate urban or rural ratio was weighted by the total number of vehicles miles traveled under the respective type of highway system by medium size combinations in 1964.[22] Final ratios of the Interstate cost component

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[19]Roberts and Grover, op. cit., p. 22, note that small trucks are used almost entirely on short hauls.

[20]Friedlaender, op. cit., p. 165.

[21]Ibid., pp. 37-45. Since Friedlaender was unable to separate costs for combinations on urban systems into fixed and variable components, these ratios were computed for large straight trucks. The ratios for large straight trucks operating on rural highway systems agreed closely with those for medium size combinations. Accordingly, it was assumed that the straight-truck ratios would be appropriate for combinations used on urban systems.

[22]Total vehicle miles traveled under each system by medium size combinations were obtained from ibid., p. 47.

TABLE V

FIXED AND VARIABLE COSTS IN CENTS PER VEHICLE MILE FOR CONVENTIONAL AND INTERSTATE HIGHWAY SYSTEMS[a]

Cost Component	(1) Interstate System	(2) Conventional System	Ratio of (1) Divided by (2)
Fixed cost, rural system	11,661	14,950	.7800
Fixed cost, urban system	31,176	32,086	.9716
Variable cost, rural system	20,351	20.020	1.0165
Variable cost, urban system	49,498	60.320	.8206

[a]Source: Ann Fetter Friedlaender, The Interstate Highway System, A Study in Public Investment (Amsterdam: North-Holland Publishing Company, 1965), pp. 37-45.

to the conventional highway component were as follows:

$$\frac{F_I}{F_C} = .820 \; ; \; \frac{V_I}{V_C} = .935,$$

where

F = fixed cost component

V = variable cost component

Subscripts denote Interstate and conventional highway systems.

It was assumed the same vehicle payload would be used on each highway system, and that transportation cost reductions will be passed on to shippers. Under these assumptions, cost functions applicable to the Interstate Highway System were estimated as follows:

$$Y = a(.820) + b(.935) X,$$

where

Y = cost in dollars per hundredweight, Interstate System

X = highway distance in miles

a = fixed cost component, conventional highway system

b = variable cost components, conventional highway system.

This procedure was used to adjust transportation cost functions both for cattle, in hundredweight of dressed beef equivalent, and for beef. The resulting interarea transportation cost matrices are presented in Tables XXI and XXII, in Appendix A.

CHAPTER IV

ESTIMATED BEEF CONSUMPTION AND SLAUGHTER CATTLE MARKETINGS IN 1975, BY AREAS

Demand estimates for this study required selection of an appropriate base year, and adjustment of United States average per capita consumption in the base year to obtain estimated consumption levels in 1975, by areas. The general adjustment procedure necessitated selection of the most important variables affecting future consumption and estimation of 1975 levels of these variables.

Estimates of area slaughter cattle marketings required projection of cattle and calf production to 1975, and estimation of marketings, using 1962 marketing-production relationships. In the sections that follow, methods used to estimate 1975 levels of area demands and marketings are described.

I. ADJUSTMENT FACTORS USED FOR ESTIMATING AREA DIFFERENCES IN PER CAPITA BEEF CONSUMPTION

Variables Considered

At the wholesale level, variables affecting the aggregate quantity of beef demanded include population, per capita income, the price of beef, the price of pork, racial composition of the population, residential composition (urban vs. rural), and tastes.[1] Factors that influenced the selection of variables for area demand estimates included relative importance in determining aggregate consumption, availability of data, and required assumptions of the model. Given these constraints, population, income, racial composition, and a residual group consisting of tastes and other factors, were selected as the appropriate variables for estimating quantities of beef demanded in 1975, by areas. The year, 1962, was selected as a base from which to make projections since it represented approximately average cyclical conditions, based on the cyclical beef supply pattern estimated by Purcell.[2]

In the remainder of this section, income and racial adjustment factors are defined. These were developed for adjusting United States average per capita beef consumption to reflect lower income levels and a higher proportion of non-white population in the South. Initially, adjustment factors were computed using 1955 per capita income data and 1960 racial composition data, and were used to adjust 1955 United States

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[1]See J. C. Purcell, in Prospective Demand for Meat and Livestock in the South, Southern Cooperative Series Bulletin 43 (Knoxville: Tennessee Agricultural Experiment Station, 1955). Purcell analyzed the effects of changes in these variables on meat consumption in the South prior to 1955 and made regional projections of total meat consumption to 1975.

[2]J. C. Purcell, Livestock Prices and Meat Supplies, Trends and Interrelationships, 1950-1959, Technical Bulletin N. S. 24 (Experiment: Georgia Experiment Station, May 1961), p. 20.

average per capita consumption.[3] Adjusted per capita consumption was then compared with per capita beef consumption in the South in 1955, as estimated from the 1955 Household Food Consumption Survey. The difference between these two consumption figures was attributed to differences in tastes, and other factors in the South, as compared with the United States average.

Because data for future projections of these residual factors were not available, they were assumed to remain constant. Thus, using the adjustment factors, it was possible to estimate effects of future income and racial composition changes on per capita consumption in the South, holding other factors constant. To obtain such estimates, an unchanging residual adjustment factor was used in conjunction with income and racial adjustment factors computed using 1975 data.

Since non-white groups are relatively less important as a percent of total population in non-South regions, racial composition and changes in it were not incorporated into 1975 demand estimates for areas 28 through 33. This procedure is based on the assumption that no significant interregional movement of non-white population will occur by 1975 for these areas. An additional justification for including racial composition as a variable in the South, but not for other areas, was that the objectives of the study required greater detail in the South than for other areas.

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[3]Racial composition data for 1955 were not available. Thus, it was assumed that changes in racial composition in the South between 1955 and 1960 were not economically significant.

Income Adjustment Factor

An income adjustment factor, to adjust United States average per capita consumption for interregional variations in income levels, was defined as follows:

$$\alpha = 1 - \left(\frac{I_u - I_k}{I_u}\right) E_k \quad ,$$

where

α = income adjustment factor

I_u = per capita disposable income, U. S. average[4]

I_k = per capita disposable income in the k^{th} region[5]

E_k = income elasticity of demand for beef in the k^{th} region.[6]

To obtain United States per capita consumption, adjusted to reflect a lower per capita income level in the South, the United States consumption figure was multiplied by the adjustment factor.

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[4]For 1955, this figure was obtained from Department of Commerce, Survey of Current Business, 40(8):13, August 1950.

[5]For 1955, this figure was computed from data in Survey of Current Business, 40(8):13, August 1960, and Census Bureau, "Revised Estimates of the Population of States and Components of the Population Change 1950 to 1960," Current Population Reports, Series P-25, No. 304 (Washington: Government Printing Office, April 8, 1965), p. 11. The South and each of areas 28 through 33 were considered as regions here.

[6]For areas in the South, an income elasticity of demand of .47 was used. This estimate is given in R. Raunikar, J. C. Purcell and J. C. Elrod, Consumption and Expenditure Analysis for Meat, Meat Products, and Eggs in Atlanta, Georgia, Technical Bulletin N. S. 46 (Experiment: Georgia Agricultural Experiment Station, September 1965), p. 38. It was based on an analysis of data obtained from the Atlanta consumer panel, for the period 1958-1962. For other areas, income elasticities of demand were obtained from G. G. Judge, J. Havlicek, Jr., and R. L. Rizek, Spatial Structure of the Livestock Economy, I. Spatial Analyses of the Meat Marketing Sector in 1955 and 1960, North

Racial Adjustment Factor

A racial adjustment factor, to adjust United States average per capita consumption for a higher percentage of non-white population in the South, was defined as follows:[7]

$$\gamma = 1 - \left(\frac{P'_n}{P'_w} - \frac{P_n}{P_w}\right) \frac{C_n}{C_w} \quad ,$$

where

γ = racial adjustment factor

P'_n = total non-white population, South

P'_w = total white population, South

P_n = total non-white population, United States

P_w = total white population, United States

C = per capita consumption of beef; subscripts denote race.[8]

Central Regional Research Bulletin No. 157 (South Dakota Bulletin 520) (Brookings: South Dakota Agricultural Experiment Station, May 1964), p. 10. These regional elasticity estimates, from linear-in-logs functions, were estimated from 1955 Household Food Consumption Survey data. For non-South areas, the income elasticity figures used were as follows:

Area	Income elasticity	Area	Income elasticity
28	.155	31	.272
29	.113	32	.272
30	.113	33	.272

[7]The 1960 population figures were obtained from Department of Commerce, Statistical Abstract of the U. S., 1965 (Washington: Government Printing Office, 1965), p. 27.

[8]Obtained from Raunikar, Purcell and Elrod, *op. cit.*, p. 19.

When racial composition in the South equals United States average racial composition, the racial adjustment factor equals one. However, when the proportion of non-white to total population in the South is greater than the United States average proportion, the adjustment factor is less than one. The proportion by which per capita consumption is reduced equals the difference in racial composition ratios, times the ratio of non-white to white per capita beef consumption.

Residual Adjustment Factor

A residual adjustment factor, that attributed differences between United States average per capita beef consumption and per capita consumption in the South to differences in tastes and other factors such as residential composition, type of employment, and age distribution, was defined as follows:

$$\sigma' = 1 - (\delta - \beta) = .881 \quad ,$$

where

σ' = residual adjustment factor

δ = the combined effect of income and racial adjustment factors, computed using 1955 income and 1960 racial composition data

β = average per capita consumption of beef in the South, divided by U. S. average per capita beef consumption; both figures are based on the 1955 Household Food Consumption Survey.[9]

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[9]Data were obtained from Harold F. Breimyer and Charlotte A. Kause, Consumption Patterns for Meat, U. S. Department of Agriculture, Agricultural Marketing Service--249 (Washington: Government Printing Office, May 1958), p. 11.

The logic of the residual adjustment factor is as follows. Income and racial adjustment factors for 1955 express Southern per capita consumption as a ratio to United States average per capita consumption when 1955 income and racial composition differences alone are considered. The Household Food Consumption ratio, however, represents the actual 1955 consumption ratio. Thus, the difference between the two ratios represents effects of residual factors, and this is subtracted from one to give a ratio of residually adjusted consumption to United States average per capita consumption.

Limitations of the Adjustments

These adjustment factors partition the difference between United States average per capita beef consumption and Southern per capita beef consumption into differences accounted for by:

1. Regional per capita disposable income differences
2. Regional racial composition differences
3. Other factors.

They were used here to estimate regional per capita beef consumption levels by adjusting United States average per capita consumption in the base year. However, various limitations of the adjustments should be pointed out. First, in using the residual adjustment factor to estimate the Southern demand for beef in 1975, it was assumed that tastes and other factors going into this residual category remained unchanged relative to the United States average, over the time span for which projections are made.

In particular, while changes in residential composition have in the past, produced important effects on the demand for beef,[10] lack of data for estimating 1975 residential composition prevented its use in computing area demands. As a result, residential compositions were assumed to remain constant. While this assumption limits the accuracy of the demand estimates, future differences in per capita consumption by residence may be narrowed by decreases in per capita income differences. This may reduce the importance of changes in residential composition as a variable affecting aggregate beef consumption.

Due to limitations of the model, interrelationships between pork and beef, possible changes in their relative wholesale prices, and possible changes in marketing margins also were omitted. Along with this, it should be noted that income and racial composition may be highly intercorrelated. Accordingly, the procedure used to separate effects of income changes from effects of racial composition changes is only approximate. In addition, no attempt was made to estimate effects from possible future changes in income distribution.

Finally, income elasticity differences among different cuts and grades of beef were neglected. Raunikar, Purcell and Elrod estimated income elasticities of demand for various cuts of beef as follows:[11]

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[10] G. S. Shepherd, J. C. Purcell and L. V. Manderscheid, Economic Analysis of Trends in Beef Cattle and Hog Prices, Research Bulletin 405 (Ames: Iowa Agricultural Experiment Station, 1954), p. 740.

[11] Raunikar, Purcell and Elrod, op. cit., p. 38.

Cut	Income Elasticity
Ground beef	.30
Beef roast	.56
Beef steak	.78

These income elasticity estimates imply that future increases in per capita disposable income will not only shift the area demands for beef to the right, but may raise the average quality of beef demanded. Although this aspect of the demand for beef was not incorporated in the analytical model, its potential effects should be noted. Changes in the quality of beef demanded may lead to changed feeding rates for slaughter cattle produced in the South and/or increased shipments of higher quality cattle into the region.

II. ESTIMATES OF CONSUMPTION BY AREAS, 1975

The preceding section described the method used for estimating the combined effects of residual variables such as tastes, residence, age composition, income distribution, and type of employment on regional per capita beef consumption levels. In addition, income and racial adjustment factors were defined for the purpose of estimating the effects of changes in these variables on area per capita consumption levels, relative to United States average per capita consumption. In this section, use of the adjustment factors to estimate area consumption levels for 1975 is explained.

Procedure for Estimating 1975 Consumption Levels

The adjustment factors defined and computed above first were used to estimate aggregate beef consumption in the South in 1975, taking into account both deviations of Southern per capita income and racial composition from the United States average, and increases in per capita income in the South over the 1962-1975 period. Southern beef consumption was estimated using the following relationships:

$$C'_{62} = \alpha_{62} \, C_{u62} \quad , \qquad (1)$$

where

C'_{62} = income-adjusted United States average per capita beef consumption in 1962

α_{62} = the income adjustment factor, computed using 1962 data

C_{u62} = United States average per capita beef consumption in 1962.[12]

The term, C'_{62}, represents United States average per capita consumption in 1962, adjusted for the lower average income level in the South in 1962. This term was next used in the following relationships:

$$C_{s75} = (C'_{62} + \Delta C') \, \gamma_{75} \cdot \sigma \qquad (2)$$

$$\Delta C' = E_s \, (\Delta I_s) \, C'_{62} \quad , \qquad (3)$$

where

C_{s75} = estimated per capita beef consumption in the South in 1975

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[12] U. S. Department of Agriculture, Economic Research Service, U. S. Food Consumption, Sources of Data and Trends, 1909-1963, U. S. Department of Agriculture, Statistical Bulletin No. 364 (Washington: Government Printing Office, June 1965), p. 22. This figure is on a retail weight basis.

$\Delta C'$ = estimated change in Southern per capita beef consumption resulting from increased per capita income over the period, 1962-1975

γ_{75} = the racial adjustment factor, computed using 1975 racial composition data for the South

σ' = residual adjustment factor

E_s = income elasticity of demand for beef in the South

ΔI_s = ratio of the change in per capita disposable income in the South, 1962-1975, to per capita disposable income in the South in 1962.

In effect, United States average per capita beef consumption in 1962 was first adjusted to reflect the lower average 1962 income level in the South. This figure was next adjusted for (1) estimated increases in per capita disposable income occurring in the South between 1962 and 1975, (2) estimated changes in Southern racial composition occurring over this period and (3) residual factors that were assumed to remain constant. Estimated 1975 per capita consumption in the South was used, in combination with estimated 1975 population, to obtain aggregate beef consumption in the South for 1975.

For areas outside the South, aggregate beef consumption was estimated using these relationships and the appropriate area adjustment factors, with one exception. For non-South areas the racial adjustment factor was omitted.

Next, average per capita consumption by race, for the South, was estimated using the procedure outlined in Appendix B. These data were used along with population estimates by race to obtain initial estimates of total beef consumption for areas in the South. Initial area estimates were then adjusted as shown in Appendix B, for estimated variations in income levels, to obtain area aggregate consumption estimates. Procedures used for estimating per capita disposable income by areas, and population by race and area for 1975 are presented in Appendix C.

Two further adjustments were made in aggregate beef consumption for all areas. First, farm slaughter of cattle, in equivalent units of beef, was expressed as a ratio to total state beef consumption in 1962. Area consumption estimates for 1975 were then reduced for farm slaughter by an amount computed using this ratio. To obtain total beef from farm slaughter in 1962, number of head of farm slaughter by state[13] was multiplied by estimated average liveweight per head of commercially slaughtered cattle in the area. This in turn was multiplied by the ratio of United States average liveweight per head for farm slaughter, to average liveweight per head commercially slaughtered.[14] The resulting number was then converted to pounds of beef, using the appropriate beef yield coefficient developed in Chapter III. In effect, the percentage of animals slaughtered on farms was assumed to remain at 1962 rates and was considered uniform throughout a given state.

In addition to an adjustment for farm slaughter, consumption estimates for each area were reduced by 2.8 percent to account for

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[13]Obtained from U. S. Department of Agriculture, Agricultural Statistics, 1963 (Washington: Government Printing Office, 1963), pp. 316-317.

[14]Obtained from Agricultural Statistics, 1963, p. 321.

imports of fresh and frozen beef. This assumed level of imports is based on 1962 United States import data.[15]

Quarterly Consumption Patterns

As noted earlier, quarterly quantities of beef demanded were needed for the analysis. To estimate this information for the South, data generated by the Atlanta consumer panel were used. Seasonal beef consumption as a percent of total annual consumption for areas 1 through 27 was as follows and was assumed to apply identically to each of these areas:[16]

Quarter	Percent
January-March	24.1
April-June	24.1
July-September	26.1
October-December	25.7

For areas 28 through 33, the seasonal consumption pattern was treated as the quarterly difference between total United States beef production[17] and beef consumption in the South.

In addition, changes in United States average end of quarter cold storage inventories of beef as a percent of total quarterly beef

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[15] Obtained from Agricultural Statistics, 1963, p. 321.

[16] R. G. Stout, J. C. Purcell and W. L. Fishel, Marketing, Slaughter, and Consumption of Livestock and Meats in the South, Southern Cooperative Series Bulletin No. 66 (Knoxville: Tennessee Agricultural Experiment Station, 1961), p. 27.

[17] These estimates are developed in the next section of this chapter.

consumption were examined for 1962. These percentages were as follows:[18]

Quarter	Inventory Change as a Percent of Quarterly Consumption
January-March	.96
April-June	1.70
July-September	.72
October-December	1.42

Because of the small size of quarterly changes in cold storage inventories, this information was not included in quarterly demand estimates.

Estimated quantities of beef demanded in 1975, by areas, are presented in Table XXII, in Appendix D.

III. PROJECTION OF AREA SLAUGHTER CATTLE MARKETINGS TO 1975

The profitability of cattle production, relative to other enterprises in a given area, and relative to other areas depends on a complex network of both intra- and interregional competitive forces. These forces encompass grain production and marketing, as well as competition among livestock species. The purpose here is not to specify rigorously such an interregional model, but to point out briefly some important factors affecting area slaughter cattle production levels.

[18]Estimated from data in Economic Research Service, U. S. Department of Agriculture, Livestock and Meat Statistics, 1964. Supplement for 1964 to Statistical Bulletin No. 333 (Washington: Government Printing Office, September 1965), pp. 146 and 153; and U. S. Food Consumption, 1909-1963, op. cit., p. 20.

At the farm level, livestock demand functions depends on the location, technological organization and structure of the relevant processing and distribution segments of the marketing system, as well as per capita income, population levels, and tastes. From a cattle supply viewpoint, one important element is feed requirements per unit of final product. However, since concentrates and roughages in general are not perfect complements, this relationship is economically determined by feed price ratios. In addition, a quality-of-final-product dimension is involved for slaughter cattle.[19] And finally, there is an inventory adjustment dimension that may vary with changes in seasonal and cyclical price patterns.

The first of these aspects on the supply side requires examination of area supplies and demands for feed grains and forage, as well as possible economies of scale in cattle production enterprises. The supply of feeds, it should be noted, depends upon factors such as soil and climatic conditions that influence grain and forage productivity levels in the area under consideration. Other important elements include opportunity costs of producing alternative crops, and transportation costs for shipping feeds into the area. Taking these factors into consideration, Butz and Baker suggest:

> Cattle feeding in the South also will increase, at least for locally consumed beef. The declines in the acreage of typical Southern crops, such as tobacco and cotton, and the increase in the production of pasture, hay, and grain sorghums

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[19]Earl O. Heady, Glen P. Roehrkasse, Walter Woods and J. M. School, Beef-Cattle Production Functions in Forage Utilization, Research Bulletin 517 (Ames: Iowa Agricultural Experiment Station, July 1963), pp. 906-910.

> make it likely that greater numbers of cattle will be fed in the South.[20]

Ideally, an analytical model applied to the interregional location of cattle slaughtering would incorporate the simultaneous location analysis of a series of intermediate activities from grain and forage production through the consumption of the final product. However, since a model of that scope is not presently feasible, a more restrictive procedure was used here to obtain projections of area slaughter cattle marketings for 1975.

In obtaining projections of slaughter cattle marketings, marketings in areas of the South for 1975 were assumed to bear the same relationship to their respective state cattle and calf production as they did in 1962. This permitted use of 1962 marketing/production relationships that were estimated in a previous Southern livestock marketing study. These data were obtained from a sample of packers, taken through cooperation of the Southern Experiment Stations.[21] However, in the case of areas 20 and 21, other sources of information had to be used since sample data were not available for Oklahoma. The procedure used to estimate marketing/production relationships for these areas is presented in Appendix D.

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[20] Dale E. Butz and George L. Baker, Jr., The Changing Structure of the Meat Economy (Norwood: Plimpton Press, 1960), p. 101.

[21] The data will be published in J. C. Purcell, Trend in Production, Marketings, Slaughter and Consumption of Livestock and Meats in the South, forthcoming Southern Cooperative Series Bulletin.

Marketings for Areas in the South

In projecting marketings to 1975, aggregate cattle and calf production was first projected to 1975 by states. Estimated marketing/production relationships were then used to obtain projected marketings of slaughter cattle by area and season. The procedure for projecting cattle production can be summarized as follows:

$$CP_{j75} = \left[CP_{j64} + (g_j \times 11)\right] \frac{CP_{j62}}{CP_{j64}} ,$$

where

CP_j = cattle production in the j^{th} state; numerical subscripts denote years

g_j = estimated annual percent change in cattle production for the j^{th} state, computed as described below.

Purcell has computed the percent increase in cattle production by states in the South over the period, 1954 through 1964. These years, he indicates, represented cyclical peak years.[22] As a basis for projections of cattle production here, two other sets of cyclical conditions were considered along with Purcell's estimates. These were the annual percent increase in cattle production by states, based on trough-to-trough years, and based on average cyclical-to-average cyclical years. Using Purcell's estimate of the cattle cycle,[23] the relevant periods were assumed to be 1951-59 and 1952-53-1962

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[22] Ibid.

[23] J. C. Purcell, Livestock Prices and Meat Supplies, Trends, and Interrelationship, 1950-1959, op. cit., p. 20.

respectively. The g_j were computed as averages of these three estimated annual rates of increase in cattle production. Finally, since 1964 was used as a base from which to make 1975 projections, state projections were adjusted to average cyclical conditions by using the ratio of 1962 production to 1964 production.

From the projected cattle production figures by state, area marketings for slaughter were estimated by:[24]

$$M_{ijs} = b^{*}_{ijs} \, (CP_{j75}) \quad ,$$

where

$$b^{*}_{ijs} = \frac{M_{ijs62}}{CP_{js62}} \quad ,$$

M_{ijs} = cattle marketings for slaughter in the i^{th} area of the j^{th} state, for the s^{th} season, in liveweight.[25]

Marketings for Areas Outside the South

Because of a required restriction in the model, total 1975 commercial United States beef production was set equal to estimated total 1975 United States beef consumption minus imports and farm slaughter. Using this constraint, total non-South marketings of slaughter cattle were treated as a residual. The estimated residual quantity was allocated among areas 28 through 33, quarterly, on the basis of 1960

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[24]Production data were obtained from Economic Research Service, U. S. Department of Agriculture, *Livestock and Meat Statistics, 1962*, Statistical Bulletin No. 333 (Washington: Government Printing Office, 1963), p. 28.

[25]Obtained from a forthcoming Southern Cooperative Series Bulletin by J. C. Purcell, *op. cit.*

cattle production for slaughter by areas. Quarterly production data for these areas were developed from a recent North Central Regional Study.[26]

Conversion of Liveweight Marketings to Dressed Weight

One requirement of the analytical model was that supplies, demands and marketing costs for cattle and beef must be expressed in terms of a common denominator. For this reason, projected cattle marketings were converted from pounds liveweight to equivalent pounds of beef. To make the conversion, liveweight of marketings was multiplied by the appropriate yield coefficient developed in Chapter III.

Quarterly Marketing Patterns

For the Southern region and for non-South regions as a group, estimated quarterly patterns of slaughter cattle marketings, expressed as a percent of aggregate annual production in the region, were as follows:

Quarter	South: Percent	Non-South: Percent
January-March	20.22	24.55
April-June	21.00	23.74
July-September	29.85	26.27
October-December	28.93	25.45

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[26] A description of the estimating procedures is given in J. Havlicek, Jr., R. L. Rizek and G. G. Judge, Spatial Structure of the Livestock Economy, II. Spatial Analyses of the Flows of Slaughter Livestock in 1955 and 1960, North Central Regional Research Bulletin 159 (South Dakota Bulletin 521) (Brookings: South Dakota Agricultural Experiment Station, June 1964), pp. 7-11.

These figures suggest that quarterly variations in cattle marketings within the South are considerably larger than quarterly variations both in Southern beef consumption, presented earlier, and in non-South marketings. Although possible future increases in Southern feedlot operations could tend to smooth out the seasonal marketing pattern, seasonal marketings were assumed to remain unchanged from the 1962 pattern.

Final projected annual slaughter cattle marketings by areas are shown in Table XXIV, in Appendix E. These figures were adjusted so that estimated aggregate United States beef consumption equals projected aggregate marketings, in beef equivalent units.

CHAPTER V

COST FUNCTIONS FOR CATTLE SLAUGHTERING

The objective of this chapter was to develop long-run cost functions for specialized cattle slaughtering plants, based on factor prices in the Southern region. In the long run, plant size and technology are variable, so that under the usual assumptions of perfect competition, the individual firm will select the plant capacity at which average total costs are minimized.[1] Average total costs here include assembly, processing, and distribution costs.

Estimation of slaughtering cost functions required an examination of alternative methods for deriving operating costs in processing plants, and a review of modifications in economic theory needed for analysis of processing operations. These provided the background for estimating average slaughtering costs per unit of dressed beef, using available physical input requirements and input cost data.

I. ALTERNATIVE APPROACHES FOR ESTIMATING SLAUGHTERING COSTS

Two general methods can be used to obtain cost functions for processing operations. One approach involves statistical analysis of

[1]See Jacob Viner, "Cost Curves and Supply Curves," Zeitschrift fur Nationalokonomie, Vol. III, 1931, pp. 23-46; reprinted in American Economic Association, Readings in Price Theory (Homewood; Richard D. Irwin, Inc., 1952).

accounting cost data obtained from one or more firms operating at various rates of output.[2] A second approach, the synthetic method, begins with identification of the different stages of operation within an individual plant. For this approach, a stage consists of all productive services that cooperate in performing a single operation or a group of minor but closely related operations.[3] Input requirements and costs for labor, equipment, and other factors are determined for each stage in the processing operation. The resulting cost functions for all stages at varying rates of utilization and for different scales of plant are then aggregated, and attention is given to coordination among stages. Aggregation thus leads to cost functions for the processing operation as a whole.

Limitations of the Statistical Approach

The statistical approach frequently can produce results with relatively small research cost, and the regression coefficients obtained can be tested for statistical reliability. However, Stollsteimer, Bressler and Boles warn that this approach should be used with caution:

> Our general conclusion must be that the analysis of such cross-section data may result in high correlations and apparently significant regression coefficients, without

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[2]For example, see W. H. Nichols, *Labor Productivity Functions in Meat Packing* (Chicago: The University of Chicago Press, 1948); and R. E. Schneidau and J. Havlicek, Jr., *Labor Productivity in Selected Indiana Meat Packing Plants*, Research Bulletin No. 769 (Lafayette: Purdue Agricultural Experiment Station, November 1963).

[3]B. C. French, L. L. Sammet and R. G. Bressler, Jr., "Economic Efficiency in Plant Operations with Special Reference to the Marketing of California Pears," *Hilgardia*, 24(10):545, July 1956.

> providing the basis for confidence in the results as even rough approximations of the basic cost relations involved. . . . These somewhat doleful findings do not mean that studies of underlying industry economies of scale and short-run average cost curves based on cross-section data are not without value, but they do emphasize that this approach should be used with care and caution.[4]

Specific problems that can arise when accounting data are used to make statistical estimates of firm cost functions include data accuracy,[5] selection of the proper functional form,[6] the simultaneity problem,[7] and problems of using cross-section data to develop intrafirm production functions.[8]

Limitations of the Synthetic Approach[9]

Problems of the statistical approach for estimating long-run average cost functions can be avoided partially by use of the synthetic method. However, this procedure has several limitations of its own. One problem, while not unique to the synthetic method, is that many

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[4]J. F. Stollsteimer, R. G. Bressler, Jr., and J. N. Boles, "Cost Functions From Cross-Section Data--Fact or Fantasy?", Agricultural Economics Research, 13(5):87, July 1961.

[5]French, Sammet and Bressler, op. cit., p. 580.

[6]Stollsteimer, Bressler and Boles, op. cit., pp. 79-88. For a possible means of reducing this problem, see R. L. Gum and S. H. Logan, "Labor Productivity in Beef Slaughter Plants," Journal of Farm Economics, 47(5):1457-1461, December 1965.

[7]J. Marschak and W. H. Andrews, Jr., "Random Simultaneous Equations and the Theory of Production," Econometrica, 12(3):143-205, July 1944.

[8]M. Bronfenbrenner, "Production Functions: Cobb-Douglas, Interfirm-Intrafirm," Econometrica, 12(1):35-44, January 1944.

[9]Guy Black, "Synthetic Method of Cost Analysis in Agricultural Marketing Firms," Journal of Farm Economics, 37(2):275-277, May 1955.

joint and overhead costs must be allocated arbitrarily. In addition, management, as a variable affecting average total cost, is ignored. Other problems include the possibility of neglecting coördination among stages and inability to uncover either diseconomies of scale or external economies.

Approach Used for Estimating Slaughtering Cost Functions

Because of time limitations, the present study utilized previous synthetic studies as sources of the physical input requirements data to develop cost function for beef slaughtering plants. Consequently, this chapter is devoted primarily to developing factor price data appropriate for the Southern region and to applying these to the physical requirements data to estimate average slaughtering cost functions.

According to economic theory, the optimum technology to be used in a processing plant depends not only on physical relationships, but also on factor prices. For this reason, direct adjustment of average slaughtering costs estimated in previous studies for other areas was not considered valid. Therefore, estimation of slaughtering costs necessitated decomposing previous cost studies into physical input requirements for various sizes of plant and for each of the three general technologies used in slaughtering plants.[10] To obtain long-run average cost functions based on optimum technology in the South, factor

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[10]Technology is defined here as type of slaughtering system; it includes the bed-type system, and intermittent and continuous on-the rail systems.

prices appropriate for this region were applied to the physical requirements data, and average slaughtering costs were estimated for each technology. The theoretical considerations involved in this approach are presented in the following section, which contains a review of modifications in production economic theory needed for analysis of agricultural processing operations.

II. MODIFICATIONS IN ECONOMIC THEORY REQUIRED FOR ANALYSIS OF AGRICULTURAL OPERATIONS

Types of Modification Needed[11]

French, Sammet and Bressler suggested that four general modifications in economic theory are needed for analysis of operations in agricultural processing plants. The first of these is recognition that output per week can be varied either by changing the rate of output per hour or by changing the number of hours worked per week. In addition, segmentation and discontinuities in plant operations require recognition. Along with this, economic theory should reflect processing activities that consist of an integration and aggregation of many different operating stages. Finally, problems in pricing and depreciating of durables need to be considered.

Incorporation of Modifications Into Production Economics[12]

Changes in plant output rates that are affected by adjustments either in time or input rate dimensions result in a total cost surface

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[11]French, Sammet and Bressler, op. cit., pp. 548-557.

[12]Ibid., pp. 543-709, except where otherwise noted.

such as that shown in Figure 12. Constraints such as those requiring time and one-half wage rates for work in excess of forty hours per week create kinks in the total cost function in the time dimension. In the rate dimension, discontinuities result from plant segmentation. As Dean indicated in his 1941 study, segmentation of a plant into a number of similar operating units or machines, each of which can be withdrawn from operation without influencing the efficiency of others, permits increases in the rate of output by increasing the number of identical machines used and by increasing the number of workers performing identical jobs.[13]

Segmentation leads to input-output functions in the input rate dimension such as that shown in Figure 13. Total cost functions resulting from segmentation, when some cost elements vary continuously and linearly for each machine, may resemble those in Figure 14.

Segmentation thus has two general implications from a production economics standpoint. First, as Brems noted, production where marginal cost equals marginal revenue may no longer define a unique profit-maximizing output rate, since the total cost function is no longer continuous. This situation is shown in Figure 15; at output X_2, marginal cost equals

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[13]Joel Dean, Statistical Cost Functions of a Hosiery Mill (Chicago: University of Chicago Press, 1941), p. 51; and G. Stigler, "Production and Distribution in the Short-Run," Journal of Political Economy, 47(3):305-327, June 1939.

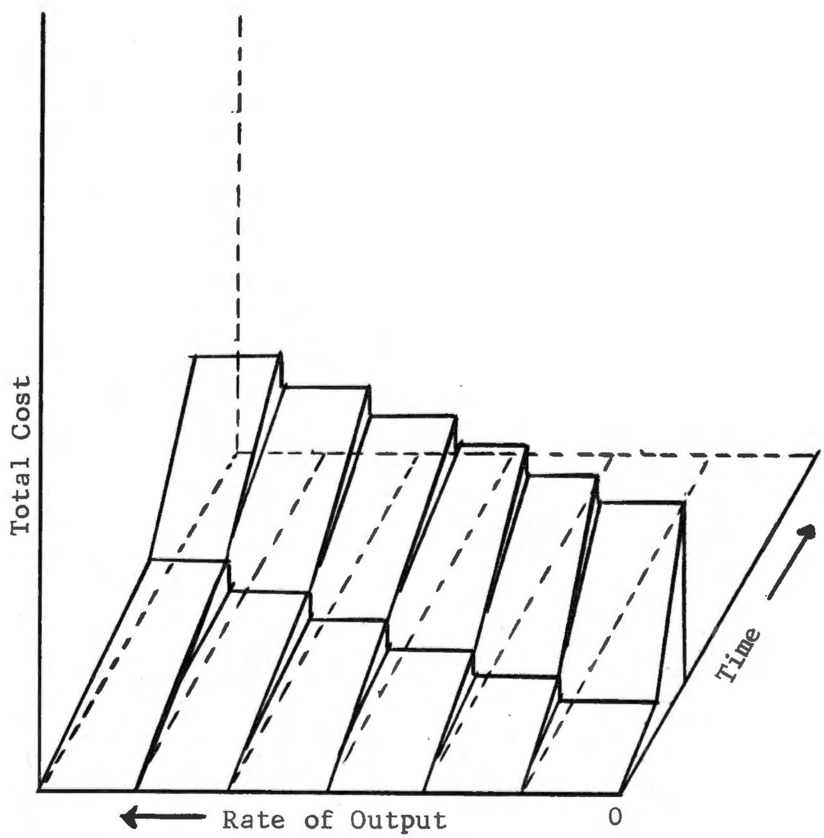

Figure 12. A cost surface showing rate and time dimensions.

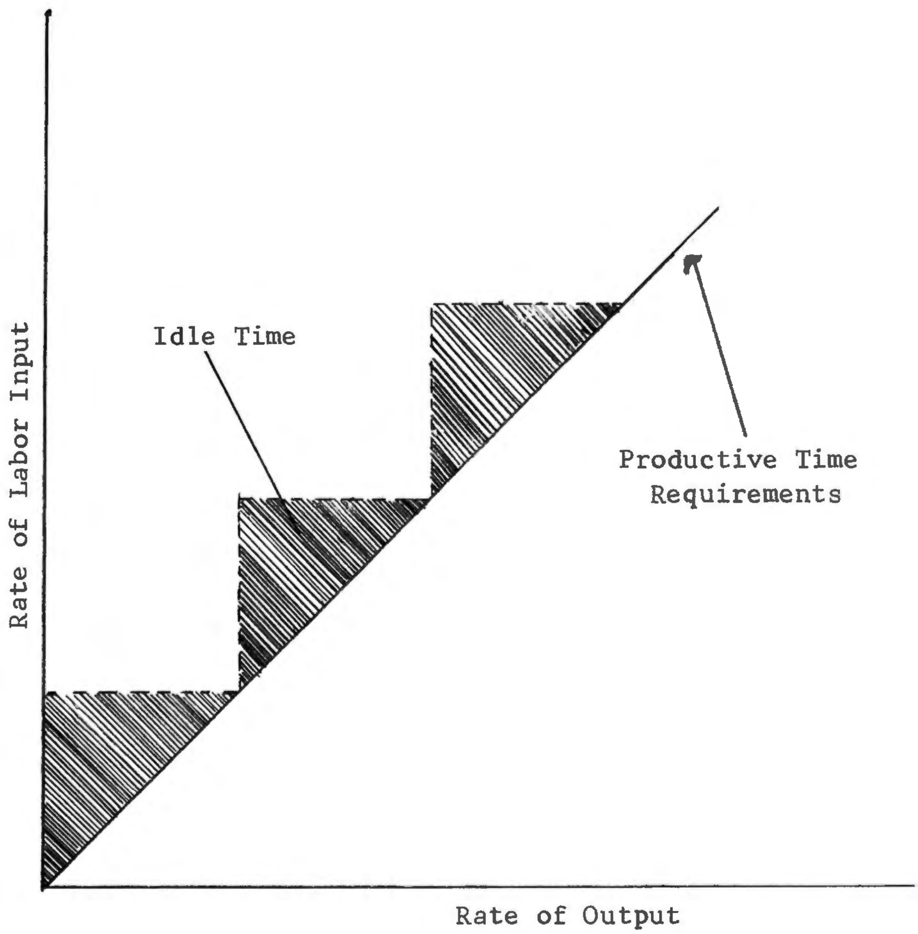

Figure 13. An input-output relationship in the rate dimension.

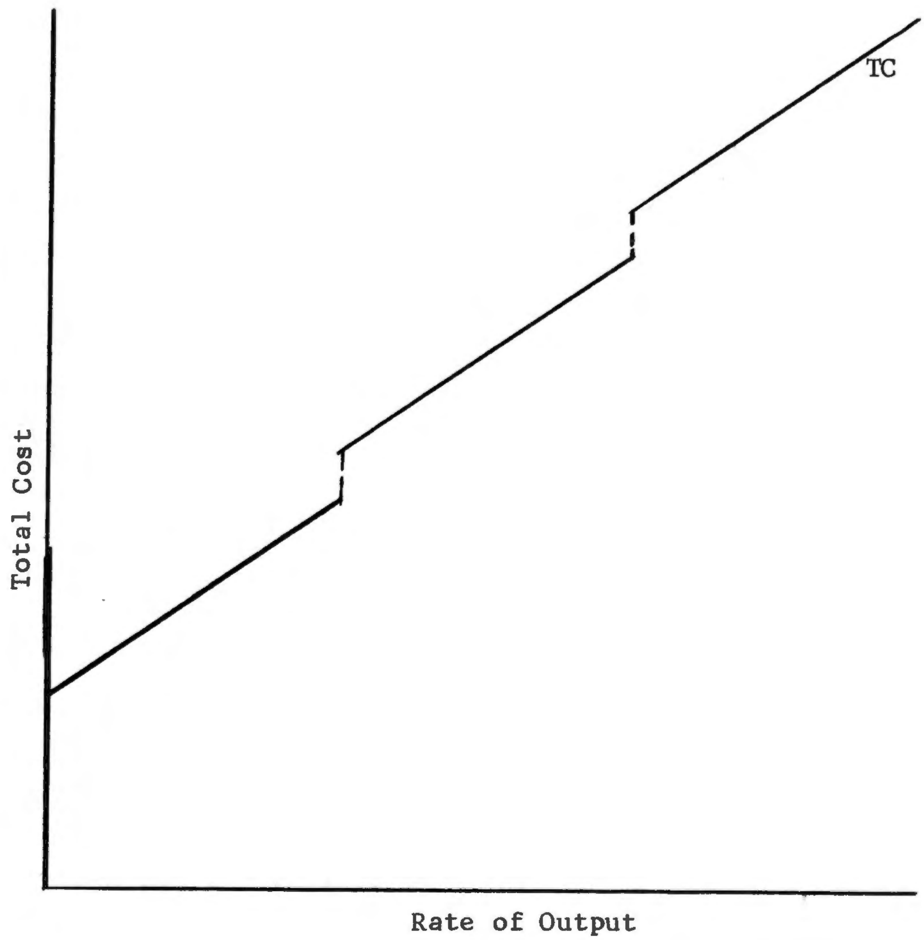

Figure 14. A discontinuous total cost function.

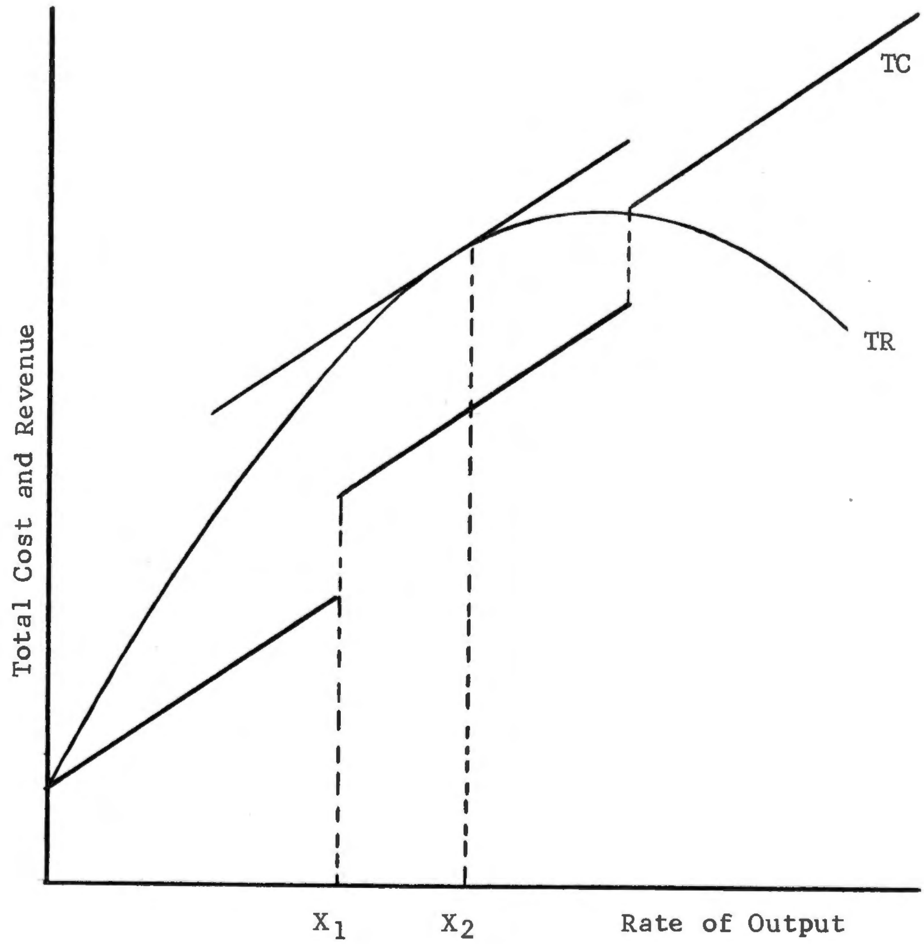

Figure 15. Profit maximization with a discontinuous total cost function.

Source: Hans Brems, "A Discontinuous Cost Function," American Economic Review, 42(4):583, September 1952.

marginal revenue, but the profit maximizing rate of output is at X_1.[14] Second, segmentation frequently may lead to the case of perfect complementarity in short-run factor combinations. This situation is illustrated in Figure 16, where the production function is represented by discontinuities and L-shaped isoquants. Optimum factor combinations are technologically determined and are fixed proportions.[15]

With the synthetic approach, plant cost functions are obtained by aggregating individual stage cost functions. The concept of plant stages lead to (a) a problem of finding "harmonious" combinations of capacities for the units of fixed but discretely variable equipment used at each stage, (b) the need to consider volume of output and the problem of harmony in selecting technology for each stage, and (c) additional kinks in the cost functions.[16]

In aggregating, distinction may be made between an economic stage and a technical stage. French, Sammet and Bressler suggest:

> An economic stage may be composed of several technical stages wherein, given the rate of plant output, the use of a certain technology at one of these stages may limit or modify the use of some other technology at another of these stages. The minimum cost technologies can be determined

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[14] Hans Brems, "A Discontinuous Cost Function," American Economic Review, 42(4):583, September 1952.

[15] Sune Carlson, A Study of the Pure Theory of Production (New York: Kelley and Millman, Inc., 1956), p. 25.

[16] Brems, op. cit., p. 580.

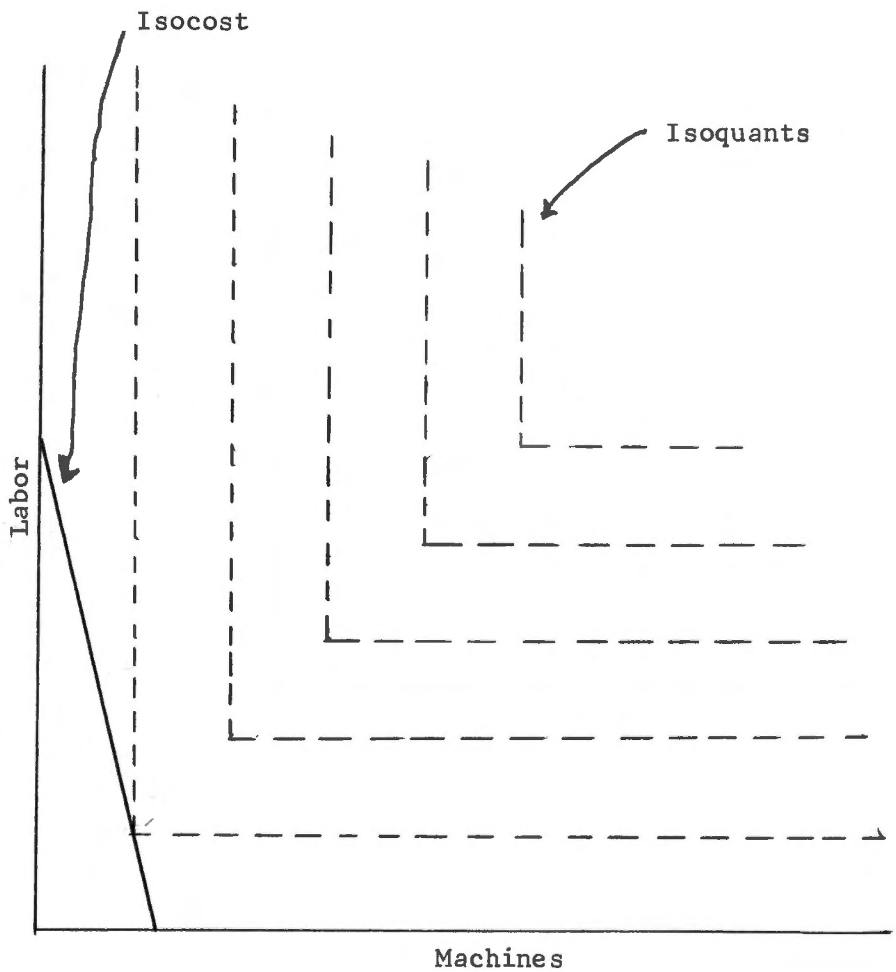

Figure 16. Optimum factor combinations in the short-run with plant segmentation.

only by joint consideration of all stages that are so related.[17]

In generating plant cost functions, each economic-stage cost function is based on the most economically efficient technology available for that stage. A method for economic selection of the technology for each stage, for various rates of output, holding hours of operation constant, is presented in Figure 17. The total cost curve for each technology, represented by curves A, B, C, and D, can be considered an "envelope" to the short-run cost curves for plants of various sizes and employing different quantities of the same type of technology.[18] Other envelopes may be drawn to the curves representing different technologies to obtain the long-run cost function (or envelope) for each economic stage. This function is represented by the solid curve in Figure 14, page 90; similar envelopes may be obtained for all other stages. The resulting stage cost functions are then aggregated, and general costs are included to obtain the long-run total cost function for the plant.

As the number of technologies available at each stage increases and as stage cost functions are aggregated, the size of the discontin-

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[17]French, Sammet and Bressler, op. cit., p. 574.

[18]See R. H. Leftwich, The Price System and Resource Allocation, Revised Edition (New York: Holt, Rinehart and Winston, 1960), pp. 152-158. The "envelope curve" can be considered as the curve that encloses the entire family of short-run cost curves for plants of various sizes, using the same type of technology. When the cost curves are curvilinear and continuous, it is the curve that is just tangent to all possible short-run average cost curves.

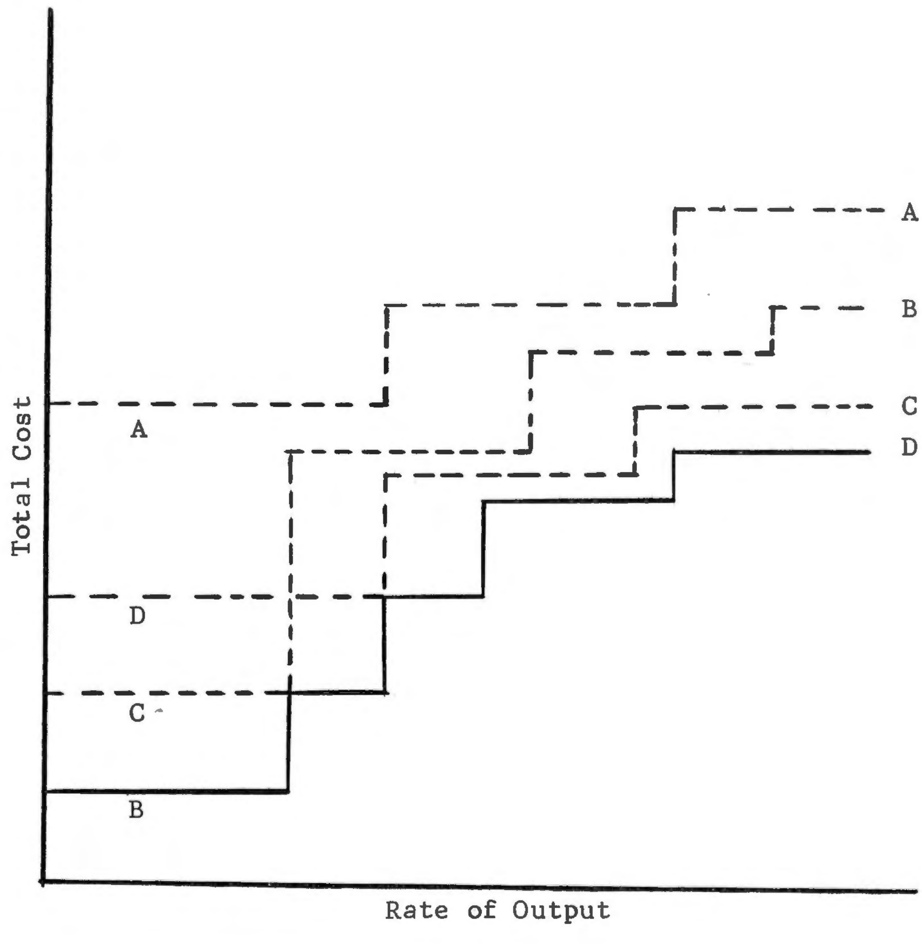

Figure 17. A method for economic selection of technology for each stage of operation.

uities in the total cost function decreases, although the number increases. The long-run total cost curve may thus approach a continuous function, and as a practical working procedure, small discontinuities can be smoothed into a continuous function.

One other problem in economic analysis of processing plant operations arises from uncertainty faced by management. Following Knight, uncertainty is considered to be situations in which no objective probability can be attached to the outcome of the situation.[19] The important variables for which uncertainty may exist include (1) future product and factor prices and (2) the amount of the return above variable costs required to maintain and replace the durable items of the plant. The latter involves uncertainty about rates of deterioration of durable items and about the introduction of new technology that may render the equipment obsolete.[20] One approach that may hold some promise here for the individual manager is the use of the subjective probability concept in decision theory as employed in Bayesian statistics. However, since this approach appears to require separate application and a special case for each manager, no attempt was made here to incorporate it into the economic analysis of slaughtering plant operations.[21]

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[19] Frank H. Knight, Risk, Uncertainty and Profit (New York: A. M. Kelley, 1964), p. 233.

[20] French, Sammet and Bressler, op. cit., p. 577.

[21] For some possible ways of handling this problem, see Clifford Hildreth, "Bayesian Statisticians and Remote Clients," Econometrica, 31(3):422-438, July 1963.

In discussing uncertainty, the problem of achieving flexibility as a type of informal insurance should be recognized. Four general types of flexibility include provisions for adjustment to: (1) seasonal changes in output, (2) changes in factor prices and innovations, (3) product changes and (4) long-term changes in the quantity of output demanded.[22] The first type of flexibility may be achieved through variable hours of operation and by use of technology that permits fairly uniform average variable cost over a considerable range in rates of output.[23] The second may be obtained by substituting variable factors for fixed factors. The third may be achieved by use of general purpose rather than highly specialized technology.[24]

This brief summary of the general conceptual framework is intended to bring out important problem areas involved in applying economic theory to empirical cost analyses. It provides a background for the next section which contains a description of the main types of technology used in beef slaughter plants and the operations required by these technologies.

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[22]National Bureau of Economic Research, Cost Behavior and Price Policy (New York: National Bureau of Economic Research, 1943), pp. 223-225; and French, Sammet and Bressler, op. cit., pp. 578-579.

[23]Stigler, op. cit., pp. 305-327.

[24]National Bureau of Economic Research, op. cit., pp. 224-225.

III. ESTIMATION OF SLAUGHTERING COST FUNCTIONS

Operations in Bed-Type and On-the-Rail Slaughtering Systems[25]

Basic technology used in killing-floor work includes the bed-type system, the intermittent powered on-the-rail system, and a continuous powered on-the-rail system. The bed-type system requires that carcasses be pushed manually along the rail, and in one work area, removed from the rail to a cradle or pritch plates on the floor, where one or more carcasses are worked on at a time.[26] With the intermittent on-the-rail system, carcasses are suspended from the rail and are moved to operating stations by means of an intermittently operated drive. The drive unit is pre-set to determine the rate of slaughter. Continuous on-the-rail systems differ from the intermittent systems in that the dressing line is in continuous motion. For both intermittent and continuous on-the-rail systems, slaughtering operations are performed while the carcass is suspended from the rail.

Operations that are identical both for bed-type and on-the-rail systems include driving the cattle to a knocking pen, knocking or stunning, bleeding, and head removal. In bed-type plants, the next

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[25]Based on Logan and King, op. cit., pp. 22-26; the Allbright-Nell Co., Cattle Dressing on the Rail Systems, Folder No. 87 (Chicago: Allbright-Nell Co., 1963); Sanders, Frazier and Padgett, An Appraisal of Economic Efficiencies Within Livestock Slaughter Plants, Bulletin N. S. 122 (Experiment: Georgia Agricultural Experiment Station, December 1964), pp. 7-10; and D. R. Miller, Cattle Killing-Floor Systems and Layouts, Agricultural Marketing Service, U. S. Department of Agriculture, Marketing Research Report No. 657 (Washington: Government Printing Office), p. 4.

[26]A cradle consists of two parallel bars that hold the carcass on its back about six inches off the floor; pritch plates are large metal plates in the floor.

operation following head removal involves lowering the carcass to a cradle or pritch plates where the legs are cut off and the hide is removed from the sides of the animal. The carcass is then raised off the floor, the hide is removed from the flanks and tail, and the animal is eviscerated. Following this, the carcass is split, scribed, washed, and weighed. After weighing, wet shrouds are pinned on the carcass halves to provide a smoother appearance after cooling and to prevent drying. The carcass is next placed in the chill cooler, usually overnight; later, it is moved to the sales cooler and left for about two days.

Slaughtering in on-the-rail systems differs from bed-type plants in that operations from legging and siding through scribing are performed while the carcass is suspended from the rail. This permits increased specialization in operations performed by each worker, as well as the use of hydraulic platforms for adjusting worker height to carcass height. In addition, for slaughter rates of over forty head per hour, a moving-top viscers inspection table is used for the evisceration operation.

Total Annual Slaughtering Costs

Major cost items in cattle slaughtering include expenses for labor, depreciation, interest, taxes, insurance, and utilities. The most important single cost component is labor; this element accounts for about 50 percent of total slaughtering costs.[27] For this reason, area slaughtering costs were estimated by first developing functions based on Tennessee wage rates and currently available slaughtering systems, and then adjusting these for estimated differences in wage and salary costs for other areas. Other cost items were not adjusted for interarea differences, since data were not available for estimating interarea price variations.

For the purpose of this study, total costs were estimated for slaughtering capacities of 17, 35, and 50 head per hour for bed-type plants and 20, 40, 60, 75, and 120 head per hour for on-the-rail plants. Table VI indicates the sources of physical requirements and cost data used for estimating annual slaughtering costs. Labor expenses were computed by estimating average wage rates in meatpacking in 1963 by areas, and by job classification for Tennessee, using the procedure described in Appendix F.

Two limitations of the wage cost data should be pointed out. First, wage rates within areas of each state may vary considerably, depending on local availability of skilled labor and the extend of unionization in slaughter plants in the area. Although data are not available concerning the extent and distribution of unionization in the Southern cattle slaughtering industry, Brody indicates such factors as

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[27] Donald B. Agnew, "Meatpackers' Costs and Spreads for Beef," Marketing and Transportation Situation--150, Economic Research Service, U. S. Department of Agriculture (Washington: Government Printing Office, August, 1963), p. 37.

TABLE VI

SOURCES OF PHYSICAL REQUIREMENTS AND PRICE DATA FOR COMPUTING CATTLE SLAUGHTERING COSTS

	Cost Component						
	Wages and Salaries	Depreciation: Equipment	Depreciation: Building	Interest and Insurance	Taxes	Util- ities	Miscel- laneous
Source of Physical Require- ments	1) Logan and King[a] 2) Hammons and Miller[b]	1) Logan and King[a] 2) Hammons and Miller[b]	Logan and Miller and Hammons[c]	N. A.	N. A.	Logan and King[a]	Logan and King[a]
Source of Price Data	Department of Labor Studies	Logan and King[a]	Adjusted Logan and King-Data[e]	Adjusted Logan and King Data[e]	Median Tennes- see Tax Rate[f]	Rates in Tennes- see[g]	Logan and King[a]

[a]Logan and King, "Economics of Scale in Beef Slaughter Plants," Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, December 1962).

[b]Hammons and Miller, Improving Methods and Facilities for Cattle Slaughtering Plants in the Southwest, U. S. Department of Agriculture, Marketing Research Report No. 436 (Washington: Government Printing Office, 1961).

[c]Miller and Hammons, Independent Meat Packing Plants in Texas, MP-306 (College Station: Texas Agricultural Experiment Station, September 1958).

TABLE VI (continued)

[d]U. S. Department of Labor, Bureau of Labor Statistics, Industry Wage Survey, Meat Products, November 1963, Bulletin 1415 (Washington: Government Printing Office, June 1964), and other data reported in Appendix F.

[e]The adjustment procedure is presented in Appendix G.

[f]Obtained from Tennessee Taxpayers Association, A Report Upon the 1964 or Twenty-Ninth Annual Survey of County, City and Town Government in Tennessee, Research Report No. 162 (Nashville: Tennessee Taxpayers Association, May 15, 1965).

[g]Obtained from Knoxville Utilities Board; and Tennessee Valley Authority, 1963 Operations, Municipal and Cooperative Distributors of TVA Power (Knoxville: Tennessee Valley Authority, November 1963).

N. A. indicates not applicable.

state laws, allegedly hostile public officials, and employer and community resistances have made unionization of independent meatpacking companies in the South difficult.[28] Second, in the absence of data for projecting interarea wage differentials to 1975, the 1963 wage pattern was assumed to remain unchanged.

Estimating salaries of management personnel presented a problem, since information was not available concerning variations in salary levels among regions of the country. Also, management compensation rates in meatpacking are likely to vary with the relative profitability of the firm, and thus may vary widely within any given area. To resolve these problems, management salaries were assumed to vary among areas in the same proportion as wage rates of production workers vary.

Other salary expenses include costs of sales, purchasing, and clerical personnel. The first two of these were assumed to bear the same relation to the average production worker wage rate in meatpacking as United States average manufacturing sales salaries in 1959 had to the average production worker wage rate in manufacturing.[29] For clerical workers, average salary levels in the South were estimated from salary levels in thirteen Southern cities in 1963 and 1964.[30]

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[28]David Brody, _The Butcher Workmen_ (Cambridge: Harvard University Press, 1964), p. 247.

[29]Manufacturing wages and salaries were obtained from _Statistical Abstract of the U. S., 1965_, _op. cit._, pp. 231, 232.

[30]U. S. Department of Labor, Bureau of Labor Statistics, _Occupational Wage Survey_, Bulletin 1345, Nos. 39, 43, 44 and 71; and Bulletin 1385, Nos. 2, 3, 7, 23, 35, 41, 57, 63 and 68 (Washington: Government Printing Office).

Utility costs in slaughter plants include expenses for electricity, water, and fuel. Water and fuel cost rates may vary widely within and among areas, depending on local supply and demand conditions. In addition, an element of uncertainty enters into the problem of selecting the most economical fuel for a given area, due to possible future requirements of equipment for air pollution control, as well as the possible development of technology for converting coal into gas.[31] In view of these problems, natural gas was considered the appropriate fuel for all areas, and fuel costs were not adjusted for area differences. Similarly, although lower electrical rates in TVA distribution areas may provide some competitive advantage in slaughtering relative to other areas, lack of data presented adjustments for interregional rate variations.

Average Slaughtering Cost Functions

To obtain a function showing the relationship between slaughtering cost per head and number of head slaughtered per year, cost data described in the preceding section were aggregated for each synthetic plant. Total annual slaughtering costs in Tennessee for various plant sizes are shown in Table VII, and are plotted as average total cost per head in Figure 18. The unit cost curves in Figure 18 suggest that under Tennessee wage rates, bed-type plants provide the most economical system

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[31]See Henry R. Linden, "Pipeline Gas From Coal: Status and Future Prospects," Coal Age (New York: McGraw Hill Book Co., Inc.), 71(1):64-71, January 1966.

TABLE VII

ESTIMATED TOTAL ANNUAL SLAUGHTERING COSTS IN TENNESSEE FOR VARIOUS SYNTHETIC PLANTS OPERATING AT PEAK CAPACITY FOR 2032 HOURS PER YEAR

Plant	Total Annual Cost
Bed-type Plants:	
17 head/hr.	$ 273,780
35 head/hr.	443,010
50 head/hr.	630,240
Intermittent On-the-Rail Plants:	
20 head/hr.	371,030
40 head/hr.	608,760
Continuous On-the-Rail Plants:	
60 head/hr.	824,630
75 head/hr.	946,840
120 head/hr.	1,412,620

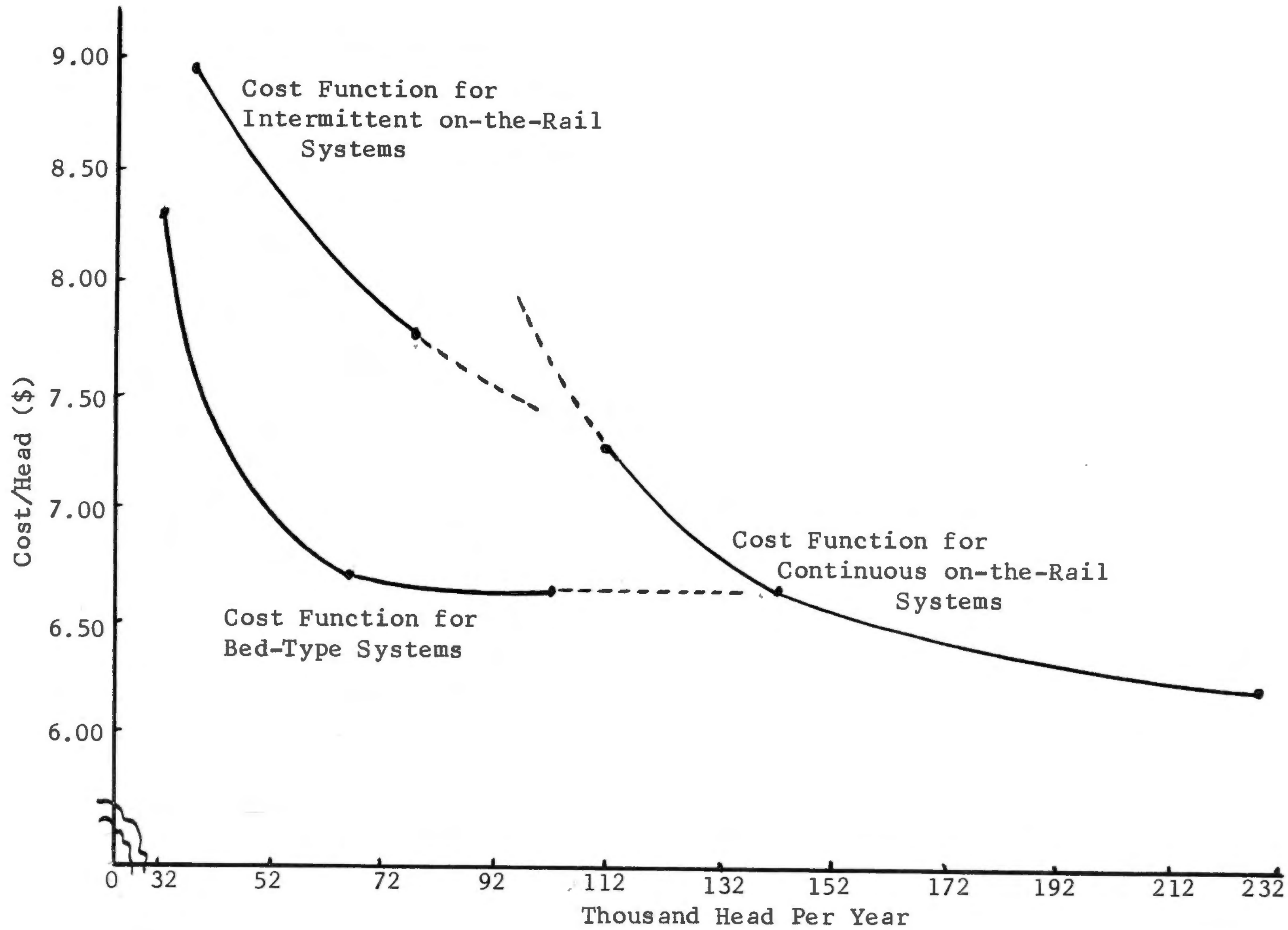

Figure 18. Estimated long-run average slaughtering cost functions per head for Tennessee.

for slaughtering rates of less than 93,000 head per year. In addition, above that rate of output there is considerably less unit cost differential, as compared with continuous on-the-rail systems, than was estimated by Logan and King, using California wage rates.[32]

To obtain a long-run average cost curve expressed in terms of beef output, total annual slaughtering costs for bed-type and continuous on-the-rail plants were divided by liveweight slaughtered per year multiplied by the appropriate yield coefficient developed in Chapter III.[33] Since the cost curves in Figure 19 indicated intermittent on-the-rail plants were less economical than bed-type plants, the former were excluded from long-run average cost functions. The estimated long-run average cost curve in terms of beef output, based on estimated 1963 Tennessee wage rates, is shown in Figure 19.

To adjust the Tennessee average cost curve for other areas, the following procedure was used. First, total wage and salary costs for plants operating at 120 head per hour in Tennessee were adjusted by the percent that estimated meatpacking wages in each area were of Tennessee wage rates. The resulting wage and salary costs for each area were next added to total non-labor and non-salary costs. This provided estimated total annual slaughtering costs for each area, for

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[32]Logan and King, op. cit., p. 103.

[33]The lower yield rate for the South creates a slaughtering cost disadvantage for areas 1 through 27, relative to areas 28 through 33. It should be pointed out that the cost disadvantage may be overestimated here, since inedible by-products may have a value that is greater than handling costs.

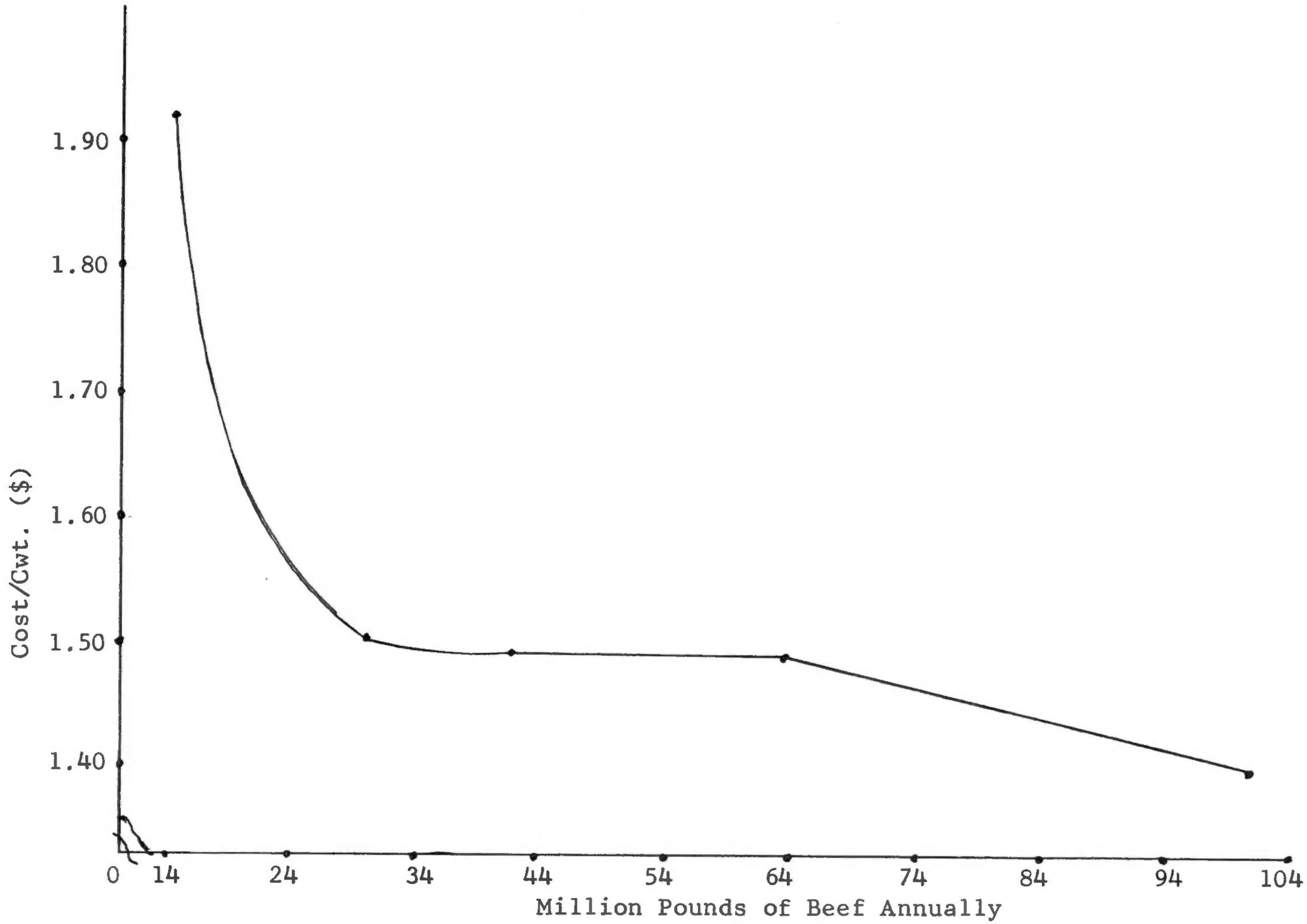

Figure 19. Estimated long-run average cost curve for cattle slaughtering plants in Tennessee.

plants operating at 120 head per hour. Total costs were then converted to unit costs by dividing by annual output of beef. Finally, slaughtering costs per hundredweight of beef, by areas, were expressed as a percent of Tennessee slaughtering costs per hundredweight of beef, for plants operating at 120 head per hour. These percentages were used to vertically adjust the long-run average cost curve for areas outside Tennessee.

The procedure described above was used to estimate area slaughtering costs, assuming no seasonal variation in slaughtering rates. The same procedure was used in estimating slaughtering costs with seasonal variations in output, with the following exception. When total annual costs were converted to unit costs, the pounds liveweight slaughtered annually was computed by:[34]

$$N = \sum_{i=1}^{4} A_i d_i$$

where

N = pounds liveweight slaughtered annually

A_i= average pounds liveweight slaughtered per day, for quarter i

d_i= number of days operated during quarter i .

In computing the pounds liveweight slaughtered per day for each quarter, the marketing patterns presented in Chapter IV were used. Output rates per season were reduced from the peak plant capacity of 120

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[34]Based on Logan and King, op. cit., pp. 108-110.

head per hour, in accordance with the percent marketings in the i^{th} quarter were of marketings in the peak quarter.

In effect, the seasonal adjustment was made by assuming all slaughtering costs were fixed. Average slaughtering cost was then estimated by reducing the annual slaughtering volume while holding plant capacity constant at the level required to slaughter peak quarter supplies. This procedure represents the upper limit of the effects of seasonal supply variations on average slaughtering costs. Since its validity depends on the ability of slaughtering firms to adjust the quantity of labor employed in response to seasonal variations in output, it was assumed here that labor unions, as well as supply and demand conditions for skilled labor, would prevent such adjustments.

Area slaughtering costs per hundredweight of beef, for plants with a capacity of 120 head per hour, with and without seasonal output variations, are shown in Table XXV, in Appendix H. In addition, Table XXV contains estimated percentages that slaughtering costs in other areas are of Tennessee costs, with and without seasonal slaughtering variations.

Approximate unit cost estimates for plants with capacities of less than 120 head per hour were obtained from the estimated long-run average cost curve presented in Figure 19, page 108. For areas outside of Tennessee, the long-run average cost curve for Tennessee was adjusted using the percentages presented in Table XXV in Appendix H.[35]

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[35]A similar procedure was used by <u>ibid</u>., p. 169.

CHAPTER VI

OPTIMUM SLAUGHTERING LOCATIONS AND SPATIAL FLOW PATTERNS FROM ANNUAL MODELS FOR 1975

Using the supply, demand, transportation cost, and slaughtering cost data developed in Chapters III, IV, and V, three annual models of interregional competition in cattle slaughtering were solved. These models contained a jointly determined spatial analysis of slaughter cattle and dressed beef flows, in which combined total transportation costs for live cattle and dressed beef shipments, and total cattle slaughtering costs were minimized. Thus, the models determined optimum interregional shipments for slaughter cattle and dressed beef, and optimum locations and volumes of cattle slaughtering, given area production and consumption estimates, and estimated costs of transportation and slaughtering activities.

In the first annual model, slaughtering costs were estimated assuming no seasonal variations exist in slaughter cattle supplies. Model II utilized slaughtering costs that reflected seasonal variations in cattle supplies. Both Model I and II used slaughtering cost estimates that were based on average liveweights per head and beef yield coefficients that were lower for the South than for non-South areas. In Model III, slaughtering costs were estimated under the assumption that regional yield and weight differences in cattle supplies would be eliminated by 1975.

I. RESULTS FROM MODEL I

Optimum Solution With All Slaughtering Costs at Minimum Level

Initially, all regional slaughtering costs were set at the lowest point on the long-run average cost curve for cattle slaughtering and were adjusted for interarea variations in labor costs as described in Chapter V. The optimum geographic flow patterns and slaughtering volumes that resulted from these costs are presented in Tables VIII and IX. In the optimum solution, there were three surplus cattle producing areas in the South. These consisted of area 8 (Southwest Georgia), area 21 (Western Oklahoma), and area 26 (Central Kentucky). In addition, there were four surplus slaughtering areas: area 15 (Northern Alabama), area 20 (Western Arkansas-Eastern Oklahoma), area 25 (Western Kentucky), and area 26 (Central Kentucky).

Nine of the twenty-seven areas in the South did not receive in-shipments of beef from the Western North Central Region. These areas were 3 (Eastern North Carolina and Virginia), 5 (Western North Carolina), 8 (Southwest Georgia), 15 (Northern Alabama), 19 (Southwestern Louisiana), 20 (Western Arkansas-Eastern Oklahoma), 21 (Western Oklahoma), 25 (Western Kentucky), and 26 (Central Kentucky). Areas 3, 5, and 8 were supplied by cattle or dressed beef from surplus areas in the South.

The results suggest that, given the estimated transportation rate structure, it is generally more economical to slaughter cattle at the location of production, and to ship dressed beef to deficit consuming areas, than to ship live cattle into consuming areas for slaughter.

TABLE VIII

ESTIMATED OPTIMUM CATTLE AND DRESSED BEEF SHIPMENTS IN THE INITIAL SOLUTION TO MODEL I

Beef Shipments				Cattle Shipments	
Areas From-To	Hundredweight	Areas From-To	Hundredweight	Areas From-To	Hundredweight
15-11	421,360	30-13	120,140	8-10	229,580
20-17	669,020	30-14	491,920	21-31	2,391,680
20-19	179,960	30-16	364,160	26-5	302,090
25-3	308,460	30-17	573,320		
25-24	86,260	30-18	184,330		
26-3	642,920	30-22	256,400		
30-1	49,680	30-23	262,660		
30-2	1,424,020	30-24	337,970		
30-4	1,256,700	30-27	713,420		
30-6	1,549,760	30-28	33,775,640		
30-7	1,445,260	30-29	5,026,870		
30-9	67,190	30-31	1,951,010		
30-10	592,080	30-33	7,115,100		
30-11	1,172,510	32-33	7,129,060		
30-12	1,665,820				

TABLE IX

ESTIMATED OPTIMUM AREA SLAUGHTERING VOLUMES IN THE INITIAL SOLUTION MODEL I

Area	Hundredweight Slaughtered
1--Western Virginia	629,230
2--Central Virginia	496,790
3--Eastern Virginia-North Carolina	223,260
4--Central North Carolina	293,010
5--Western North Carolina	408,750
6--South Carolina	279,160
7--Northern Georgia	458,090
8--Southwestern Georgia	331,170
9--Southeastern Georgia	338,050
10--Northern Florida	540,370
11--Central Florida	309,420
12--Southern Florida	126,830
13--Southern Alabama	364,740
14--Central Alabama	630,620
15--Northern Alabama	804,530
16--Northern Mississippi-Eastern Arkansas	489,690
17--Southern Mississippi-Eastern Louisiana	656,900
18--Northern Louisiana	286,290

TABLE IX (continued)

Area	Hundredweight Slaughter
19--Southwestern Louisiana	296,370
20--Eastern Oklahoma-Western Arkansas	2,097,000
21--Western Oklahoma	899,510
22--West Tennessee	432,250
23--Middle Tennessee	432,720
24--East Tennessee	383,810
25--Western Kentucky	688,770
26--Central Kentucky	1,710,510
27--Eastern Kentucky-West Virginia	675,830
28--Northeast	6,617,900
29--Eastern North Central Region	28,343,340
30--Western North Central Region	73,422,460
31--Southwest	12,640,310
32--Mountain Region	12,838,690
33--Western Region	13,948,700

However, in some cases variations in slaughtering costs resulting from economies of scale and/or lower wage rates appeared to encourage interarea cattle movements. Wage rate differentials apparently explain the movements of cattle from area 8 to area 10, from area 26 to 5, and from area 21 to area 31.

Optimum Solution With Revised Slaughtering Costs

Using the initial optimum solution to Model I and slaughtering cost data from Chapter V, area slaughtering costs were revised in order to be consistent with estimated area slaughtering volumes. Changes in slaughtering volumes, and interregional cattle and beef shipments that resulted from the new slaughtering cost figures are presented in Table X. A new pattern of slaughter cattle shipments resulted from the elimination of slaughtering in areas 3 (Eastern North Carolina and Virginia) and 12 (Southern Florida). Area 3 shipped its cattle into area 4 (Central North Carolina) for slaughtering, and cattle from area 12 were shipped into area 11 (Central Florida).

An increase in dressed beef movements into areas 5 and 12 from area 30, and decreases in beef movements from area 30 into areas 4 and 11 accompanied these shifts in slaughtering location. In addition, area 25 (Western Kentucky) decreased its beef shipments into area 3 and increased beef shipments to area 24 (East Tennessee). Also, in the revised solution the demand for beef in area 3 was met by beef inshipments from area 26. Finally, cattle shipments between area 26 and area 5 were eliminated, thus increasing the slaughtering volume in area 26 and decreasing it in area 5.

TABLE X

CHANGES IN OPTIMUM INTERREGIONAL CATTLE AND DRESSED BEEF SHIPMENTS, AND SLAUGHTERING VOLUMES RESULTING FROM SLAUGHTER COST REVISIONS IN MODEL I

Hundredweight Beef Shipments			Hundredweight Cattle Shipments			Hundredweight Slaughtering Volume		
Areas From-To	Initial Volume	New Volume	Areas From-To	Initial Volume	New Volume	Area	Old Volume	New Volume
25-3	308,460	229,630	3-4	0	223,260	3	223,260	0
25-24	86,260	165,080	5-6	0	106,660	4	293,010	516,270
26-3	642,920	945,010	12-11	0	126,830	5	408,750	0
30-4	1,256,700	1,033,430	26-5	302,085	0	6	279,160	385,830
30-5	0	408,750				11	309,420	436,250
30-6	1,549,760	1,433,090				12	126,830	0
30-11	1,172,510	1,045,680				26	1,710,520	2,012,600
30-12	1,665,820	1,792,650						
30-24	337,970	259,150						

A comparison of slaughtering volumes in the revised solution with cost-volume relationships from the average slaughtering cost curve presented in Chapter V indicated that an additional cost revision was needed for the slaughtering activity in area 5. While the linear programming problem was not re-solved with a third slaughtering cost revision, an examination of slaughtering and transportation costs indicated that area 5 would go out of slaughtering and would ship its cattle to area 6. This would be accompanied by decreased dressed beef inshipments to area 6 from area 30, and increased dressed beef shipments into area 5 from area 30.

Estimated optimum interarea shipments of cattle and dressed beef, and slaughtering volumes and locations are shown in Figures 20, 21, and 22 respectively. In the optimal solution, six areas in the South received particularly large inshipments of dressed beef from the Western North Central Region. These areas were 2 (Central Virginia), 4 (Central North Carolina), 6 (South Carolina), 7 (Northern Georgia), 11 (Central Florida), and 12 (Southern Florida). This result implies that if slaughter cattle production in the South should increase at a rate greater than past trends, these six areas would be important potential markets for Southern beef.

The possibility of increased slaughter cattle production in the South calls for an examination of the estimated relative positions of

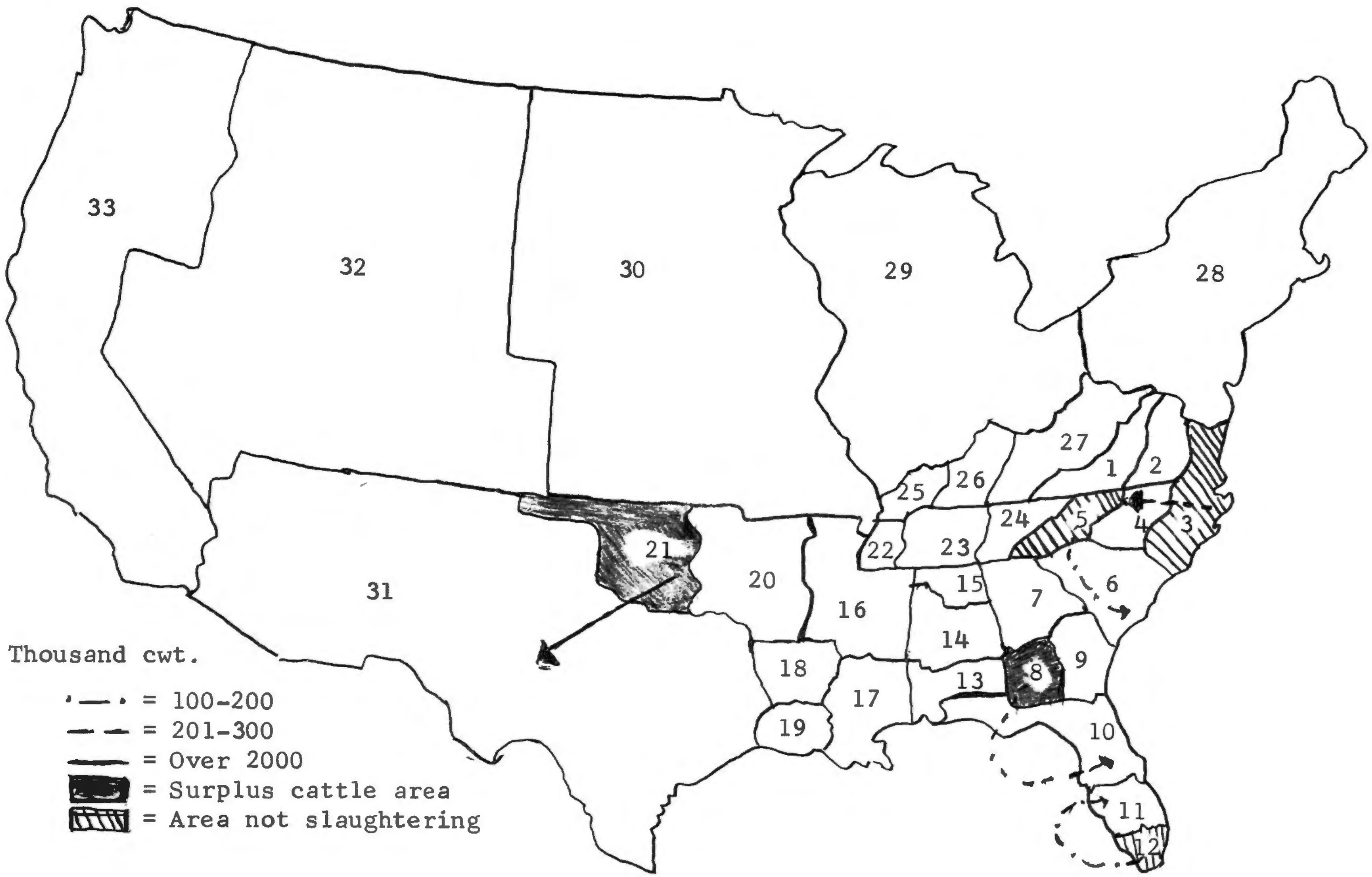

Figure 20. Estimated optimum interregional shipments of slaughter cattle in 1975, assuming no seasonal variation in cattle supplies.

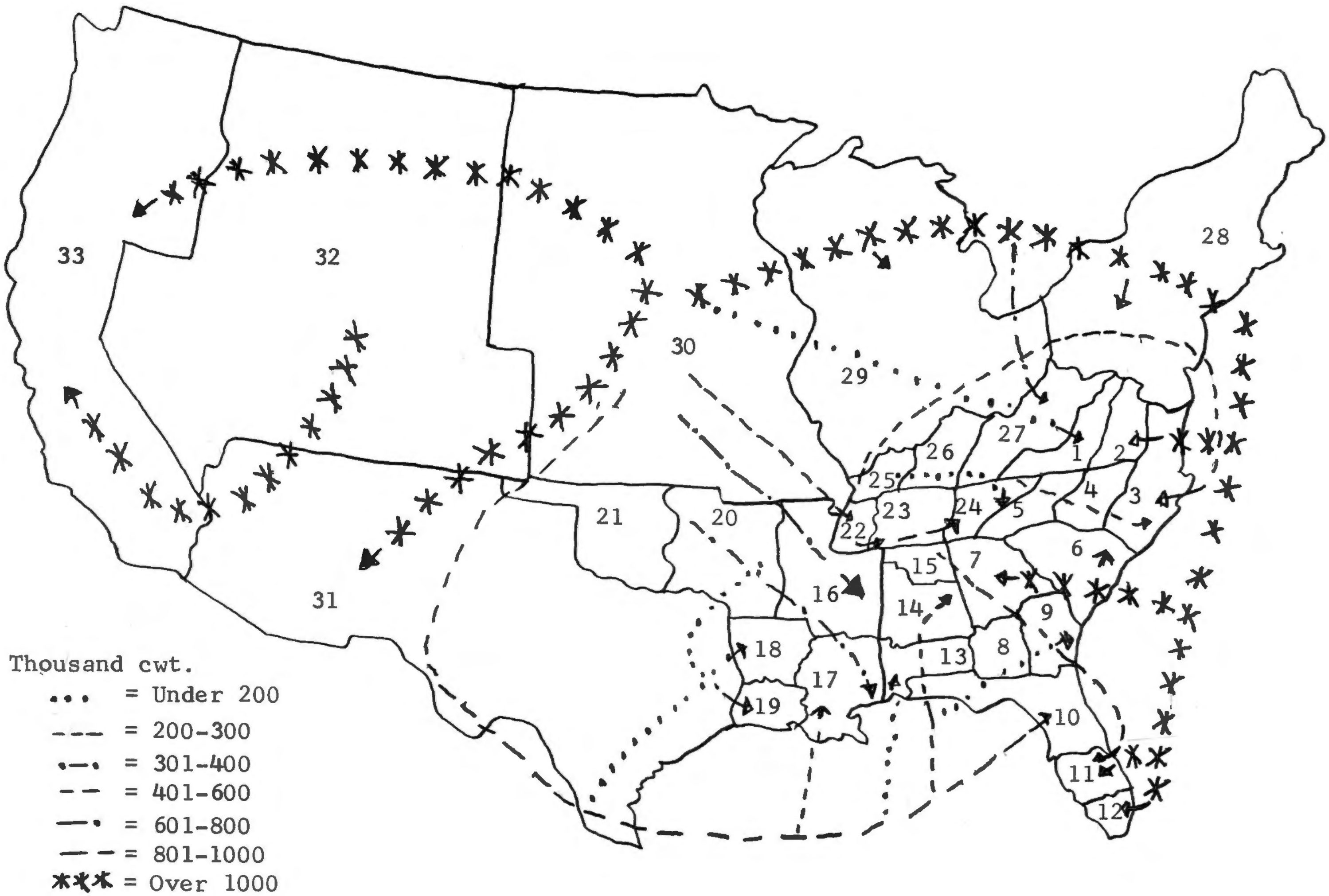

Figure 21. Estimated optimum interregional shipments of dressed beef in 1975, assuming no seasonal variation in cattle supplies.

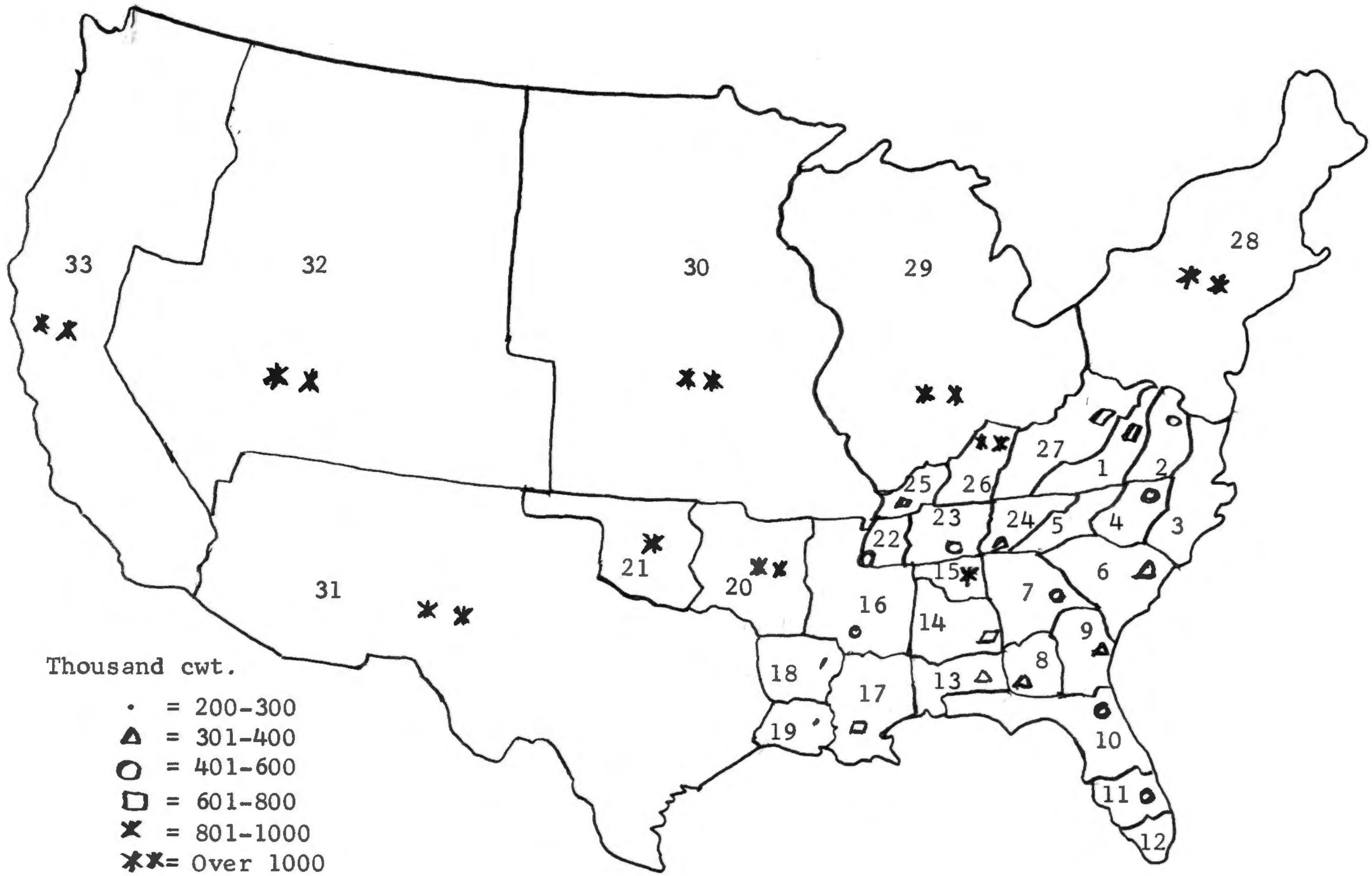

Figure 22. Estimated optimum locations and volumes of cattle slaughtering in 1975, assuming no seasonal variation in cattle supplies.

various areas in expanded cattle production, from a demand standpoint.[1] Approximate measures of this are represented by the area price differentials for slaughter cattle (relative to the Eastern North Central Region) obtained from the dual formulation of the linear programming problem.[2] These values are shown in Table XXVI in Appendix I; areas with relatively favorable positions are those with large positive price differentials. The nine areas in the South that were estimated to have the most favorable positions are the shaded areas shown in Figure 23; they include areas 15, 16, 20, 21, 22, 23, 24, 25, and 26. Within the limitations of the model and data used, the price differentials suggest these areas would be in a more favorable position, from a demand standpoint, relative to other areas in the South, to expand slaughter cattle production.

II. RESULTS FROM MODEL II

Slaughtering Costs Used

Model II differed from Model I in that slaughtering costs were adjusted as described in Chapter V to reflect seasonal variations in slaughter cattle marketings. Slaughtering costs were adjusted for

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[1]The relative positions estimated here are from a demand standpoint only, since they indicate the relative accessibility of a given production area (in terms of transportation cost) to deficit consumption areas. They do not reflect relative cattle production costs, and accordingly are not estimates of comparative advantages in cattle production.

[2]See Chapter II above, pp. 43-44.

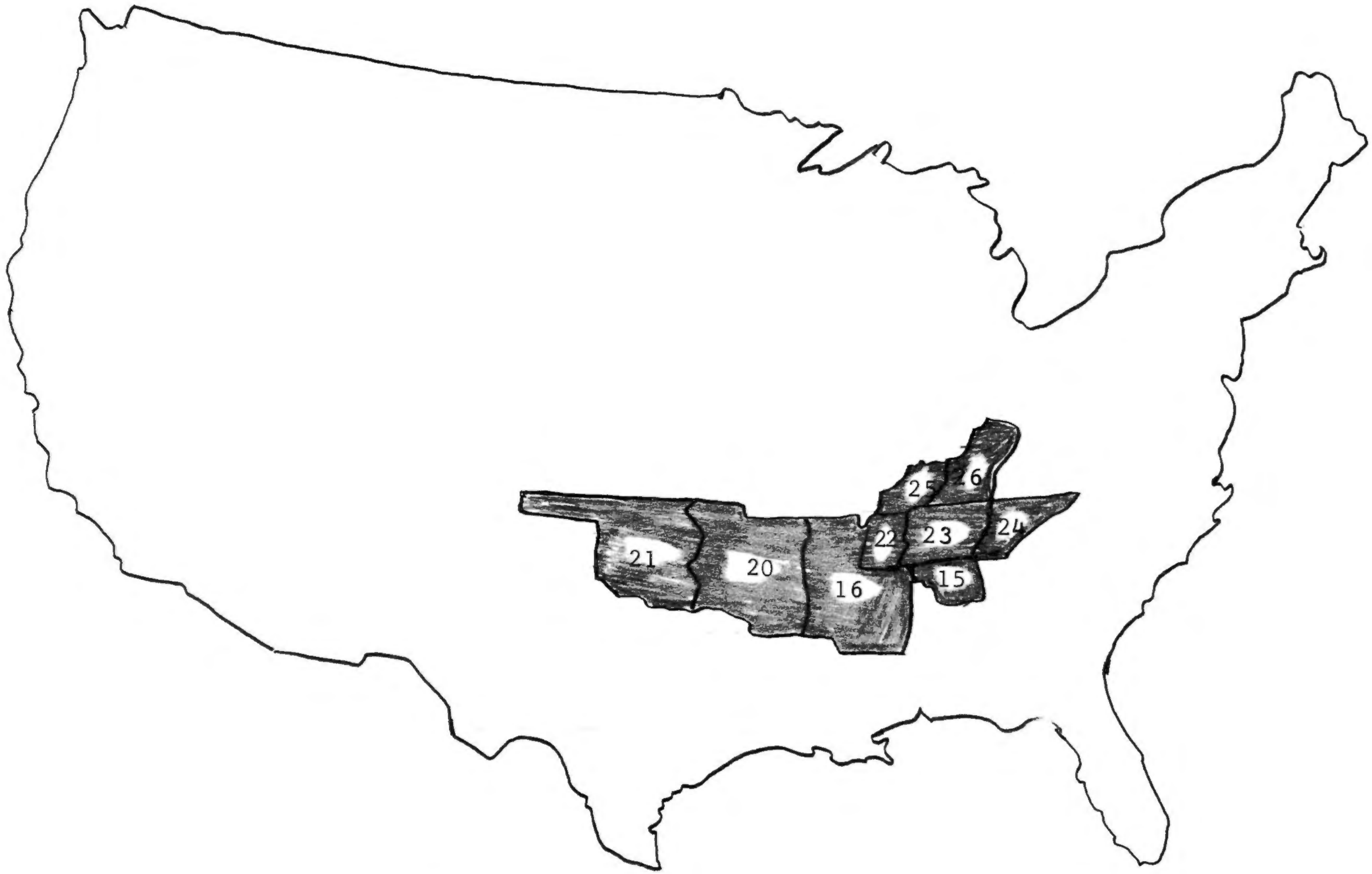

Figure 23. Areas in the South with the most favorable relative positions in slaughter cattle production from a demand standpoint, as estimated in Model I.

areas 1 through 27 by using the estimated average quarterly pattern of marketings for the South as a whole; the average quarterly marketing pattern for non-South areas was used to adjust costs for areas 28 through 33. As in Model I, costs also were adjusted to reflect volumes slaughtered.

Since seasonal fluctuations in slaughter cattle supplies in the South were estimated to be considerably larger than in non-South areas, Model II was used to estimate the effects of seasonality on optimum slaughtering locations and interregional shipment patterns. Inasmuch as Model I, with no seasonal variations in supplies, indicated that the optimum cattle shipment pattern would not include shipments into the South, the main effect of the seasonal adjustment, if it were economically significant, would be to encourage increased slaughter cattle shipments from the South into other areas for slaughter. This would be accompanied by increased dressed beef shipments into the South from other areas.

Optimum Cattle and Beef Shipments, and Slaughtering Locations

After three iterations were made in slaughtering costs to reflect the volume slaughtered in each area, the optimum solution in Model II differed from that in Model I by the changes indicated in Table XI. The main change from Model I was that 394,720 hundredweight of cattle (carcass weight equivalent) were shipped from area 25 (Western Kentucky) into area 29 (Eastern North Central Region). This led to a reduction in dressed beef shipments from area 30 to area 29,

TABLE XI

CHANGES IN OPTIMUM CATTLE AND DRESSED BEEF SHIPMENTS, AND SLAUGHTERING VOLUMES, MODEL II AS COMPARED WITH MODEL I

Hundredweight Beef Shipments			Hundredweight Cattle Shipments			Hundredeight Slaughtering Volume		
Areas From-To	Model I	Model II	Areas From-To	Model I	Model II	Area	Model I	Model II
25-3	229,630	0	25-29	0	394,720	25	688,770	294,050
25-24	165,080	0				29	28,343,340	28,738,060
30-3	0	229,630						
30-24	259,150	424,230						
30-29	5,026,870	4,632,150						

combined with offsetting increases in beef shipments to areas 3 and 24, which area 25 formerly supplied.

In addition to the changes in shipment patterns and slaughtering volumes produced by Model II, a new set of relative area positions in cattle production, from a demand standpoint, was generated. These are shown in Table XXVII in Appendix I, while the sizes of the relative positions were affected, the nine areas in the South with the most favorable relative positions in cattle production remained unchanged.

III. RESULTS FROM MODEL III

Slaughtering Costs Used

Model III differed from Models I and II in that slaughtering costs were computed under the assumptions that regional differences in the grade and weight composition of cattle supplies would be eliminated by 1975, and that no seasonal variations in cattle supplies existed. Results from Model III were expected to differ from those of the previous two models in that no slaughter cattle would be shipped out of the Southern Region. In addition, there was a possibility that some areas in the South would import cattle from non-South areas for slaughter.

Optimum Cattle and Beef Shipments, and Slaughtering Locations

After adjusting slaughtering costs to reflect the volume slaughtered in each area, the optimum solution in Model III differed from that in Model I in that area 21 (Western Oklahoma) shipped dressed beef rather than live cattle into area 31. This increased the volume of cattle slaughtering in area 21 to 3,291,190 hundredweight.

The new set of regional slaughter cattle price differentials consistent with the optimum solution from Model III is shown in Table XXVII in Appendix I. Model III indicated that positions of the areas in the South, from a demand standpoint, relative to the Eastern North Central Region, would be reduced as compared with relative positions estimated from Models I and II. In addition, the relative position of East Tennessee (area 24) in slaughter cattle production fell below that of Western North Carolina (area 5).

Total transportation and slaughtering costs for Model III were $301,114,900 compared with $311,015,400 for Model II and $308,694,300 for Model I. Assuming the data used were relatively accurate, a reduction in regional weight and yield differences for slaughter cattle could thus reduce total slaughtering and transportation costs by up to $7.5 million annually, while the potential cost saving from reductions in seasonal slaughter cattle supply variations could be up to $2.3 million annually.

IV. GENERAL CONCLUSIONS SUGGESTED BY THE ANNUAL MODELS

The competitive positions of various areas in cattle slaughtering, it should be noted, were reflected by the optimum volumes slaughtered, since the analytical model did not contain slaughter capacity restrictions.[3] The optimum volume slaughtered in a given area reflected its accessibility to deficit consumption and surplus cattle production areas, as well as relative slaughtering costs in the area. Accordingly, optimum slaughtering volumes were used here as approximate indicators of the comparative advantages of various areas in cattle slaughtering. Optimum cattle slaughtering volumes for areas in the South in 1975 were estimated under the following assumptions:

1. Changes in area slaughter cattle production will follow past trends until 1975.

2. The cyclical pattern of slaughter cattle production and marketings will remain unchanged through 1975.

3. The relative interarea pattern of wage rates in cattle slaughtering will remain constant at estimated 1963 levels.

4. Transportation cost reductions from the Interstate System will be passed on to shippers.

5. Specialized cattle slaughtering plants are economically justified.

6. The locations of livestock auctions, as well as specialized processing and rendering facilities, do not affect the locations of slaughtering plants among areas.

7. Entrepreneurial objectives other than cost minimization are non-existent.

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[3] If the analytical model had included slaughter capacity constraints, the dual formulation would have generated estimated slaughtering rents for areas whose capacity was fully utilized.

8. Quantities of slaughter cattle marketed and dressed beef consumed in 1975 are given and fixed for each area.

Given these assumptions, the optimum solutions generated by Models I, II, and III suggested four areas in the South that may maintain relatively large comparative advantages in cattle slaughtering under estimated 1975 supply, demand, and cost conditions. These areas are Central Kentucky (26), Northern Alabama (15), Western Arkansas-Eastern Oklahoma (20), and Western Oklahoma (21). The advantages of these areas in slaughtering appear to stem largely from large cattle supplies. A second group of areas in the South that maintained substantial comparative advantages in cattle slaughtering includes Western Virginia (1), Central North Carolina (4), Central Alabama (14), Southern Mississippi-Eastern Louisiana (17), Western Kentucky (25), and Eastern Kentucky-West Virginia (27). Comparative advantages of the Western North Central Region, the South's main competitor, appear to come from large surplus cattle supplies coupled with higher weight and grade compositions than those in the South.

The results suggest that, provided changes in area slaughter cattle marketings follow past trends, the main area in the South to obtain increased comparative advantages in cattle slaughtering from elimination of the regional yield and weight differentials in cattle supplies would be Western Oklahoma (area 21). Western Kentucky (area 25) appeared to be the only area in the South that would obtain an increased comparative advantage in slaughtering from elimination of seasonal variations in slaughter cattle marketings. These results were due to the absence of slaughter cattle shipments into the Southern Region in the optimal solutions. In the absence of cattle inshipments, the main effect from these sources of potential Southern slaughtering cost decreases was to reduce cattle exports from the Southern Region.

The optimal solutions also indicated that the nine areas in the South with the most favorable positions in slaughter cattle production, from a demand standpoint, in Models I and II, were Northern Alabama (15), Northern Mississippi-Eastern Arkansas (16), Eastern Oklahoma-Western Arkansas (20), Western Oklahoma (21), West, Middle, and East Tennessee (22, 23 and 24), and Western and Central Kentucky (25 and 26). In Model III, Western North Carolina (area 5) had a more favorable position in slaughter cattle production than East Tennessee. Within the limitations of the data and the analytical model, these areas appear to be in a more favorable position, from a demand standpoint, to expand slaughter cattle production than other areas in the South. In addition, the annual models suggested that Central Virginia and North Carolina, Northern Georgia, South Carolina, and Central and Southern Florida represent important markets for possible future increases in the Southern slaughter cattle production.

Optimal solutions from the annual models also suggested some tentative conclusions concerning possible changes in the geographic concentration of cattle slaughtering in the South, and in the future position of the cattle slaughtering industry in Tennessee, given the limitations of the data and the analytical model. Some of the more important of these limitations include (1) omission of meat processing and other possible services that might be performed by slaughtering plants, (2) exclusion of possible competitive advantages from diversification and product differentiation, and (3) omission of possible entrepreneurial motives other than minimization of total slaughtering and distribution costs.[4] Given these limitations, the results suggest a possible tendency toward increased geographical concentration in the cattle slaughtering industry in the South. Also, they suggest that forces underlying changing patterns of interregional competition could call for decreases in cattle slaughtering volumes in Tennessee, given the assumptions of the study. Estimated optimal slaughtering volumes in Tennessee for 1975, as compared with 1962 slaughtering volumes were as follows:

Area	Hundredweight Slaughtered, Beef Equivalent[5] 1962	Estimated 1975
East Tennessee	787,420	383,810
Middle Tennessee	653,760	432,720
West Tennessee	498,530	432,250

[4]See W. F. Williams and R. A. Dietrich, "An Interregional Analysis of the Fed Beef Economy," Agricultural Economic Report No. 88, U. S. Department of Agriculture, Economic Research Service (Washington: Government Printing Office, April 1966), pp. 18, 45. Williams and Dietrich suggest that considerations such as these are important influences on interregional competition patterns.

[5]The 1962 slaughtering figures, on a liveweight basis, were obtained from J. C. Purcell, Trend in Production, Marketings, Slaughter, and Consumption of Livestock and Meats in the South, forthcoming Southern Cooperative Series Bulletin. They were converted to equivalent hundredweight of beef by using the yield coefficient for the South, developed in Chapter III above.

Particularly important assumptions influencing both geographic concentration and Tennessee's future slaughtering position include the assumptions that past trends in area cattle production will continue, and that the interarea pattern of relative wage rates for cattle slaughtering will remain constant at estimated 1963 levels. Given these assumptions, the results suggest that all three areas of Tennessee may face increased competition from dressed beef slaughtered in the Western North Central Region. In addition, East Tennessee may face competition from Western Kentucky dressed beef.

CHAPTER VII

ESTIMATED OPTIMUM QUARTERLY SLAUGHTERING VOLUMES AND SPATIAL FLOW PATTERNS FOR 1975

In order to examine changes in the optimum interregional shipment patterns for slaughter cattle and dressed beef resulting from within-year variations in area cattle supplies and beef demands, a series of quarterly models was solved. One objective of the quarterly models was to determine whether, in the optimum solution, any areas in the South might "import" slaughter cattle from other areas during periods of reduced cattle supplies. This would enable slaughtering firms to utilize more fully plant capacities and labor forces during slack seasons for local cattle supplies, thus placing them in a more advantageous interregional competitive position relative to other areas. A related objective was to determine the extent to which, in the optimum solution, the pattern of market areas served by surplus slaughtering areas varied among seasons. In addition, an estimate was desired of the extent to which the relative positions of various areas in the South in slaughter cattle production varied seasonally, from a demand standpoint. This information should supplement and qualify the estimated relative positions obtained from the annual models.

Using quarterly marketing and consumption data in addition to transportation cost estimates developed in previous chapters, the linear programming model specified in Chapter II was used to obtain an optimum jointly determined spatial analysis for slaughter cattle and dressed beef flows, and slaughtering volumes for each quarter in the year. Slaughtering costs employed in the quarterly models were those used in the final solution to Model II in Chapter VI. These costs reflected seasonal variations in cattle marketings, as well as regional differences in the average weight and beef yield of slaughter cattle supplies. Model IV estimated the optimum spatial patterns for the first quarter (January-March); Model V represented the second quarter (April-June). The third (July-September) and fourth (October-December) quarters were represented by Models VI and VII, respectively.

I. RESULTS FROM MODEL IV: FIRST QUARTER

Estimated optimum geographical flow patterns and area slaughtering volumes for the first quarter of 1975 are presented in Tables XII and XIII. As the data indicate, eight areas in the South were surplus slaughter cattle producing areas. These were 3 (Eastern Virginia and North Carolina), 5 (Western North Carolina), 8 (Southwestern Georgia), 9 (Southeastern Georgia), 12 (Southern Florida), 21 (Western Oklahoma), 23 (Middle Tennessee), and 25 (Western Kentucky). Three of these areas (3, 5, and 12) exported all of their cattle supplies to other areas for slaughtering, since the optimum solutions from the annual models indicated that slaughtering would not be done in the areas. Estimated interarea shipment patterns for slaughter cattle during the first quarter are shown by the map in Figure 24.

TABLE XII

ESTIMATED OPTIMUM INTERAREA SHIPMENTS OF SLAUGHTER CATTLE AND DRESSED BEEF FOR THE FIRST QUARTER, 1975

Beef Shipments				Cattle Shipments	
Areas From-To	Hundred-weight	Areas From-To	Hundred-weight	Areas From-To	Hundred-weight
20-17	30,760	30-14	132,680	3-4	51,580
20-19	54,870	30-16	112,080	5-6	22,620
26-3	66,170	30-17	316,070	8-10	92,850
30-1	36,850	30-18	78,010	9-6	16,980
30-2	354,620	30-22	97,030	12-11	15,310
30-3	216,920	30-23	71,100	21-31	394,060
30-4	256,700	30-24	124,870	23-15	14,370
30-5	98,510	30-27	233,610	25-15	43,360
30-6	326,170	30-28	8,208,400		
30-7	379,310	30-29	865,810		
30-10	91,230	30-31	875,960		
30-11	368,760	30-33	1,839,360		
30-12	432,030	32-33	1,609,340		
30-13	58,880				

TABLE XIII

ESTIMATED OPTIMUM AREA SLAUGHTERING VOLUMES FOR THE FIRST QUARTER, 1975

Area	Hundredweight Slaughtered
1--Western Virginia	126,770
2--Central Virginia	108,300
3--Eastern Virginia-North Carolina	0
4--Central North Carolina	116,780
5--Western North Carolina	0
6--South Carolina	114,600
7--North Carolina	79,400
8--Southwestern Georgia	79,810
9--Southeastern Georgia	97,660
10--Northern Florida	181,690
11--Central Florida	89,930
12--Southern Florida	0
13--Southern Alabama	57,980
14--Central Alabama	137,850
15--Northern Alabama	92,340
16--Northern Mississippi-Eastern Arkansas	93,700
17--Southern Mississippi-Eastern Louisiana	110,890
18--Northern Louisiana	35,410

TABLE XIII (continued)

Area	Hundredweight Slaughtered
19--Southwestern Louisiana	59,930
20--Eastern Oklahoma-Western Arkansas	386,260
21--Western Oklahoma	216,780
22--West Tennessee	68,940
23--Middle Tennessee	96,490
24--West Tennessee	69,870
25--Western Kentucky	70,870
26--Central Kentucky	323,460
27--Eastern Kentucky-West Virginia	101,200
28--Northeast Region	1,728,410
29--Eastern North Central Region	7,343,260
30--Western North Central Region	18,779,460
31--Southwest Region	2,713,510
32--Mountain Region	3,013,910
33--Western Region	3,486,740

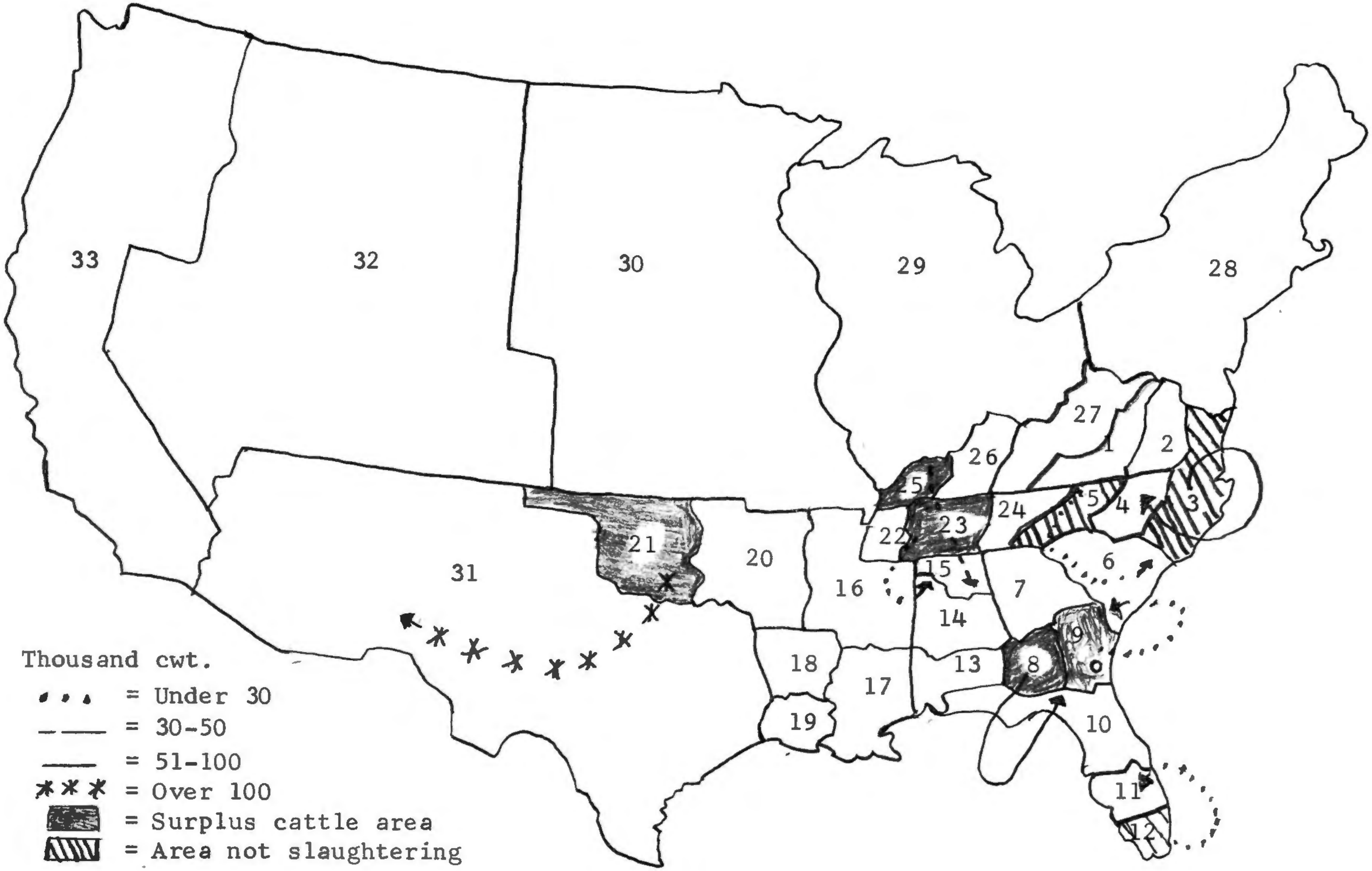

Figure 24. Estimated optimum interregional shipments of slaughter cattle for the first quarter, 1975.

The optimum solution for Model IV indicated that two areas in the South, areas 20 (Eastern Oklahoma-Western Arkansas) and 26 (Central Kentucky), produced surplus supplies of dressed beef. In total, eight areas in the South did not receive beef inshipments from the Western North Central Region. These were areas 8 (Southwest Georgia), 9 (Southeastern Georgia), 15 (Northern Alabama), 19 (Southwestern Louisiana), 20 (Eastern Oklahoma-Western Arkansas), 21 (Western Oklahoma), 25 (Western Kentucky), and 26 (Central Kentucky). All areas in this group except area 15, which imported slaughter cattle from areas 23 and 25, were either surplus cattle producing or surplus slaughtering areas, or received dressed beef inshipments from other areas in the South. Estimated optimum first quarter beef shipments are shown in Figure 25.

Estimated relative positions of areas in the South in slaughter cattle production during the first quarter, as indicated by area price differentials relative to the Eastern North Central Region, are shown in Table XXVIII in Appendix I. The nine areas in the South with the most favorable positions, from a demand standpoint, were areas 5, 16, 20, 21, 22, 23, 24, 25, and 26. This set of areas was the same as that estimated from the annual models I and II.

II. RESULTS FROM MODEL V: SECOND QUARTER

Estimated optimum geographical flow patterns and area slaughtering volumes for the second quarter are presented in Tables XIV and XV, respectively. As the data indicate, there were seven surplus slaughter

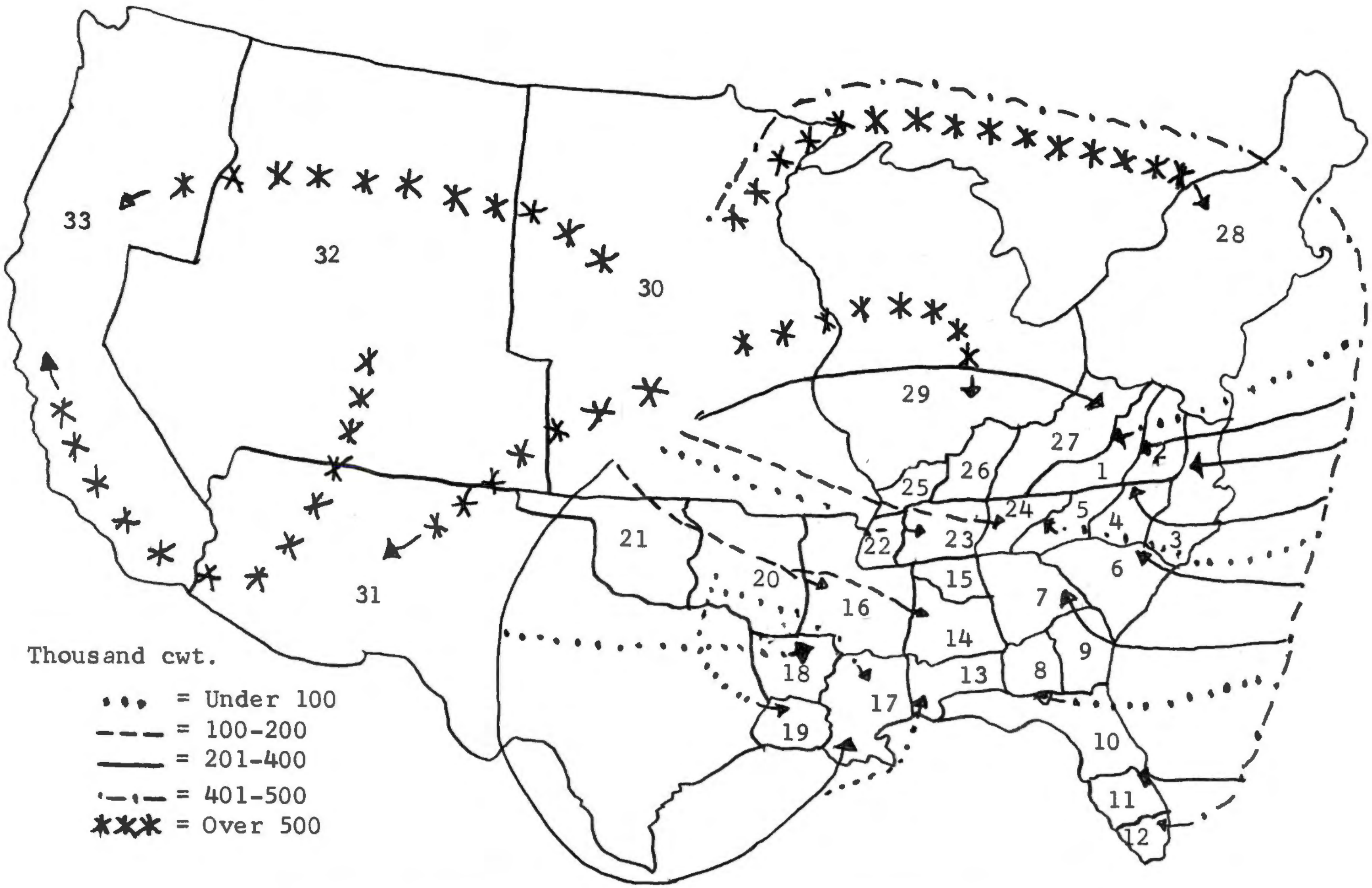

Figure 25. Estimated optimum interregional shipments of dressed beef for the first quarter, 1975.

TABLE XIV

ESTIMATED OPTIMUM INTERAREA SHIPMENTS OF SLAUGHTER CATTLE AND DRESSED BEEF FOR THE SECOND QUARTER, 1975

Beef Shipments				Cattle Shipments	
Areas From-To	Hundred-weight	Areas From-To	Hundred-weight	Areas From-To	Hundred-weight
13-10	15,370	30-12	432,030	3-4	69,060
20-17	108,340	30-14	101,620	5-6	18,330
20-19	36,070	30-16	105,190	8-10	55,970
26-3	80,310	30-17	204,330	12-11	13,120
30-1	60,360	30-18	53,220	21-31	514,850
30-2	368,470	30-22	83,990	23-15	32,600
30-3	202,780	30-23	130,320	25-15	21,870
30-4	248,390	30-24	92,730		
30-5	98,510	30-27	233,760		
30-6	352,800	30-28	7,912,700		
30-7	358,400	30-29	707,270		
30-9	3,930	30-31	257,340		
30-10	120,670	30-33	1,373,490		
30-11	387,620	32-33	1,908,880		

TABLE XV

ESTIMATED OPTIMUM AREA SLAUGHTERING VOLUMES FOR THE SECOND QUARTER, 1975

Area	Hundredweight Slaughtered
1--Western Virginia	103,260
2--Central Virginia	94,450
3--Eastern Virginia-North Carolina	0
4--Central North Carolina	125,090
5--Western North Carolina	0
6--South Carolina	87,970
7--North Georgia	100,310
8--Southwestern Georgia	79,810
9--Southeastern Georgia	93,730
10--Northern Florida	136,880
11--Central Florida	71,070
12--Southern Florida	0
13--Southern Alabama	132,230
14--Central Alabama	168,910
15--Northern Alabama	92,340
16--Northern Mississippi-Eastern Arkansas	100,590
17--Southern Mississippi-Eastern Louisiana	145,050
18--Northern Louisiana	60,200

TABLE XV (continued)

Area	Hundredweight Slaughtered
19--Southwestern Louisiana	78,720
20--Eastern Oklahoma-Western Arkansas	445,040
21--Western Oklahoma	216,780
22--West Tennessee	81,980
23--Middle Tennessee	37,260
24--East Tennessee	102,010
25--Western Kentucky	70,870
26--Central Kentucky	337,600
27--Eastern Kentucky-West Virginia	101,050
28--Northeast	1,620,180
29--Eastern North Central Region	7,168,100
30--Western North Central Region	16,964,160
31--Southwest	3,186,210
32--Mountain Region	3,255,350
33--Western Region	3,372,150

cattle producing areas in the South, compared with eight for the first quarter. Area 9 (Southeastern Georgia), which was a surplus cattle producing area in the first quarter, did not export slaughter cattle in the second quarter. Estimated slaughter cattle shipment patterns during the second quarter are shown in Figure 26.

The optimum solution to Model V indicated that three areas in the South produced surplus supplies of dressed beef; these were areas 13 (Southern Alabama), 20 (Eastern Oklahoma-Western Arkansas), and 26 (Central Kentucky). In total, eight areas in the South did not receive beef inshipments from the Western North Central Region. This set of areas differed from those for the first quarter in that area 9 (Southeastern Georgia) received beef inshipments from area 30, while area 13 (Southern Alabama) did not receive inshipments. The estimated interarea beef shipment pattern for the second quarter is shown in Figure 27.

Estimated relative positions of areas in the South in slaughter cattle production during the second quarter, as indicated by area price differentials relative to the Eastern North Central Region, are presented in Table XXIX in Appendix I. The nine areas in the South with the most favorable positions, from a demand standpoint, are the same as those in Model IV, except that area 24 (East Tennessee) was replaced by area 13 (Southern Alabama).

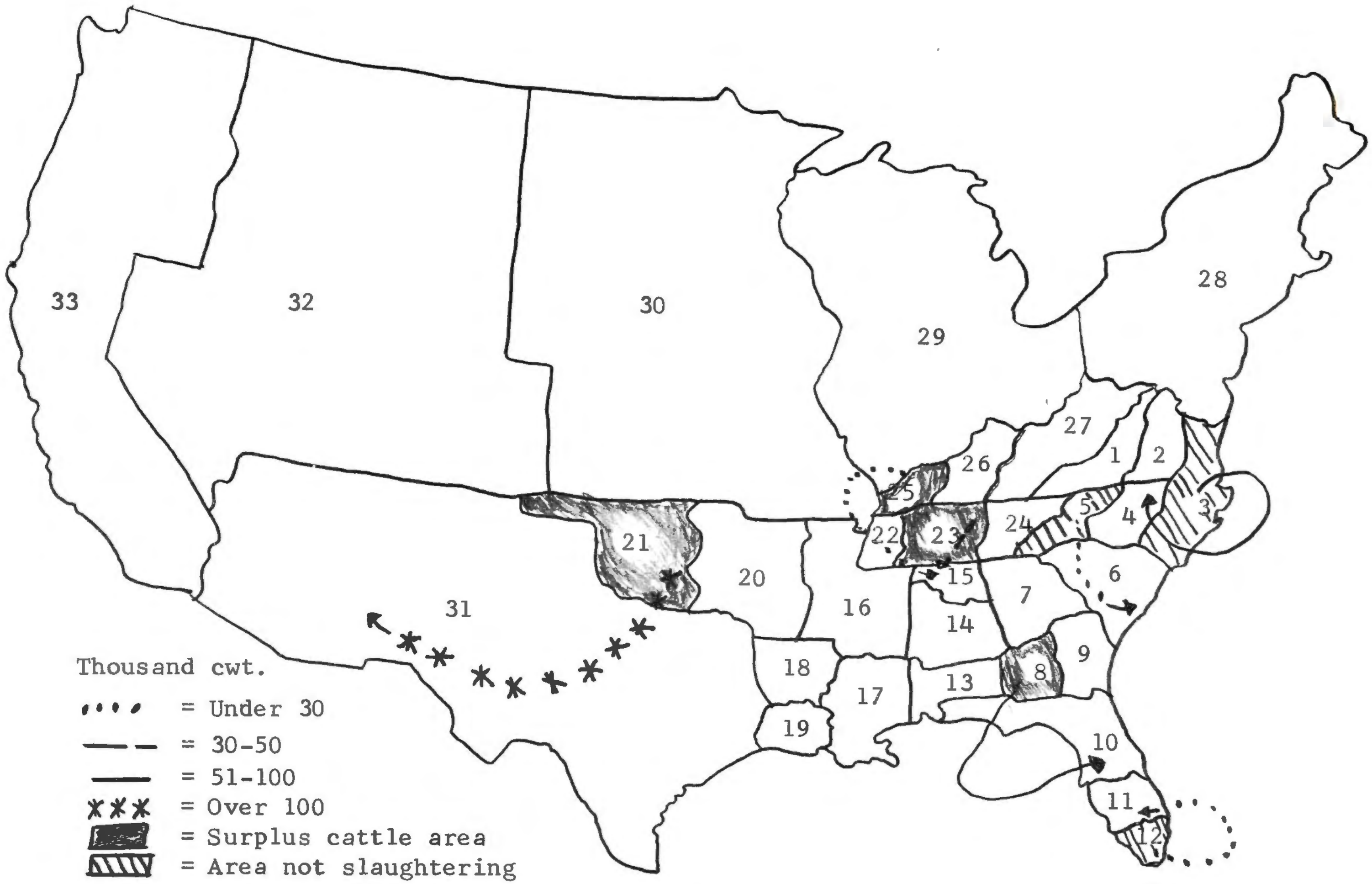

Figure 26. Estimated optimum interregional shipments of slaughter cattle for the second quarter, 1975.

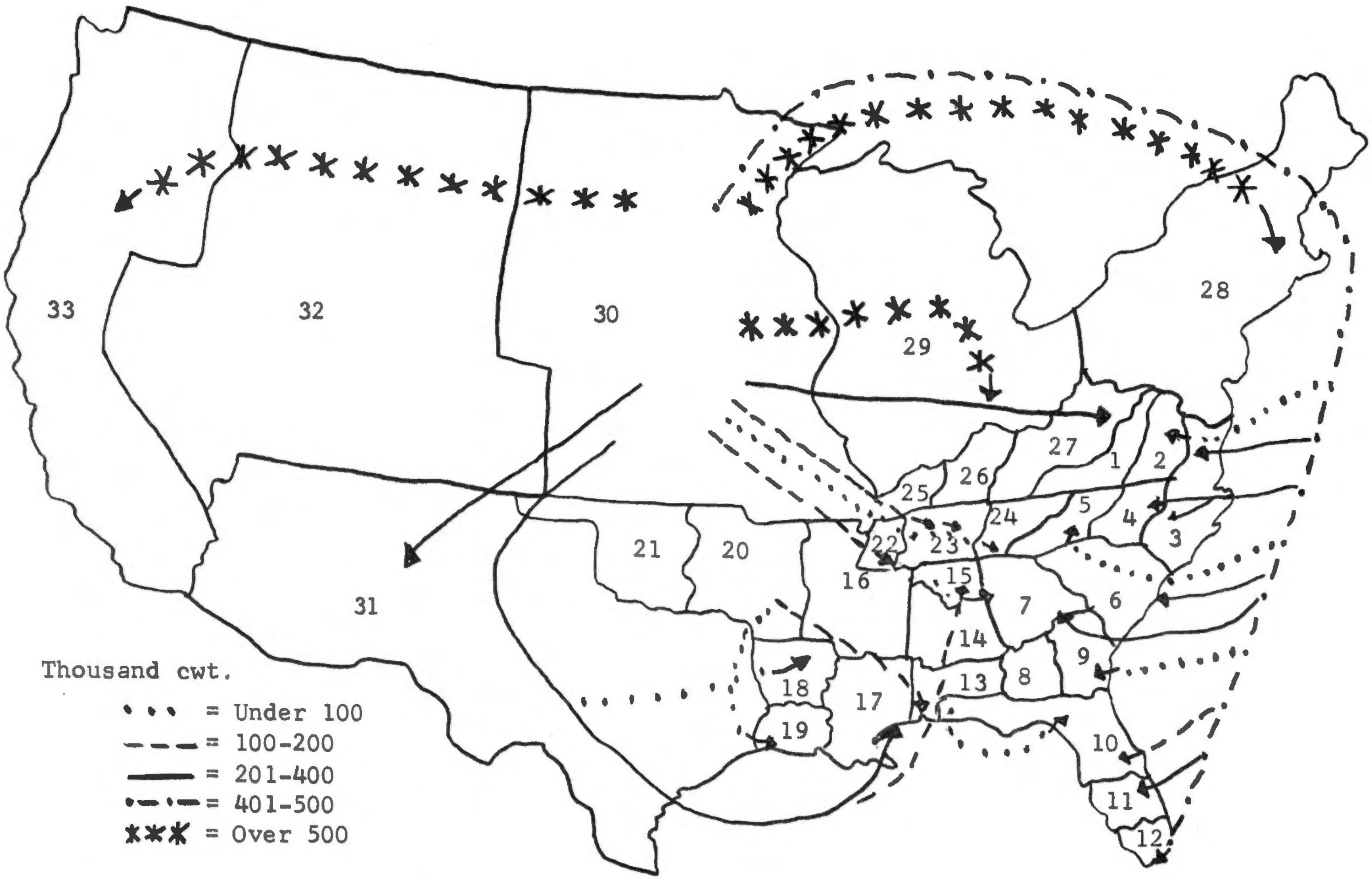

Figure 27. Estimated optimum interregional shipments of dressed beef for the second quarter, 1975.

III. RESULTS FROM MODEL VI: THIRD QUARTER

Estimated optimum geographical flow patterns and area slaughtering volumes for the third quarter are presented in Tables XVI and XVII. As the data indicate, there were five third quarter surplus slaughter cattle producing areas in the South, compared with eight the first quarter and seven the second quarter. Areas 9 (Southeastern Georgia), 12 (Southern Florida), and 23 (Middle Tennessee), which were surplus cattle producing areas in the first quarter, did not export slaughter cattle during the third quarter. The reason that Southern Florida did not export slaughter cattle was that sample data, from which cattle supplies were estimated, indicated a zero level of marketings for the third quarter. Estimated interarea cattle shipments for the third quarter are shown in Figure 28.

The optimum solution to Model VI indicated also that four areas in the South produced surplus supplies of dressed beef during the third quarter. These areas were 1 (Western Virginia, 13 (Southern Alabama), 20 (Eastern Oklahoma-Western Arkansas), and 26 (Central Kentucky). In total, thirteen areas in the South did not receive beef inshipments from the Western North Central Region. This set of areas included 1 (Western Virginia), 3 (Eastern Virginia and North Carolina), 5 (Western North Carolina), 8 (Southwestern Georgia), 13 (Southern Alabama), 15 (Northern Alabama), 17 (Southern Mississippi and Eastern Louisiana), 18 (Northern Louisiana), 19 (Southwestern Louisiana), 20 (Eastern Oklahoma-Western Arkansas), 21 (Western Oklahoma), 25 (Western

TABLE XVI

ESTIMATED OPTIMUM INTERAREA SHIPMENTS OF SLAUGHTER CATTLE AND DRESSED BEEF FOR THE THIRD QUARTER, 1975

Beef Shipments				Cattle Shipments	
Areas From-To	Hundred-weight	Areas From-To	Hundred-weight	Areas From-To	Hundred-weight
1-3	33,530	30-10	183,440	3-4	38,780
13-10	5,970	30-11	405,190	5-6	35,640
20-16	550	30-12	467,880	8-10	31,260
20-17	301,730	30-14	155,720	21-31	833,220
20-18	34,580	30-16	75,120	25-15	35,820
20-19	33,340	30-22	4,600	25-29	168,490
26-3	273,050	30-23	58,990		
26-5	106,680	30-24	118,670		
26-6	74,320	30-27	114,020		
30-2	356,510	30-28	9,032,320		
30-4	297,580	30-29	1,490,710		
30-6	336,090	30-31	309,510		
30-7	345,020	30-33	2,040,900		
30-9	49,620	32-33	1,769,990		

TABLE XVII

ESTIMATED OPTIMUM AREA SLAUGHTERING VOLUMES FOR THE THIRD QUARTER, 1975

Area	Hundredweight Slaughtered
1--Western Virginia	210,720
2--Central Virginia	144,820
3--Eastern Virginia-North Carolina	0
4--Central North Carolina	106,900
5--Western North Carolina	0
6--South Carolina	76,930
7--Northern Georgia	151,760
8--Southwestern Georgia	86,440
9--Southeastern Georgia	56,150
10--Northern Florida	106,150
11--Central Florida	91,570
12--Southern Florida	0
13--Southern Alabama	132,260
14--Central Alabama	137,260
15--Northern Alabama	100,010
16--Northern Mississippi-Eastern Arkansas	147,190
17--Southern Mississippi-Eastern Louisiana	193,970
18--Northern Louisiana	88,260

TABLE XVII (continued)

Area	Hundredweight Slaughtered
19--Southwestern Louisiana	90,980
20--Eastern Oklahoma-Western Arkansas	695,780
21--Western Oklahoma	234,770
22--West Tennessee	175,140
23--Middle Tennessee	122,500
24--East Tennessee	92,230
25--Western Kentucky	76,750
26--Central Kentucky	722,700
27--Eastern Kentucky-West Virginia	248,570
28--Northeast	1,631,580
29--Eastern North Central Region	7,319,020
30--Western North Central Region	19,280,910
31--Southwest	3,542,600
32--Mountain Region	3,277,330
33--Western Region	3,632,020

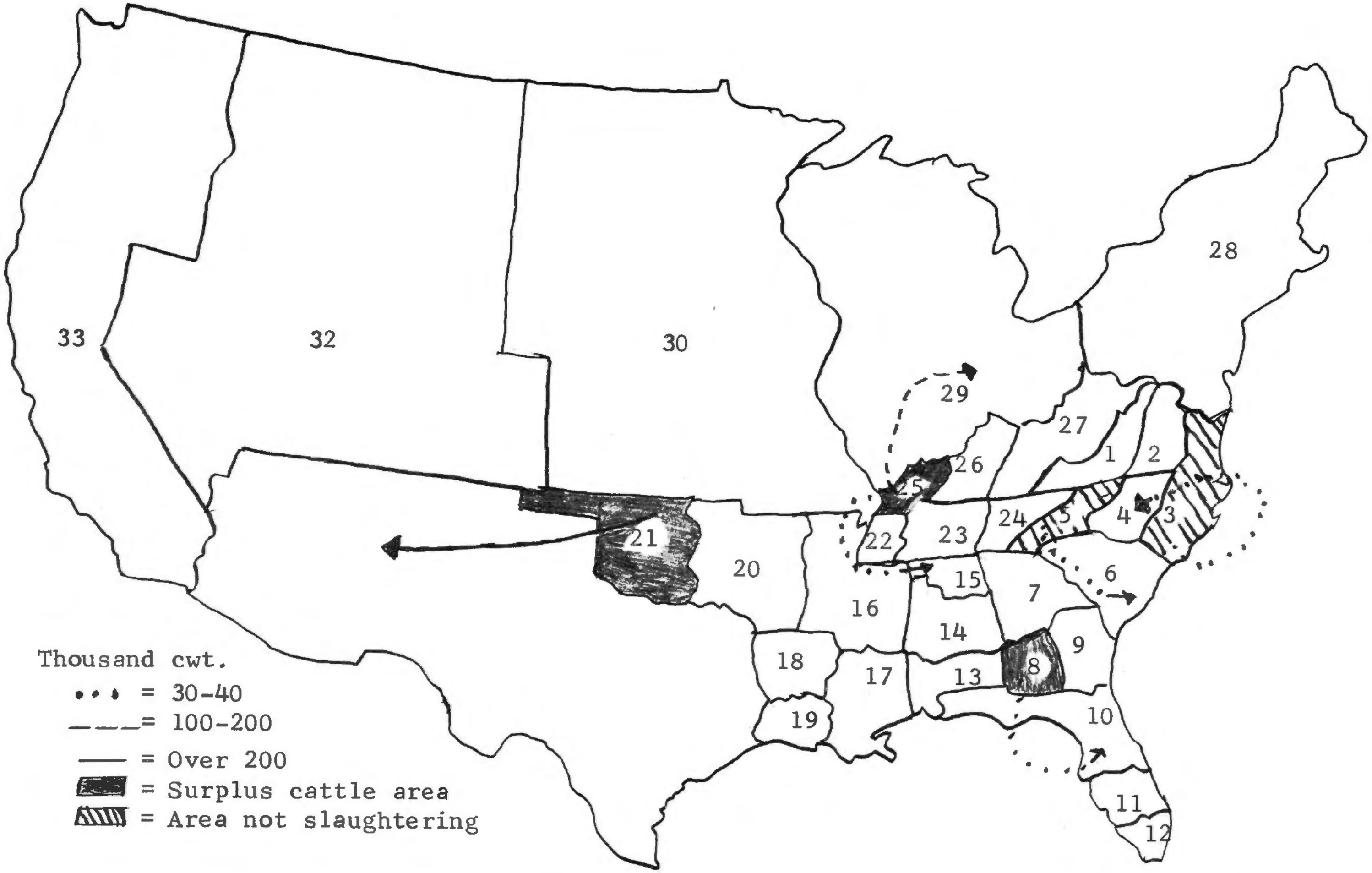

Figure 28. Estimated optimum interregional shipments of slaughter cattle for the third quarter, 1975.

Kentucky), and 26 (Central Kentucky). In five of these areas (3, 5, 17, 18, and 19) deficit beef demands were filled entirely by shipments from areas 1, 20, and 26. Estimated interarea beef shipments for the third quarter are shown in Figure 29.

Estimated relative positions of areas in the South in slaughter cattle production during the third quarter, as indicated by area price differentials relative to the Eastern North Central Region, are presented in Table XXX in Appendix I. The nine areas in the South with the most favorable positions, from a demand standpoint, were the same as those in Model V.

IV. RESULTS FROM MODEL VII: FOURTH QUARTER

Estimated optimum geographical flow patterns and area slaughtering volumes for the fourth quarter of 1975 are presented in Tables XVIII and XIX, respectively. As the data indicate, there were six surplus slaughter cattle producing areas in the South, compared with eight for the first quarter, seven in the second quarter and five in the third quarter. These areas were 3 (Eastern Virginia and North Carolina), 5 (Western North Carolina), 8 (Southwestern Georgia), 12 (Southern Florida), 21 (Western Oklahoma), and 25 (Western Kentucky). Estimated slaughter cattle shipments for the fourth quarter are shown in Figure 30.

The optimum solution to Model VII indicated that three areas in the South produced surplus supplies of dressed beef during the fourth quarter. These areas were 1 (Western Virginia), 20 (Eastern Oklahoma-

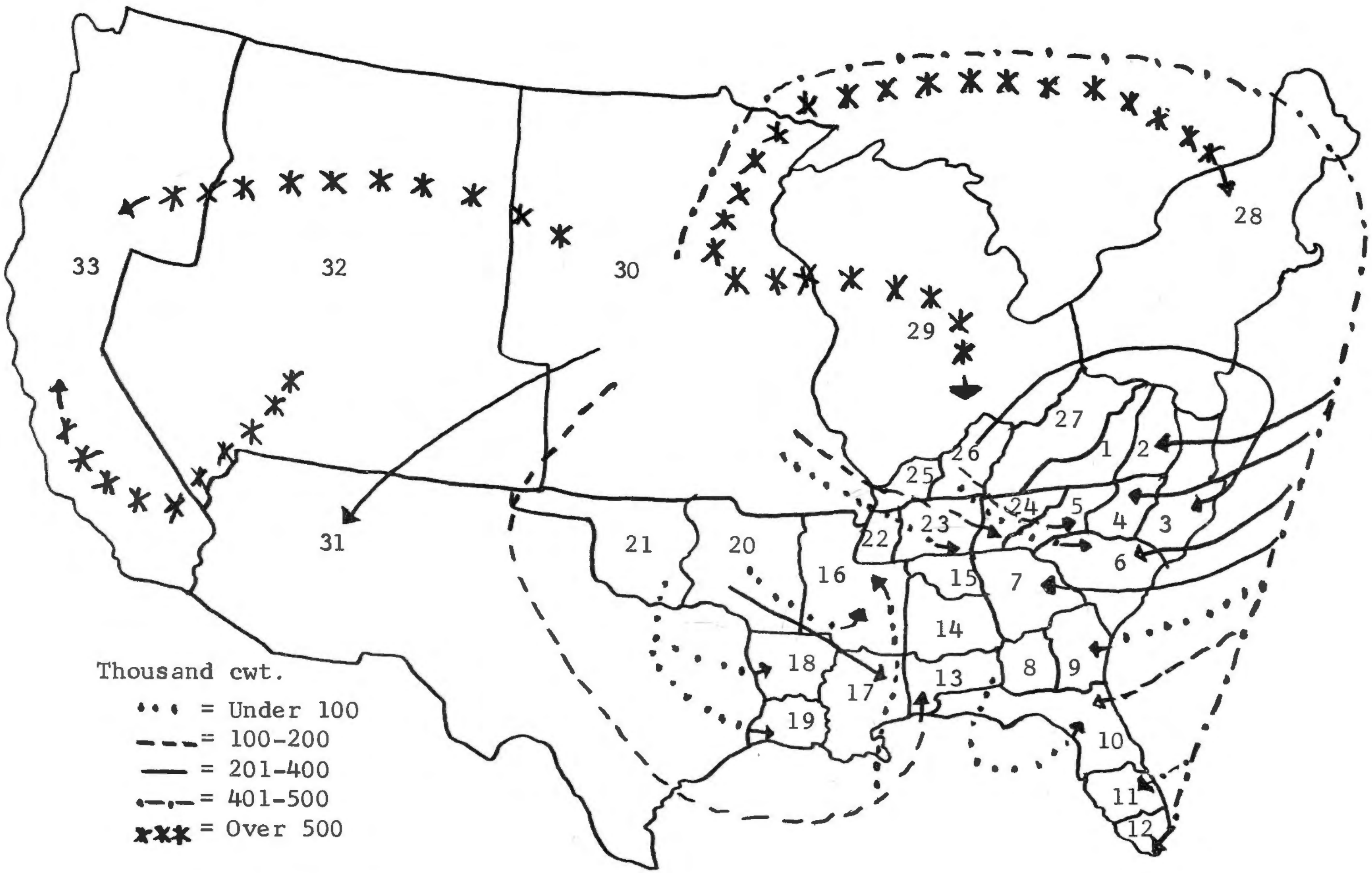

Figure 29. Estimated optimum interregional shipments of dressed beef for the third quarter, 1975.

TABLE XVIII

ESTIMATED OPTIMUM INTERAREA SHIPMENTS OF SLAUGHTER CATTLE AND DRESSED BEEF FOR THE FOURTH QUARTER, 1975

Beef Shipments				Cattle Shipments	
Areas From-To	Hundred-weight	Areas From-To	Hundred-weight	Areas From-To	Hundred-weight
1-3	14,000	30-13	82,610	3-4	63,840
20-17	193,650	30-14	101,890	5-6	30,070
20-19	55,680	30-16	71,220	8-10	49,500
26-3	287,890	30-17	87,460	12-11	9,840
26-5	66,570	30-18	18,530	21-31	649,550
30-2	344,420	30-22	70,780	25-15	39,610
30-4	230,770	30-23	49,220	25-29	85,570
30-5	38,480	30-24	87,960		
30-6	346,730	30-27	132,030		
30-7	362,540	30-28	8,590,580		
30-9	30,620	30-29	1,570,190		
30-10	175,390	30-31	459,820		
30-11	394,020	30-33	1,733,910		
30-12	460,710	32-33	1,902,810		

TABLE XIX

ESTIMATED OPTIMUM AREA SLAUGHTERING VOLUMES FOR THE FOURTH QUARTER, 1975

Area	Hundredweight Slaughtered
1--Western Virginia	188,480
2--Central Virginia	149,230
3--Eastern Virginia-North Carolina	0
4--Central North Carolina	167,510
5--Western North Carolina	0
6--South Carolina	123,310
7--Northern Georgia	126,620
8--Southwestern Georgia	85,110
9--Southeastern Georgia	73,530
10--Northern Florida	115,650
11--Central Florida	95,120
12--Southern Florida	0
13--Southern Alabama	42,010
14--Central Alabama	186,600
15--Northern Alabama	98,470
16--Northern Mississippi-Eastern Arkansas	148,220
17--Southern Mississippi-Eastern Louisiana	206,990
18--Northern Louisiana	102,420

TABLE XIX (continued)

Area	Hundredweight Slaughtered
19--Southwestern Louisiana	66,740
20--Eastern Oklahoma-Western Arkansas	569,920
21--Western Oklahoma	231,170
22--West Tennessee	106,200
23--Middle Tennessee	129,490
24--East Tennessee	119,710
25--Western Kentucky	75,570
26--Central Kentucky	628,830
27--Eastern Kentucky-West Virginia	225,010
28--Northeast	1,669,380
29--Eastern North Central Region	6,905,840
30--Western North Central Region	18,748,620
31--Southwest	3,246,380
32--Mountain Region	3,353,050
33--Western Region	3,524,270

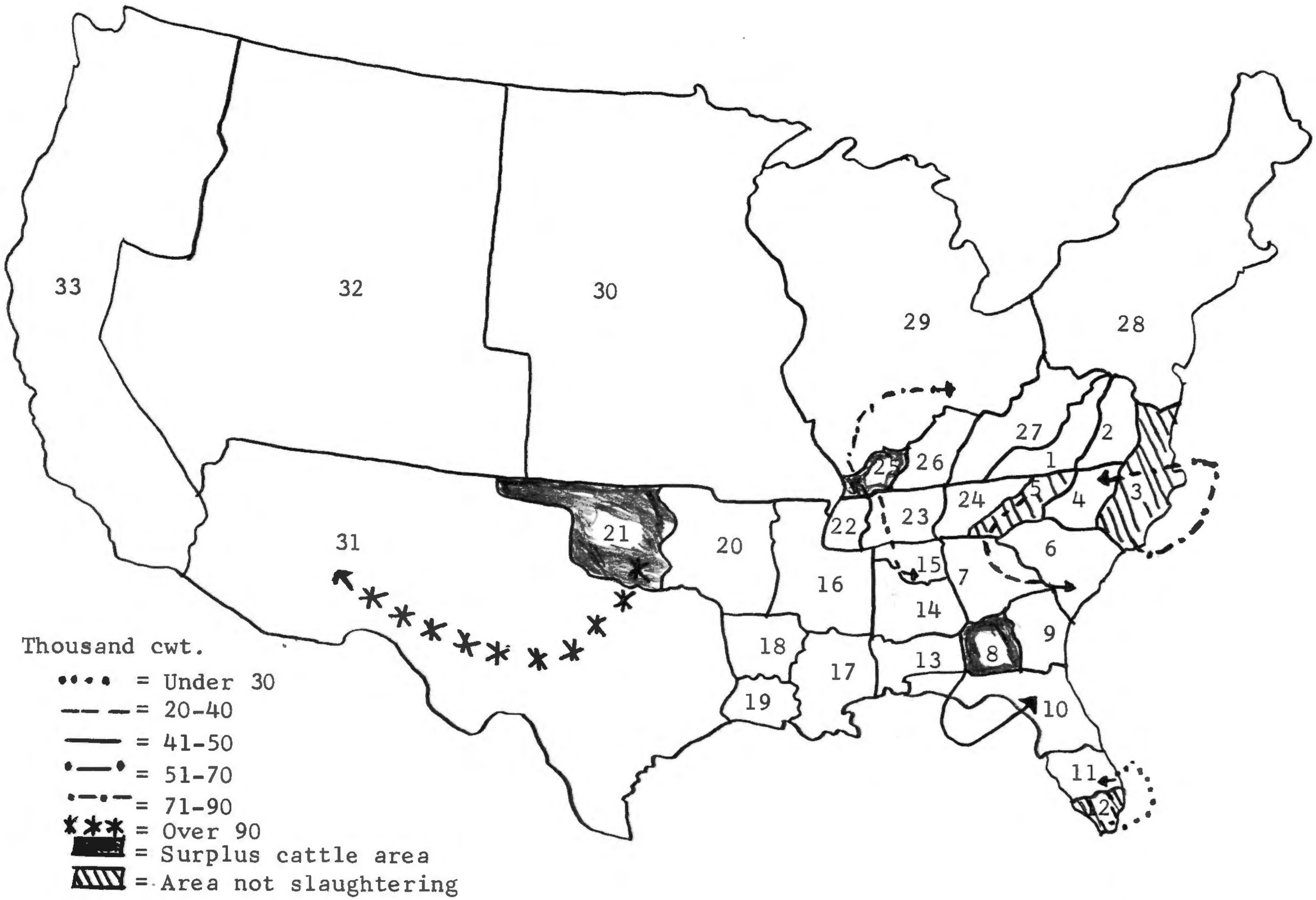

Figure 30. Estimated optimum interregional shipments of slaughter cattle for the fourth quarter, 1975.

Western Arkansas), and 26 (Central Kentucky). In total, nine areas in the South did not receive beef inshipments from the Western North Central Region. These areas were 1 (Western Virginia), 3 (Eastern Virginia and North Carolina), 8 (Southwestern Georgia), 15 (Northern Alabama), 19 (Southwestern Louisiana), 20 (Eastern Oklahoma-Western Arkansas), 21 (Western Oklahoma), 25 (Western Kentucky), and 26 (Central Kentucky). The estimated optimum beef shipment pattern for the fourth quarter is shown in Figure 31.

Estimated relative positions of areas in the South in slaughter cattle production during the fourth quarter, as indicated by area price differentials relative to the Eastern North Central Region, are presented in Table XXXI in Appendix I. The nine areas in the South with the most favorable positions, from a demand standpoint, were the same as those in Model IV. East Tennessee had a more favorable position in slaughter cattle production than Southern Alabama.

V. GENERAL CONCLUSIONS SUGGESTED FROM THE QUARTERLY MODELS

Assuming the estimated quarterly marketing and consumption patterns used here remain unchanged in 1975, and given the assumptions behind the analytical model, the quarterly analyses suggested four areas that might derive additional comparative advantages in cattle slaughtering, relative to other areas in the South, from comparatively stable slaughtering volumes throughout the year. As the data in Table XX indicate, these areas were 8 (Southwestern Georgia), 15

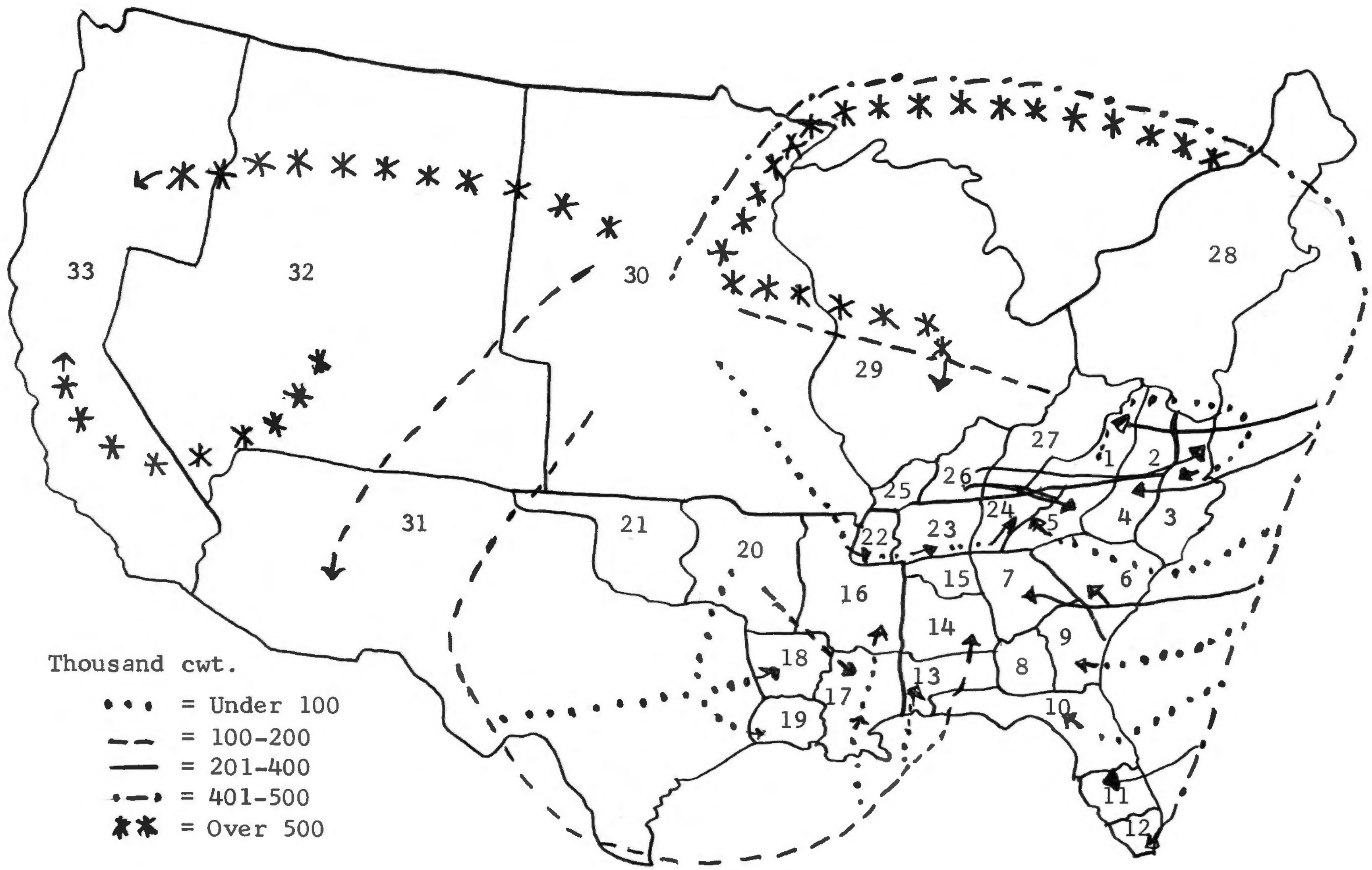

Figure 31. Estimated optimum interregional shipments of dressed beef for the fourth quarter, 1975.

TABLE XX

ESTIMATED OPTIMUM SLAUGHTERING VOLUMES IN THE FIRST, SECOND AND FOURTH QUARTERS AS A PERCENT OF ESTIMATED OPTIMUM THIRD QUARTER SLAUGHTERING VOLUMES IN 1975

Area	First Quarter	Second Quarter	Fourth Quarter
	- - - - -	Percent	- - - - -
1--Western Virginia	60.2	49.0	89.4
2--Central Virginia	74.8	65.2	103.0
3--Eastern Virginia-North Carolina	N	N	N
4--Central North Carolina	109.2	117.0	156.7
5--Western North Carolina	N	N	N
6--South Carolina	149.0	114.3	160.3
7--Northern Georgia	52.3	66.1	83.4
8--Southwestern Georgia	92.3	92.3	98.5
9--Southeastern Georgia	173.9	166.9	131.0
10--Northern Florida	171.2	128.9	108.9
11--Central Florida	98.2	77.6	103.9
12--Southern Florida	N	N	N
13--Southern Alabama	43.8	99.8	31.7
14--Central Alabama	100.4	123.1	135.9
15--Northern Alabama	92.3	92.3	98.5
16--Northern Mississippi-Eastern Arkansas	63.7	68.3	100.7
17--Southern Mississippi-Eastern Louisiana	57.2	74.8	106.7
18--Northern Louisiana	40.1	68.2	116.0
19--Southwestern Louisiana	65.9	86.5	73.4
20--Eastern Oklahoma-Western Arkansas	55.5	64.0	81.9
21--Western Oklahoma	92.3	92.3	98.5
22--West Tennessee	39.4	46.8	60.6
23--Middle Tennessee	78.8	30.4	105.7
24--East Tennessee	75.8	110.6	129.8
25--Western Kentucky	92.3	92.3	98.5
26--Central Kentucky	44.8	46.7	87.0
27--Eastern Kentucky-West Virginia	40.7	40.7	90.5
28--Northeast	105.9	99.3	102.3
29--Eastern North Central Region	100.3	97.9	94.4
30--Western North Central Region	97.4	88.0	97.2

TABLE XX (continued)

Area	First Quarter	Second Quarter	Fourth Quarter
	- - - - -	Percent	- - - - -
31--Southwest	76.6	89.9	91.6
32--Mountain Region	92.0	99.3	102.3
33--Western Region	96.0	92.8	97.0

N indicates no slaughtering was done in the area.

(Northern Alabama), 21 (Western Oklahoma), and 25 (Western Kentucky).[1] In the optimum solutions, stable slaughtering volumes in three of these areas (8, 21, and 25) were achieved through exports of cattle to other areas. Area 25 smoothed out seasonal fluctuations in slaughter cattle supplies by shipping cattle to area 15 each quarter, and to the Eastern North Central Region during the third and fourth quarters. Additional cattle shipments into area 15 from area 23 (Middle Tennessee) during the first and second quarters helped to even out seasonal variations for Northern Alabama.

The interregional model used here did not incorporate interarea differences in seasonal slaughtering patterns into the analysis. If it had, the effect probably would have been to increase further the comparative advantages of areas that maintained relatively stable slaughtering volumes in the present analysis.

It should be noted that relative wage rates in cattle slaughtering plants were a key variable in determining cattle movements between Western Kentucky, Middle Tennessee, and Northern Alabama. In the present study, the estimated 1963 relative wage pattern was assumed to remain constant until 1975, thus giving Alabama a slight competitive advantage in slaughtering relative to Tennessee.[2] However, if

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[1]No special significance is attached to the use of the third quarter as a seasonal reference point in Table XX. This quarter was selected only because it represented peak aggregate cattle supplies in the South, and provided a handy reference point.

[2]See Table XXV in Appendix H.

wage rates in Tennessee and Alabama were equalized by 1975, cattle from Western Kentucky probably would be slaughtered in Middle Tennessee rather than Northern Alabama during the third and fourth quarters. This would result in an increased total annual slaughtering volume for Middle Tennessee, a possible reduction in its seasonal variation in slaughtering rates, and possible reductions in estimated cattle exports from Middle Tennessee during the first and second quarters.

In addition, a reduction in regional average weight and beef yield differences of cattle supplies by 1975 might decrease cattle shipments from Western Kentucky into the Eastern North Central Region during the third and fourth quarters. Cattle shipments from Western Kentucky might then move into areas 22, 23, 24, and/or 26 for slaughter.

As the optimum solutions indicated, three areas in the South (areas 8, 21, and 25), in addition to the three areas that had no slaughtering, were surplus cattle producing areas for all quarters. These, as noted above, also were included among areas in the South having the largest comparative advantages in cattle slaughtering from the standpoint of stability of seasonal slaughtering volumes. In addition, area 23 (Middle Tennessee), was a surplus cattle producing area during the first and second quarters, and area 9 (Southwestern Georgia), was a surplus cattle producing area during the first quarter.

Areas in the South that were supplied entirely by Southern beef throughout the year were 8 (Southwestern Georgia), 15 (Northern Alabama), 19 (Southwestern Louisiana), 20 (Eastern Oklahoma-Western Arkansas), 21 (Western Oklahoma), 25 (Western Kentucky), and 26

(Central Kentucky). Other areas supplied entirely by Southern beef were area 9 (Southeastern Georgia) during the first quarter, area 13 (Southern Alabama) during the second quarter, areas 1 (Western Virginia), 3 (Eastern Virginia and North Carolina), 5 (Western North Carolina), and 13 during the third quarter, and areas 1 and 3 during the fourth quarter. In the quarterly analyses, important recipients of dressed beef from the Western North Central Region, throughout the year, were Central Virginia, South Carolina, Northern Georgia, and Central and Southern Florida. These areas are basically the same as those obtained from the annual models.

The optimum solutions from Models IV through VII indicated that relative positions of areas in the South in slaughter cattle production, from a demand standpoint, varied slightly within the year. During the first and fourth quarters the areas with the most favorable relative positions were the same as those obtained from annual Models I and II. However, during the second and third quarters Southern Alabama had a more favorable position in slaughter cattle production than East Tennessee.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

I. REVIEW OF THE APPROACH

The present study was a partial equilibrium analysis of interregional competition and location patterns in the Southern cattle slaughtering industry. It was directed toward estimating the spatial patterns that would result from an optimum (minimum cost) adjustment to changing technology and demand levels for beef, assuming changes in area slaughter cattle marketings follow past trends. The technological changes considered here included the Interstate Highway System, and on-the-rail systems in cattle slaughtering plants. Effects from the Interstate System were assumed to be reflected only through reduced interregional transportation costs.

Specific objectives of the study were: (1) to estimate the optimum locations and volumes of cattle slaughtering within a set of areas in the South, using estimated 1975 supply, demand, transportation cost and slaughtering cost data; (2) to estimate the accompanying interarea movements of slaughter cattle and dressed beef; and (3) to estimate the impact of seasonal variations in slaughtering rates on objectives (1) and (2). The year, 1975, was assumed to represent approximately average cyclical conditions in slaughter cattle production. Thus, to incorporate average cyclical conditions into the analytical framework, it was selected as the appropriate future time period for analysis.

The analytical model used to attain these objectives was a linear programming formulation containing two types of transportation activities (cattle shipments and dressed beef shipments) and one intermediate activity (slaughtering). Slaughtering costs that varied with volume were introduced initially by setting all costs at the minimum point on the long-run average slaughtering cost curve and obtaining an optimum solution. A series of iterations in slaughtering costs was then made, until estimated slaughtering volumes agreed with the cost estimates used.

Computer capacity permitted use of twenty-seven Southern areas and six non-South areas in the analysis. Areas used in the Southern region were based on area boundaries employed in the former Southern Regional Livestock Marketing Project SM-23; they were intended to represent relatively homogeneous cattle production conditions. For non-South areas, computer capacity limited the extent to which homogeneity of production and consumption could be considered.

Regional per capita beef consumption estimates for 1962 were obtained by adjusting 1962 United States per capita consumption for estimated regional differences in per capita income levels, racial compositions, and a residual group reflecting tastes, residence, age composition, and other variables. Total regional consumption estimates for 1975 were obtained by adjusting 1962 regional consumption estimates for increases in population and per capita income that were estimated to occur over the 1962-1975 period, assuming variables in the residual group remain constant. In addition, consumption for areas in the South was adjusted for estimated changes occurring in racial compositions over the 1962-1975 period.

Area slaughter cattle production levels were projected to 1975 on the basis of past trends; cattle marketings were then estimated using 1962 marketing/production relationships. Seasonal patterns of consumption and marketings were assumed to remain constant until 1975.

Unit transportation cost estimates under the Interstate System were obtained by adjusting transportation cost functions under conventional highway systems for the estimated percent that fixed and variable cost components would be reduced by the Interstate System. It was assumed that average vehicle payloads would remain unchanged, and that resulting transportation cost reductions would be passed on to shippers.

An average cost curve for cattle slaughtering plants in Tennessee was estimated by applying appropriate factor cost data to physical input requirements data developed in previous synthetic studies. The estimated cost function was then adjusted for area differences in wage and salary expenses, assuming that salary costs vary among areas proportionately to wage costs, and that relative wage rates among areas remain unchanged from the estimated 1963 pattern. To introduce effects from seasonal variations in slaughtering rates into the analysis, all slaughtering costs were assumed fixed, and average costs for given plant capacities were computed using reduced average annual slaughtering volumes. This procedure was based on the assumption that labor union pressure, along with supply and demand conditions for skilled labor, would prevent seasonal adjustments in the size of the labor force within a given plant. Accordingly, it represents an upper limit of the effects of seasonal variations in slaughtering rates on unit slaughtering costs.

II. SUMMARY OF RESULTS AND IMPLICATIONS

The results of this study are not predictions of what will occur in the Southern cattle slaughtering industry by 1975. Rather, they represent estimates of the optimum (minimum cost) interregional competition and location patterns that would result from the assumptions behind the analytical model and the input data. Some kinds of economic behavior not included in the model are those arising from entrepreneurial objectives other than cost minimization, from production of services other than slaughtering, and from product differentiation. In addition, future changes in the spatial pattern of slaughter cattle marketings were assumed to follow past trends.

Recognizing these limitations of the results, the annual models suggested that four areas in the South would maintain relatively large comparative advantages in cattle slaughtering under an optimal adjustment to assumed 1975 marketing, consumption and cost conditions. These areas were Central Kentucky, Northern Alabama, Western Arkansas-Eastern Oklahoma, and Western Oklahoma. Comparative advantages of these areas, as well as the Western North Central Region, in slaughtering appeared to be related mainly to large slaughter cattle supplies. A second group of areas in the South that maintained substantial comparative advantages in slaughtering included Western Virginia, Central North Carolina, Central Alabama, Southern Mississippi-Eastern Louisiana, Western Kentucky, and Eastern Kentucky-West Virginia.

Results from the annual models suggested the main area in the South that would obtain increased comparative advantages in cattle slaughtering from the elimination of regional weight and yield differences in slaughter cattle supplies would be Western Oklahoma. Western Kentucky appeared to be the only area in the South that would obtain increased comparative advantages in cattle slaughtering from the elimination of seasonal variations in Southern slaughter cattle marketings. These two results were due to the absence of slaughter cattle shipments into the Southern region in the optimum solutions. In the absence of cattle inshipments, the main effect from these sources of potential Southern slaughtering cost decreases was to reduce cattle exports from the Southern Region.

Optimum solutions from annual models containing regional weight and beef yield differences indicated the nine areas in the South with the most favorable positions in slaughter cattle production, from a demand standpoint, were Northern Alabama, Northern Mississippi-Eastern Arkansas, Eastern Oklahoma-Western Arkansas, Western Oklahoma, West, Middle and East Tennessee, and Western and Central Kentucky. When regional weight and beef yield differences were eliminated, Western North Carolina had a more favorable relative position in slaughter cattle production than East Tennessee. The results imply that, given the estimated input data, these areas would be in a more favorable position, from a demand standpoint, to expand slaughter cattle production than other areas in the South.[1]

In addition, the annual models indicated that six areas in the South would receive particularly large inshipments of dressed beef from the Western North Central Region. These areas were Central Virginia, Central North Carolina, Northern Georgia, South Carolina, Central Florida, and Southern Florida; under the assumed conditions they represent important markets for possible future increases in Southern slaughter cattle production.

The annual models suggested some possible conclusions concerning optimum geographical concentration in the Southern cattle slaughtering industry, as well as the future interregional competitive position of Tennessee's cattle slaughtering industry. Optimum geographical concentration, it should be emphasized, depends heavily on assumed conditions relating to entrepremeurial objectives, services provided, area cattle marketings, and relative area wage rates. Given the conditions assumed here, the annual models indicated that Eastern Virginia-Eastern North Carolina, Western North Carolina, and Southern Florida would not contain slaughtering activities. Optimum solutions from the annual models also suggested the three areas in Tennessee might face strong interregional competition from the Western North Central Region. In

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[1]The relative positions estimated here are from the demand standpoint since they represent the accessibility of supply areas to deficit consumption areas. They do not consider area differences in cattle production functions, feed supplies and feeder cattle supplies.

addition, East Tennessee faced competition from Western Kentucky dressed beef.

However, these last results must be qualified by the optimum solutions from the quarterly models. Empirical results from the quarterly analyses suggested that in event slaughtering wage rates in Tennessee and Alabama are equalized by 1975, slaughter cattle from Western Kentucky might move into Middle Tennessee (in the optimum solution) rather than Northern Alabama during the third and fourth quarters. This could improve Middle Tennessee's competitive position in cattle slaughtering by making possible additional slaughtering economies of scale and by reducing the size of seasonal variation in slaughtering rates. Accordingly, equalization of Alabama and Tennessee wage rates also might be accompanied by reductions in estimated cattle exports from Middle Tennessee during the first and second quarters.

Optimum solutions from the quarterly models suggested four areas in the South that, under assumed conditions, would derive additional competitive advantages in cattle slaughtering from relatively stable slaughtering volumes throughout the year. These were Southwestern Georgia, Northern Alabama, Western Oklahoma, and Western Kentucky.

Estimated relative positions of areas in the South in slaughter cattle production varied slightly within the year. During the first and fourth quarters the areas with the most favorable positions were the same as those obtained from annual models containing regional weight and beef yield differences in cattle supplies. However, during the second and third quarters Southern Alabama had a more favorable position in slaughter cattle production than East Tennessee.

III. POSSIBLE AREAS FOR FUTURE WORK

Future studies of optimum cattle slaughtering location and interregional competition patterns might consider in detail the kinds of economic relationships excluded from the present analysis. Particularly important dimensions are those related to changing area slaughter cattle marketings. Relationships that need to be considered in more detail here include factors affecting area feed supplies, feeder cattle production, feeder cattle distribution within the Southern Region, and the interconnectedness of cattle feeding and cattle slaughtering location patterns.

Analytically, the spatial interconnectedness of these two levels in the livestock marketing system might be achieved through a series of partial equilibrium models beginning with optimum slaughtering location, given projected future locations of slaughter cattle production. A second set of models might be used to estimate optimum cattle feeding locations, given estimated optimum slaughtering locations obtained from the first set of models. A third set of models could then be used to estimate a revised optimum slaughtering location pattern, given the revised slaughter cattle production estimates. The need for a series of partial equilibrium models is further emphasized when computer capacity limitations and the need for a large number of areas in the analytical model are recognized.

Future work might also consider diversified slaughtering plants, as well as the construction of analytical models that include both supply and demand relationships, and the location of one or more intermediate activities. One other important area for possible future work is the development of analytical models that will handle a larger number of geographic areas. In the present study, such a model would have permitted a more detailed analysis of the Southern Region, as well as a detailed analysis of what areas in the North Central Region are likely to be the South's major competitors in 1975.

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APPENDIXES

APPENDIX A

ESTIMATED TRANSPORTATION COST MATRICES FOR SLAUGHTER CATTLE AND DRESSED BEEF

PER HUNDREDWEIGHT[a]

11	12	13	14	15	16	17
.85						
1.67	2.24					
1.78	2.35	.95				
1.99	2.53	1.18	.54			
2.42	2.99	1.09	1.04	1.13		
1.36	1.66	.61	.87	1.01	.65	
1.48	1.78	.75	.84	.92	.46	.69
1.56	1.86	.81	1.06	1.19	.73	.58
1.88	2.18	1.17	1.08	1.02	.75	1.44
2.14	2.44	1.41	1.36	1.30	1.00	1.73
2.45	3.05	1.25	.94	.83	.66	.84
2.25	2.80	1.46	.85	.56	1.27	1.10
2.10	2.62	1.62	.97	.86	1.71	1.24
2.59	3.11	1.80	1.16	.90	1.45	1.24
2.64	3.15	1.92	1.31	1.00	1.67	1.35
2.62	3.09	2.48	1.83	1.61	2.33	1.73
2.96	3.39	3.01	2.41	2.30	3.08	3.37
2.84	3.30	2.18	1.62	1.35	1.84	2.37
2.91	3.19	2.34	2.15	2.02	1.98	3.10
2.36	2.67	1.63	1.70	1.71	1.29	2.09
10.77	11.67	8.59	8.37	8.20	7.49	5.50
12.24	13.13	10.06	10.22	10.10	8.98	6.57

27	28	29	30	31	32	33
	1.09	1.38	1.96	2.03	7.73	10.03
	.99	1.57	2.13	2.23	8.18	10.62
	1.18	1.64	2.27	2.18	8.41	10.40
	1.22	1.49	2.05	2.15	7.99	10.27
	1.43	1.31	1.90	1.83	7.50	9.46
	1.54	1.60	2.14	1.91	8.13	9.72
	1.61	1.41	1.89	1.67	7.29	9.26
	1.87	1.68	2.11	1.64	7.72	9.06
	1.68	1.73	2.19	1.87	8.22	9.73
	1.97	1.76	2.15	1.68	7.92	9.17
	2.16	2.09	2.46	2.00	8.88	10.13
	2.40	2.36	2.70	2.25	9.64	10.88
	2.18	1.71	1.98	1.38	7.04	8.28
	1.84	1.39	1.82	1.44	6.85	8.42
	1.78	1.23	1.71	1.45	6.71	8.31
	2.23	1.51	1.68	1.09	6.11	7.37
	2.85	2.01	2.14	1.77	4.65	5.55
	2.80	1.78	1.79	1.49	4.29	5.20
	3.13	2.18	2.15	1.54	4.36	5.27
	2.78	1.94	1.29	1.28	3.69	4.92
	3.01	1.89	1.39	.95	3.17	4.20
	2.02	1.31	1.54	1.27	5.93	7.84
	1.74	1.10	1.57	1.47	6.41	8.65
	1.47	1.18	1.79	1.70	7.09	9.08
	1.66	.93	1.46	1.55	6.09	8.35
	1.52	.84	1.49	1.63	6.27	8.55
	1.33	1.14	1.79	1.96	7.06	9.83
1.52			2.93			
1.19	1.88		1.80			
2.11	4.18	2.17				
2.32	3.80	2.64	2.03			
8.62	4.89	4.05	3.18	2.66		
11.89	5.98	5.14	4.63	3.57	2.86	

t.

ER HUNDREDWEIGHT[a]

11	12	13	14	15	16	17
.65						
1.02	1.28					
1.07	1.32	.70				
1.16	1.41	.80	.52			
1.36	1.61	.76	.74	.78		
1.28	1.53	.65	.86	.98	.68	
1.38	1.63	.76	.84	.91	.52	.61
1.44	1.70	.81	1.02	1.14	.75	.56
1.72	1.97	1.12	1.04	.99	.76	.98
1.93	2.19	1.32	1.27	1.23	.97	1.12
1.37	1.64	.83	.69	.64	.57	.84
1.28	1.52	.93	.65	.52	.84	1.06
1.21	1.45	1.00	.71	.66	1.04	1.18
1.43	1.66	1.08	.79	.68	.92	1.17
1.46	1.68	1.13	.86	.72	1.02	1.27
1.44	1.65	1.38	1.09	.99	1.32	1.56
1.65	1.86	1.67	1.38	1.33	1.71	1.85
1.59	1.82	1.27	1.00	.86	1.10	1.36
2.06	2.29	1.57	1.41	1.30	1.27	1.53
2.12	2.38	1.50	1.56	1.57	1.22	1.30
3.24	3.10	2.62	2.56	2.51	2.32	2.42
1.22	3.91	3.03	3.08	3.05	2.73	2.83

27	28	29	30	31	32	33
.95						
.78	1.06					
1.38	1.56	.95				
2.09	2.40	1.73	1.46			
2.63	2.90	2.26	1.72	1.51		
3.56	3.74	3.09	2.71	1.92	1.39	

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APPENDIX B

PROCEDURE FOR ADJUSTING CONSUMPTION IN THE SOUTH TO REFLECT INTERAREA VARIATIONS IN RACIAL COMPOSITIONS AND INCOME LEVELS

To incorporate variations in racial composition among areas in the South, per capita consumption by race for the South as a whole was estimated by solving the following relationships simultaneously:

$$TC_{s75} = a\,P'_{w75} + b\,P'_{n75} \qquad (1)$$

$$b = .850(a) \quad , \qquad (2)$$

where

a = estimated per capita consumption, white population

b = estimated per capita consumption, non-white population

P'_{w75} = estimated total white population in the South, 1975

P'_{n75} = estimated total non-white population in the South, 1975

TC_{s75} = estimated aggregate beef consumption in the South, 1975 .

Estimated per capita consumption figures obtained from these relationships were used to compute aggregate beef consumption in the i^{th} area of the South as follows:

$$Q^*_i = aP_{wi} + bP_{ni} \qquad (i = 1, 2, \ldots, 27) \qquad (3)$$

$$TC_{i75} = Q^*_i - \left(\frac{I_{s75} - I_{i75}}{I_{s75}}\right) E_s \cdot Q^*_i \qquad (i = 1, 2, \ldots, 27) \,, \qquad (4)$$

where

Q^*_{i75} = initial estimate of total beef consumption for the i^{th} area, 1975

TC_{i75} = estimated aggregate beef consumption in the i^{th} area of the South, 1975

I_{i75} = estimated per capita disposable income in the i^{th} area, 1975

I_{s75} = estimated per capita disposable income in the South, 1975

E_s = income elasticity of demand for beef in the South .

These estimating procedures are based on the assumption that the ratio of non-white to white per capita beef consumption is uniform throughout the South.

APPENDIX C

PROCEDURES FOR ESTIMATING POPULATION AND PER CAPITA INCOME BY AREAS, FOR 1975

I. AREA POPULATION ESTIMATES FOR 1975

As a starting point, population estimates by states are available for 1975 from Current Population Reports published by the Census Bureau. These estimates were aggregated to obtain 1975 population estimates for areas outside the South. However, for areas in the South, the Census estimates were used to introduce non-linear trends into linear population projections by area and race. The procedure for estimating 1975 area populations may be summarized as follows:[1]

$$\bar{P}_{ijr} = P'_{ijr} + A' (P'_{ijr} - P''_{ijr})$$

(i = areas 1, 2, . . . , 27)
(j = states 1, 2, . . . , 13)
(r = race 1, 2)

where

$\bar{P}_{ijr}$ = linear estimate of the 1975 population for the i^{th} area of the j^{th} state and the r^{th} race

P'_{ijr} = 1960 population of the i^{th} area of the j^{th} state and the r^{th} race[2]

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[1]This procedure was used in Roy G. Stout, J. C. Purcell and W. L. Fishel, Marketing, Slaughter and Consumption of Livestock and Meats in the South, Southern Cooperative Series Bulletin No. 66 (Knoxville: Tennessee Agricultural Experiment Station, August 1961), pp. 38-39. It was also used by D. H. Carley, V. G. Hurt and A. D. Seale, Jr., Milk Movement Patterns in the Lower Mississippi Valley, 1956 and Projected 1975, Southern Cooperative Series Bulletin 86 (Knoxville: Tennessee Agricultural Experiment Station, May 1963), pp. 31-36.

[2]These population data were obtained by aggregating county data into area data. County population data were obtained from U. S. Census Bureau, Census of Population, 1960 (Washington: Government Printing Office, 1964).

P''_{ijr} = 1950 population of the i^{th} area of the j^{th} state and the r^{th} race[3]

A' = linear adjustment factor = 1.5.

Non-linearity in the final area population estimates is introduced by:

$$P_{ijr} = b_{jr} \cdot \overline{P}_{ijr} ,$$

where

$$b_{jr} = \frac{P_{jr}}{\overline{P}_{jr}}$$

$$\overline{P}_{jr} = \sum_{i=1}^{n} \overline{P}_{ijr}$$

P_{jr} = Census Bureau Series I-B estimate of the 1975 population for the j^{th} state and the r^{th} race[4]

n = number of areas in the j^{th} state.

Estimates of non-white populations for states with less than 250,000 non-white population in 1960 were obtained by assuming racial composition of the areas involved remained at 1960 levels. In addition, the relative change in population for each substate area was assumed to continue until 1975 at the same rate as occurred between 1950 and 1960.

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[3]Based on county population obtained from U. S. Census Bureau, Census of Population, 1950 (Washington: Government Printing Office, 1953).

[4]U. S. Census Bureau, Current Population Reports, Series P-25, No. 301 (Washington: Government Printing Office, February 26, 1965), p. 4, and "Illustrated Projection of the Population of States: 1970 to 1985," Current Population Reports, Series P-25, No. 326 (Washington: Government Printing Office, February 7, 1966), pp. 86-88. The latter provides 1975 estimates of non-white populations for states whose non-white population in 1960 was 250,000 or more.

II. AREA INCOME ESTIMATES FOR 1975

Estimates of per capita personal income in constant 1964 dollars, by states, for 1975 have been published by the National Planning Association.[5] These data provided a base from which to estimate 1975 per capita disposable income by areas. Initially, the estimates were adjusted as follows to obtain estimated per capita disposable income by states:[6]

$$I_{dj} = f_j \, I_{pj} \quad ,$$

where

$$f_j = \frac{I_{dj62}}{I_{pj62}}$$

I_{dj} = per capita disposable income of the j^{th} state

I_{pj} = per capita personal income of the j^{th} state.

The numerical subscripts denote the year 1962.

Next, a population weighted average per capita disposable income for the South was computed from:

$$I_{ds75} = \frac{\sum_{j=i}^{13} P_{j75} \cdot I_{dj75}}{\sum_{j=1}^{13} P_{j75}} \qquad (j = \text{states } 1, \ldots, 13)$$

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[5]National Planning Association, loc. cit.

[6]The data were obtained from Department of Commerce, Survey of Current Business (Washington: Government Printing Office) 46(4):8, April 1966.

where

I_{ds75} = estimated per capita disposable income in the South, 1975

P_{j75} = estimated total population of the j^{th} state in 1975 .

Area per capita disposable incomes in the South were next estimated by:

$$I_{dij75} = e_{ij} I_{dj75} \qquad (i = \text{area},\ j = \text{state}) \qquad (1)$$

$$e_{ij} = g_{ij} + h_{ij} (t) \quad . \qquad (2)$$

In equation (2), t represents time in years since year one. The g_{ij} and h_{ij} are least square regression coefficients for the i^{th} area of the j^{th} state, derived from equations of the following form:

$$\frac{I_{dij}}{I_{dj}} = g_{ij} + h_{ij} (t) \quad ,$$

where

t = time in years, beginning with 1954 .

In event g_{ij} was not significantly different from zero at the 20 percent level of probability, e_{ij} was set equal to g_{ij}.

To obtain data for the set of regression equations, estimated per capita effective buying incomes by counties, published annually in _Sales Management_, were aggregated into areas for the years 1954 through 1964.[7] Since _Sales Management_ defines its net effective buying income as ". . . what the Government calls the disposable income available for spending in the various states,"[8] its income concept was appropriate for use here.

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[7]"Survey of Buying Power," published annually in _Sales Management_ (New York: Sales Management, Inc.).

[8]_Ibid._, 92(12):228, June 10, 1964.

Regression analysis provided a means of estimating the ratio of area per capita disposable income to its respective state per capita disposable income, while taking into consideration year-to-year variations in the relative level of business activity within areas. However, it should be noted that use of these estimates for making projections to 1975 requires the assumption that past trends in area per capita incomes relative to their respective state per capita incomes will continue. Area development programs and other factors could produce important changes in these trends.

It should also be noted that by expressing the dependent variable as a ratio, effects of changes in the general price level cancel out, provided the level of prices in each area varied by the same amount as the general price level for its respective state. This estimating procedure was used because it was consistent with the state estimates, which were in 1964 dollars.

For each of areas 28 through 33, 1975 per capita disposable income estimates were obtained by computing population weighted averages of National Planning Association income estimates, adjusted to a disposable income basis.

APPENDIX D

PROCEDURE FOR ESTIMATING SLAUGHTER CATTLE MARKETINGS FOR OKLAHOMA

Since sample data were not available for slaughter cattle marketing/production relationships in Oklahoma, the following relationships were used to obtain projected marketings:[1]

$$X = CS + F + O \quad ,$$

where

X = pounds liveweight of cattle and calves produced

CS = pounds liveweight of cattle for slaughter

F = pounds liveweight of cattle for feeder purposes

O = pounds liveweight of cattle for other uses, primarily dairy and breeding stock.

Of these variables, only X is published by the U. S. Department of Agriculture. Liveweight production figures were next converted to a head basis by:

$$X^h = A(CM) + A(C'M) \quad ,$$

where

X^h = number of head of cattle and calves produced

$A = \frac{X}{M}$

M = liveweight of marketings for all purposes[2]

CM = cattle marketing for all purposes, in number of head[3]

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[1]These relationships were used by J. D. Goodwin, Optimum Distribution Patterns of Feeder Cattle from the Southeast, Southern Cooperative Series Bulletin No. 101 (Knoxville: Tennessee Agricultural Experiment Station, October 1965), pp. 28-30.

[2]Economic Research Service, U. S. Department of Agriculture, Livestock and Meat Statistics, 1962, Statistical Bulletin No. 333 (Washington: Government Printing Office, 1963), p. 38.

[3]Ibid., p. 37.

C'M = calf marketings for all purposes, in number of head.[4]

As a third step, number of head of feeders and cattle for other uses were estimated by:

$$F = h(X^h)$$

$$O = h'(X^h) \quad ,$$

where

h = the ratio of feeder cattle receipts to total cattle receipts at public markets in Oklahoma[5]

h' = the ratio of the change in dairy and beef breeding stock inventory, January 1, 1962-January 1, 1963, to the total number of cattle on farms in Oklahoma, January 1, 1962.[6]

The final estimate of cattle produced for slaughter in Oklahoma in 1962 was converted to marketings of slaughter cattle by:

$$MS^h = \frac{M}{X} (CS) \quad ,$$

where

MS^h = number of head slaughter cattle marketings.

To convert marketings to a liveweight basis, this figure was multiplied by 878 pounds per head, the average liveweight per head for Oklahoma slaughter cattle in 1962.[7] After deducting estimated 1962

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[4]*Ibid.*

[5]*Ibid.*, pp. 47, 75.

[6]*Ibid.*, p. 10.

[7]*Ibid.*, p. 161.

calf marketings for slaughter from this figure, it was expressed as a ratio to total liveweight production of cattle and calves for the state. Next, estimated 1975 slaughter cattle marketings were allocated to areas within the state on the basis of average marketings for 1956, 1957 and 1958, as estimated in a previous Southern livestock marketing study.[8] Finally, the average quarterly marketing pattern for the Southern Region was assumed to apply to each of the areas 20 and 21.[9]

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[8]R. G. Stout, J. C. Purcell and W. L. Fishel, Marketing, Slaughter and Consumption of Livestock and Meats in the South, Southern Cooperative Series Bulletin No. 66 (Knoxville: Tennessee Agricultural Experiment Station, 1961), pp. 27-29 and 55-57.

[9]Based on J. C. Purcell, Trend in Production, Marketings, Slaughter, and Consumption of Livestock and Meats in the South, forthcoming Southern Cooperative Series Bulletin.

APPENDIX E

ESTIMATED QUANTITIES OF BEEF DEMANDED AND SLAUGHTER CATTLE MARKETINGS BY AREAS, FOR 1975

TABLE XXIII

ESTIMATED TOTAL BEEF CONSUMPTION BY AREAS IN 1975

Area	Thousand Pounds Retail Weight Consumed			
	January-March	April-June[a]	July-September	October-December
1	15,362	--	17,720	17,448
2	46,291	--	50,133	49,365
3	28,309	--	30,658	30,188
4	37,348	--	40,447	39,827
5	9,851	--	10,668	10,505
6	44,077	--	47,735	47,003
7	45,871	--	49,677	48,916
8	7,981	--	8,644	8,511
9	9,766	--	10,577	10,415
10	27,292	--	29,557	29,104
11	45,869	--	49,676	48,914
12	43,203	--	46,788	46,071
13	11,686	--	12,655	12,461
14	27,053	--	29,298	38,849
15	9,234	--	10,001	9,847
16	20,578	--	22,285	21,944
17	45,772	--	49,570	48,810
18	11,342	--	12,382	12,095
19	11,480	--	12,432	12,242
20	30,064	--	32,559	32,060
21	21,678	--	23,477	23,117
22	16,697	--	17,974	17,698
23	16,759	--	18,149	17,871
24	19,474	--	21,090	20,767
25	7,087	--	7,675	7,557
26	25,729	--	27,864	27,437
27	33,481	--	36,259	35,704
South	670,234	--	725,950	724,726
28	993,681	953,287	1,066,389	1,025,996
29	820,907	787,537	880,974	847,603
30	320,453	307,426	343,900	330,874
31	358,947	344,355	385,211	370,620
32	140,457	134,747	150,734	145,025
33	693,544	665,352	744,292	716,099

[a]For areas in the South, consumption levels in the first and second quarters were estimated to be equal.

TABLE XXIV

ESTIMATED TOTAL SLAUGHTER CATTLE MARKETINGS IN EQUIVALENT UNITS OF DRESSED BEEF, BY AREAS IN 1975

	Thousand Pounds Retail Weight Marketed			
Area	January-March	April-June	July-September	October-December
1	12,677	10,326	21,072	18,848
2	10,830	9,445	14,482	14,923
3	5,158	6,906	3,878	6,384
4	6,520	5,603	6,811	10,367
5	2,262	1,833	3,564	3,007
6	7,500	6,964	4,129	9,323
7	7,940	10,031	15,176	12,662
8	17,267	13,578	11,770	13,461
9	11,464	9,373	5,615	7,353
10	8,884	8,091	7,490	6,615
11	7,462	5,795	9,157	8,528
12	1,531	1,312	0	984
13	5,798	13,223	13,253	4,201
14	13,785	16,891	13,726	18,660
15	3,461	3,787	6,419	5,887
16	9,370	10,059	14,719	14,822
17	11,089	14,505	19,397	20,699
18	3,541	6,020	8,826	10,242
19	5,993	7,872	9,098	6,674
20	38,626	44,504	69,578	56,992
21	61,084	73,163	106,799	88,072
22	6,894	8,198	17,514	10,620
23	11,086	6,987	12,250	12,949
24	6,987	10,201	9,223	11,971
25	11,423	9,274	28,105	20,075
26	32,346	33,760	72,270	62,883
27	10,120	10,105	24,857	22,501
South	331,098	357,806	529,178	479,703
28	172,841	162,018	163,158	166,938
29	734,326	716,810	715,053	682,027
30	1,877,946	1,696,416	1,928,091	1,874,862
31	231,945	267,136	270,938	259,683
32	301,391	325,535	327,733	335,305
33	348,674	337,215	363,202	352,427

APPENDIX F

PROCEDURE FOR ESTIMATING WAGE RATES IN MEATPACKING BY AREA

The procedure for estimating average wage rates in meatpacking by states in the South, for 1963, was as follows: (1) first, the percentage increase in average production worker's wage between 1954 and 1958 was computed for each state in the South, for areas outside the South and for the United States as a whole.[1] (2) percentage increases by states and areas outside the South were next expressed as a percent of the 1954-1958 percent increase for the United States as a whole. (3) From data in various issues of Employment and Earnings, the percent increase in production worker's wages in meatpacking for United States as a whole, 1958-1963, was computed.[2] (4) The percentages computed in (2) were divided by 100 and multiplied by (3) above. This provided an estimate of the percent increase in wages of production workers in meatpacking by states, 1958-1963. The 1958 state and area wage rates were then adjusted by this estimated percent increase to obtain estimated average wage rates by states and non-South areas for 1963. Algebraically, the adjusted procedure was:

$$WI_{j58-63} = \frac{\left(\frac{W_{58}}{W_{54}} - 1\right)_j}{\left(\frac{W_{58}}{W_{54}} - 1\right)_{us}} \cdot \left(\frac{W_{63}}{W_{58}} - 1\right)_{us}$$

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[1]U. S. Department of Commerce, Census Bureau, Census of Manufactures, 1954 (Washington: Government Printing Office, 1957), and Census of Manufactures, 1958 (Washington: Government Printing Office, 1961).

[2]U. S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings (Washington: Government Printing Office), Vols. 9 and 10.

$$W_{j63} = WI_{j58-63} \cdot W_{j58} \quad ,$$

where

W = average wage rate per hour

W_{ij} = estimated ratio of wage increase for the j^{th} area or state. The numerical subscripts denote years, while j denotes states, and areas outside the South. The subscripts, us, denote United States average.

Estimated average 1963 wage rates by states and areas outside the South were next expressed as a percent of the average November 1963 wage rate in beef slaughter plants in the Southeast, based on data from a Bureau of Labor Statistics survey.[3] Wage rates for specific jobs, as obtained from the survey, were then adjusted to estimated 1963 levels for Tennessee by using estimated average wage rate for Tennessee as a percent of the average wage rate for the Southeast.

In some cases the Bureau of Labor Statistics data did not provide a sufficiently detailed job classification for the purposes of the present study. This problem was handled by subjectively estimating the relative levels of skill required. Job rates used by Logan and King,[4] and by Sanders, Frazier and Padgett[5] provided a check on these adjustments.

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[3]Bureau of Labor Statistics, U. S. Department of Labor, Industry Wage Survey, Meat Products, November 1963, Bulletin 1415 (Washington: Government Printing Office, June 1964).

[4]S. H. Logan and G. A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, 1962), p. 120.

[5]Adolph Sanders, T. L. Frazier and J. H. Padgett, An Appraisal of Economic Efficiencies Within Livestock Slaughter Plants, Bulletin N. S. 122 (Experiment: Georgia Experiment Station, December 1964), p. 14.

Annual wages by job were computed on the basis of 1992 hours worked per year. In addition, workers were assumed to be paid for six holidays per year[6] and to receive five days paid vacation annually.[7] The employer's share of social security, unemployment benefits, and other required programs was set equal to 5 percent of gross wages. Private insurance and pension plan contributions, pay for a temporary employee during vacation periods, etc., were assumed to equal 5 percent of gross pay.[8]

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[6]Bureau of Labor Statistics, U. S. Department of Labor, Industry Wage Survey, Meat Products, November 1963, op. cit., Table 21, p. 60, indicates this is the most common number of paid holidays in the Southeast.

[7]Ibid., p. 60. The Bureau of Labor Statistics Study indicates 90 percent of the meatpacking workers in the Southeast received paid vacations. One week of vacation after one year of service appeared to be the most common vacation, although its length varied with the number of years service.

[8]Bureau of Labor Statistics, U. S. Department of Labor, Employer Expenditures for Selected Supplementary Compensation Practices for Production and Related Workers, Meatpacking and Processing Industries, 1962, Bulletin 1413 (Washington: Government Printing Office, June 1963), pp. 8, 67. Eighty-one percent of the firms surveyed in the Southeast indicated employees received insurance that was at least partly financed by the employer. At the same time, only 35 percent indicated an employee retirement plan was in effect. Accordingly, in this study average firm expenditure for insurance as a percent of gross payroll, for the United States as a whole, was used. However, average firm expenditure for pension plans was reduced from the United States average figure. The breakdown used was: insurance, 3.3 percent of gross pay; other benefits, 1.7 percent of gross pay. The latter figure compares with 2.9 percent for the United States average.

APPENDIX G

PROCEDURE FOR ADJUSTING BUILDING INVESTMENTS TO REFLECT LOWER COST LEVELS IN THE SOUTH

Total construction costs estimated by Logan and King for the Los Angeles area were adjusted to reflect lower cost levels in the South, using construction cost indexes computed by the F. W. Dodge Corporation. These construction cost indexes are based on data compiled by E. H. Boeckh and Associates, and are available for twenty-three United States cities. Prior to 1963, they were published for specific types of construction for four cities, including San Francisco and Atlanta. Beginning in 1963, the indexes were published for an average of all building types, for each of twenty-three cities, including four Southern cities: Atlanta, Birmingham, Miami, and New Orleans.[1] These indexes were used as follows:

1. Los Angeles costs as a percent of San Francisco costs were estimated, using March and April 1963 indexes.[2]

2. The fourth quarter 1963 indexes for all building types were used to estimate the average percent that costs in Birmingham, Miami, and New Orleans were above the Atlanta cost level.

3. An average percent increase in construction costs in Atlanta, Birmingham, New Orleans, and Miami from 1961 to the fourth quarter of 1963 was computed.

4. The third quarter 1961 Atlanta index for brick and concrete commercial and factory buildings was increased by (2) plus (3) above.

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[1] Architectural Review (New York: McGraw-Hill Book Company, Inc.), Vol. 135, April 1964, p. 28.

[2] This is the earliest date for which indexes are published for both cities.

5. The adjustment factor was computed as:[3]

$$\frac{I_{s63}}{I_{L61}} = .905 \quad ,$$

where

I_{s63} = the Atlanta index as adjusted in (4) above

I_{L61} = the San Francisco index as adjusted in (1) above.

Building costs in the South were estimated by multiplying Logan and King[4] costs by (.905) obtained in (5) above.

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[3]This procedure is suggested in Architectural Review, op. cit., Vol. 130, December 1961, p. 20, for comparing cost levels in two cities.

[4]S. H. Logan and G. A. King, Economies of Scale in Beef Slaughter Plants, Giannini Foundation Research Report No. 260 (Berkeley: California Agricultural Experiment Station, 1962), pp. 55-65.

APPENDIX H

ESTIMATED AREA SLAUGHTERING COSTS

TABLE XXV

ESTIMATED UNIT SLAUGHTERING COSTS BY STATES AND NON-SOUTH AREAS, WITH AND WITHOUT SEASONAL OUTPUT VARIATIONS, FOR PLANTS OPERATING AT 120 HEAD PER HOUR[a]

State or Area	Unit Slaughtering Cost, Dollars Per Hundredweight: Seasonal Variation	No Seasonal Variation	Percent of Tennessee Cost
Virginia	$1.21	$1.10	78.6
North Carolina	1.25	1.05	75.0
South Carolina	1.26	1.06	75.7
Georgia	1.46	1.23	87.9
Florida	1.36	1.14	81.4
Alabama	1.54	1.29	92.1
Mississippi	1.58	1.33	95.0
Louisiana	1.52	1.28	91.4
Arkansas	1.49	1.25	89.3
Oklahoma	1.77	1.49	106.4
Tennessee	1.67	1.40	100.0
Kentucky	1.76	1.48	105.7
West Virginia	1.51	1.27	90.7
Area 28	1.25	1.05	75.0
Area 29	1.33	1.12	80.0
Area 30	1.42	1.19	85.0
Area 31	1.31	1.10	78.6
Area 32	1.36	1.14	81.4
Area 33	1.43	1.20	85.7

[a]For the sources of data used to obtain these estimates, see Table VI, page 101.

APPENDIX I

ESTIMATED AREA PRICE DIFFERENTIALS FOR SLAUGHTER CATTLE

TABLE XXVI

SLAUGHTER CATTLE PRICE DIFFERENTIALS ESTIMATED FOR AREAS IN THE SOUTH FROM MODEL I

Area	Price Differential[a]
1--Western Virginia	-.55
2--Central Virginia	-.71
3--Eastern Virginia-North Carolina	-.10
4--Central North Carolina	-.68
5--Western North Carolina	-.53
6--South Carolina	-.76
7--North Carolina	-.34
8--Southwestern Georgia	-.19
9--Southeastern Georgia	-.63
10--Northern Florida	-.69
11--Central Florida	-1.00
12--Southern Florida	-.15
13--Southern Alabama	-.36
14--Central Alabama	-.20
15--Northern Alabama	+.22
16--Northern Mississippi-Eastern Arkansas	-.01
17--Southern Mississippi-Eastern Louisiana	-.34
18--Northern Louisiana	-.10
19--Southwestern Louisiana	-.28

TABLE XXVI (continued)

Area	Price Differential[a]
20--Eastern Oklahoma-Western Arkansas	+.57
21--Western Oklahoma	+.59
22--West Tennessee	+.20
23--Middle Tennessee	+.17
24--East Tennessee	-.05
25--Western Kentucky	+.75
26--Central Kentucky	+.57
27--Eastern Kentucky-West Virginia	-.20

[a]Area price minus price in the Eastern North Central Region, in dollars per hundredweight.

TABLE XXVII

SLAUGHTER CATTLE PRICE DIFFERENTIALS ESTIMATED FOR AREAS IN THE SOUTH FROM MODELS II AND III

Area	Price Differential[a] Model II	Model III
1--Western Virginia	-.32	-.86
2--Central Virginia	-.48	-1.02
3--Eastern Virginia-North Carolina	+.11	-.40
4--Central North Carolina	-.47	-.98
5--Western North Carolina	-.32	-.25
6--South Carolina	-.54	-1.06
7--Northern Georgia	-.09	-.69
8--Southwestern Georgia	+.04	-.51
9--Southeastern Georgia	-.38	-.98
10--Northern Florida	-.46	-1.01
11--Central Florida	-.77	-1.33
12--Southern Florida	+.08	-.48
13--Southern Alabama	-.10	-.73
14--Central Alabama	+.06	-.57
15--Northern Alabama	+.22	-.12
16--Northern Mississippi-Eastern Arkansas	+.26	-.39
17--Southern Mississippi-Eastern Louisiana	-.08	-.70
18--Northern Louisiana	+.16	-.47
19--Southwestern Louisiana	-.03	-.64

TABLE XXVII (continued)

Area	Price Differential[a] Model II	Model III
20--Eastern Oklahoma-Western Arkansas	+.57	+.23
21--Western Oklahoma	+.59	+.29
22--West Tennessee	+.49	-.20
23--Middle Tennessee	+.46	-.23
24--East Tennessee	+.24	-.45
25--Western Kentucky	+.82	+.33
26--Central Kentucky	+.56	+.18
27--Eastern Kentucky-West Virginia	+.06	-.56

[a]Area price minus price in the Eastern North Central Region, in dollars per hundredweight.

TABLE XXVIII

ESTIMATED SLAUGHTER CATTLE PRICE DIFFERENTIALS FOR AREAS IN THE SOUTH, FIRST QUARTER 1975

Area	Price Differential[a]
1--Western Virginia	-.32
2--Central Virginia	-.48
3--Eastern Virginia-North Carolina	+.11
4--Central North Carolina	-.47
5--Western North Carolina	+.27
6--South Carolina	-.54
7--Northern Georgia	-.09
8--Southwestern Georgia	+.04
9--Southeastern Georgia	+.02
10--Northern Florida	-.46
11--Central Florida	-.77
12--Southern Florida	+.08
13--Southern Alabama	-.10
14--Central Alabama	+.06
15--Northern Alabama	-.10
16--Northern Mississippi-Eastern Arkansas	+.26
17--Southern Mississippi-Eastern Louisiana	-.08
18--Northern Louisiana	+.16
19--Southwestern Louisiana	-.03

TABLE XXVIII (continued)

Area	Price Differential[a]
20--Eastern Oklahoma-Western Arkansas	+.57
21--Western Oklahoma	+.59
22--West Tennessee	+.49
23--Middle Tennessee	+.46
24--East Tennessee	+.24
25--Western Kentucky	+.80
26--Central Kentucky	+.56
27--Eastern Kentucky-West Virginia	+.06

[a]Area price minus price in the Eastern North Central Region, in dollars per hundredweight.

TABLE XXIX

ESTIMATED SLAUGHTER CATTLE PRICE DIFFERENTIALS FOR AREAS IN THE SOUTH, SECOND QUARTER 1975

Area	Price Differential[a]
1--Western Virginia	-.32
2--Central Virginia	-.48
3--Eastern Virginia-North Carolina	+.11
4--Central North Carolina	-.47
5--Western North Carolina	+.27
6--South Carolina	-.54
7--Northern Georgia	-.09
8--Southwestern Georgia	+.04
9--Southeastern Georgia	-.38
10--Northern Florida	-.46
11--Central Florida	-.77
12--Southern Florida	+.08
13--Southern Alabama	+.43
14--Central Alabama	+.06
15--Northern Alabama	-.10
16--Northern Mississippi-Eastern Arkansas	+.26
17--Southern Mississippi-Eastern Louisiana	-.08
18--Northern Louisiana	+.16
19--Southwestern Louisiana	-.03

TABLE XXIX (continued)

Area	Price Differential[a]
20--Eastern Oklahoma-Western Arkansas	+.57
21--Western Oklahoma	+.59
22--West Tennessee	+.49
23--Middle Tennessee	+.46
24--East Tennessee	+.24
25--Western Kentucky	+.80
26--Central Kentucky	+.56
27--Eastern Kentucky-West Virginia	+.06

[a]Area price minus price in the Eastern North Central Region, in dollars per hundredweight.

TABLE XXX

ESTIMATED SLAUGHTER CATTLE PRICE DIFFERENTIALS FOR AREAS IN THE SOUTH, THIRD QUARTER 1975

Area	Price Differential[a]
1--Western Virginia	+.08
2--Central Virginia	-.48
3--Eastern Virginia-North Carolina	+.11
4--Central North Carolina	-.47
5--Western North Carolina	+.27
6--South Carolina	-.54
7--Northern Georgia	-.09
8--Southwestern Georgia	+.04
9--Southeastern Georgia	-.38
10--Northern Florida	-.46
11--Central Florida	-.77
12--Southern Florida	+.08
13--Southern Alabama	+.43
14--Central Alabama	+.06
15--Northern Alabama	-.08
16--Northern Mississippi-Eastern Arkansas	+.26
17--Southern Mississippi-Eastern Louisiana	-.04
18--Northern Louisiana	+.19

TABLE XXX (continued)

Area	Price Differential[a]
19--Southwestern Louisiana	+.01
20--Eastern Oklahoma-Western Arkansas	+.61
21--Western Oklahoma	+.59
22--West Tennessee	+.49
23--Middle Tennessee	+.46
24--East Tennessee	+.24
25--Western Kentucky	+.82
26--Central Kentucky	+.62
27--Eastern Kentucky-West Virginia	+.06

[a]Area price minus price in the Eastern North Central Region, in dollars per hundredweight.

TABLE XXXI

ESTIMATED SLAUGHTER CATTLE PRICE DIFFERENTIALS FOR AREAS IN THE SOUTH, FOURTH QUARTER 1975

Area	Price Differential[a]
1--Western Virginia	+.08
2--Central Virginia	-.48
3--Eastern Virginia-North Carolina	+.11
4--Central North Carolina	-.47
5--Western North Carolina	+.27
6--South Carolina	-.54
7--Northern Georgia	-.09
8--Southwestern Georgia	+.04
9--Southeastern Georgia	-.38
10--Northern Florida	-.46
11--Central Florida	-.77
12--Southern Florida	+.08
13--Southern Alabama	-.10
14--Central Alabama	+.06
15--Northern Alabama	-.08
16--Northern Mississippi-Eastern Arkansas	+.26
17--Southern Mississippi-Eastern Louisiana	-.08
18--Northern Louisiana	+.16
19--Southwestern Louisiana	-.03

TABLE XXXI (continued)

Area	Price Differential[a]
20--Eastern Oklahoma-Western Arkansas	+.57
21--Western Oklahoma	+.59
22--West Tennessee	+.49
23--Middle Tennessee	+.46
24--East Tennessee	+.24
25--Western Kentucky	+.82
26--Central Kentucky	+.62
27--Eastern Kentucky-West Virginia	+.06

[a]Area price minus price in the Eastern North Central Region, in dollars per hundredweight.