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To the Graduate Council:

I am submitting herewith a dissertation written by Billy G. Hicks entitled "Optimum Number, Size and Location of Livestock Auction Markets in Tennessee." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

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OPTIMUM NUMBER, SIZE AND LOCATION OF LIVESTOCK AUCTION MARKETS IN TENNESSEE

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

Billy G. Hicks

June 1970

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ABSTRACT

The objectives of this study were: (1) to determine the number, size, and location of livestock auction markets in Tennessee that would minimize the combined costs of assembling and selling the annual livestock marketings of producers in Tennessee, and (2) to determine the area to be served by each of these auctions. It was postulated that there are too many livestock auction markets in the state to develop an efficient, low cost livestock market system.

Estimates of the annual marketings of cattle, calves, hogs, and sheep were made for all counties in the state using data from the 1959 and 1964 Censuses of Agriculture and the 1968 Crop Reporting Board estimates. Costs of assembling the estimated volume of livestock were computed for all possible combinations of the potential market locations in the West, Middle and East Tennessee areas. From these possible combinations, that combination of potential market locations which minimized annual assembly costs for any given number of markets, and thus for various numbers of markets, was selected.

Annual costs of operating livestock auction markets were developed in a previous study (Gibb, 1959) and then were adjusted to reflect present marketing costs. These annual costs were expressed in terms of the number of markets.

Determination of the optimum number, size, and location of auction markets was accomplished by combining the minimized annual assembly and

annual auction market costs with respect to the number of markets. Specification of the optimum number of markets was achieved by selecting the number of markets with the minimum combined cost. The optimum market locational pattern was obtained by identifying the market sites which minimized annual assembly costs in the solution for the optimum number of markets. Annual marketings of livestock transported to each market from all origins in that supply area were summed to determine the size of market required at each location.

Under the assumption that all livestock be sold through auction agencies, total combined annual assembly and annual market costs were minimized for the state with the selection of 18 markets. The optimum number was determined to be six markets for West Tennessee located at Dresden, Memphis, Lexington, Selmer, Ripley, and Troy; seven markets for Middle Tennessee located at Cookeville, Columbia, Manchester, Lebanon, Clarksville, Lawrenceburg, and Shelbyville; and five markets for East Tennessee located at Knoxville, Athens, Johnson City, Pikeville, and Morristown. The volume of livestock marketed at these optimal locations ranged from a low of 60,376 head of livestock at Memphis to a high of 282,481 head at Cookeville.

When assembly costs were increased by 10 percent from the original estimate, the optimum number of markets for the state increased from 18 to 19 with the additional market located at Trenton. There was no change in the optimum solution when assembly costs were reduced by 10 percent.

Under the assumption that the total volume of livestock sold through auction agencies be composed of annual cattle marketings increased by 25 percent, annual hog marketings decreased by 50 percent, and with no change in annual marketings of calves and sheep, total combined annual assembly and annual market costs were minimized for the state with 17 markets. This was one market less than the optimum number derived under the assumed condition that all the annual livestock marketings be sold through auctions. West Tennessee was the only area of the state where the number and location of markets were affected by the changes in livestock marketings. In this case, the optimum number was determined to be five markets located at Memphis, Dresden, Ripley, Troy, and Jackson. The Lexington and Selmer locations that were originally included in the optimum combination of markets were replaced by a single market located at Jackson. The volume of livestock marketed at these optimal locations ranged from a low of 56,525 head of livestock at Memphis to a high of 206,980 head at Dresden.

When assembly costs were increased by 10 percent from the original estimate, the optimum number of markets for the state increased from 17 to 18 with the additional market located at Nashville. When assembly costs were decreased by 10 percent, the optimum number of markets for the state decreased from 17 to 16, eliminating the market location at Troy.

Results of this study support the hypothesis that Tennessee has too many markets to develop an efficient, low cost livestock auction

market system. The optimal solutions under the various postulated conditions indicating a least cost structure of from 16 to 19 strategically located auction markets emphasize the need to give serious consideration to reducing the number of auction markets operating in Tennessee. The tendency to establish new marketing facilities in local communities, further dividing the available supply of livestock, poses a serious problem for the livestock industry. Continuation of this trend will insure a high-cost, inefficient livestock market system in Tennessee.

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CHAPTER I

THE PROBLEM AND OBJECTIVES OF THE STUDY

I. INTRODUCTION

The primary functions of a livestock market are to provide a place for the assembly of livestock and to effect the exchange process between sellers and buyers. A market outlet, whether it be a stockyard company, an auction agency, or a commission firm engaged in some phase of livestock marketing, should satisfy the needs of both the seller and buyer more efficiently than either one acting independently of the market. It is to the seller's advantage to have a market conveniently located, with competition adequate to insure price competition, and with low marketing charges. The buyer wants to procure the number, weight, and grade of livestock to meet his particular needs from as few sources as possible and near his base of operations. The number of markets is, therefore, an important factor affecting the efficiency and performance of the marketing system. A large number of markets might satisfy the convenience requirement of both the seller and buyer; however, when too many markets exist, some are likely to be weak financially and lack the resources to perform efficiently the necessary marketing functions.[1]

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[1] Edgar A. Miller and George F. Henning, Suggested Location of Ohio Livestock Markets to Reduce Total Marketing Costs, Research Bulletin 981 (Wooster: Ohio Agricultural Research and Development Center, February, 1966), p. 1.

II. THE PROBLEM

There is evidence that too many livestock marketing agencies exist for maximum operating efficiency in many production areas. An Ohio study reported that there was about eight times more livestock marketing agencies in Ohio than were needed to minimize average total marketing costs.[2] In a Texas study, Wootan and McNeely[3] found average unit livestock auction market costs much higher in that state than would exist if there were fewer firms. Other studies have also shown that considerable opportunity exists for reducing average unit livestock auction market costs.[4] Williams and Stout, in their college textbook on livestock marketing, state that "the inescapable fact is that in many areas auction costs per animal must remain high, and efficiency

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[2] Ibid., p. 15.

[3] Charley V. Wootan and John G. McNeely, Factors Affecting Auction Market Operating Costs, Bulletin 1056 (College Station: Texas Agricultural Experiment Station, Texas A & M University, October, 1966), p. 2.

[4] For example see: G. F. Henning and M. B. Evans, Livestock Auction Markets in Ohio, Research Bulletin 473 (Wooster: Ohio Agricultural Experiment Station, April, 1954); Clifton B. Cox and Martin A. Blum, Cost of Operating Selected Indiana Livestock Markets, Station Bulletin 618 (Lafayette: Purdue University Agricultural Experiment Station, February, 1955); J. G. McNeely and G. R. Turner, Texas Livestock Auction Markets--Operating Costs and Returns, Miscellaneous Publication 118 (College Station: Texas Agricultural Experiment Station, 1954); R. C. Lindberg and G. G. Judge, Estimated Cost Functions for Oklahoma Livestock Auctions, Bulletin B-502 (Stillwater: Oklahoma Agricultural Experiment Station, January, 1958); or James T. McDowell, Dennis L. Wold and Emory E. Anderson, Cost-Volume Relationships at North Dakota Livestock Auctions, Bulletin 452 (Fargo: Agricultural Experiment Station, North Dakota State University, March, 1965).

must remain low so long as the number of auctions in the area remains so large that none can achieve a satisfactory volume. . . ."[5]

From this and other evidence, it is postulated that Tennessee also has too many livestock markets to develop an efficient, low cost livestock marketing system.[6] In 1969, there were 70 auction markets, 189 independent local livestock dealers, and two terminal livestock markets operating in the state.[7] Moreover, buyers representing 27 packing plants in the state engaged in direct buying of livestock to meet a portion of their plants' slaughter needs. Thus, there were 288 known livestock marketing agencies operating in Tennessee in 1969.

The number of livestock auction markets in Tennessee has increased steadily over the past 20 years. In 1952 there were 54,[8] in

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[5]Willard F. Williams and Thomas T. Stout, Economics of the Livestock-Meat Industry (New York: The Macmillan Company, 1964), p. 254.

[6]For a description of the different type of livestock markets in Tennessee see: M. B. Badenhop, Selling and Buying Livestock by Tennessee Farmers, Bulletin 233 (Knoxville: The University of Tennessee Agricultural Experiment Station, June, 1953), pp. 3-4. A brief description follows: Auction markets assemble and sell livestock of consignors by public bidding to the party offering the highest price. Local dealers include any local market where livestock are bought for resale. Some markets are referred to as combination markets, or dealer-auctions. These markets act as auctions, usually during one day of the week, and as dealers during the remainder of the week. Packing plants also buy a portion of their livestock direct from the producer for slaughter. Terminal markets refer to those markets where a stockyard company furnishes physical facilities and assumes responsibility for yarding and caring for livestock. Actual buying and selling, however, are usually entrusted to commission firms or order buyers.

[7]United States Department of Agriculture, Packers and Stockyards Administration List of Registrants, Memphis Area (Memphis: Room 831, Federal Building, November, 1969).

[8]M. B. Badenhop, op. cit., p. 3.

1955, 62,[9] and in 1969, 70 such markets.

An estimated 2.7 million head of livestock were sold by Tennessee producers in 1968 and of these 67 percent, or 1.8 million head, were marketed through auctions.[10] Thus, the auction market is the most important outlet for the sale of livestock in the state. In 1968, only 21, or 31 percent, of the livestock auction markets handled more than 25,000 head of livestock per auction, 22, or 33 percent, handled between 15,000 and 25,000 head, and 24, or 36 percent, handled less than 15,000 head. The 21 largest markets accounted for 56 percent of all livestock sold through auctions in 1968, whereas the 24 smallest markets accounted for only 16 percent.[11] Possibly, some of these markets were inefficient and submarginal operations. Evidence from other studies suggests this as highly probable.[12]

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[9] M. B. Badenhop, Marketing Cattle and Calves Through Auction Markets in Tennessee, Bulletin 247 (Knoxville: The University of Tennessee Agricultural Experiment Station, June, 1956), p. 7.

[10] For the purpose of this study livestock marketed is defined as the number of cattle, hogs, and sheep sold by Tennessee producers. All market classes of these livestock species are included in the total marketings. Market classes are comprised of those animals sold for either slaughter, feeding or breeding purposes. In addition to the 1.8 million head of livestock sold through auction markets in 1968, considerable livestock were sold through special auction sales.

[11] Market volume data were obtained from unpublished reports of the Tennessee Department of Agriculture, Ellington Agricultural Center, Nashville, Tennessee.

[12] Wootan and McNeely, op. cit., p. 2.

When there are many small auction markets, it is difficult to assemble livestock efficiently and in adequate volumes to meet buyer demand. Also, sorting and grading are frequently ineffective because of too few animals being offered for sale. Consequently, large volume buyers with specialized needs often do not participate in these sales. When large volume buyers do participate in sales at auctions having a small number of offerings, extra labor, housing, feed, and intra-area transportation costs are incurred to get the specific weight, grade, and class of livestock needed to fill their order requirements. Thus, marketing expenses per unit of livestock handled are higher than they would be in markets having larger volumes. There is evidence that the efficiency with which livestock are assembled and processed through primary markets in an area influences the price producers receive for their livestock relative to prices in other producing areas.[13]

Costs per unit of livestock marketed are also higher than they should be because of poorly located market facilities.[14] Once auction markets are built, there is a tendency toward asset fixity since the facilities have few alternative uses. Therefore, poorly located markets continue to operate so long as revenue exceeds variable costs.

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[13] W. K. McPherson, "How Well Do Auctions Discover the Price of Cattle?" Journal of Farm Economics, Vol. 38, No. 1, February, 1956, pp. 30-43.

[14] Development of the trucking industry accompanied by an expanded and improved highway system enabled auction markets to locate close to livestock producing areas, whereas terminal markets when they began operation were compelled to locate at railroad centers.

These markets may be forced out of business only because the market facilities become worn and obsolete.[15] While such markets are in operation, however, livestock are frequently diverted from the larger, more efficient auctions.[16] Thus, location not only affects the operation of a particular firm, but also affects the efficiency of other firms in the industry.

III. OBJECTIVES OF THE STUDY

This study is concerned with the "operational" efficiency of livestock auction markets in the state as opposed to "pricing" efficiency.[17] It is recognized, however, that an improved physical marketing system would also be more efficient in establishing equitable prices. Primary concern is with long-run adjustments in minimizing

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[15] Wootan and McNeely, loc. cit. Even then, civic pressure for a local market as well as an apparent abundance of risk capital for this purpose may result in the market being refinanced and operation resumed under new management.

[16] Glenn Grimes and Charles Cramer, Missouri Livestock Auction Markets--Operating Costs and Returns, Circular Bulletin 833 (Columbia: The University of Missouri Extension Division, February, 1966), p. 3. In this study, it was found that over 50 percent of the auction markets in Missouri had changed ownership within a five year period prior to 1962.

[17] Marketing efficiency can be divided into two categories, operational efficiency and pricing efficiency. Operational efficiency is concerned with the output of goods and services relative to the cost of the resources utilized to produce those goods and services. It assumes the nature of output of goods and services remains unchanged and is concerned primarily with reducing the cost of inputs of performing the marketing functions. Pricing efficiency is concerned with the rapidity and accuracy with which equitable prices are established at all market levels. Williams and Stout, op. cit., pp. 120-125.

the combined costs of assembling and selling annual livestock marketings of Tennessee producers. The problem centers on: (1) where to locate the markets, (2) what area each market should serve, and (3) the size of the market to handle the number of livestock marketed. Resolving this problem should aid those serving industry groups, farm organizations, and government regulatory agencies who are interested in improving the organizational structure of the marketing system.

Specific objectives are: (1) to determine the number, size, and location of livestock auction markets in the state that would minimize the combined transportation and market costs in assembling and selling the annual livestock marketings of Tennessee producers, and (2) to determine the area to be served by each of these auctions.

The model and analytical methods used to develop the required data are presented in the following chapter.

CHAPTER II

THE MODEL AND ANALYTICAL METHODS USED

I. THE MODEL

Specification of the number, size, and location of livestock auction markets in Tennessee is based on the premise that the annual supply of livestock marketed in the state must be assembled at primary markets and sold at least cost. Assuming transportation costs are an increasing function of distance traveled, the total assembly cost for a given number of livestock would decline as the number of market destinations is increased. Conversely, given economies of scale in livestock auction market operations over the relevant range in livestock volume, total market costs would increase as the number of auction markets is increased. To resolve the objectives of this study, a model is needed which provides a method of minimizing the combined costs of assembling the annual volume of livestock marketed in varying numbers from the 95 counties of Tennessee and, then, selling the total supply at one or more possible market locations. A model developed by John F. Stollsteimer[1] and extended by Leo Polopolus[2] to encompass multiple

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[1]John F. Stollsteimer, "A Working Model for Plant Numbers and Location," Journal of Farm Economics, Vol. 45, No. 3, August, 1963, pp. 631-645.

[2]Leo Polopolus, "Optimum Plant Numbers and Locations for Multiple Product Processing," Journal of Farm Economics, Vol. 47, No. 2, May, 1965, pp. 287-295.

products provides the analytical procedure for obtaining the desired solution.[3] The minimization procedure of selecting the number, size, and location of auction markets, however, requires the assembly and market cost functions be expressed as a function of the number of markets.

A special computer program has been developed to derive the minimum total assembly cost function in relation to a varying number of markets.[4] Input data used in the computer program are: (1) the number of each species of livestock marketed in each county (origin),[5] (2) the location of potential auction market sites, and (3) the cost of transporting each species of livestock from each origin to each potential auction market site. The program then selects that combination

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[3]Some of the other empirical studies making use of this model include: Gene A. Mathia and Richard A. King, Planning Data for the Sweet Potato Industry: 3. Selection of the Optimum Number, Size and Location of Processing Plants in Eastern North Carolina, A. E. Information Series 97 (Raleigh: North Carolina State College, December, 1962); R. J. Peeler, Jr., and Richard A. King, Optimum Location of Egg Grading and Packing Plants in North Carolina, A. E. Information Series 111 (Raleigh: North Carolina State of the University of North Carolina at Raleigh, March, 1964).

[4]The basic computer program was furnished by Dr. Leo Polopolus, University of Florida, Gainesville, Florida.

[5]Producers do not normally sell "livestock" as such. For example, just within the bovine species, producers may bring to market cows, bulls, slaughter steers and heifers, feeder cattle, calves, etc. The point is that the different species and classes of livestock are sold as individual products and must receive separate treatment in the market. Four "products" were considered in this study as follows: (1) cattle, (2) calves, (3) hogs, and (4) sheep. Cattle are defined as bovine animals weighing over 500 pounds. Calves, therefore, are defined as bovine animals weighing under 500 pounds.

of potential auction market sites which minimizes total assembly costs for any given number of markets, and therefore for various numbers of markets. In other words, the computer program first selects the one market out of all potential markets which minimizes the total cost of transporting all livestock from all origins to one market. On the next iteration, two markets are selected out of the combination of all potential markets taken two at a time which minimize the total transportation cost. Livestock marketings at each origin are sent to the market site that minimizes transportation costs for that origin. This process is continued until the total number of potential markets are all considered at one time. In this case there can be only one "combination" of markets and one total transportation cost. An illustration of the general relationship between total assembly costs for a given number of livestock and varying numbers of markets is shown in Figure 1.

In this study it is assumed that auction market costs are independent of location. This assumption requires that markets at different locations use the same operating techniques and that factor prices are the same at each location. Under this assumption, the same operating cost curve would be obtained at every market location. It is further assumed that the total (annual) auction market cost function with respect to volume is linear and positively sloping with a positive intercept (Figure 2). The positive intercept represents "fixed costs," or according to Stollsteimer," . . . the minimum average annual long-run

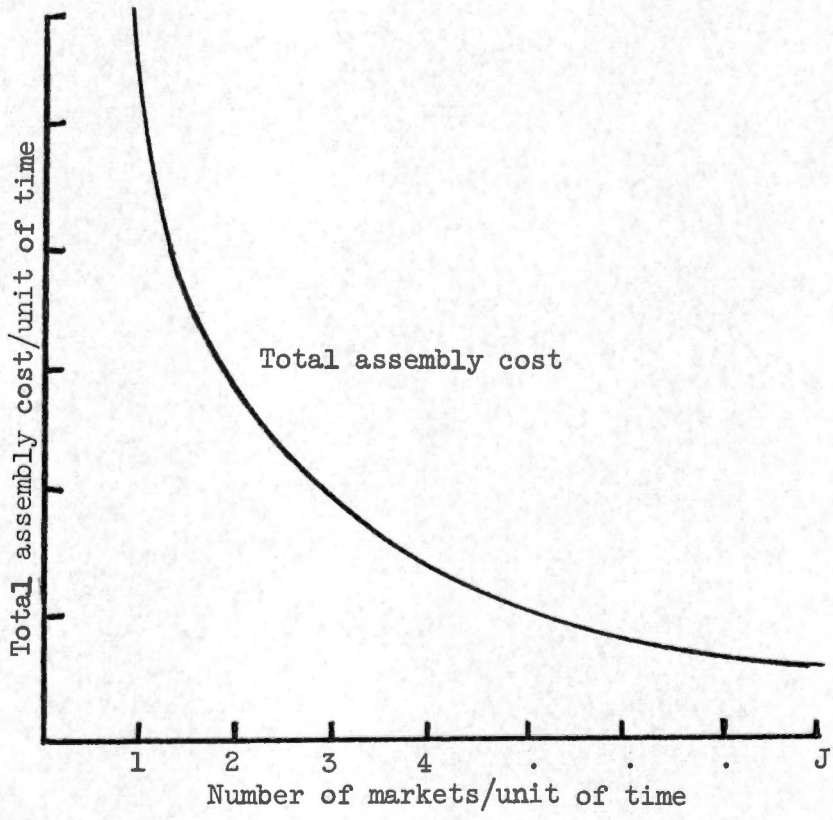


Figure 1. Total assembly cost with respect to varying numbers of markets.

Source: R. J. Peeler, Jr. and Richard A. King, Optimum Location of Egg Grading and Packing Plants in North Carolina, A. E. Information Series No. 111 (Raleigh: North Carolina State of the University of North Carolina, March, 1964), p. 8.

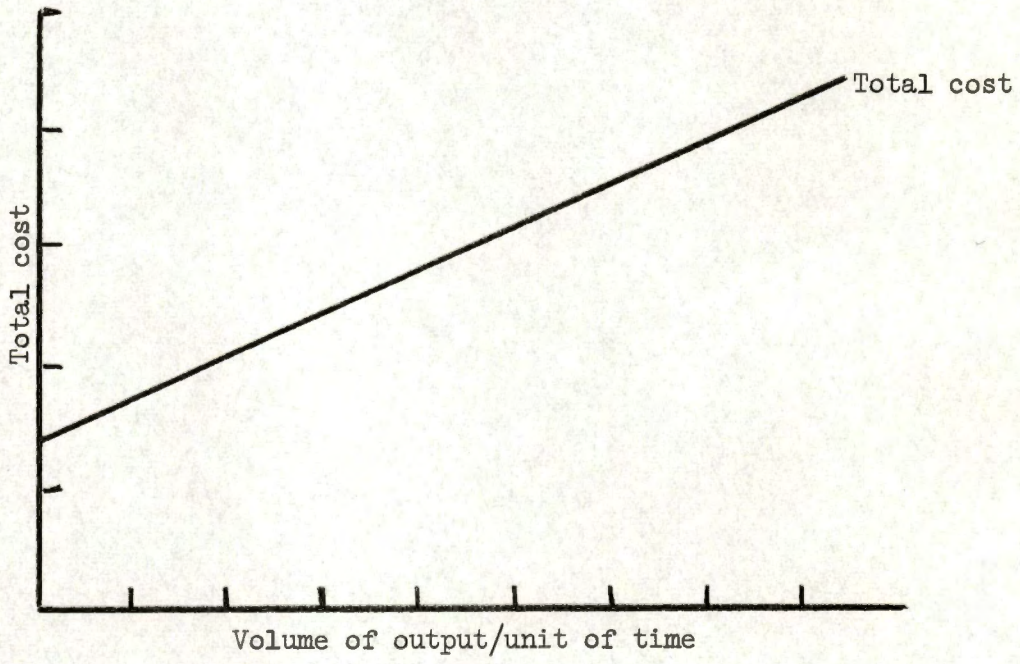


Figure 2. Linear total cost function for each firm.

Source: R. J. Peeler, Jr. and Richard A. King, Optimum Location of Egg Grading and Packing Plants in North Carolina, A. E. Information Series No. 111 (Raleigh: North Carolina State of the University of North Carolina, March, 1964), p. 8.

cost of establishing and maintaining a . . . [market]."[6] The required function is obtained by converting the annual market cost function as related to volume to a function relating the annual market cost for a given number of livestock to varying numbers of markets. The annual market cost for a given number of livestock is obtained for any number of markets, J, by increasing the annual market cost by (A), the amount it costs to establish and maintain one additional market (Figure 3).[7]

Summation of the relationships shown in Figures 1 and 3 provides a method for determining the number of markets with the minimum combined annual livestock assembly and auction market costs. The combined cost function depicting a hypothetical least cost number of markets is shown in Figure 4. The number of markets which minimize total costs is found where the absolute change in annual assembly costs are just offset by the absolute change in annual market costs. Stated in another manner, the desired least cost (optimum) number of markets is obtained by selecting the number with the minimum combined cost. Once the optimum (least cost) number of markets is determined, market locations can be ascertained by identifying from the computer results the market sites which minimize total assembly costs for that particular number of markets. The computer program also provides information as to where the supply of livestock should be shipped by assigning livestock from each

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[6]Stollsteimer, op. cit., p. 636.

[7]Figure 3 is consistent with the assumed economies of scale. For evidence of the existence of economies of scale see references cited in footnote 4.

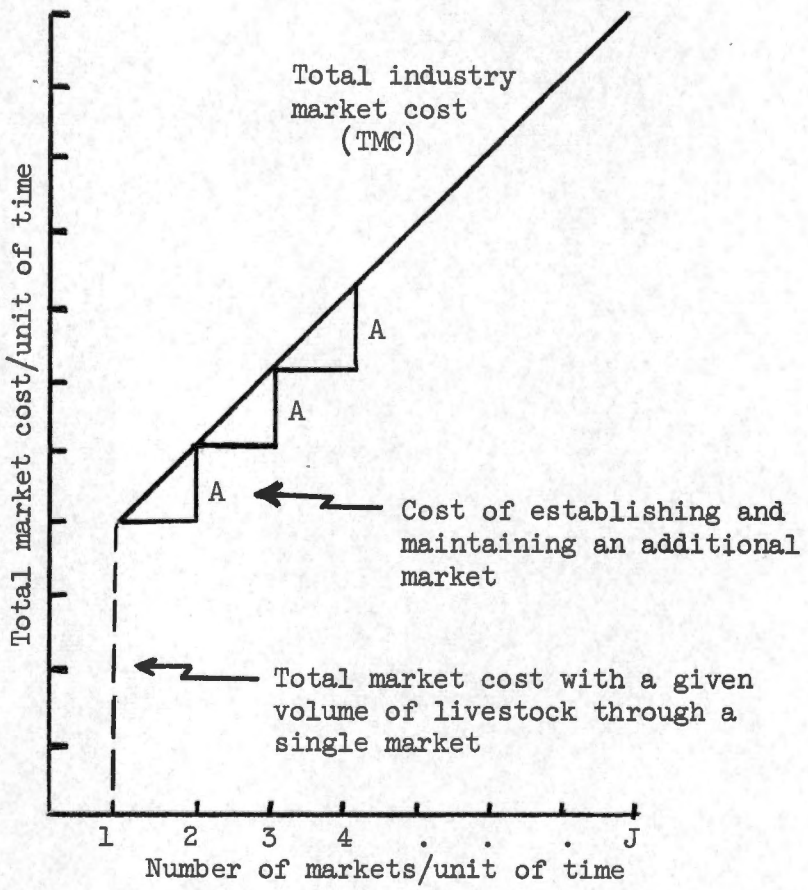


Figure 3. Total industry operating cost with respect to varying numbers of markets.

Source: Adapted from R. J. Peeler, Jr. and Richard A. King, Optimum Location of Egg Grading and Packing Plants in North Carolina, A. E. Information Series No. 111 (Raleigh: North Carolina State of the University of North Carolina, March, 1964), p. 12.

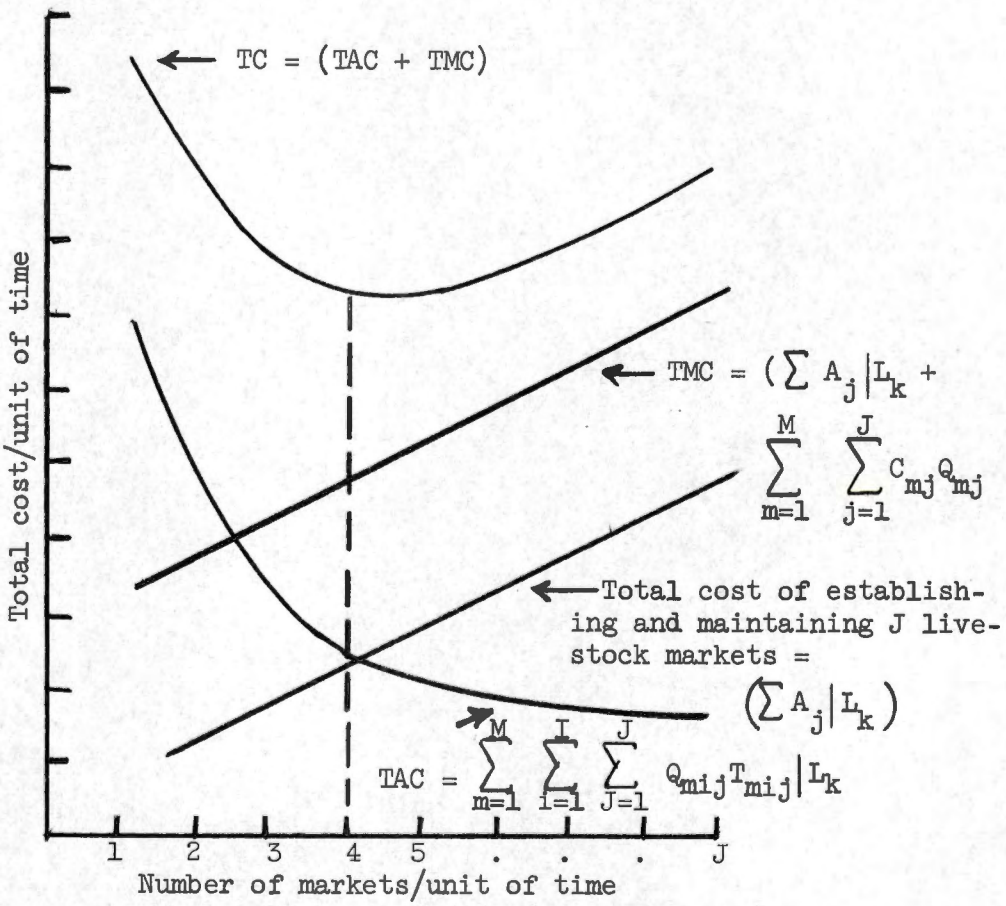


Figure 4. Combined industry total cost with respect to varying market numbers.

Source: Adapted from R. J. Peeler, Jr. and Richard A. King, Optimum Location of Egg Grading and Packing Plants in North Carolina, A. E. Information Series No. 111 (Raleigh: North Carolina State of the University of North Carolina, March, 1964), p. 13.

origin to the market which minimizes assembly costs for that origin. The assignment of a known supply of livestock from a given area to a specific destination implies a definite market size. Under the added assumption that transportation costs from each market to the next destination (farm, slaughterhouse, or feedlot) are the same regardless of where the markets are located, this procedure yields the most efficient set of livestock markets for a given marketing method, for example, auction markets. Algebraically, the model may be stated as follows:

$$TC_{(J,L_k)} = \sum_{j=1}^{J} A_j \Big| L_k + \sum_{m=1}^{M} \sum_{j=1}^{J} C_{mj} Q_{mj} + \sum_{m=1}^{M} \sum_{i=1}^{I} \sum_{j=1}^{J} Q_{mij} T_{mij} \Big| L_k$$

with respect to market number ($J \leq L$) and locational pattern L_k = 1, 2, . . . $\binom{L}{J}$[8] subject to:

$\sum_{j=1}^{J} Q_{mij} = Q_{mi}$ = number of livestock m available at origin i per year; a constant.

$\sum_{i=1}^{I} Q_{mij} = Q_{mj}$ = number of livestock m sold at market j per year.

$\sum_{i=1}^{I} \sum_{j=1}^{J} Q_{mij} = Q_m$ = total number of livestock m produced and sold per year; a constant.

$\sum_{m=1}^{M} \sum_{i=1}^{I} \sum_{j=1}^{J} Q_{mij} = Q$ = total number of all livestock produced and sold per year; a constant.

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[8] $\binom{L}{J}$ denotes the total possible combinations of L locations taken J at a time: $\binom{L}{J} = \frac{L!}{(L-J)!\, J!}$, where $j \leq L$.

$$Q_{mij},\ Q_{mj},\ Q_{mi} \geq 0 \text{ and } A_j,\ T_{mij} > 0$$

where

TC = total market operating and assembly cost.

I = livestock origins.

M = livestock (cattle, calves, hogs, and sheep).

L = potential market locations.

J = number of livestock markets.

A_j = cost of establishing and maintaining a livestock market.

C_{mj} = unit operating cost of selling livestock m in market j ($j = 1 \ldots J \leq L$) located at L_j; a constant over all j and L_j.

Q_{mij} = number of livestock m shipped from origin i to market j located at L_j.

T_{mij} = unit cost of shipping livestock m from origin i to market j located at L_j.

L_k = minimum assembly cost locational pattern for J markets among the $\binom{L}{J}$ possible combinations of locations for J markets given L possible locations.

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

The object is to minimize the total cost equation with respect to market numbers J and locational pattern L_k. This can be done in a three-step process.[9] The first step is to compute an assembly cost

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[9] Stollsteimer, op. cit., pp. 634-638.

function which is minimized with respect to market locations for varying numbers of markets for each livestock m. The minimized assembly costs of the livestock m are then aggregated with regard to market numbers and locational pattern.[10]

The second step in minimizing the total cost function is to derive the auction market cost function for selling a given number of livestock m in varying numbers of markets. Under the assumption of constant and equal marginal operating costs for all markets and a positive intercept, the total cost of selling all of the livestock will increase by the amount of the intercept value with each additional market.

Finally, the total assembly cost function and the total auction market cost function for varying numbers of markets are combined to derive the total cost function.

II. MARKET DETERMINATION UNDER VARIOUS POSTULATES

Tennessee producers in general accept the auction method of selling livestock. However, auction markets constitute only a part of the primary livestock marketing system, therefore, one would not expect all livestock marketed by producers in the state to be sold through auction markets. For example, about 50 percent of Tennessee's 1968 hog marketings were sold through auction agencies. The other 50 percent were sold to dealers, direct to packers, or through other outlets. Auctions are

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[10] This part of the computational technique is given in Polopolus, op. cit., pp. 289-290.

relatively more important as a market outlet for cattle and calves than for hogs. In 1968, 1,025,000 head of cattle and calves were sold in Tennessee auction markets[11] compared with total producer sales of 1,037,000 head.[12] Many cattle and calves are assigned by dealers and other market agencies to the auctions.

The total number of livestock marketed also varies considerably from one period of time to another. Through time, cattle marketings in the state have been increasing steadily. In 1958, cattle marketings were 395,000 head[13] compared with 598,000 in 1968.[14] This was an increase of about 51 percent. Calf marketings, on the other hand, have increased over the same period by only 7 percent. Hog marketings in the state have fluctuated with the production cycle, however, marketings have remained fairly stable over longer periods of time.

Determination of the optimum solution relative to the number, size, and location of livestock auction markets is made under each of the following postulated conditions:

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[11]Tennessee Department of Agriculture, unpublished reports.

[12]United States Department of Agriculture, Livestock and Meat Statistics, Supplement for 1968 to Statistical Bulletin 333 (Washington, D. C.: Government Printing Office, July, 1969), p. 30.

[13]United States Department of Agriculture, Livestock and Meat Statistics, Supplement for 1959 to Statistical Bulletin 333, p. 28.

[14]United States Department of Agriculture, Livestock and Meat Statistics, Supplement for 1968 to Statistical Bulletin 333, p. 30.

1. That total annual livestock marketings, with the exception of sales from one producer to another,[15] be sold through auction agencies.

2. That the total volume of livestock sold through auction agencies be composed of annual cattle marketings increased by 25 percent, annual hog marketings decreased by 50 percent, and with no change in the annual marketings of calves and sheep.

3. That the annual cost of assembling livestock under conditions stated in (1) and (2) above be increased by 10 percent from the original estimate and then decreased by 10 percent from the original estimate.

III. SOURCES OF DATA

Data required to determine the optimum number, size, and location of livestock auction markets in the state include: (1) the estimated volume of livestock in each county, (2) a transportation cost matrix which specifies the estimated cost of transporting the livestock from each county to each potential market location, and (3) the estimated cost of performing the auction market functions. The information needed to make these estimates is obtained from secondary sources.

Sources of data used to develop the estimated volume of livestock marketed in each county are:

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[15] In the process of estimating county sales, marketings on a statewide basis were used which exclude interfarm sales. Ibid., pp. 28-37.

1. The 1959 and 1964 United States Censuses of Agriculture which provide county estimates for the 1959 and 1964 livestock inventory and the number of livestock sold.[16]

2. Livestock and Meat Statistics for 1959, 1964, and 1968 which provide state estimates of the number of livestock sold based on the method used for making such estimates by the United States Department of Agriculture, Statistical Reporting Service, Crop Reporting Board.[17]

3. Tennessee Agricultural Statistics, Annual Bulletin--1968 which provies estimates of the January 1, 1965-1968, county livestock inventories.[18]

The basic transportation cost function used in the study is adjusted from the transportation cost function derived by Miller and Henning in their Ohio study.[19] Distances from points of origins to

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[16]United States Department of Commerce, Bureau of the Census, 1959 United States Census of Agriculture, Tennessee, Vol. 1, Part 31 (Washington, D. C.: United States Government Printing Office, 1961); United States Department of Commerce, Bureau of the Census, 1964 United States Census of Agriculture, Tennessee, Vol. 1, Part 31 (Washington, D. C.: United States Government Printing Office, 1967).

[17]United States Department of Agriculture, Livestock and Meat Statistics, Supplement for 1960 to Statistical Bulletin 333 (Washington, D. C.: Government Printing Office, June, 1961); United States Department of Agriculture, Livestock and Meat Statistics, Supplement for 1965 to Statistical Bulletin 333 (Washington, D. C.: Government Printing Office, August, 1966); Livestock and Meat Statistics, Supplement for 1968 to Statistical Bulletin 333.

[18]United States Department of Agriculture, Statistical Reporting Service and Tennessee Department of Agriculture, Tennessee Agricultural Statistics, Annual Bulletin 1968 (Nashville: Tennessee Crop Reporting Service, August, 1968).

[19]Edgar A. Miller and George F. Henning, Suggested Location of Ohio Livestock Markets to Reduce Total Marketing Costs, Research Bulletin 981 (Wooster: Ohio Agricultural Research and Development Center, February, 1966), p. 1.

potential market locations are obtained from the "Official Map of Tennessee Highways, 1969."[20]

To estimate the cost of performing auction market functions, Tennessee data on volume estimates are applied to the basic market cost function developed by Gibb in his Michigan study in 1959.[21]

IV. POTENTIAL AUCTION MARKET LOCATIONS AND LIVESTOCK ORIGINS

Potential Market Locations

Within any given area there are an infinite number of potential market sites. However, the number of potential market locations that could be considered at one time in the assembly cost matrix is limited to a maximum of 12 due to computer restrictions. To avoid an arbitrary selection of the "optimum" locations, more than 12 market locations for the entire state should be considered even if the optimum number of markets should happen to be 12 or less. It is necessary, therefore, to divide the state into its three Grand Divisions--West, Middle, and East Tennessee--for analytical purposes. Because of the small size of West Tennessee compared with Middle and East Tennessee, only 11 potential market sites are allowed to enter the transportation cost matrix

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[20] Tennessee Department of Highways, "Official Map of Tennessee Highways, 1969" (Nashville: Tennessee Department of Highways, February, 1969).

[21] R. D. Gibb, "Economics of Scale in Michigan Livestock Auctions" (Unpublished Ph. D. dissertation, Michigan State University, 1959).

for that area. Thus, for the state as a whole, the total number of potential market locations is 35. All demand for services of livestock markets is assumed to be concentrated at these potential locations.

In an attempt to select objectively the 35 potential livestock auction market locations, each of the three Grand Divisions of the state was further subdivided. For example, West Tennessee was divided into three subareas. The computer program was then used to derive the minimum total assembly cost function in relation to a varying number of markets in each of the subareas. In this manner, one location in each of the 95 counties had an opportunity to be included in the final list of 35 potential market locations. However, only two to a maximum of four locations could be selected from each subarea due to the limit of 12 markets for each Grand Division. The potential markets chosen from the subareas were selected on the basis of the number of times they appeared in the minimum cost combinations of markets with market numbers varying from one to twelve.

In most cases, the county seat was selected as the potential market location for that county. However, in order to more centrally localize the potential market sites in Obion and Shelby Counties, Troy is substituted for Union City in Obion County and the intersection of U. S. highways 64 and 70 is substituted for Memphis in Shelby County.[22] Johnson City, because of its proximity to the uppermost counties of

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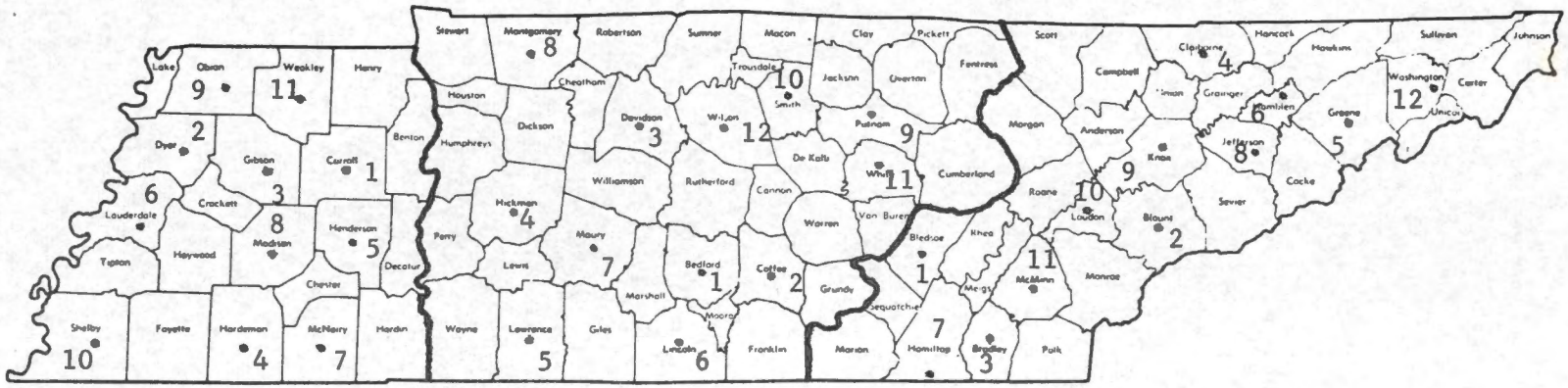
[22]However, the Shelby County location is still referred to in this study as "Memphis."

East Tennessee, is substituted for Jonesboro in Washington County. Chattanooga, although it is situated on the southernmost border of Hamilton County, is allowed in the transportation matrix, because rivers and lakes prohibit cross county travel.

Other sets of potential market locations could be selected which would yield a more efficient assembly cost function. Even by dividing the Grand Divisions into subareas, only one location per county could be included in the assembly cost matrix, therefore, a number of places had to be overlooked. If it had been feasible to consider all possible locations, some of the additional locations would likely replace those selected. Newbern, for example, could be regarded as a close substitute for Dyersburg. The final solution that included Dyersburg would most likely have included Newbern, if that site had been substituted in the computer program. However, the method used appears to have some merit over a strictly arbitrary selection. The computer program weighs each site with respect to production density in the immediate area and its location relative to all origins in the subarea. A map showing the final group of 35 potential livestock market sites and their location within the Grand Divisions of Tennessee is given in Figure 5.

Livestock Origins

Each of the 95 counties in Tennessee is considered as a distinct production area. Livestock availability is assumed to be concentrated at a central point in each of the counties (origins). With but three exceptions, county seats serve as the points of origin. Again, Troy is



• Potential livestock auction market locations

West Tennessee	Middle Tennessee	East Tennessee
1. Huntingdon	1. Shelbyville	1. Pikeville
2. Dyersburg	2. Manchester	2. Maryville
3. Trenton	3. Nashville	3. Cleveland
4. Bolivar	4. Centerville	4. Tazewell
5. Lexington	5. Lawrenceburg	5. Greeneville
6. Ripley	6. Fayetteville	6. Morristown
7. Selmer	7. Columbia	7. Chattanooga
8. Jackson	8. Clarksville	8. Dandridge
9. Troy	9. Cookeville	9. Knoxville
10. Memphis	10. Carthage	10. Loudon
11. Dresden	11. Sparta	11. Athens
	12. Lebanon	12. Johnson City

Figure 5. Location of potential livestock auction markets within the three Grand Divisions of Tennessee.

substituted for Union City in Obion County, the intersection of U. S. highways 64 and 70 is substituted for Memphis in Shelby County, and Johnson City is substituted for Jonesboro in Washington County. There is no dividing of counties to achieve a unique set of supply boundaries for the potential market locations, since the smallest area for which livestock marketings are estimated is the county. It is assumed that livestock produced in any origin within a Grand Division can be shipped to any of the potential market locations within that same Grand Division. Any flow of producer owned livestock out of an area is assumed to be exactly offset by producer owned livestock entering into the area.

V. ESTIMATED VOLUME OF LIVESTOCK MARKETINGS

The most recent data on the number of cattle, calves, hogs, and sheep sold in Tennessee by counties are those reported in the 1964 Census of Agriculture.[23] However, marked changes have taken place in the state's production and marketing of livestock since 1964. In 1968, for example, there were 16 percent more cattle, 10 percent more calves and 11 percent more hogs sold than in 1964. Over the same period, sheep and lamb sales declined 45 percent.[24] Furthermore, substantial changes in livestock production occurred between counties. The 1964 census

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[23] United States Department of Commerce, Bureau of the Census, 1964 United States Census of Agriculture, pp. 358-367.

[24] United States Department of Agriculture, Livestock and Meat Statistics, Supplement for 1965 to Statistical Bulletin 333, pp. 27-28; Livestock and Meat Statistics, Supplement for 1968 to Statistical Bulletin 333, pp. 28-39.

data, therefore, were considered inadequate to achieve the objectives of this study.

The method used to estimate the number of livestock marketed in each county by species consists of a number of steps, and these steps are slightly different for each species. The base year for which the livestock estimates are made is 1968.

Cattle

The first step in estimating county cattle sales for 1968 is to obtain from the 1959 and 1964 Censuses of Agriculture data on the number of cattle sold for these years in Tennessee by counties. These data are then converted to new estimates of the number of cattle sold based upon the method used by the Crop Reporting Board for making such estimates.[25] The conversion factors for estimating the number of cattle

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[25]Three reasons are given for converting the census data to Crop Reporting Board equivalents:

1. The Crop Reporting Board, SRS, USDA publish annual (and, therefore, 1968) estimates of state livestock marketings.
2. The estimates exclude interfarm sales, an exclusion which is required for this study.
3. The Crop Reporting Board's definition of "cattle" and "calves"is specific and the same as the one used in this study. In the census questionnaire, farmers, especially in Tennessee, may include yearling cattle in their "calf" sales instead of reporting them in their "cattle" sales. In 1964, for example, the Crop Reporting Board estimated cattle sales to be 1.5 times greater than the count given in the census that year. Calf sales were correspondingly only a little over one-half as great.

sold are 1.1381 and 1.5283, respectively, for 1959 and 1964.[26] An average is then taken of the 1959 and the 1964 estimates of cattle sold per county. This procedure yields the following results, for example, for Bedford County:

$$\frac{\left[\begin{array}{l}\text{Number of cattle sold, 1959 census} \times \text{Conversion factor} \\ + \text{Number of cattle sold, 1964 census} \times \text{Conversion factor}\end{array}\right]}{2} =$$

Average number of cattle sold, 1959 and 1964

$$\frac{6{,}334\ (1.1381) + 6{,}160\ (1.5253}{2} = 8{,}303$$

The second step is to obtain an average of the inventory of cattle and calves on farms by counties for the years 1959 and 1964.[27] The third step is to divide the average cattle sales by counties derived in step one by the average inventories of cattle and calves in the respective counties derived in step two to obtain estimates of the proportion

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[26]The conversion factors are obtained in the following manner:
For 1959, the Crop Reporting Board estimate of state cattle marketings divided by the Census of Agriculture report of state cattle marketing yields 1.1381 (366,000 ÷ 321,595 = 1.381), Livestock and Meat Statistics, Supplement for 1960 to Statistical Bulletin 333, p. 29; 1959 Census of Agriculture, p. 10.
For 1964, the same procedure yields 1.5253 (503,000 ÷ 329,771 = 1.5253), Livestock and Meat Statistics, Supplement for 1965 to Statistical Bulletin 333, p. 27; 1964 Census of Agriculture, p. 13.

[27]The county inventory estimates are obtained from 1959 Census of Agriculture, pp. 200-207; 1964 Census of Agriculture, pp. 348-357.

of cattle sold out of the inventories.[28] The results, for example, for Bedford County are as follows:

$$\text{Average number of cattle sold, 1959 and 1964} \div \frac{\left[\text{Inventory of cattle and calves, 1959} + \text{Inventory of cattle and calves, 1964}\right]}{2} = \text{Proportion of cattle sold out of the 1959 and the 1964 inventory}$$

$$8{,}303 \div \frac{37{,}145 + 44{,}462}{2} = .20348$$

The fourth step is to multiply the historical estimates of the proportion of cattle sold out of inventory by the January 1, 1968, inventory of cattle and calves.[29] This step provides an estimate of the number of cattle sold based on the historical 1959 and the 1964 sales-inventory relationship. The final step is to distribute among the counties any difference that may exist between the aggregated county data derived in step four and the 1968 state sales estimate published by the Crop Reporting Board.[30] This is accomplished by applying an adjustment factor of 1.1629 to each of the historically derived county

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[28] Data are not available on the number of cattle, that is, bovine animals weighing 500 pounds or more, in the January 1 inventory. The data include calves as well as cattle.

[29] The January 1, 1968 county inventory estimates are obtained from Tennessee Agricultural Statistics, Annual Bulletin 1968, pp. 60-61.

[30] This estimate is given as 598,000 head of cattle sold in Livestock and Meat Statistics, Supplement for 1968 to Statistical Bulletin 333, p. 31.

cattle sales estimates.[31] The final results, again for Bedford County, are as follows:

$$\left[\begin{array}{l}\text{January 1, 1968}\\ \text{inventory of}\\ \text{cattle and calves}\end{array} \times \begin{array}{l}\text{Proportion of cattle}\\ \text{sold out of the 1959}\\ \text{and the 1964 inventory}\end{array}\right] \times \begin{array}{l}\text{Adjustment}\\ \text{factor}\end{array} = \begin{array}{l}\text{Estimated number}\\ \text{of cattle sold}\\ \text{in 1968}\end{array}$$

$$(55{,}000 \times .20348) \times 1.16285 = 13{,}014$$

Calves

The process of estimating the number of calves marketed in 1968 in Tennessee by counties is exactly the same as that described for estimating cattle numbers. The step-by-step procedure is illustrated using Bedford County data as follows:

$$\frac{\left[\begin{array}{l}\text{Number of}\\ \text{calves sold,}\\ \text{1959 census}\end{array} \times \begin{array}{l}\text{Conversion}^{32}\\ \text{factor}\end{array} + \begin{array}{l}\text{Number of}\\ \text{calves sold,}\\ \text{1964 census}\end{array} \times \begin{array}{l}\text{Conversion}^{32}\\ \text{factor}\end{array}\right]}{2} = \begin{array}{l}\text{Average number of}\\ \text{calves sold, 1959}\\ \text{and 1964}\end{array}$$

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[31] The adjustment factor is derived by dividing the 1968 Crop Reporting Board estimate of state cattle marketings by the sum of all county cattle marketings derived in step four (598,000 ÷ 514,252 = 1.16285).

[32] The Census of Agriculture account of the number of calves sold is also converted to new estimates of the number of calves sold based upon the method used by the Crop Reporting Board. For 1959, the Crop Reporting Board estimate of the number of calves sold in Tennessee divided by the census report of numbers sold yields a factor of .6687 (345,000 ÷ 515,947 = .6687), Livestock and Meat Statistics, Supplement

$$\frac{11,950 \times .6687 + 15,747 \times .5475}{2} = 8,306$$

$$\text{Average number of calves sold, 1959 and 1964} \div \frac{\left[\text{Inventory of cattle and calves, 1959} + \text{Inventory of cattle and calves, 1964}\right]}{2} = \text{Proportion of calves sold out of the 1959 and the 1964 inventory}$$

$$8,306 \div \frac{37,145 + 44,462}{2} = .20356$$

$$\left[\text{January 1, 1968 inventory of cattle and calves} \times \text{Proportion of calves sold out of the 1959 and 1964 inventory}\right] \times \text{Adjustment factor}^{33} = \text{Estimated number of calves sold in 1968}$$

$$(55,000 \times .20356) \times .9921 = 11,108$$

Hogs

The same method used to obtain the 1968 county estimates of cattle and calves marketed gave erratic and questionable estimates of hog marketings for several of the counties. Therefore, a slightly different

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for 1960 to Statistical Bulletin 333, p. 29; 1959 Census of Agriculture, p. 10.

The same procedure for 1964 gives a conversion factor of .5475 (399,000 ÷ 728,715 = .5475), Livestock and Meat Statistics, Supplement for 1965 to Statistical Bulletin 333, p. 27; 1964 Census of Agriculture, p. 13.

[33]The adjustment factor is obtained by dividing the 1968 Crop Reporting Board estimate of state calf marketings by the sum of all county calf marketings derived by multiplying the proportion of calves sold out of the 1959 and the 1964 inventory by the January 1 inventory of cattle and calves. The adjustment factor is .9921 (439,000 ÷ 442,485 = .9921). The 1968 Crop Reporting Board estimate of 439,000 head of calves sold is obtained from Livestock and Meat Statistics, Supplement for 1968 to Statistical Bulletin 333, p. 31.

method is used to estimate county hog marketings. The method adopted requires that the number of hogs sold as reported in the 1964 Census of Agriculture by counties be converted to the number of hogs sold based upon the method used by the Crop Reporting Board for making such estimates.[34] The next step is to determine the changes in state as well as county hog inventories between January 1, 1965, and January 1, 1968. For the state, there was an increase of 74,000 hogs.[35] Next, it is necessary to calculate the change in hog marketings for the state as a whole between 1964 and 1968. In 1968, the number of hogs sold by Tennessee producers was 130,000 more than was sold in 1964.[36] Thus, the increase in state hog marketings was 1.76 times greater than the increase in inventory. Multiplying this factor of 1.76 times the change in the individual county hog inventories provides an estimate of the change in hog marketings between 1964 and 1968 for each county. By combining these results with the 1964 county marketings, estimated 1968 hog marketings are obtained for the 95 counties. Once again the procedure is illustrated using Bedford County data as follows:

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[34]The conversion factor is obtained by dividing the Crop Reporting Board estimate of hog marketings by the census report of state hog marketings. In this case the conversion factor is 1.0406 (1,539,000 ÷ 1,478,932 = 1.0406). Livestock and Meat Statistics, Supplement for 1965 to Statistical Bulletin 333, p. 31; 1964 Census of Agriculture, p. 13.

[35]Tennessee Agricultural Statistics, Annual Bulletin 1968, pp. 62-63.

[36]Livestock and Meat Statistics, Supplement for 1965 to Statistical Bulletin 333, p. 31; Livestock and Meat Statistics, Supplement for 1968 to Statistical Bulletin 333, p. 34.

$$\left[\begin{array}{l}\text{Number of}\\ \text{hogs sold,}\\ \text{1964 census}\end{array} \times \begin{array}{l}\text{Conversion}\\ \text{factor}\end{array}\right] + \left[\begin{array}{l}\text{Change in}\\ \text{the Jan. 1}\\ \text{county hog}\\ \text{inventory}\\ \text{between}\\ \text{1965 and}\\ \text{1968}\end{array} \times \frac{\begin{array}{l}\text{Change in state}\\ \text{marketings be-}\\ \text{tween 1964 and}\\ \text{1968}\end{array}}{\begin{array}{l}\text{Change in state}\\ \text{inventory, be-}\\ \text{tween 1965 and}\\ \text{1968}\end{array}}\right] = \begin{array}{l}\text{Estimated number of}\\ \text{hogs sold, 1968}\end{array}$$

$$(23{,}387 \times 1.0406) + (800 \times 1.7568) = 25{,}742$$

Sheep

There were only 37,000 sheep and lambs sold in Tennessee during 1968 out of a January 1 inventory of 57,000 head.[37] Due to the small size of this enterprise, compared to cattle, calves, and hogs, a simple method for estimating county marketings is used.

County marketings for 1968 are merely taken as the product of the number on farms in the respective counties and the ratio of sales to inventory for the state as a whole.[38] For those counties with under 100 sheep on farms as of January 1, 1968, the resulting sales figure is assumed to be zero.[39] The estimated number of sheep and lambs sold in 1968 in those counties having more than 100 sheep on farms as of

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[37] Livestock and Meat Statistics, Supplement for 1968 to Statistics Bulletin 333, p. 38.

[38] The January 1, 1968 county inventory estimates are obtained from Tennessee Agricultural Statistics, Annual Bulletin 1968, pp. 60-61.

[39] The Tennessee Crop Reporting Service does not provide county estimates for counties where the sheep inventory as of January 1 is under 100 head.

January 1 is calculated as follows with Bedford County data used in the example:

$$\left[\begin{array}{l}\text{January 1, 1968}\\ \text{county inventory}\\ \text{of sheep and lambs}\end{array}\right] \times \left[\frac{\begin{array}{l}\text{State marketings of}\\ \text{sheep and lambs, 1968}\end{array}}{\begin{array}{l}\text{January 1, 1968 state}\\ \text{inventory of sheep}\\ \text{and lambs}\end{array}}\right] = \begin{array}{l}\text{Estimated number}\\ \text{of sheep and}\\ \text{lambs sold, 1968}\end{array}$$

$$5{,}200 \times \frac{37{,}000}{57{,}000} = 3{,}375$$

The estimated number of cattle and calves as well as hogs and sheep marketed in each county is presented for the Grand Divisions of the state in Appendix A, Tables 17-28.

VI. ASSEMBLY COSTS

Cost Functions

For the purpose of this study, it is assumed that the motor truck is the only relevant mode of transportation used to move livestock from farm to auction markets in Tennessee.[40] It is further assumed that the transportation cost paid by producers is a linear function of distance traveled and no additional assembly expenses are incurred.

An important factor affecting assembly costs is the natural terrain. Rough topography, rivers, reservoirs, and other impediments to land travel increase assembly costs. These natural and man-made

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[40] Jack D. Johnson, Livestock Marketing in the Southern Region, Southern Cooperative Series Bulletin 26 (Knoxville: Tennessee Agricultural Experiment Station, July, 1952), p. 91. This study reports that practically all livestock sold by producers to primary markets in the South were transported to market by truck.

obstructions influence the type and number of roads and bridges constructed in a given area. The network of roads acceptable for transporting livestock will determine the number of miles necessary to travel in transporting livestock to a given market location. A number of other factors also affect livestock transportation costs, such as the density of production and size of lot marketed. It is assumed in this study that transportation tariffs paid by producers reflect these factors.

The linear equation derived by Miller and Henning[41] is the basic function used to estimate costs of transporting livestock to auction markets in Tennessee. In order to use this function, however, it must be adjusted: (1) to reflect increases in livestock transportation costs since 1959, and (2) to reflect costs of transporting livestock on a per head per mile basis instead of on the basis of costs per hundredweight per mile.[42]

To make the first adjustment, the 1968 Index of Prices Paid by Farmers for production items of 111.4 (1957-59 = 100)[43] is used to

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[41]Miller and Henning, op. cit., p. 20. The authors obtained transportation cost data that Corn Belt farmers paid in 1959 for moving their livestock to market. From the cost data, the following linear regression equation was obtained: TC = .105393 + .0020278(X), where TC is the cost of transporting the livestock and X is the number of miles traveled.

[42]Since the auction market cost function is in dollars per head, the transportation cost function must also be expressed in dollars per head in order to derive the combined assembly and market cost function required to meet the study objectives.

[43]United States Department of Agriculture, The Farm Index (Washington, D. C.: Government Printing Office, February, 1970), p. 23. The Index of Prices Paid by Farmers for production items is a measure of the average changes in prices paid by farmers for goods and services used in production.

inflate the Miller and Henning transportation cost function. Thus, the adjusted function became:

$$TC = .117425 + .0022593\ (X)$$

where TC is the total cost of transporting livestock from farm to market in dollars per hundredweight per mile, and X is the distance in miles from the origin to the market location.

To make the second adjustment, the cost function is multiplied by the average weight per head of cattle, calves, hogs, and sheep marketed in Tennessee during 1968. This converts the cost function expressed in dollars per hundredweight per mile into four separate cost functions expressed in dollars per head per mile. The average weight per head is estimated at 921.9 pounds for cattle, 273.4 pounds for calves, 188.7 pounds for hogs, and 93.7 pounds for sheep.[44] Thus, the four desired transportation cost functions expressed in dollars per head per mile are:

$$Y_1 = 1.082573 + .0208289\ (X)$$

$$Y_2 = .321068 + .0061774\ (X)$$

$$Y_3 = .221546 + .0042626\ (X)$$

$$Y_4 = .110000 + .0021164\ (X)$$

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[44] Estimates of the average weight of cattle and calves are obtained from data contained in the following sources: Livestock and Meat Statistics, Supplement for 1968 to Statistical Bulletin 333, pp. 30-31; L. D. Malphrus, C. Y. Liu and R. J. Freund, Cattle and Calf Movement in the South, Southern Cooperative Series Bulletin 134 (Knoxville: Tennessee Agricultural Experiment Station, March, 1968). For further details on the method used to derive the estimates see Appendix B.

where Y_1, Y_2, Y_3, and Y_4 are the respective total costs per head per mile of transporting cattle, calves, hogs, and sheep; and X is the number of miles from the origin to the market location.

Cost Matrices

Assembly costs per head of livestock are computed between each origin and each potential market location in each of the three Grand Divisions of the state. Road miles from each origin to each potential destination are inserted in the transportation cost functions in order to make the computations. Only officially designated interstate, federal, or state highways are considered. In all cases where an origin is also a potential market site, an average distance of ten miles from farm to market is assumed. There is a per head assembly cost matrix for cattle, calves, hogs, and sheep for each of the Grand Divisions, or a total of 12 matrices (Appendix A, Tables 17-28).

Minimum Annual Assembly Costs

Given the assembly costs for each species and class of livestock and the number of each marketed annually per origin, annual assembly cost may then be derived. To obtain the minimum assembly cost function in relation to a varying number of markets, the computer program outlined in the first section of this chapter is used. Unit livestock assembly costs and livestock marketings from each origin are the required program inputs. The computer output contains the minimum annual assembly cost for each number of markets, varying from one to 11 in West Tennessee and one to 12 in Middle and in East Tennessee.

VII. AUCTION MARKET COSTS

Cost Function Used

Demand for livestock and costs incidental to the transportation of livestock to the ultimate destinations are assumed to have no bearing on the location of livestock auction markets. Therefore, auction market costs are handled as if all expenses ceased at the loading docks, and any cost incurred beyond this point is assumed to be associated with distribution.

In order to estimate annual livestock auction market costs, the basic market cost function developed by Gibb[45] is used. The linear function is:

$$Y = 10,547.6 + .597X_1 + .526X_2 + .445X_3 + .486X_4$$

where Y is the estimated total annual cost of operating a livestock auction market, X_1 the number of cattle, X_2 the number of calves, X_3 the number of hogs, and X_4 the number of sheep marketed annually. To use this function, however, it was necessary to adjust the constant and the coefficients to reflect increased marketing costs since the time of the study. To make the adjustment, the 1968 Consumer Price Index of 121.2 (1957-59 = 100)[46] was used to inflate the constant and the

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[45] R. D. Gibb, "Economies of Scale in Michigan Livestock Auctions" (Unpublished Ph.D. dissertation, Michigan State University, 1959), p. 124.

[46] United States Department of Agriculture, The Farm Index (Washington, D. C.: Government Printing Office, February, 1970), p. 23. The Consumer Price Index is a measure of the average change in prices of goods and services customarily purchased by families of wage earners and clerical workers living in cities of the United States.

coefficients. Thus, the adjusted equation used in this study became:

$$Y = 12,784 + .724X_1 + .638X_2 + .539X_3 + .589X_4 .$$

Relevant Market Costs for Determining Auction Market Numbers

The methodology requires the assumption of constant per unit auction market costs over the entire range of production for each market. Marginal costs are also assumed to be equal at all potential market locations. Since marginal costs are constant over all volume ranges and equal between all potential market locations, these costs could be eliminated and the optimum number, size, and location of auction markets would not be changed. Once total market costs as a function of volume are converted to a function relating market costs for a given volume to varying numbers of markets, then under the assumption of this study, marginal per unit market costs cease to have any relevant influence on the cost function. The relevant cost is the annual cost incurred in "establishing and maintaining" an additional market which is $12,784 in the estimated auction market cost function.[47] The $12,784 is interpreted as the annual amount of money it takes to permit an auction market to operate. Therefore, given the assumptions,

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[47]The annual cost of establishing and maintaining only one market in each Grand Division of the state would be much higher than $12,784. However, even if this annual cost was a much higher figure, the optimal solution would not be affected. The $12,784 is considered appropriate for the sizes of markets in the optimal solutions.

each auction market added to those already in operation increases the cost of operating all livestock auction markets by precisely $12,784.[48]

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[48]The restriction imposed by the model of using one fixed market cost appears, at first, to place severe limitations on its use. However, if for study purposes, alternative marketing systems were to be analyzed, appropriate fixed and marginal costs could be used for each marketing system and the results compared. For example, the auction system of marketing livestock could readily be compared (on a least cost operating basis only) to, say, a system of dealers and country buying stations. The model could possibly be extended to determine the least cost combination of different market types, such as auction markets and buying stations, for a specific area.

CHAPTER III

RELATION OF COST TO NUMBER OF MARKETS

Relationships describing livestock assembly costs and auction market costs are presented in Chapter II. In this chapter, the relationship between these costs and the number of auction markets is examined. As the number of market destinations is increased, annual livestock assembly costs decline and annual auction market costs increase (Figure 4, page 15).

I. ASSEMBLY COSTS

Assembly Costs When All Livestock are Sold Through Auction Markets

Annual livestock assembly costs related to varying number of markets is presented in Table 1 and Figure 6 for each Grand Division of the state. Assembly costs decline rapidly as the number of markets is increased from one to five markets; then, as additional markets are added, the decline become more gradual. For example, the decline in assembly costs as the number of markets is increased from one to two is $72,544 for West Tennessee, $159,529 for Middle Tennessee, and $97,444 for East Tennessee. For comparison, a decline of $11,961, $17,022, and $6,651 occurs in the respective areas when the market number in each area is increased from six to seven.

The combination of potential auction market sites which minimizes annual assembly costs for every possible number of potential markets is

TABLE 1

MINIMUM ANNUAL LIVESTOCK ASSEMBLY COSTS FOR VARYING NUMBER OF MARKETS IN WEST, MIDDLE, AND EAST TENNESSEE, 1968

Number of markets	Annual assembly costs		
	West Tennessee	Middle Tennessee	East Tennessee
	----------Dollars----------		
1	622,378	1,217,187	537,706
2	549,834	1,057,658	440,265
3	514,549	952,147	396,560
4	491,180	901,842	371,758
5	474,624	856,991	349,473
6	460,223	838,056	342,233
7	448,262	821,034	335,582
8	440,702	809,584	330,716
9	434,388	800,767	326,598
10	428,410	793,140	323,995
11	424,025	786,275	322,199
12	--	782,321	320,490

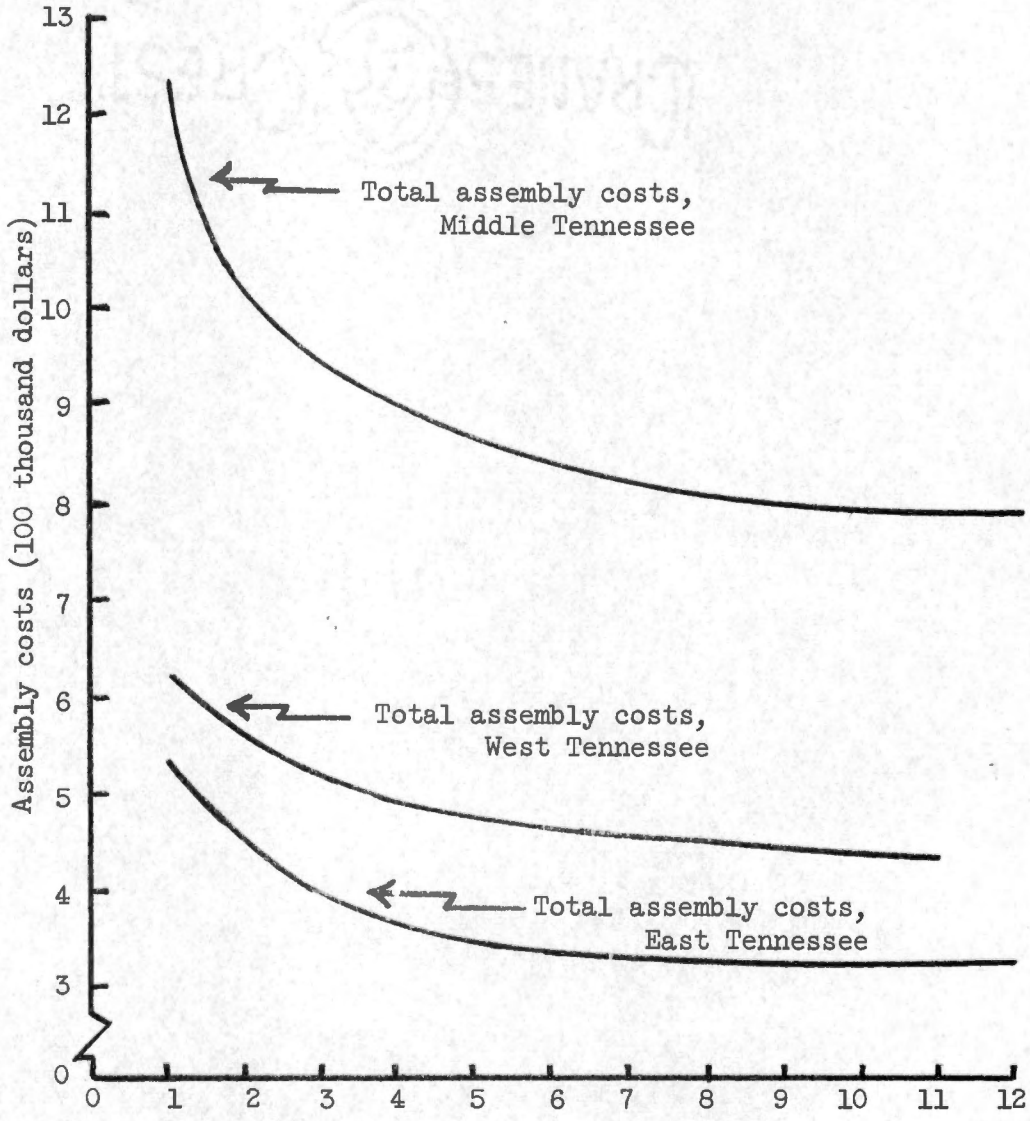


Figure 6. Minimum total assembly cost function related to number of markets, West, Middle, and East Tennessee, 1968.

given in the computer output. The potential market locations appearing in the various minimum cost combinations are shown in Figures 7, 8, and 9. Trenton in West Tennessee, Nashville in Middle Tennessee, and Knoxville in East Tennessee, for example, are the least-cost assembly points if there is to be only one market in each of these major areas. Similarly, Dresden and Jackson in West Tennessee, Columbia and Lebanon in Middle Tennessee, and Greeneville and Loudon in East Tennessee are the two least-cost assembly points when there is a combination of two markets for each of the Grand Divisions. It is interesting to note that neither location in the single market situation is included when two markets are designated as the least-cost assembly points. The selection of market sites in combinations consisting of two or more markets when related to assembly cost is determined largely by the density of livestock in the area and the location of the market relative to other markets.

Assembly Costs Associated with Changes in Livestock Marketings

A change in the number, mix, or distribution of livestock marketings affects the number, size, and location of auction markets. To determine this affect, it is assumed that 25 percent more cattle, 50 percent fewer hogs, and the same number of calves and sheep are sold through auctions. Under this assumption, total assembly costs for transporting this livestock mix to auction markets are lower for West and Middle Tennessee and higher for East Tennessee than when all livestock marketings are transported to the auction markets. Because of

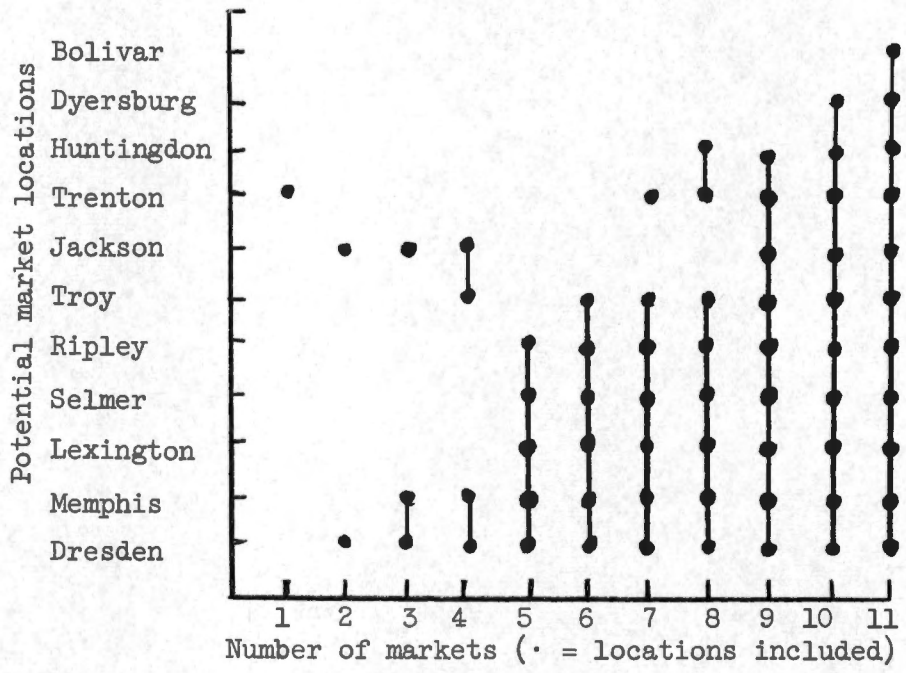


Figure 7. Location of markets which minimizes assembly costs for every possible number of potential markets when all livestock are sold through these markets, West Tennessee, 1968.

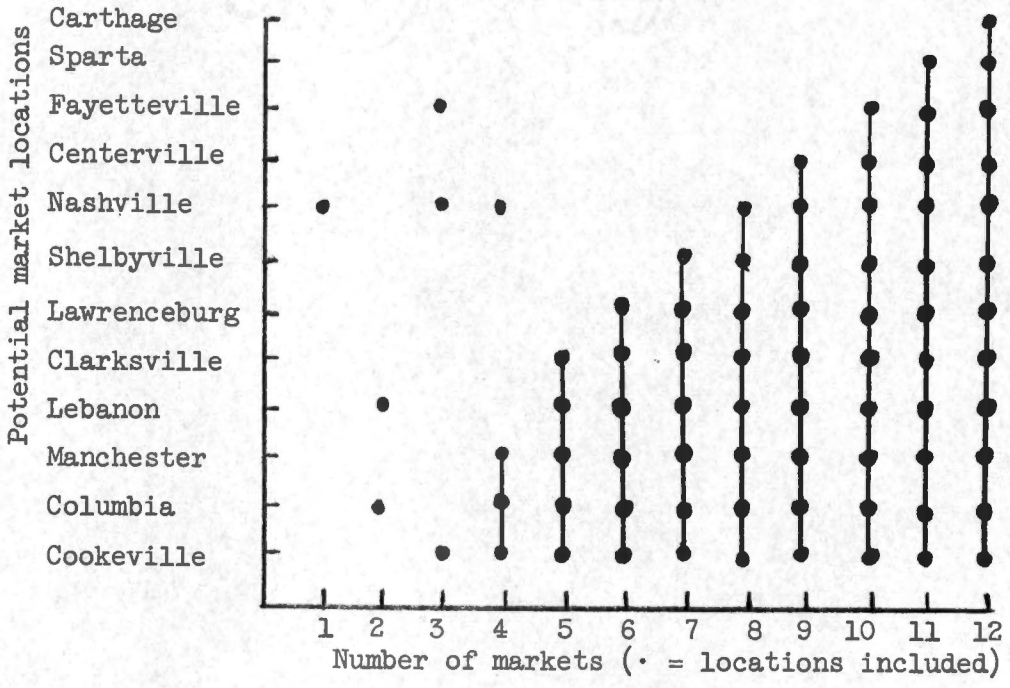


Figure 8. Location of markets which minimizes assembly costs for every possible number of potential markets when all livestock are sold through these markets, Middle Tennessee, 1968.

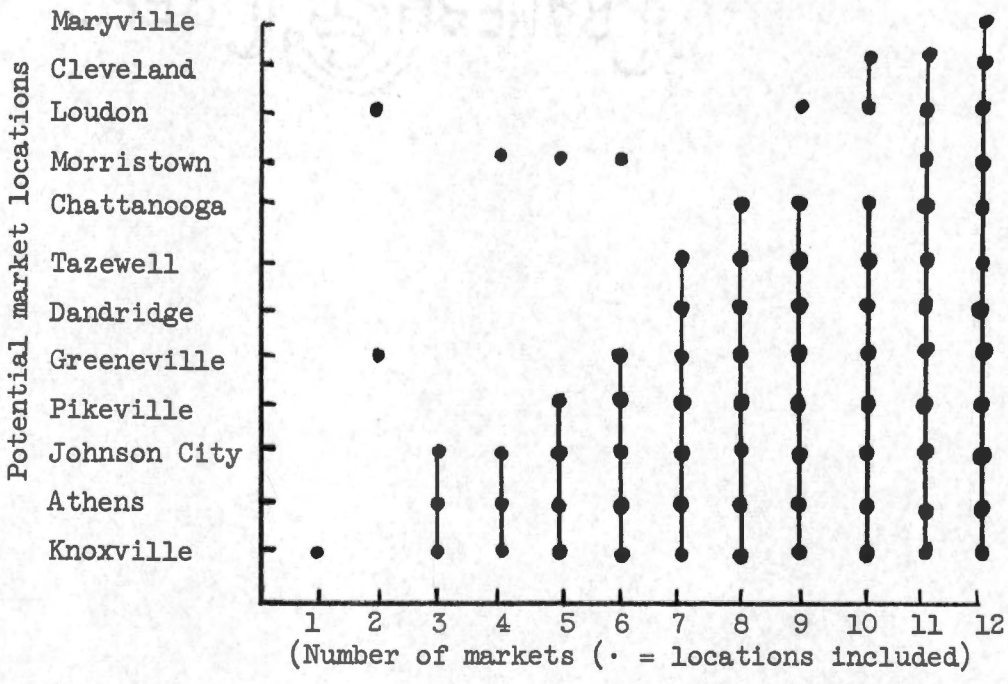


Figure 9. Location of markets which minimizes assembly costs for every possible number of potential markets when all livestock are sold through these markets, East Tennessee, 1968.

the relative importance of cattle compared with hogs in East Tennessee, total assembly costs are higher. Assembly costs for each Grand Division of the state are presented in Table 2.

Market locations appearing in the various combinations of markets which minimize the assembly cost function with respect to the number of markets are also altered by the assumed changes in livestock marketings. The market locations under this assumption appear in the various combinations shown in Figures 10, 11, and 12. There is some shifting of locations in the least-cost combinations of markets, because of the change in relative livestock densities from origin to origin. The tendency is to shift away from those locations where there is a high proportion of hogs to cattle marketed and toward those areas where the proportion of hogs to cattle marketed is not so high. These changes are noted in Table 3.

The assumed change in livestock marketings creates a rearrangement in the areas served by some markets and at the same time allows new market locations to enter and others to leave the least-cost combination of markets. For example, in the case of the five West Tennessee markets, the Selmer and Lexington markets are replaced by markets located at Troy and Jackson. Livestock marketings in the Lexington and Selmer areas are comprised of 80 percent hogs, 12 percent cattle, and 8 percent calves and sheep. In the Troy and Jackson areas, 75 percent of the livestock marketings are hogs, 15 percent cattle, and 10 percent calves and sheep. Thus, the assumed 25 percent increase in cattle,

TABLE 2

MINIMUM ANNUAL ASSEMBLY COSTS FOR LIVESTOCK MARKETED THROUGH AUCTIONS BY VARYING NUMBER OF MARKETS IN WEST, MIDDLE, AND EAST TENNESSEE ASSUMING A 25 PERCENT INCREASE IN ANNUAL CATTLE MARKETINGS, A 50 PERCENT DECREASE IN ANNUAL HOG MARKETINGS, AND NO CHANGE IN CALF AND SHEEP MARKETINGS, 1968

Number of markets	Annual assembly costs		
	West Tennessee	Middle Tennessee	East Tennessee
	----------Dollars----------		
1	587,754	1,152,726	592,330
2	522,131	1,002,626	483,967
3	481,198	908,356	428,451
4	457,013	862,196	401,230
5	443,084	819,800	382,655
6	432,124	801,218	374,600
7	421,880	784,048	366,671
8	415,343	772,203	359,361
9	408,893	764,574	354,079
10	402,471	757,049	351,815
11	398,301	751,103	349,859
12	--	747,837	347,971

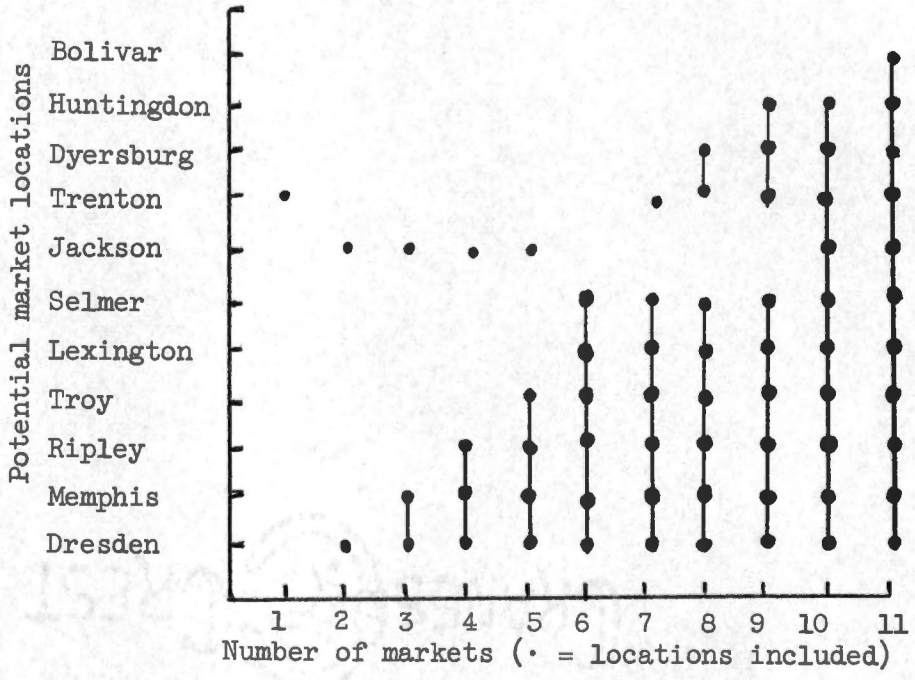


Figure 10. Location of markets which minimizes assembly costs for every possible number of potential markets assuming a 25 percent increase in annual cattle marketings, a 50 percent decrease in annual hog marketings, and no changes in calf and sheep marketings, West Tennessee, 1968.

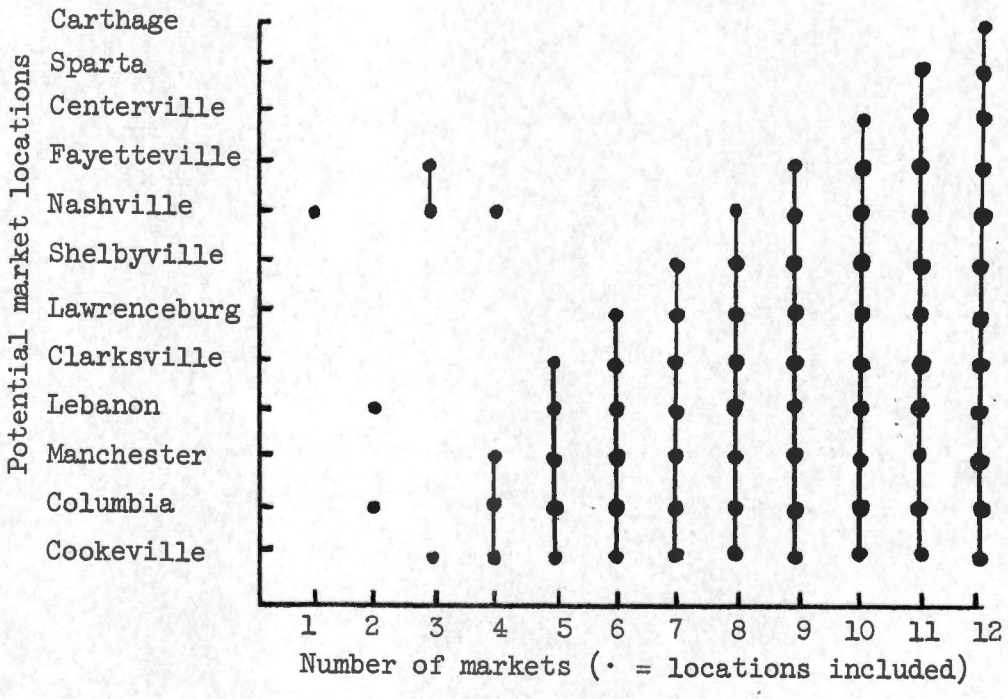


Figure 11. Location of markets which minimizes assembly costs for every possible number of potential markets assuming a 25 percent increase in annual cattle marketings, a 50 percent decrease in annual hog marketings, and no changes in calf and sheep marketings, Middle Tennessee, 1968.

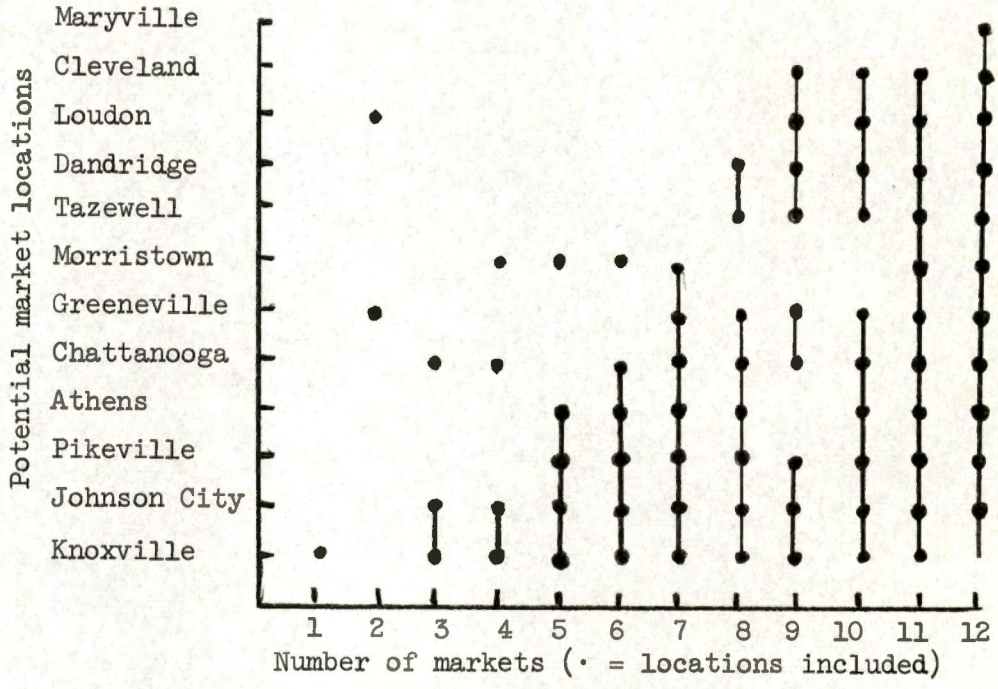


Figure 12. Location of markets which minimizes assembly costs for every possible number of potential markets assuming a 25 percent increase in annual cattle marketings, a 50 percent decrease in annual hog marketings, and no changes in calf and sheep marketings, East Tennessee, 1968.

TABLE 3

CHANGES IN THE LEAST-COST COMBINATION OF MARKETS AS A RESULT OF THE ASSUMED 25 PERCENT INCREASE IN ANNUAL CATTLE MARKETINGS, A 50 PERCENT DECREASE IN ANNUAL HOG MARKETINGS, AND NO CHANGE IN CALF AND SHEEP MARKETINGS, 1968

Number of markets	Change in least-cost combinations		
	West Tennessee	Middle Tennessee	East Tennessee
1	--	--	--
2	--	--	--
3	--	--	Chattanooga (Athens)
4	Ripley (Troy)	--	Chattanooga (Athens)
5	Troy, Jackson (Selmer, Lexington)	--	--
6	--	--	Chattanooga (Greeneville)
7	--	--	Chattanooga, Morristown (Dandridge, Tazewell)
8	Huntingdon (Dyersburg)	--	--
9	Huntingdon (Jackson)	Centerville (Fayetteville)	Cleveland (Athens)
10	--	--	--
11	--	--	--
12	--	--	--

-- denotes no change in least-cost combination of market.

( ) denotes market(s) replaced in the least-cost combination of potential markets.

50 per cent decrease in hogs, and no change in calf and sheep marketings, allows the Troy and Jackson locations to replace those located at Selmer and Lexington in the least-cost combination of five potential markets. The shift is toward the locations having higher proportions of cattle to hogs marketed.

II. AUCTION MARKET COSTS

Annual livestock auction market costs under the assumptions made are a minimum with only one market operating in each Grand Division of the state and a maximum with all potential markets in operation. Annual auction market costs are increased by the same amount, or $12,784, for each market added to those in operation (see page 39).

Assuming all livestock sold by producers in public markets is sold through auction agencies, the annual auction market costs for the West Tennessee area increased from $509,674 for only one potential market to $637,514 for 11 markets. The $127,840 increase is equal to the cost of establishing and maintaining an additional 10 potential markets, the total number of potential markets selected in West Tennessee. For the Middle Tennessee area, the estimated total auction market costs increased from $858,032 for one market to $998,656 for 12 potential markets. Similarly, for East Tennessee, auction market costs ranged from $304,530 for one market to $445,154 for 12 potential markets (Figure 13).

Under the assumption of a 25 percent increase in annual cattle marketings, a 50 percent decrease in annual hog marketings, and with

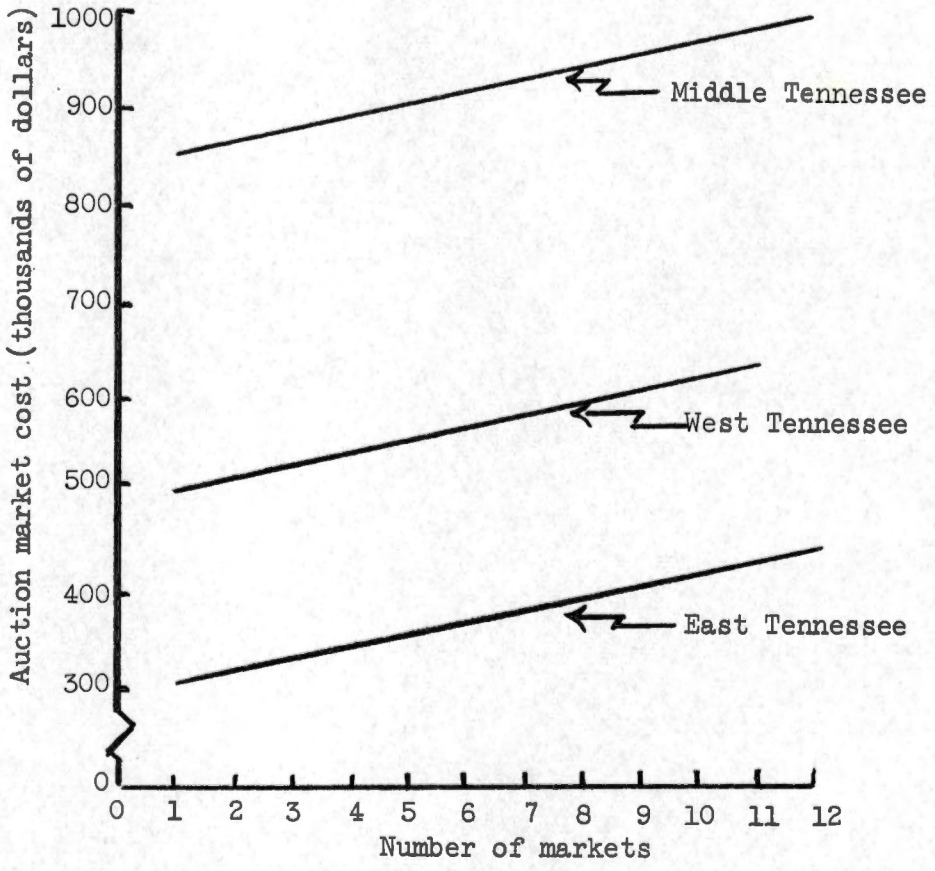


Figure 13. Auction market cost functions related to number of markets when all area livestock marketings are sold through auction markets, West, Middle, and East Tennessee, 1968.

calf and sheep marketings remaining the same, the auction market cost functions in each Grand Division of the state are, necessarily, uniformly lower. Annual auction market costs when all the livestock sold are marketed through one market in West Tennessee are estimated at $380,979; for one market in Middle Tennessee, $654,694; and for one market in East Tennessee, $282,264. Each market added in any of the areas through which all livestock are sold adds $12,784 to annual auction market costs.

CHAPTER IV

OPTIMUM SOLUTIONS OF THE NUMBER, SIZE, AND LOCATION OF LIVESTOCK AUCTION MARKETS

The final phase in determining the optimum number, size, and location of auction markets is to sum the minimized annual assembly and annual market cost functions as they are related to the number of markets. In general, the combined costs decrease as long as the decrease in assembly costs is less than the increase in market costs. Conversely, the combined costs increase after the decrease in assembly costs is less than the increase in market costs. Therefore, the combined costs are at a minimum at the point where the rate of change of the two relationships is equal.

Specification of the optimum number, size, and location of livestock auction markets involves a three step process: (1) determination of the minimum point on the combined cost function in order to specify the optimum number of auction markets, (2) identification of the potential market sites which minimize annual assembly costs in the process of ascertaining the optimum number of markets in order to determine the optimum location of the markets, and (3) determination of the volume of livestock marketed at each location by allocating the livestock marketings from each origin to the location which minimizes annual assembly costs for that origin in order to specify the optimum size of market at each location. Size of market refers to the volume

of livestock marketed annually.

I. OPTIMUM SOLUTION ASSUMING ALL LIVESTOCK MARKETINGS ARE SOLD THROUGH AUCTION MARKETS

Optimum Solution with Assembly and Market Costs as Estimated

Number of markets. Given the 1968 volume of livestock marketings, the optimum number of auction markets is six for West Tennessee, seven for Middle Tennessee, and five for East Tennessee. These results are derived by selecting the number of markets that provide the minimum combined costs for marketing all the livestock in each of these areas (Table 4 and Figures 14, 15, and 16). The combined assembly and auction market costs associated with these 18 optimum market locations for the state are $3,494,726. A decrease in the number of markets from 18 to three, or one for each Grand Division of the state, results in an increase of $554,781 in total marketing costs. When the number of markets is decreased from 35, or the maximum number of potential markets, to 18 there is a decrease in total marketing costs of $113,434. The magnitude of the decrease in total marketing costs is relatively small for the range of markets from 35 to 18.[1]

Differences in annual assembly and annual market costs are relatively insensitive to the number of markets varying upward from the

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[1] However, since there are 70 livestock auction markets operating in the state along with numerous other market agencies, movement from 35 markets to the optimal 18 markets would involve only the final stages of moving toward the minimum cost livestock marketing organization in Tennessee.

TABLE 4

COMBINED ANNUAL LIVESTOCK ASSEMBLY AND AUCTION MARKET COSTS BY GRAND DIVISIONS OF THE STATE, 1968

Number of markets	Combined cost		
	West Tennessee	Middle Tennessee	East Tennessee
	----------	Dollars	----------
1	1,132,052	2,075,219	842,236
2	1,072,292	1,928,474	757,579
3	1,049,791	1,825,747	726,658
4	1,039,206	1,798,226	714,640
5	1,035,434	1,766,159	705,139*
6	1,033,817*	1,760,008	710,683
7	1,034,640	1,755,770*	716,816
8	1,039,864	1,757,104	724,734
9	1,046,334	1,761,071	733,400
10	1,053,140	1,766,228	743,581
11	1,061,539	1,772,147	754,569
12	--	1,780,977	765,644

*Indicates the minimum combined annual livestock assembly and auction market cost. The number of markets associated with these costs represents the optimum solution.

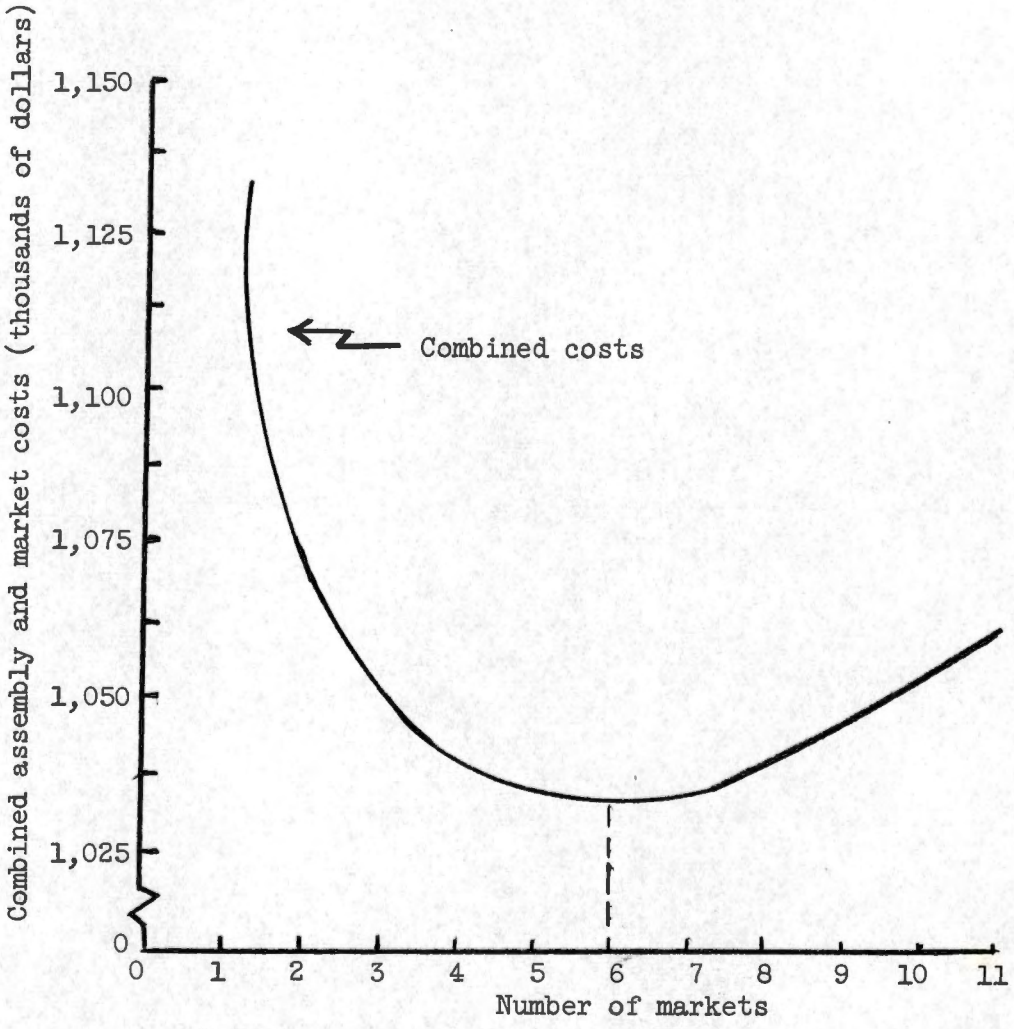


Figure 14. Combined assembly and auction market costs with varying number of markets, West Tennessee, 1968.

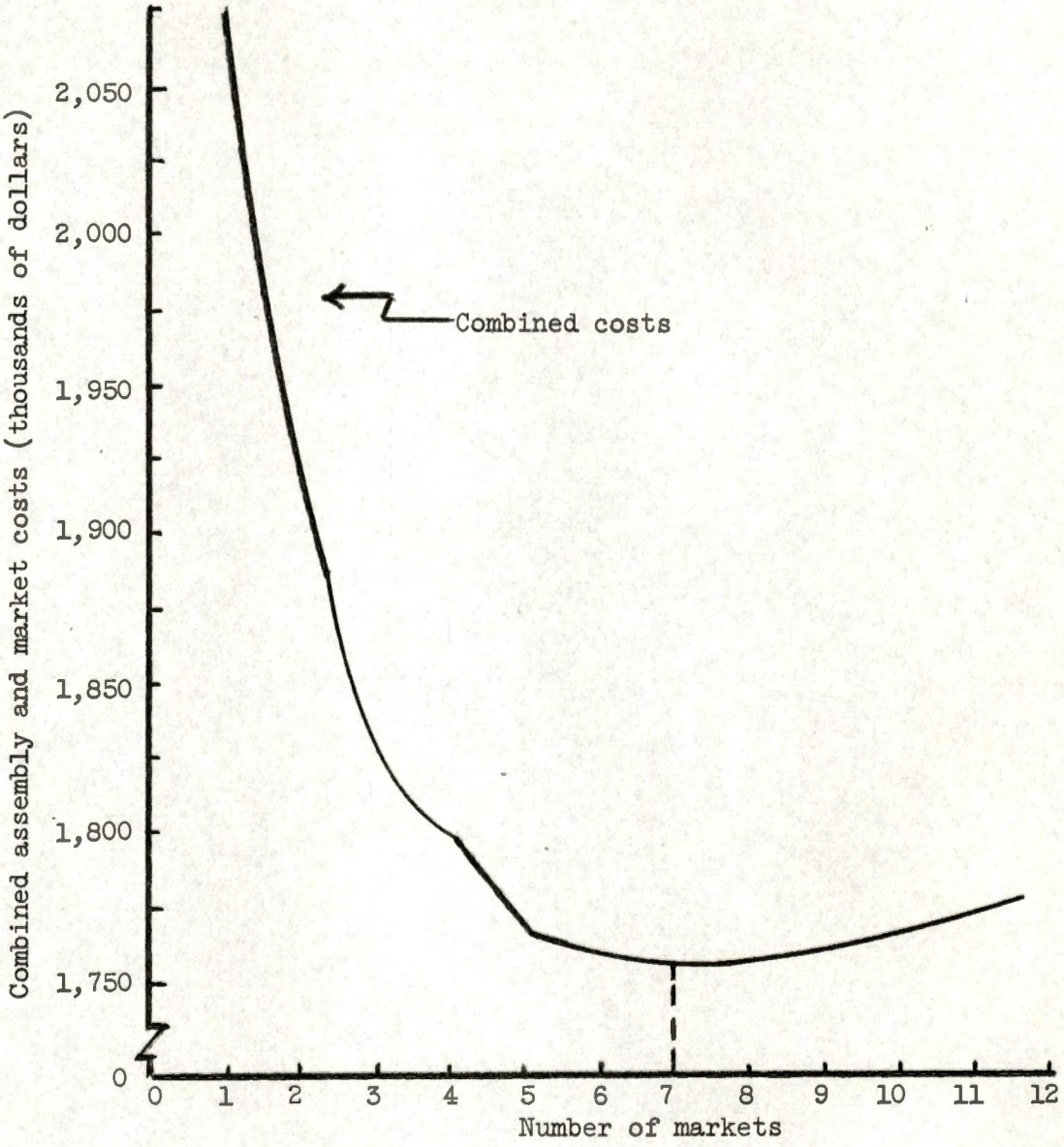


Figure 15. Combined assembly and auction market costs with varying number of markets, Middle Tennessee, 1968.

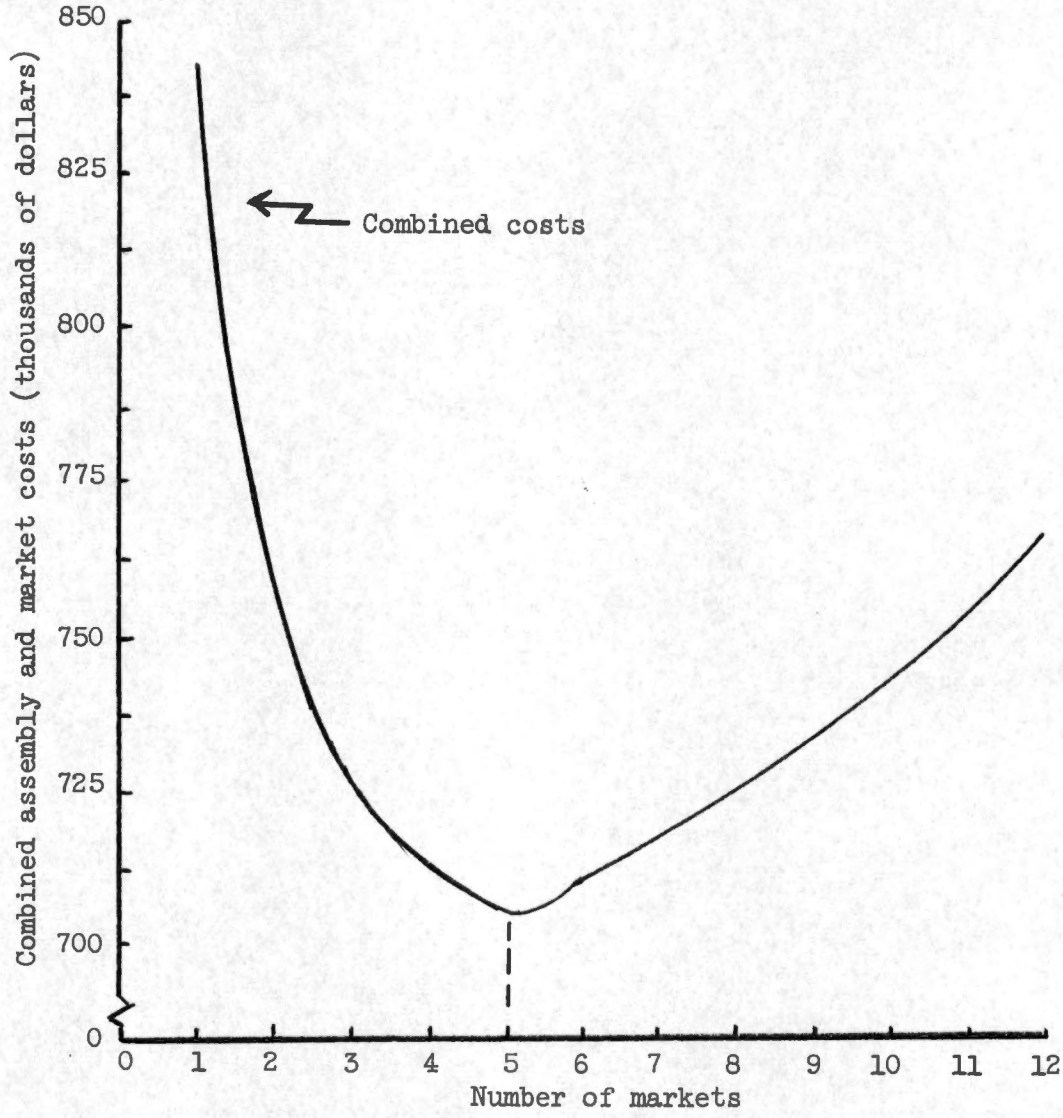


Figure 16. Combined assembly and auction market costs with varying number of markets, East Tennessee, 1968.

optimum to the maximum number of 35 allowed in this model. For example, when the number of markets in West Tennessee is increased by only one from the optimum number, or from six to seven, total marketing costs are increased by only $823. In Middle Tennessee, when the optimum number of markets, seven, is increased to eight, total marketing costs are increased by $1,334, and in East Tennessee when the optimum number of five markets is increased to six, the cost increases by $5,544.

Location of markets. Optimum location of the auction markets is determined by identifying the market sites which minimize annual assembly costs in the solution given the optimum number of markets (Table 4, page 59). Potential market locations that minimize assembly costs for each possible number of markets are given in Figures 7, 8, and 9, pages 45, 46, and 47, respectively. Therefore, the optimum locations are determined by identifying the locations associated only with the optimum number of markets. Through this identification process, the six optimum West Tennessee market locations are: Dresden, Memphis, Lexington, Selmer, Ripley, and Troy. In Middle Tennessee, the seven optimum locations are: Cookeville, Columbia, Manchester, Lebanon, Clarksville, Lawrenceburg, and Shelbyville. The five optimum East Tennessee locations are: Knoxville, Athens, Johnson City, Pikeville, and Morristown.

Market size and supply areas. The size of markets required in the optimum solution is shown in Table 5. Annual marketings of livestock

TABLE 5

VOLUME OF LIVESTOCK MARKETED THROUGH AUCTION MARKETS, BY THE GRAND DIVISION OF THE STATE AND THEIR LOCATION, 1968

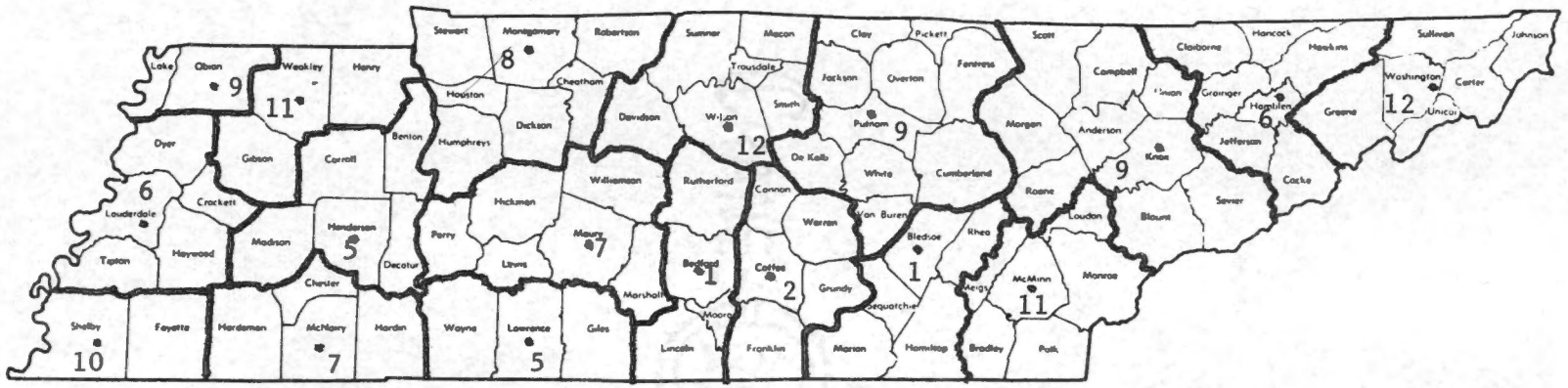
Grand Division and location	Annual volume			
	Cattle	Calves	Hogs	Sheep
	----------	----------	Number ----------	----------
West Tennessee				
Lexington	25,884	17,500	143,975	324
Ripley	36,133	21,687	63,298	259
Selmer	14,236	9,851	116,752	260
Troy	20,304	10,923	60,398	292
Memphis	26,701	12,396	21,052	227
Dresden	41,821	19,599	182,942	1,266
Middle Tennessee				
Shelbyville	39,960	33,390	103,834	7,302
Manchester	30,322	22,170	139,007	2,013
Lawrenceburg	28,026	20,133	66,274	1,006
Columbia	50,174	32,557	126,592	7,205
Clarksville	38,295	30,362	124,668	941
Cookeville	38,350	39,822	202,555	1,754
Lebanon	55,577	42,338	132,782	10,970
East Tennessee				
Pikeville	14,235	10,174	40,620	227
Morristown	36,492	34,145	36,726	292
Knoxville	36,604	23,140	59,117	617
Athens	26,387	22,809	21,439	227
Johnson City	38,499	35,994	26,975	909

transported to each market from all origins in the supply area are summed to determine the size of market required at each market location. The Memphis market, handling a total volume of 60,376 livestock, is the smallest market. The Pikeville, Athens, and Troy markets are also relatively small compared with other markets in the optimum solution. In general, the largest markets are located in Middle Tennessee with Cookeville being the largest.

The volume of livestock assigned to each market is determined by the unit assembly costs and relative densities of livestock marketings in the area. Given the auction market locations, livestock from each origin is sent to that location which minimizes assembly costs for that origin. Therefore, markets in an area of highly concentrated livestock marketings will be allocated more of the total volume than markets in an area with a lower concentration of livestock marketings.

The supply areas for the 18 optimal livestock markets are identified in Figure 17. The market boundaries for these supply areas would change if the size of the origin were decreased. If, for example, the county origins were divided into civil districts and the livestock were shipped to the nearest market, livestock would tend to come to market from more equi-distant points. Subdivision of the county origins into civil districts, however, would not make substantial changes in the volume of livestock handled.

In determining the supply areas for the optimum market locations, certain problems developed that had to be resolved. An example of such



• Location of the auction markets

West Tennessee	Middle Tennessee	East Tennessee
5. Lexington	1. Shelbyville	1. Pikeville
6. Ripley	2. Manchester	6. Morristown
7. Selmer	5. Lawrenceburg	9. Knoxville
9. Troy	7. Columbia	11. Athens
10. Memphis	8. Clarksville	12. Johnson City
11. Dresden	9. Cookeville	
	12. Lebanon	

Figure 17. Market areas served by the 18 optimal livestock auction markets, 1968.

a problem is in Greene County where the origin, Greeneville, is equally close to two optimal market locations. Greeneville is 30 miles from either Johnson City or Morristown. Subdivisions of Greene County on the basis of civil districts would send approximately one-half of the livestock from that county to each market. However, data are not available for any size of unit less than a county; therefore, all the livestock were arbitrarily allocated to the Johnson City market. The reason for the allocation to the Johnson City market is that it is a substitute for the Jonesboro location which is only 23 miles from Greeneville.

Optimum Solution with Changes in Estimated Annual Assembly Costs

An analysis of the effects of changes in annual assembly costs is a means of estimating the stability of the optimum solution. The optimal solution can be considered relatively stable if the number, size, and location of the markets change little with changes in annual assembly costs. To make this analysis, total annual assembly costs are assumed to be increased by 10 percent from the original cost estimates given in Table 7 (Chapter III) and, then, decreased by 10 percent from the original cost estimates. The newly derived assembly costs for the number of markets ranging from one to 11 in West Tennessee and one to 12 in Middle and East Tennessee are given in Tables 6, 7, and 8, respectively. The critical factor is the reduction in assembly costs as markets are added to those in operation. As long as the reduction in assembly costs is greater than the cost of adding another market ($12,784), the additional market is justified from the standpoint of operational efficiency.

TABLE 6

TOTAL ASSEMBLY COSTS BY VARYING NUMBER OF MARKETS AND CHANGE IN ASSEMBLY COSTS AS ADDITIONAL MARKETS ARE ADDED ASSUMING A 10 PERCENT INCREASE IN TOTAL ESTIMATED ASSEMBLY COSTS AND A 10 PERCENT DECREASE IN TOTAL ESTIMATED ASSEMBLY COSTS, WEST TENNESSEE, 1968

Number of markets	Assembly costs			
	Annual costs increased 10 percent	Change in costs as additional markets are added	Annual costs decreased 10 percent	Change in costs as additional markets are added
	Dollars			
1	684,616		560,140	
2	604,817	-79,799	494,851	-65,289
3	566,004	-38,813	463,094	-31,757
4	540,298	-25,706	442,062	-21,032
5	522,086	-18,212	427,162	-14,900
6	506,245	-15,841	414,201	-12,961*
7	493,088	-13,157*	403,436	-10,765
8	484,772	-8,316	396,632	-6,804
9	477,827	-6,945	390,949	-5,683
10	471,251	-6,576	385,569	-5,380
11	466,428	-4,823	381,623	-3,946

*Indicates the smallest reduction in annual assembly costs that would justify the addition of another market to those in operation. The number of markets associated with these costs represents the optimum solution.

TABLE 7

TOTAL ASSEMBLY COSTS BY VARYING NUMBER OF MARKETS AND CHANGE IN ASSEMBLY COSTS AS ADDITIONAL MARKETS ARE ADDED ASSUMING A 10 PERCENT INCREASE IN TOTAL ESTIMATED ASSEMBLY COSTS AND A 10 PERCENT DECREASE IN TOTAL ESTIMATED ASSEMBLY COSTS, MIDDLE TENNESSEE, 1968

Number of markets	Assembly costs			
	Annual costs increased 10 percent	Change in costs as additional markets are added	Annual costs decreased 10 percent	Change in costs as additional markets are added
	Dollars			
1	1,338,906		1,095,468	
2	1,163,424	-175,482	951,892	-143,576
3	1,047,362	-116,062	856,932	-94,960
4	992,026	-55,336	811,658	-45,274
5	942,690	-49,336	771,292	-40,366
6	921,862	-20,828	754,250	-17,042
7	903,137	-18,725*	738,931	-15,319*
8	890,542	-12,595	728,626	-10,305
9	880,843	-9,698	720,690	-7,936
10	872,454	-8,390	713,826	-6,864
11	864,903	-7,551	707,648	-6,178
12	860,553	-4,350	704,089	-3,559

*Indicates the smallest reduction in annual assembly costs that would justify the addition of another market to those in operation. The number of markets associated with these costs represents the optimum solution.

TABLE 8

TOTAL ASSEMBLY COSTS BY VARYING NUMBER OF MARKETS AND CHANGE IN ASSEMBLY COSTS AS ADDITIONAL MARKETS ARE ADDED ASSUMING A 10 PERCENT INCREASE IN TOTAL ESTIMATED ASSEMBLY COSTS AND A 10 PERCENT DECREASE IN TOTAL ESTIMATED ASSEMBLY COSTS, EAST TENNESSEE, 1968

Number of markets	Assembly costs			
	Annual costs increased 10 percent	Change in costs as additional markets are added	Annual costs decreased 10 percent	Change in costs as additional markets are added
	Dollars			
1	591,477		483,935	
2	484,292	-107,185	396,239	-87,696
3	436,216	-48,076	356,904	-39,335
4	408,934	-27,282	334,582	-22,322
5	384,420	-24,514*	314,526	-20,056*
6	376,456	-7,964	308,010	-6,516
7	367,140	-7,316	302,024	-5,986
8	363,788	-5,352	297,644	-4,380
9	359,258	-4,530	293,938	-3,706
10	356,395	-2,863	291,596	-2,342
11	354,419	-1,976	289,979	-1,617
12	352,539	-1,880	288,441	-1,538

*Indicates the smallest reduction in annual assembly costs that would justify the addition of another market to those in operation. The number of markets associated with these costs represents the optimum solution.

Number of markets. There is a tendency for the optimum solution to contain more markets when assembly costs are increased.[2] Under the assumption of a 10 percent increase in annual assembly costs, there is a net reduction in costs of $13,157 when a seventh market is added in West Tennessee (Table 6). Since the additional cost of establishing and maintaining the extra (seventh) market is only $12,784, the market is justified. This is the only change in the number of markets for the state as a whole when assembly costs are increased by 10 percent. When another market is added in Middle Tennessee, or the eighth market, there would be a reduction in total assembly costs of $12,595 which is very near the extra cost of establishing and maintaining an additional market and consequently, an additional market might be justified (Table 7). However, for East Tennessee five markets represent a stable optimum (Table 8).

There is a tendency for the optimum number of markets to be fewer when assembly costs are reduced.[3] Under the assumption of a 10 percent reduction in annual assembly costs, however, there is no change in the

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[2]The tendency exists because an increase in total annual assembly costs will also increase the size of the net reductions in assembly costs as markets are added to those in operation.

[3]An extreme example of how this could happen is to assume assembly costs to be reduced by 100 percent, or to zero. From the standpoint of operational efficiency, there could be only one market in a given area under this condition because the cost of establishing and maintaining the second market would always be greater than the "reduction" in assembly cost resulting from the addition of the extra market.

number of markets entering into the solution in any of the Grand Divisions of the state.

Location of markets. The assumption of a uniform change in the entire assembly cost function does not change the relative cost of transporting annual livestock marketings from each origin to the various market locations. Consequently, the combination of potential market locations which minimize total annual assembly costs for any given number of markets is not affected by a shift in the assembly cost function. Thus, the optimum location of markets is not affected by a uniform change in assembly costs if the number of markets in a given area remains constant. The only justified change in market locations is in West Tennessee where the 10 percent increase in annual assembly costs resulted in the addition of a seventh market.[4] The seventh market in West Tennessee included a market at Trenton in addition to the previous combination of six markets.

Market size and supply areas. If there is no change in the number and location of markets as a result of the assumed changes in assembly costs from the original estimates, there is no change in the size of markets or their supply areas. Therefore, the only change in size of markets and supply areas is in West Tennessee when assembly costs are increased by 10 percent. The size of markets, measured by

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[4] A movement from seven markets in Middle Tennessee, the optimum, to eight involves a net increase in costs of only $189 ($12,784 - $12,595). Should the eighth market be added in this area, the optimum location would be Nashville.

volume of marketings, required in the optimum solution for West Tennessee under this assumption is given in Table 9. When the seventh market, Trenton, is added only the Dresden and Ripley supply areas are affected. Gibson County livestock that originally went to Dresden and Crockett County livestock that were sent to Ripley are marketed at Trenton in the system of seven markets (Figure 18).

II. OPTIMUM SOLUTION ASSUMING A 25 PERCENT INCREASE IN ANNUAL CATTLE MARKETINGS, A 50 PERCENT DECREASE IN ANNUAL HOG MARKETINGS, AND WITH CALF AND SHEEP MARKETINGS UNCHANGED

Optimum Solution with Assembly and Market Costs as Estimated

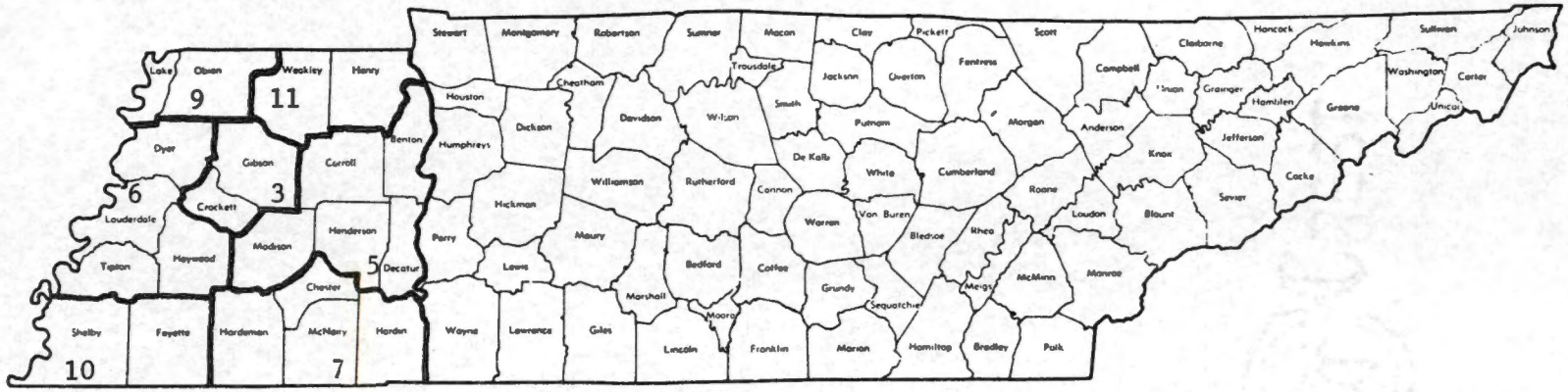
To determine the effects on the optimum market solution of a change in the number, mix, and distribution of livestock marketings, it is assumed that 25 percent more cattle, 50 percent fewer hogs, and the same number of calves and sheep are sold through auctions. Although they are arbitrary, the assumed changes in marketings represent about the same number of each species and class of livestock actually marketed in 1968 through Tennessee auctions.

Number of markets. Under the assumed changes in livestock marketings, the optimum number of markets is five for West Tennessee, seven for Middle Tennessee, and five for East Tennessee. Thus, the optimum number of auction markets for the state is 17 compared with 18 when all livestock are sold through the auctions. These results are

TABLE 9

VOLUME OF LIVESTOCK MARKETED AND LOCATION OF AUCTION MARKETS ASSUMING 10 PERCENT GREATER ASSEMBLY COSTS THAN THE TOTAL ESTIMATED, WEST TENNESSEE, 1968

Location	Annual volume			
	Cattle	Calves	Hogs	Sheep
	Number			
Dresden	29,417	12,566	103,467	844
Memphis	26,701	12,396	21,052	227
Lexington	25,884	17,500	143,975	324
Selmer	14,236	9,851	116,752	260
Ripley	31,660	18,132	50,503	194
Troy	20,304	10,923	60,398	292
Trenton	16,877	10,588	92,270	487



• Location of the auction markets

West Tennessee

3. Trenton
5. Lexington
6. Ripley
7. Selmer
9. Troy
10. Memphis
11. Dresden

Figure 18. Market areas served by the seven optimal West Tennessee livestock auction markets assuming 10 percent greater assembly costs than the total estimated, West Tennessee, 1968.

obtained by selecting the number of markets in each area representing the minimum combined assembly and market cost (Table 10). The combined cost associated with the 17 optimal markets for the state is $3,106,700. West Tennessee is the only area where the number of markets is affected by the changes in livestock marketings. Since hogs constitute a large share of total livestock marketings in that area, 69 percent, the reduction in assembly costs as a result of the 50 percent decrease in hog numbers is sufficient to reduce the optimum number of auction markets from six to five in West Tennessee.

Location of markets. The optimum auction market locational pattern for each area is obtained by identifying the market sites which minimize annual assembly costs in the solution for the optimum number of markets. Potential market locations that minimize assembly costs for each possible number of markets, under the assumptions of a 25 percent increase in annual marketings of cattle, a 50 percent decrease in annual hog marketings, and no change in calf and sheep marketings, are given in Figures 10, 11, and 12, pages 50, 51, and 52, respectively. The optimum locations are those associated with the optimum number of markets. Since West Tennessee is the only area where the number of markets is affected, it is also the only area with a change in locations. Thus, the five optimum West Tennessee market locations include: Memphis, Dresden, Ripley, Troy, and Jackson. The Lexington and Selmer locations that were included in the optimum combination of markets under the assumption that all livestock are marketed at auctions are replaced by

TABLE 10

COMBINED ANNUAL LIVESTOCK ASSEMBLY AND AUCTION MARKET COSTS BY GRAND DIVISIONS OF THE STATE ASSUMING A 25 PERCENT INCREASE IN ANNUAL CATTLE MARKETINGS, A 50 PERCENT DECREASE IN ANNUAL HOG MARKETINGS, AND WITH CALF AND SHEEP MARKETINGS UNCHANGED, 1968

Number of markets	Combined cost		
	West Tennessee	Middle Tennessee	East Tennessee
	----------Dollars----------		
1	968,733	1,807,420	874,594
2	915,894	1,670,104	779,015
3	887,745	1,588,618	736,283
4	876,344	1,555,242	721,846
5	875,199*	1,525,630	716,055*
6	877,023	1,519,832	720,784
7	879,563	1,515,446*	725,639
8	885,810	1,516,385	731,113
9	892,144	1,521,540	738,615
10	898,506	1,526,799	749,135
11	907,120	1,533,637	759,963
12	--	1,543,155	770,859

*Indicates the minimum combined annual livestock assembly and auction market cost. The number of markets associated with these costs represents the optimum solution.

a single location at Jackson in this case. Lexington and Selmer are most vulnerable to a reduction in hog numbers because hogs constitute 80 percent of all livestock marketings in the nine-county area surrounding these markets which include: Benton, Carroll, Chester, Decatur, Hardeman, Hardin, Henderson, Madison, and McNairy counties.

Market sizes and supply areas. The size of markets required in the optimum solution reflects the increase in cattle numbers and the decrease in hog numbers. In addition, the West Tennessee market sizes also reflect the reduced number of markets (Table 11). The Middle Tennessee markets remain generally larger than those in other areas of the state. Dresden replaces Cookeville, however, as the largest market in terms of total volume of livestock marketed.

The supply areas for the 17 optimal livestock markets are identified in Figure 19. The only change in supply areas is in West Tennessee where the number of markets is reduced from six to five. Replacement of the Lexington and Selmer locations by the new optimum location at Jackson affects all but two of the West Tennessee supply areas. Troy and Memphis supply areas are the same under the assumed changes in livestock marketings as those when all livestock are sold through auctions. The Jackson supply area under the new assumptions includes all of the counties in the original Selmer supply area, Henderson and Decatur counties from the original Lexington area, and Crockett County from the original Ripley area. Thus, the Ripley supply area is reduced in size by the loss of Crockett County. The Dresden supply area includes

TABLE 11

VOLUME OF LIVESTOCK MARKETED THROUGH AUCTION MARKETS BY GRAND DIVISIONS AND LOCATION ASSUMING A 25 PERCENT INCREASE IN ANNUAL CATTLE MARKETINGS, A 50 PERCENT DECREASE IN ANNUAL HOG MARKETINGS, AND WITH CALF AND SHEEP MARKETINGS UNCHANGED, 1968

Grand Division and location	Annual volume			
	Cattle	Calves	Hogs	Sheep
	Number			
West Tennessee				
Ripley	39,576	18,132	25,252	194
Jackson	45,353	24,087	111,736	519
Troy	25,380	10,923	30,200	292
Memphis	33,376	12,396	10,526	227
Dresden	62,665	26,418	116,501	1,396
Middle Tennessee				
Shelbyville	49,950	33,399	51,918	7,302
Manchester	37,902	22,170	69,505	2,013
Lawrenceburg	35,033	20,133	33,138	1,006
Columbia	62,719	32,557	63,298	7,205
Clarksville	47,869	30,362	62,335	941
Cookeville	47,939	39,822	101,281	1,754
Lebanon	69,472	42,338	66,392	10,970
East Tennessee				
Pikeville	23,796	10,174	19,732	227
Morristown	45,616	34,145	18,365	292
Knoxville	45,755	23,140	29,560	617
Athens	26,984	22,809	11,301	227
Johnson City	48,123	35,994	13,489	909



• Location of the auction markets

West Tennessee

6. Ripley
8. Jackson
9. Troy
10. Memphis
11. Dresden

Middle Tennessee

1. Shelbyville
2. Manchester
5. Lawrenceburg
7. Columbia
8. Clarksville
9. Cookeville
12. Lebanon

East Tennessee

1. Pikeville
6. Morristown
9. Knoxville
11. Athens
12. Johnson City

Figure 19. Market areas served by the 17 optimal livestock auction markets.

two additional counties, Carroll and Benton, which makes the Dresden market the largest in the state.

Optimum Solution with Changes in Estimated Annual Assembly Costs

An analysis of the effects of changes in annual assembly costs provides a method of determining the stability of the optimum solution. To make this analysis, annual assembly costs are again assumed to be increased by 10 percent from the original cost estimates given in Table 2, page 49, and, then, decreased by 10 percent from the original cost estimates. The resulting assembly costs for one to 11 markets in West Tennessee and for one to 12 markets in Middle and East Tennessee are presented in Tables 12, 13, and 14, respectively.

Number of markets. The optimum number of markets for the state is increased from 17 to 18 when annual assembly costs are assumed to be 10 percent above the original cost estimates (Tables 12, 13, and 14). The only change in the number of markets is in Middle Tennessee, where the reduction in assembly costs of $13,030 is sufficient to justify the addition of an extra market--the eighth (Table 13). In West and East Tennessee, the optimum number of markets remains at five in each area. It is interesting to note, however, that the sixth market in West Tennessee would result in a net increase in costs of only $724 ($12,056 reduction in assembly costs - $12,784 extra auction market cost). Moreover, the addition of another market, the seventh, would cost only $1,516 extra. Thus, the two additional markets could be

TABLE 12

TOTAL ASSEMBLY COSTS BY VARYING NUMBER OF MARKETS AND CHANGE IN ASSEMBLY COSTS AS ADDITIONAL MARKETS ARE ADDED ASSUMING A 10 PERCENT INCREASE IN TOTAL ESTIMATED ASSEMBLY COSTS AND A 10 PERCENT DECREASE IN TOTAL ESTIMATED ASSEMBLY COSTS, WEST TENNESSEE, 1968

Number of markets	Assembly costs			
	Annual costs increased 10 percent	Change in costs as additional markets are added	Annual costs decreased 10 percent	Change in costs as additional markets are added
	Dollars			
1	646,529		528,979	
2	574,344	-72,185	469,918	-59,061
3	529,318	-45,026	433,078	-36,840
4	502,714	-26,604	411,312	-21,766*
5	487,392	-15,322*	398,776	-12,536
6	475,336	-12,056	388,912	-9,864
7	464,068	-11,268	379,692	-9,220
8	456,877	-7,191	373,809	-5,883
9	449,782	-7,095	368,004	-5,805
10	442,718	-7,064	362,224	-5,780
11	438,131	-4,587	358,471	-3,753

*Indicates the smallest reduction in annual assembly costs that would justify the addition of another market to those in operation. The number of markets associated with these costs represents the optimum solution.

TABLE 13

TOTAL ASSEMBLY COSTS BY VARYING NUMBER OF MARKETS AND CHANGE IN ASSEMBLY COSTS AS ADDITIONAL MARKETS ARE ADDED ASSUMING A 10 PERCENT INCREASE IN TOTAL ESTIMATED ASSEMBLY COSTS AND A 10 PERCENT DECREASE IN TOTAL ESTIMATED ASSEMBLY COSTS, MIDDLE TENNESSEE, 1968

Number of markets	Assembly costs			
	Annual costs increased 10 percent	Change in costs as additional markets are added	Annual costs decreased 10 percent	Change in costs as additional markets are added
	Dollars			
1	1,267,999		1,037,453	
2	1,102,889	-165,110	902,363	-135,090
3	999,192	-103,697	817,520	-84,843
4	948,416	-50,776	775,976	-41,544
5	901,780	-46,636	737,820	-38,156
6	881,340	-20,440	721,096	-16,724
7	862,453	-18,887	705,643	-15,453*
8	849,423	-13,030*	694,983	-10,660
9	841,031	-8,392	688,117	-6,866
10	832,754	-8,277	681,344	-6,773
11	826,213	-6,541	675,993	-5,351
12	822,621	-3,592	673,053	-2,940

*Indicates the smallest reduction in annual assembly costs that would justify the addition of another market to those in operation. The number of markets associated with these costs represents the optimum solution.

TABLE 14

TOTAL ASSEMBLY COSTS BY VARYING NUMBER OF MARKETS AND CHANGE IN ASSEMBLY COSTS AS ADDITIONAL MARKETS ARE ADDED ASSUMING A 10 PERCENT INCREASE IN TOTAL ESTIMATED ASSEMBLY COSTS AND A 10 PERCENT DECREASE IN TOTAL ESTIMATED ASSEMBLY COSTS, EAST TENNESSEE, 1968

Number of markets	Assembly costs			
	Annual costs increased 10 percent	Change in costs as additional markets are added	Annual costs decreased 10 percent	Change in costs as additional markets are added
	Dollars			
1	651,563		533,097	
2	532,364	-119,199	435,570	-97,527
3	471,296	-61,068	385,606	-49,964
4	441,353	-29,943	361,107	-24,499
5	420,921	-20,432*	344,390	-16,717*
6	412,060	-8,861	337,140	-7,250
7	403,338	-8,722	330,004	-7,136
8	395,297	-8,041	323,425	-6,579
9	389,487	-5,810	318,671	-4,754
10	386,997	-2,490	316,634	-2,037
11	384,845	-2,152	314,873	-1,761
12	382,768	-2,077	313,174	-1,699

*Indicates the smallest reduction in annual assembly costs that would justify the addition of another market to those in operation. The number of markets associated with these costs represents the optimum solution.

added to the optimum combination of five markets in West Tennessee for a net increase in costs of only $2,240 (Table 12).

Under the assumption of a 10 percent reduction in annual assembly costs from the original cost estimate, the optimum number of markets for the state would be decreased from 17 to 16 (Tables 12, 13, and 14). The optimum number of markets in Middle and East Tennessee remains stable, but in West Tennessee the optimum combination of markets is reduced from five to only four markets. With the inclusion of the fifth market, however, there would be a net increase in costs of only $248 since the $12,784 cost of establishing and maintaining a market is only that much greater than the $12,536 reduction in assembly costs with the additional fifth market.

Location of markets. The optimum location of markets is determined by identifying the potential market locations associated only with the optimum number of markets (Figures 10, 11, and 12, pages 50, 51, and 52, respectively). When annual assembly costs are assumed to be 10 percent above the estimated total, the only change in market locations in the state occurs in the Middle Tennessee area where the eighth market is feasible. Thus, the Nashville location is included in addition to the previous combination of seven markets (Figure 11, page 51). The optimum location of markets in West Tennessee is subject to considerable changes in the optimum locations when the number of markets is increased above the optimum number of five. An increase from five to six markets results in the elimination of Jackson from

the combination of markets and the addition of Lexington and Selmer. These two markets were in the optimum combination of locations when all livestock were marketed through auctions, but they were replaced by a single market at Jackson and by rearranging the market supply areas under the assumed changes in livestock marketings. The seventh market, two above the optimum number, would be located at Trenton (Figure 10, page 50).

When assembly costs are assumed to be 10 percent below the estimated total, Troy is eliminated as a market from the optimum solution in West Tennessee. Under this assumption, the optimum combination of market locations is: Memphis, Dresden, Jackson, and Ripley (Figure 10). Should the fifth market be included at an increase in net costs of $248, it would be located at Troy. All other locations in the state remain unchanged (Figures 11 and 12, pages 51 and 52).

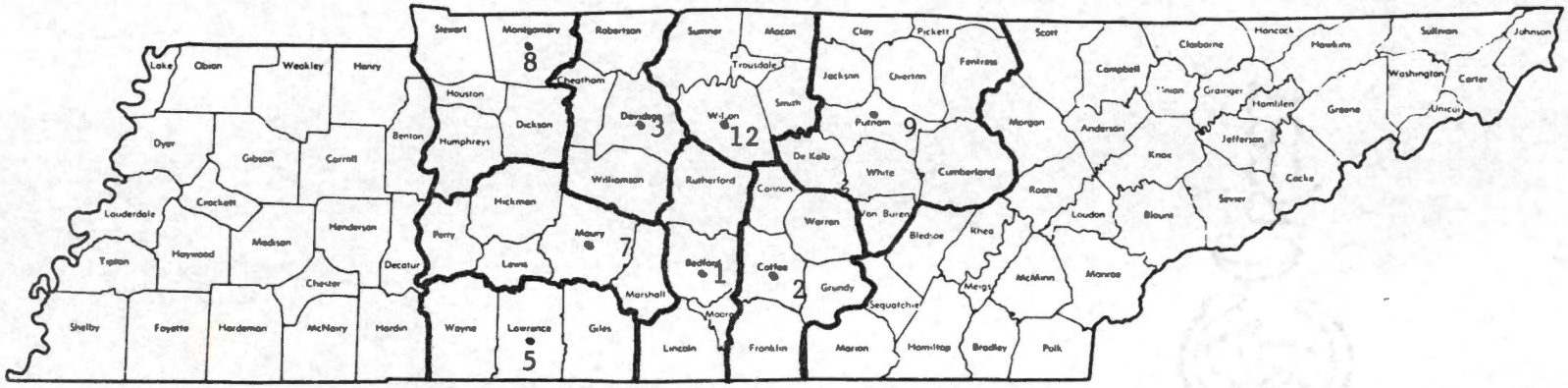
Market sizes and supply areas. The required size for the markets in the Middle Tennessee area under the assumption of a 10 percent increase in assembly costs is shown in Table 15. Market boundaries for the eight optimal Middle Tennessee locations are shown in Figure 20. The size of markets and their location in West and East Tennessee are the same as those shown in Table 11, page 79, and Figure 19, page 80.

The required market sizes in the optimum solution under the assumption of a 10 percent decrease in assembly costs are shown in Table 16 for West Tennessee. Since the reduction in assembly costs has no effect on the number and location of markets in the other areas

TABLE 15

VOLUME OF LIVESTOCK MARKETED AND LOCATION OF AUCTION MARKETS ASSUMING A 10 PERCENT INCREASE IN ASSEMBLY COSTS ABOVE THE TOTAL ESTIMATED, MIDDLE TENNESSEE, 1968

Location	Annual volume			
	Cattle	Calves	Hogs	Sheep
	----------Number----------			
Clarksville	28,438	17,090	41,288	649
Columbia	41,750	21,078	47,808	5,225
Cookeville	47,939	39,822	101,281	1,754
Lawrenceburg	35,033	20,133	33,138	1,006
Lebanon	58,079	37,508	60,187	10,710
Manchester	37,902	22,170	69,505	2,013
Nashville	51,793	29,581	42,742	2,532
Shelbyville	49,950	33,999	51,918	7,302



• Location of the auction markets

Middle Tennessee locations

1. Shelbyville
2. Manchester
3. Nashville
5. Lawrenceburg
7. Columbia
8. Clarksville
9. Cookeville
12. Lebanon

Figure 20. Market areas served by the eight optimal Middle Tennessee livestock auction markets, 1968.

TABLE 16

VOLUME OF LIVESTOCK MARKETED AND LOCATION OF AUCTION MARKETS ASSUMING A 10 PERCENT DECREASE IN ASSEMBLY COSTS BELOW THE TOTAL ESTIMATED, WEST TENNESSEE, 1968

Location	Annual volume			
	Cattle	Calves	Hogs	Sheep
	Number			
Dresden	88,045	37,341	141,753	1,688
Jackson	45,353	24,087	111,736	519
Memphis	33,376	12,396	10,526	227
Ripley	39,576	18,132	25,252	194

of the state, the sizes of the markets also are unaffected (Table 11, page 79). The supply areas also do not change under this assumption except in West Tennessee where livestock originally sent to the Troy market is now sent to the Dresden location. The size of the market is based on the volume of livestock sold in the supply area served by that market. Thus, the Dresden market is the largest in the state.

III. STABILITY OF THE RESULTS

Determination of the optimum number, size, and location of livestock auction markets was made under several postulated conditions (page 20). The effects of a substantial change in the number, mix, and distribution of livestock marketed through auctions along with the effects of changes in assembly costs were demonstrated.

Even though the postulated conditions may be "unrealistic," substantial changes in the postulates resulted in relatively minor changes in the study results. The optimal solutions under the extreme postulated conditions ranged from a least-cost structure of 16 to 19 strategically located auction markets. Since the optimal solutions cover a wide range of economic circumstances, it is concluded that the least-cost number of auction markets for the state as a whole would be less than 20. These postulated conditions were selected in an attempt to cover a range that includes the true situation. If in fact the range does include the true situation, then there are too many auction markets in Tennessee.

CHAPTER V

SUMMARY

The livestock market system in Tennessee is comprised of various types and sizes of marketing firms with locations scattered throughout the state. In 1969, there were 70 auction markets, 189 independent local livestock dealers, and two terminal markets registered with the Packers and Stockyard Administration. Moreover, buyers representing 27 packing plants in the state engaged in direct buying of livestock. It was postulated that Tennessee has too many livestock markets to develop an efficient, low cost livestock market system.

Objectives of this study were: (1) to determine the number, size, and location of livestock auction markets in Tennessee that would minimize the combined costs of assembling and selling the annual livestock marketings of producers in the state, and (2) to determine the area to be served by each of these auctions. Determination of the optimum solutions was made under the following assumed conditions:

1. That total annual livestock marketings, with the exception of sales from one producer to another, be sold through auction agencies.

2. That the total volume of livestock sold through auction agencies be composed of annual cattle marketings increased by 25 percent, annual hog marketings decreased by 50 percent, and with no change in annual marketings of calves and sheep.

3. That the annual cost of assembling livestock under conditions stated in (1) and (2) above be increased by 10 percent from the original estimate and then decreased by 10 percent from the original estimate.

To determine the optimum solution, information on the annual volume of livestock marketed, annual livestock assembly costs, and annual auction market costs was required.

Estimates of the annual marketings of cattle, calves, hogs, and sheep were made for all counties in the state using data from the 1959 and 1964 Censuses of Agriculture and the 1968 Crop Reporting Board estimates. Costs of assembling the estimated volume of livestock were computed for all possible combinations of the potential market locations in the West, Middle, and East Tennessee areas. From these possible combinations, that combination of potential market locations which minimized annual assembly costs for any given number of markets, and thus for various numbers of markets, was selected. As the number of market destinations was increased, annual livestock assembly costs for a given volume of livestock marketed declined.

Annual costs of operating livestock auction markets were developed in a previous study (Gibb, 1959) and then were adjusted to reflect present marketing costs. These annual costs were expressed in terms of the number of markets. Thus, as the number of market destinations was increased, annual market costs for a given volume of livestock increased.

Determination of the optimum number, size, and location of auction markets was accomplished by combining the minimized annual assembly

and annual auction market costs with respect to the number of markets. Specification of the optimum number of markets was achieved by selecting the number of markets with the minimum combined cost. The optimum market locational pattern was obtained by identifying the market sites which minimized annual assembly costs in the solution for the optimum number of markets. Annual marketings of livestock transported to each market from all origins in that supply area were summed to determine the size of market required at each location.

Total combined annual assembly and annual market costs, under the assumption that all livestock be sold through auction agencies, were minimized for the state with the selection of 18 markets. The optimum number was determined to be six markets for West Tennessee located at Dresden, Memphis, Lexington, Selmer, Ripley, and Troy; seven markets for Middle Tennessee located at Cookeville, Columbia, Manchester, Lebanon, Clarksville, Lawrenceburg, and Shelbyville; and five markets for East Tennessee located at Knoxville, Athens, Johnson City, Pikeville, and Morristown. The volume of livestock marketed at these optimal locations ranged from a low of 60,376 head of livestock at Memphis to a high of 282,481 head at Cookeville. The total combined cost associated with the 18 optimal markets was $3,494,726.

Differences in annual assembly and annual market costs were relatively insensitive to the number of markets varying upward from the optimum to the maximum number of 35 allowed in the model. For example, when the number of markets in West Tennessee was increased by only one

from the optimum number, or from six to seven, total marketing costs were increased by only $823. In Middle Tennessee, when the optimum number of markets, seven, was increased to eight, total marketing costs were increased by $1,334, and in East Tennessee when the optimum number of five markets was increased to six, the cost increased by $5,544.

When assembly costs were increased by 10 percent, the optimum number of markets for the state was increased from 18 to 19. The only change was in West Tennessee where the addition of the extra (seventh) market reduced annual assembly costs by $13,157 and increased annual market costs by $12,784. Trenton was included in the seven West Tennessee markets in addition to the previous combination of six markets.

When assembly costs were reduced by 10 percent, there was no change in the optimum solution in any of the Grand Divisions of the state.

Total combined annual assembly and annual market costs, under the assumption that the total volume of livestock sold through auction agencies be composed of annual cattle marketings increased by 25 percent, annual hog marketings decreased by 50 percent, and with no change in annual marketings of calves and sheep, were minimized for the state with 17 markets. This was one market less than the optimum number derived under the assumed condition that all the annual livestock marketings be sold through auctions. West Tennessee was the only area of the state where the number and location of markets were affected by the changes in livestock marketings. In this case, the optimum number

was determined to be five markets located at Memphis, Dresden, Ripley, Troy, and Jackson. The Lexington and Selmer locations that were originally included in the optimum combination of markets were replaced by a single market located at Jackson. Since hogs constitute a large share, 80 percent, of total livestock marketings in the Lexington and Selmer market areas, these locations were the most vulnerable to a reduction in hog numbers.

The volume of livestock marketed at these optimal locations ranged from a low of 56,525 head of livestock at Memphis to a high of 206,980 head at Dresden. The total combined cost associated with the 17 optimal markets was $3,106,700.

Under the assumed changes in livestock marketed through auctions, a 10 percent increase in annual assembly cost from the original estimate was sufficient to increase the optimum number of markets for the state from 17 to 18. The change was in Middle Tennessee where the addition of the extra (eighth) market reduced annual assembly costs by $13,030 and increased annual market costs by $12,784. Nashville was included in the eight Middle Tennessee markets in addition to the previous combination of seven markets which included: Cookeville, Columbia, Manchester, Lebanon, Clarksville, Lawrenceburg, and Shelbyville. In West and in East Tennessee, the optimum number of markets remained at five in each area.

Under the assumed changes in livestock marketed through auctions, a 10 percent decrease in annual assembly cost from the original estimate

was sufficient to decrease the optimum number of markets for the state from 17 to 16. In this case, the change was in West Tennessee where the optimum combination of markets was reduced from five to only four markets, eliminating the market location at Troy. Thus, the four optimal West Tennessee market locations under these assumptions included Memphis, Dresden, Jackson, and Ripley. The optimum number and location of Middle and East Tennessee markets remained stable.

Results of this study support the hypothesis that Tennessee has too many markets to develop an efficient, low cost livestock auction market system. The optimal solutions under the various postulated conditions indicating a least cost structure of from 16 to 19 strategically located auction markets emphasize the need to give serious consideration to reducing the number of auction markets operating in Tennessee. The tendency to establish new marketing facilities in local communities, further dividing the available supply of livestock, poses a serious problem for the livestock industry. Continuation of this trend will insure a high-cost, inefficient livestock market system in Tennessee.

BIBLIOGRAPHY

BIBLIOGRAPHY

A. BOOKS

Carlson, Sune. A Study of the Pure Theory of Production. New York: Kelley and Millman, Inc., 1956.

Dean, Joel. Statistical Cost Functions of a Hosiery Mill. Chicago: University of Chicago Press, 1941.

Fowler, Stewart H. The Marketing of Livestock and Meat. Danville: The Interstate Printers and Publishers, Inc., 1957.

Greenhut, Melvin L. Plant Location in Theory and Practise: The Economics of Space. Chapel Hill: The University of North Carolina Press, 1956.

Hoover, Edgar M. The Location of Economic Activity. New York: McGraw-Hill Book Company, 1948.

Isard, Walter. Location and Space Economy. New York: John Wiley and Sons, Inc., 1956.

King, Richard A. (ed.). Interregional Competition Research Methods. The Agricultural Policy Institute. Raleigh: North Carolina State University, 1963.

Kohls, Richard L. Marketing of Agricultural Products. Third edition. New York: The Macmillan Company, 1967.

Leftwich, Richard H. The Price System and Resource Allocation. Revised edition. New York: Holt, Rinehart and Winston, 1960.

Losch, August. The Economics of Location. Translated from the second revised edition by William H. Woglom and Wolfgang F. Stolper. New Haven: Yale University Press, 1954.

Ohlin, Bertil. Interregional and International Trade. Cambridge: Harvard University Press, 1935.

Ricardo, David. The Principles of Political Economy and Taxation. London: J. M. Dent and Sons, Ltd., 1948.

Shepherd, Geoffrey S. Agricultural Price Analysis. Fifth edition. Ames: Iowa State University Press, 1963.

Smith, Adam. An Inquiry Into the Nature and Causes of the Wealth of Nations. New York: The Modern Library, 1937.

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

Weber, Alfred. Theory of the Location of Industries. Translated with an introduction and notes by Carl J. Fririch. Chicago: The University of Chicago Press, 1929.

Williams, Willard F., and Thomas T. Stout. Economics of the Livestock Meat Industry. New York: The Macmillan Co., 1964.

B. PUBLICATIONS OF THE GOVERNMENT

United States Department of Agriculture. Packers and Stockyards Administration List of Registrants, Memphis Area. Memphis: Room 831, Federal Building, November, 1969.

_____. Livestock and Meat Statistics. Supplement for 1968 to Statistical Bulletin 333. Washington: Government Printing Office, July, 1969.

_____. Livestock and Meat Statistics. Supplement for 1965 to Statistical Bulletin 333. Washington: Government Printing Office, August, 1966.

_____. Livestock and Meat Statistics. Supplement for 1960 to Statistical Bulletin 333. Washington: Government Printing Office, June, 1961.

_____. Livestock and Meat Statistics. Supplement for 1959 to Statistical Bulletin 333. Washington: Government Printing Office, June, 1960.

_____, and Tennessee Department of Agriculture. Tennessee Agricultural Statistics. Annual Bulletin 1968. Nashville: Tennessee Crop Reporting Service, August, 1968.

_____. The Farm Index. Washington: Government Printing Office, February, 1970.

United States Department of Commerce, Bureau of the Census. 1964 United States Census of Agriculture, Tennessee. Vol. I, Part 31. Washington: Government Printing Office, 1967.

_____. 1959 United States Census of Agriculture, Tennessee. Vol. I, Part 31. Washington: Government Printing Office, 1961.

C. TECHNICAL BULLETINS

Aylor, F. I., and M. E. Jullerat. Least-Cost Movement of Cattle and Calves with Emphasis on the Southeast. Southern Cooperative Series Bulletin 133. Knoxville: The University of Tennessee Agricultural Experiment Station, January, 1968.

Badenhop, M. B. Selling and Buying Livestock by Tennessee Farmers. Bulletin 233. Knoxville: The University of Tennessee Agricultural Experiment Station, June, 1953.

_____. Marketing Cattle and Calves Through Auction Markets in Tennessee. Bulletin 247. Knoxville: The University of Tennessee Agricultural Experiment Station, June, 1956.

Capener, William, William P. Stephens, James S. St. Clair, and Harold Abel. Transportation of Cattle in the West. Research Journal 25. Laramie: University of Wyoming Agricultural Experiment Station, January, 1969.

Cox, Clifton B., and Martin A. Blum. Cost of Operating Selected Indiana Livestock Markets. Station Bulletin 618. Lafayette: Purdue University Agricultural Experiment Station, February, 1955.

Fishel, W. L., Irving Dubov, D. D. Rohdy, and R. G. Stout. Hog and Pork Movements in the Southeast. Southern Cooperative Series Bulletin 83. Knoxville: The University of Tennessee Agricultural Experiment Station, January, 1963.

Gibb, R. D., and H. M. Riley. An Analysis of Operating Costs at Michigan Livestock Auctions. Bulletin 282. East Lansing: Michigan State University Agricultural Experiment Station, January, 1961.

Goodwin, J. D. Optimum Distribution Patterns of Feeder Cattle from the Southeast. Southern Cooperative Series Bulletin 101. Knoxville: The University of Tennessee Agricultural Experiment Station, 1965.

Grimes, Glenn, and Charles Cramer. Missouri Livestock Auction Markets--Operating Costs and Returns. Circular Bulletin 833. Columbia: The University of Missouri Extension Division, February, 1966.

Harp, H. H., and H. D. Smith. Efficiency of Livestock Auction Markets in Maryland. Bulletin 457. College Park: Maryland Agriculture Experiment Station, 1965.

Havlicek, J., 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, 1964.

Henning, G. F., and M. B. Evans. Livestock Auction Markets in Ohio. Research Bulletin 473. Wooster: Ohio Agricultural Experiment Station, April, 1964.

Johnson, Jack D. Livestock Marketing in the Southern Region. Southern Cooperative Series Bulletin 26. Knoxville: Tennessee Agricultural Experiment Station, 1952.

Judge, G. G., J. Havlicek, Jr., and R. L. Rizek. Spatial Structure of Livestock Economy. I. Spatial Analyses of the Meat Marketing Sector in 1955 and 1960. North Central Regional Research Bulletin 157 (South Dakota Bulletin 520). Brookings: South Dakota Agricultural Experiment Station, 1964.

_____, 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, 1959.

King, G. A., and L. F. Schrader. "Regional Location of Cattle Feeding--A Spatial Equilibrium Analysis," Hilgardia. Vol. 34, No. 10. Berkeley: California Agricultural Experiment Station, 1963.

Lindburg, R. C., and G. G. Judge. Estimated Cost Functions for Oklahoma Livestock Auctions. Bulletin B-502. Stillwater: Oklahoma Agricultural Experiment Station, January, 1958.

Logan, S. H., and G. A. King. "Size and Location of Factors Affecting California's Beef Slaughtering Plants," Hilgardia. Vol. 36, No. 4. Berkeley: California Agricultural Experiment Station, 1964.

Maki, Wilbur R., Charles Y. Liu, and William C. Notes. Interregional Competition and Prospective Shifts in the Location of Livestock Slaughter. Research Bulletin 511. Ames: Iowa Agricultural Experiment Station, 1962.

Malphrus, L. D., C. Y. Liu, and R. J. Freund. Cattle and Calf Movement in the South. Southern Cooperative Series Bulletin 134. Knoxville: The University of Tennessee Agricultural Experiment Station, March, 1968.

Mathia, Gene A., and Richard A. King. Selection of the Optimum Number, Size, and Location of Processing Plants in Eastern North Carolina, Vol. 3 of Planning Data for the Sweet Potato Industry. 4 vols. A. E. Series 97. Raleigh: North Carolina State University, 1962.

McDowell, James T., Dennis L. Wold, and Emory E. Anderson. Cost-Volume Relationships at North Dakota Livestock Auctions. Bulletin 452. Fargo: North Dakota Agricultural Experiment Station, March, 1965.

McNeely, J. G., and G. R. Turner. Texas Livestock Auction Markets--Operating Costs and Returns. Miscellaneous Publication 118. College Station: Texas Agricultural Experiment Station, 1954.

Miller, B. R., and R. A. King. Models for Measuring the Impact of Technological Change on Location of Marketing Facilities. A. E. Series 115. Raleigh: North Carolina State University, 1964.

Miller, E. A., and George F. Henning. Suggested Location of Ohio Livestock Markets to Reduce Total Marketing Costs. Research Bulletin 981. Wooster: Ohio Agricultural Research and Development Center, February, 1966.

Newburg, R. R. Livestock Marketing in the North Central Region. I. Where Farmers and Ranchers Buy and Sell. Research Bulletin 846. Wooster: Ohio Agricultural Experiment Station, December, 1959.

_____. Livestock Marketing in the North Central Region. II. Channels Through Which Livestock Move from Farm to Final Destination. Research Bulletin 932. Wooster: Ohio Agricultural Experiment Station, April, 1963.

_____. Livestock Marketing in the North Central Region. III. Auction Markets. Research Bulletin 961. Wooster: Ohio Agriculture Experiment Station, December, 1963.

_____, and S. P. Hart. Livestock Marketing in the North Central Region. IV. Livestock Dealers and Local Markets. Research Bulletin 962. Wooster: Ohio Agriculture Experiment Station, December, 1963.

Peeler, R. J., Jr., and Richard A. King. Optimum Location of Egg Grading and Packing Plants in North Carolina. A. E. Information Service 111. Raleigh: North Carolina State of the University of North Carolina at Raleigh, March, 1964.

Rizek, R. L., G. G. Judge, and J. Havlicek, Jr. Spatial Structure of the Livestock Economy. III. Joint Spatial Analyses of Regional Slaughter and the Flows and Pricing of Livestock and Meat. North Central Regional Bulletin 163 (South Dakota Bulletin 522). Brookings: South Dakota Agricultural Experiment Station, 1965.

Roberts, N. K., and L. H. Grover. Transporting Utah Cattle by Truck. Bulletin 417. Logan: Utah Agricultural Experiment Station, 1959.

Stout, R. G. Marketing Cattle and Calves Through Southern Auctions--Characteristics of Animals and Types of Buyers. Southern Cooperative Series Bulletin 48. Knoxville: The University of Tennessee Agricultural Experiment Station, 1957.

_____, and R. J. Freund. Marketing Cattle and Calves Through Southern Auctions--Analysis of Factors Contributing to Price Variation. Southern Cooperative Series Bulletin 54. Knoxville: The University of Tennessee Agricultural Experiment Station, 1958.

Wootan, Charley V., and John G. McNeely. Factors Affecting Auction Market Operating Costs. Bulletin 1056. College Station: Texas Agricultural Experiment Station, October, 1966.

D. JOURNAL ARTICLES AND PAPERS

Amick, R. J. "A Review of Research in Interregional Competition," Workshop on Interregional Competition. Stillwater: Oklahoma State University, 1966.

Bawden, D. Lee. "An Evaluation of Alternative Spatial Models," Journal of Farm Economics, Vol. 45, No. 5, December, 1963, pp. 1372-1379.

Bressler, R. G., Jr. "Research Determination of Economics of Scale," Journal of Farm Economics, Vol. 27, No. 3, August, 1945, pp. 526-539.

_____. "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, 1950.

Enke, S. "Equilibrium Among Spatially Separated Markets: Solution by Electric Analogue," Econometrica, Vol. 19, No. 1, January, 1951, pp. 40-47.

Fox, Karl A. "A Spatial Equilibrium Model of the Livestock-Feed Economy in the United States," Econometrica, Vol. 21, No. 4, October, 1953, pp. 547-566.

_____, and Richard C. Taeuber. "Spatial Equilibrium Models of the Livestock-Feed Economy," American Economic Review, Vol. 45, No. 4 September, 1955, pp. 584-608.

Gibb, R. D. "Economies of Scale in Michigan Livestock Auctions." Unpublished Ph. D. dissertation, Michigan State University, 1959.

Hurt, Verner G., and Thomas E. Tramel. "Alternative Formulations of the Transhipment Problem," Journal of Farm Economics, Vol. 47, No. 3, August, 1965, pp. 763-773.

Judge, G. G., J. Havlicek, Jr., and R. L. Rizek. "An Interregional Model--Its Formulation and Application to the Livestock Industry," Agricultural Economics Research, Vol. 17, No. 1, January, 1965, pp. 1-9.

King, Gordon A., and Samuel H. Logan. "Optimum Location, Number and Size of Processing Plants with Raw Product and Final Product Shipments," Journal of Farm Economics, Vol. 46, No. 1, February, 1964, pp. 94-108.

King, Richard A., and William R. Henry. "Transportation Models in Studies of Interregional Competition," Journal of Farm Economics, Vol. 41, No. 5, December, 1959, pp. 997-1011.

Kribel, Charles H. "Warehousing with Transhipment Under Seasonal Demand," Journal of Regional Science, Vol. 3, No. 1, Summer, 1961, pp. 57-69.

Kohls, R. L. "Toward a More Meaningful Concept of Marketing Efficiency," Journal of Farm Economics, Vol. 38, No. 1, February, 1956, pp. 68-73.

McLeary, Joseph W. "Optimum Interregional Shipments of Beef, Pork, Broilers and Eggs, and 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.

McPherson, W. K. "How Well Do Auctions Discover the Price of Cattle?," Journal of Farm Economics, Vol. 38, No. 1, February, 1956, pp. 30-43.

Olson, Fred L. "Location Theory as Applied to Milk Processing Plants," Journal of Farm Economics, Vol. 41, No. 5, December, 1959, pp. 1546-1556.

Polopolus, Leo. "Optimum Plant Numbers and Locations for Multiple Product Processing," Journal of Farm Economics, Vol. 47, No. 2, May, 1965, pp. 287-295.

Samuelson, P. A. "Spatial Price Equilibrium and Linear Programming," American Economic Review, Vol. 43, No. 3, June, 1952, pp. 283-303.

Seaver, S. K. "Spatial Research--Measurement for What?," Journal of Farm Economics, Vol. 46, No. 5, December, 1964, pp. 1365-1371.

Stollsteimer, John F. "A Working Model for Plant Numbers and Locations," Journal of Farm Economics, Vol. 45, No. 3, August, 1963, pp. 631-545.

Williams, Willard F. "Interregional Competition--The Relevant Theory," Workshop on Interregional Competition. Stillwater: Oklahoma State University, 1966.

Williamson, J. C., Jr. "Equilibrium Size of Marketing Plants in a Spatial Market," Journal of Farm Economics, Vol. 44, No. 4, November, 1962, pp. 953-967.

Wisner, Robert Newell. "Estimated Optimum Interregional Competition and Location Patterns in the Southern Cattle Slaughtering Industry in 1975." Unpublished Ph. D. dissertation, The University of Tennessee, Knoxville, 1967.

E. OTHER SOURCES

Tennessee Department of Agriculture. Unpublished livestock market data. Nashville: Ellington Agricultural Center.

Tennessee Department of Highways. "Official Map of Tennessee Highways, 1969." Nashville: Tennessee Department of Highways, February, 1969.

APPENDICES

APPENDIX A

ESTIMATED NUMBER OF LIVESTOCK MARKETED BY COUNTIES, AND PER HEAD TRANSPORTATION COST MATRICES

TABLE 17

ESTIMATED NUMBER OF CATTLE SOLD BY COUNTIES AND TRANSPORTATION COSTS IN DOLLARS PER HEAD FROM 21 POINTS OF ORIGIN TO 11 DESTINATIONS, WEST TENNESSEE, 1968

Origins		Estimated no. of cattle sold	Destinations (potential market sites)										
County	City		Huntingdon	Dyersburg	Trenton	Bolivar	Lexington	Ripley	Selmer	Jackson	Troy	Memphis	Dresden
			Dollars per head										
Benton	Camden	2,278	1.4992	2.7281	2.1865	2.8114	2.0199	3.0821	2.8947	2.2490	2.7281	3.9153	2.0615
Carroll	Huntingdon	6,033	1.2909	2.3531	1.7699	2.3948	1.6033	2.6656	2.4781	1.8324	2.3115	3.4987	1.6450
Chester	Henderson	1,938	2.0824	2.5406	2.0407	1.6033	1.5616	2.3740	1.4783	1.4367	2.9155	2.5614	2.5406
Crockett	Alamo	4,473	2.0615	1.6658	1.4575	2.1032	2.1240	1.6658	2.2906	1.5408	2.2282	2.3740	1.9990
Decatur	Decaturville	2,320	2.0407	3.2071	2.5823	2.3531	1.5200	3.0197	2.2073	2.0824	3.2696	3.3113	2.6031
Dyer	Dyersburg	15,203	2.3531	1.2909	1.6241	2.6447	2.5823	1.5825	2.8322	2.0824	1.6450	2.3948	2.2073
Fayette	Somerville	6,936	2.7697	2.4989	2.3740	1.5825	2.5198	1.9990	2.0615	2.0199	3.0613	1.6658	2.9780
Gibson	Trenton	12,404	1.7699	1.6241	1.2909	2.2490	2.1448	2.1032	2.4365	1.6866	1.8324	2.8739	1.6241
Hardeman	Bolivar	6,315	2.3948	2.6447	2.2490	1.2909	2.0824	2.4989	1.5616	1.6450	3.2071	2.1657	2.7457
Hardin	Savannah	2,850	2.4781	3.1655	2.9155	2.0407	1.8116	3.1030	1.5616	2.1657	3.6445	3.1238	2.8947
Haywood	Brownsville	4,011	2.2906	1.9574	1.8532	1.9157	2.1448	1.4575	2.3948	1.6450	2.5198	1.9782	2.3948
Henderson	Lexington	4,425	1.6033	2.5823	2.1448	2.0824	1.2909	2.5198	1.9990	1.6450	2.8322	3.0405	2.1657
Henry	Paris	17,725	1.5616	2.6447	2.1032	2.8947	2.1032	3.0197	2.9363	2.3323	2.1240	3.5404	1.5200
Lake	Tiptonville	313	2.7457	1.6241	2.1657	3.1863	3.1238	2.1240	3.3738	2.6239	1.5200	3.1655	2.1240
Lauderdale	Ripley	6,362	2.6656	1.5825	2.1032	2.4989	2.5198	1.2909	2.7697	2.0199	2.1448	2.1240	2.7697
McNairy	Selmer	3,133	2.4781	2.8322	2.4365	1.5616	1.9990	2.7697	1.2909	1.8324	3.3321	2.6447	2.9363
Madison	Jackson	10,828	1.8324	2.0824	1.6866	1.6450	1.6450	2.0199	1.8324	1.2909	2.5823	2.5406	2.1865
Obion	Troy	19,991	2.3115	1.6450	1.8324	3.2071	2.8322	2.1448	3.3321	2.5823	1.2909	3.1863	1.6866
Shelby	Intersection U.S. 64 & 70	19,765	3.4987	2.3948	2.8739	2.1657	3.0405	2.1240	2.6447	2.5406	3.1863	1.2909	3.3529
Tipton	Covington	6,084	2.7457	1.8949	2.3115	2.1865	2.6031	1.3950	2.6656	2.1032	2.4573	1.8116	2.7281
Weakley	Dresden	11,692	1.6450	2.2073	1.6241	2.7457	2.1657	2.7697	2.9363	2.1865	1.6866	3.3529	1.2909

TABLE 18

ESTIMATED NUMBER OF CALVES SOLD BY COUNTIES AND TRANSPORTATION COSTS IN DOLLARS PER HEAD FROM 21 POINTS OF ORIGIN TO 11 DESTINATIONS, WEST TENNESSEE, 1968

Origins		Estimated no. of calves sold	Destinations (potential market sites)										
County	City		Huntingdon	Dyersburg	Trenton	Bolivar	Lexington	Ripley	Selmer	Jackson	Troy	Memphis	Dresden
			Dollars per head										
Benton	Camden	1,597	.4446	.8091	.6548	.8338	.5991	.9141	.8585	.6670	.8091	1.1612	.6114
Carroll	Huntingdon	5,222	.3828	.6979	.5249	.7102	.4755	.7906	.7350	.5435	.6855	1.0376	.4879
Chester	Henderson	1,610	.6176	.7535	.6052	.4755	.4632	.7041	.4384	.4261	.8647	.7597	.7535
Crockett	Alamo	3,555	.6114	.4940	.4323	.6238	.6299	.4941	.6794	.4570	.6608	.7041	.5929
Decatur	Decaturville	2,041	.6052	.9512	.7658	.6979	.4508	.8956	.6547	.6176	.9697	.9821	.7720
Dyer	Dyersburg	5,114	.6979	.3828	.4817	.7844	.7658	.4693	.8400	.6176	.4879	.7102	.6547
Fayette	Somerville	6,838	.8214	.7411	.7041	.4693	.7473	.5929	.6114	.5991	.9079	.4940	.8832
Gibson	Trenton	7,033	.5249	.4817	.3828	.6670	.6361	.6238	.7226	.5002	.5435	.8523	.4817
Hardeman	Bolivar	4,336	.7102	.7844	.6670	.3828	.6176	.7411	.4632	.4879	.9512	.6423	.8153
Hardin	Savannah	2,090	.7350	.9388	.8647	.6052	.5373	.9203	.4632	.6423	1.0809	.9265	.8585
Haywood	Brownsville	5,078	.6793	.5805	.5496	.5682	.6361	.4323	.7102	.4879	.7473	.5867	.7102
Henderson	Lexington	2,610	.4755	.7658	.6361	.6176	.3828	.7473	.5929	.4879	.8400	.9017	.6423
Henry	Paris	4,585	.4632	.7844	.6238	.8585	.6238	.8956	.8709	.6917	.6299	1.0500	.4508
Lake	Tiptonville	235	.8153	.4817	.6423	.9450	.9265	.6299	1.0006	.7782	.4508	.9388	.6299
Lauderdale	Ripley	3,430	.7906	.4693	.6238	.7411	.7473	.3828	.8214	.5991	.6361	.6299	.8214
McNairy	Selmer	1,815	.7350	.8400	.7226	.4632	.5929	.8214	.3828	.5435	.9882	.7844	.8709
Madison	Jackson	6,030	.5435	.6176	.5002	.4879	.4879	.5991	.5435	.3828	.7658	.7535	.6548
Obion	Troy	10,688	.6855	.4879	.5435	.9512	.8400	.6361	.9882	.7658	.3828	.9450	.5002
Shelby	Intersection U.S. 64 & 70	5,558	1.0376	.7102	.8523	.6423	.9017	.6299	.7844	.7535	.9450	.3828	.9944
Tipton	Covington	4,510	.8153	.5620	.6855	.6548	.7720	.4137	.7906	.6238	.7288	.5373	.8091
Weakley	Dresden	7,981	.4879	.6547	.4817	.8153	.6423	.8214	.8709	.6548	.5002	.9944	.3828

TABLE 19

ESTIMATED NUMBER OF HOGS SOLD BY COUNTIES AND TRANSPORTATION COSTS IN DOLLARS PER HEAD FROM 21 POINTS OF ORIGIN TO 11 DESTINATIONS, WEST TENNESSEE, 1968

Origins		Estimated no. of hogs sold	Destinations (potential market sites)										
County	City		Huntingdon	Dyersburg	Trenton	Bolivar	Lexington	Ripley	Selmer	Jackson	Troy	Memphis	Dresden
			Dollars per head										
Benton	Camden	13,000	.3068	.5583	.4475	.5753	.4134	.6308	.5924	.4603	.5583	.8013	.4219
Carroll	Huntingdon	37,058	.2642	.4816	.3622	.4901	.3281	.5455	.5071	.3750	.4730	.7160	.3366
Chester	Henderson	18,563	.4262	.5199	.4176	.3281	.3196	.4858	.3025	.2940	.5967	.5242	.5199
Crockett	Alamo	12,795	.4219	.3409	.2983	.4304	.4347	.3409	.4688	.3153	.4560	.4858	.4091
Decatur	Decaturville	27,125	.4176	.6563	.5285	.4816	.3111	.6180	.4517	.4262	.6691	.6776	.5327
Dyer	Dyersburg	18,425	.4816	.2642	.3324	.5412	.5285	.3239	.5796	.4262	.3366	.4901	.4517
Fayette	Somerville	14,552	.5668	.5114	.4858	.3239	.5157	.4091	.4219	.4134	.6265	.3409	.6094
Gibson	Trenton	79,475	.3622	.3324	.2642	.4603	.4389	.4304	.4986	.3452	.3750	.5881	.3324
Hardeman	Bolivar	23,945	.4901	.5412	.4603	.2642	.4262	.5114	.3196	.3366	.6563	.4432	.5626
Hardin	Savannah	35,079	.5071	.6478	.5967	.4176	.3707	.6350	.3196	.4432	.7459	.6393	.5924
Haywood	Brownsville	11,978	.4688	.4006	.3793	.3921	.4389	.2983	.4901	.3366	.5157	.4048	.4901
Henderson	Lexington	44,909	.3281	.5285	.4389	.4262	.2642	.5157	.4091	.3366	.5796	.6222	.4432
Henry	Paris	29,194	.3196	.5412	.4304	.5924	.4304	.6180	.6009	.4773	.4347	.7245	.3111
Lake	Tiptonville	2,369	.5626	.3324	.4432	.6521	.6393	.4347	.6904	.5370	.3111	.6478	.4347
Lauderdale	Ripley	12,542	.5455	.3239	.4304	.5114	.5157	.2642	.5668	.4134	.4389	.4347	.5668
McNairy	Selmer	39,165	.5071	.5796	.4986	.3196	.4091	.5668	.2642	.3750	.6819	.5412	.6009
Madison	Jackson	21,883	.3750	.4262	.3452	.3366	.3366	.4134	.3750	.2642	.5285	.5199	.4475
Obion	Troy	58,029	.4730	.3366	.3750	.6563	.5796	.4389	.6819	.5285	.2642	.6521	.3452
Shelby	Intersection U.S. 64 & 70	6,500	.7160	.4901	.5881	.4432	.6222	.4347	.5412	.5199	.6521	.2642	.6862
Tipton	Covington	7,558	.5626	.3878	.4730	.4475	.5327	.2855	.5455	.4304	.5029	.3707	.5583
Weakley	Dresden	74,273	.3366	.4517	.3324	.5626	.4432	.5668	.6009	.4475	.3452	.6862	.2642

TABLE 20

ESTIMATED NUMBER OF SHEEP SOLD BY COUNTIES AND TRANSPORTATION COSTS IN DOLLARS PER HEAD FROM 21 POINTS OF ORIGIN TO 11 DESTINATIONS, WEST TENNESSEE, 1968

Origins		Estimated no. of sheep sold	Destinations (potential market sites)										
County	City		Huntingdon	Dyersburg	Trenton	Bolivar	Lexington	Ripley	Selmer	Jackson	Troy	Memphis	Dresden
			Dollars per head										
Benton	Camden	0	.1523	.2772	.2222	.2857	.2052	.3132	.2941	.2285	.2772	.3978	.2095
Carroll	Huntingdon	130	.1312	.2391	.1798	.2433	.1629	.2709	.2518	.1862	.2349	.3555	.1671
Chester	Henderson	0	.2116	.2582	.2074	.1629	.1587	.2412	.1502	.1460	.2962	.2603	.2582
Crockett	Alamo	65	.2095	.1693	.1481	.2137	.2158	.1693	.2328	.1566	.2264	.2412	.2031
Decatur	Decaturville	0	.2074	.3259	.2624	.2391	.1544	.3068	.2243	.2116	.3332	.3365	.2645
Dyer	Dyersburg	97	.2391	.1312	.1650	.2687	.2624	.1608	.2878	.2116	.1671	.2433	.2243
Fayette	Somerville	162	.2814	.2539	.2412	.1608	.2560	.2031	.2095	.2052	.3111	.1693	.3026
Gibson	Trenton	422	.1798	.1650	.1312	.2285	.2179	.2137	.2476	.1714	.1862	.2920	.1650
Hardeman	Bolivar	195	.2433	.2687	.2285	.1312	.2116	.2539	.1587	.1671	.3259	.2201	.2793
Hardin	Savannah	65	.2518	.3216	.2962	.2074	.1841	.3153	.1587	.2200	.3703	.3174	.2941
Haywood	Brownsville	0	.2328	.1989	.1883	.1947	.2179	.1481	.2433	.1671	.2560	.2010	.2433
Henderson	Lexington	97	.1629	.2624	.2179	.2116	.1312	.2560	.2031	.1671	.2878	.3089	.2201
Henry	Paris	519	.1587	.2687	.2137	.2941	.2137	.3068	.2983	.2370	.2158	.3597	.1544
Lake	Tiptonville	0	.2793	.1650	.2201	.3238	.3174	.2158	.3428	.2666	.1544	.3216	.2158
Lauderdale	Ripley	0	.2709	.1608	.2137	.2539	.2560	.1312	.2814	.2052	.2179	.2158	.2814
McNairy	Selmer	0	.2518	.2878	.2476	.1587	.2031	.2814	.1312	.1862	.3386	.2687	.2984
Madison	Jackson	97	.1862	.2116	.1714	.1671	.1671	.2052	.1862	.1312	.2624	.2582	.2222
Obion	Troy	292	.2349	.1671	.1862	.3259	.2878	.2179	.3386	.2624	.1312	.3238	.1714
Shelby	Intersection U.S. 64 & 70	65	.3555	.2433	.2920	.2201	.3089	.3158	.2687	.2582	.3238	.1312	.3407
Tipton	Covington	97	.2793	.1925	.2349	.2222	.2645	.1418	.2709	.2137	.2497	.1841	.2772
Weakley	Dresden	325	.1671	.2243	.1650	.2793	.2201	.2814	.2984	.2222	.1714	.3407	.1312

ION COSTS IN DOLLARS PER HEAD
DLE TENNESSEE, 1968

otential market sites)

	Columbia	Clarksville	Cookeville	Carthage	Sparta	Lebanon
rs per head----------						
41	1.9782	3.1446	3.0613	2.5823	2.7457	2.1657
65	2.4781	3.1031	2.2698	1.8741	2.0615	1.9366
38	2.3531	1.7283	3.2071	2.5406	3.2904	2.1240
11	3.9986	4.0403	1.8949	2.1031	2.2906	2.5198
.57	2.5823	3.3738	2.4989	2.3948	2.1448	2.2906
12	3.9778	4.4152	1.7699	2.5614	1.6658	2.8322
72	1.9366	2.0407	2.7905	2.1240	2.8739	1.7074
88	2.9572	3.3946	1.7283	1.7699	1.5200	1.8116
55	2.3323	1.6241	3.6445	2.9780	3.7278	2.5614
.11	4.5402	4.6860	2.0615	2.6864	2.4156	3.1030
99	2.6447	4.0611	3.0197	2.9572	2.7072	2.8530
74	1.7283	3.5404	3.8945	3.4154	3.6029	2.9988
31	3.2488	3.9570	2.6031	2.7281	2.2282	2.7697
72	1.7283	2.3948	3.9153	3.2488	3.9986	2.8322
61	2.9572	1.6658	4.1236	3.4571	4.2069	3.0405
54	2.8322	2.0615	4.1444	3.4779	4.2277	3.0613
95	3.6237	3.6237	1.5200	1.6241	2.0407	2.0407
24	1.7699	3.5196	4.2486	3.7695	3.9778	3.2488
81	1.7491	2.8114	4.0866	3.6445	4.0611	3.2488
09	2.0615	3.6654	3.3321	3.1238	2.9780	2.7072
38	3.2071	2.8947	2.2906	1.6241	2.6864	1.7699
41	1.5200	3.0821	3.3738	2.8947	3.2071	2.4781
15	1.2909	2.8947	3.5612	3.0821	3.3946	2.5614
54	2.8947	1.2909	3.7487	3.0821	3.8320	2.6656
50	2.3115	3.4779	3.0405	2.9572	2.6656	2.5406
78	3.9570	4.1444	1.4783	2.1032	1.8324	2.5614
63	2.1448	2.9155	4.4985	3.8320	4.7068	3.4154
61	4.4152	4.7068	2.0407	2.6656	2.4156	3.0821

potential market sites)

	Columbia	Clarksville	Cookeville	Carthage	Sparta	Lebanon
ars per head						
321	3.5612	3.7487	1.2909	1.7491	1.4367	2.1657
904	2.5198	1.7491	3.1238	2.4573	3.2904	2.1240
357	2.1240	2.7072	2.5198	2.0407	2.3531	1.6658
238	3.0821	3.0821	1.7491	1.2909	2.1240	1.4992
735	3.3946	1.6866	4.3527	3.6862	4.6443	3.4779
030	2.5406	2.3948	2.4781	1.8116	2.6447	1.4783
313	2.9155	2.7457	2.1032	1.4367	2.4781	1.4367
322	3.2904	3.9778	1.7491	2.3948	1.3533	2.5198
948	2.8530	3.5404	2.0199	2.1448	1.6658	2.2073
364	2.3323	3.2279	4.8109	4.2277	4.5818	4.4569
780	3.3946	3.8320	1.4367	2.1240	1.2909	2.2490
323	1.5616	2.4156	3.1030	2.4989	2.9363	2.0824
072	2.5614	2.6656	2.1657	1.4992	2.2490	1.2909

:ION COSTS IN DOLLARS PER HEAD
)DLE TENNESSEE, 1968

tential market sites)

	Columbia	Clarksville	Cookeville	Carthage	Sparta	Lebanon
)llars per head----------						
317	.5867	.9326	.9079	.7658	.8153	.6423
226	.7350	.9203	.6732	.5558	.6114	.5743
265	.6979	.5126	.9512	.7535	.9759	.6299
)44	1.1859	1.1983	.5620	.6238	.6794	.7473
582	.7658	1.0006	.7411	.7102	.6361	.6794
562	1.1797	1.3095	.5249	.7597	.4940	.8400
)29	.5743	.6052	.8276	.6299	.8523	.5064
394	.8770	1.0068	.5126	.5249	.4508	.5373
588	.6917	.4817	1.0809	.8832	1.1056	.7597
'86	1.3465	1.3898	.6114	.7967	.7164	.9203
249	.7844	1.2044	.8956	.8770	.8029	.8461
)64	.5126	1.0500	1.1550	1.0129	1.0685	.8894
'20	.9635	1.1735	.7720	.8091	.6608	.8214
)29	.5126	.7102	1.1612	.9635	1.1859	.8400
574	.8770	.4940	1.2230	1.0253	1.2477	.9017
371	.8400	.6114	1.2291	1.0315	1.2539	.9079
.80	1.0747	1.0747	.4508	.4817	.6052	.6052
.76	.5249	1.0438	1.2600	1.1180	1.1797	.9635
)91	.5187	.8338	1.2539	1.0809	1.2044	.9635
328	.6114	1.0871	.9882	.9265	.8832	.8029
)06	.9512	.8585	.6794	.4817	.7967	.5187
317	.4508	.9141	1.0006	.8585	.9512	.7350
114	.3828	.8585	1.0562	.9141	1.0068	.7597
371	.8585	.3828	1.1118	.9141	1.1365	.7906
137	.6855	1.0315	.9017	.8770	.7906	.7535
)56	1.1735	1.2291	.4384	.6238	.5435	.7597
450	.6361	.8647	1.3342	1.1365	1.3959	1.0129
415	1.3095	1.3959	.6052	.7906	.7164	.9141

)tential market sites)

	Columbia	Clarksville	Cookeville	Carthage	Sparta	Lebanon
's per head----------						
82	1.0562	1.1118	.3828	.5187	.4261	.6423
59	.7473	.5187	.9265	.7288	.9759	.6299
23	.6299	.8029	.7473	.6052	.6979	.4940
65	.9141	.9141	.5187	.3828	.6299	.4446
71	1.0068	.5002	1.2909	1.0932	1.3774	1.0315
03	.7535	.7102	.7350	.5373	.7844	.4384
79	.8647	.8153	.6238	.4261	.7350	.4261
00	.9759	1.1797	.5187	.7102	.4014	.7473
02	.8461	1.0500	.5991	.6361	.4940	.6546
67	.6917	.9573	1.4268	1.2539	1.3589	1.3218
32	1.0068	1.1365	.4261	.6299	.3828	.6670
17	.4631	.7164	.9203	.7411	.8709	.6176
29	.7597	.7906	.6423	.4446	.6670	.3828

TABLE 23

ESTIMATED NUMBER OF HOGS SOLD BY COUNTIES AND TRANSPORTATION COSTS IN DOLLARS PER HEAD FROM 41 POINTS OF ORIGIN TO 12 DESTINATIONS, MIDDLE TENNESSEE, 1968

Origins		Estimated no. of hogs sold	Destinations (potential market sites)											
County	City		Shelbyville	Manchester	Nashville	Centerville	Lawrence-burg	Fayetteville	Columbia	Clarksville	Cookeville	Carthage	Sparta	Lebanon
			Dollars per head											
Bedford	Shelbyville	25,742	.2642	.3452	.4475	.5370	.4986	.3324	.4048	.6435	.6265	.5285	.5626	.4432
Cannon	Woodbury	22,858	.4134	.3281	.4389	.6350	.6904	.4986	.5071	.6350	.4645	.3835	.4219	.3963
Cheatham	Ashland City	12,881	.5327	.5796	.3068	.4773	.6222	.6393	.4816	.3537	.6563	.5199	.6734	.4347
Clay	Celina	14,989	.7373	.6606	.6435	.8780	.9590	.8311	.8183	.8268	.3878	.4304	.4688	.5157
Coffee	Manchester	30,284	.3452	.2642	.4944	.6606	.5967	.3921	.5285	.6904	.5114	.4901	.4389	.4688
Cumberland	Crossville	19,651	.6819	.5583	.7075	.9377	.9334	.7288	.8140	.9036	.3622	.5242	.3409	.5796
Davidson	Nashville	12,410	.4475	.4944	.2642	.4517	.5370	.5540	.3963	.4176	.5711	.4347	.5881	.3494
DeKalb	Smithville	13,824	.5242	.4006	.4986	.7203	.7458	.6137	.6052	.6947	.3537	.3622	.3111	.3707
Dickson	Charlotte	18,162	.5753	.6478	.3963	.3452	.5753	.6478	.4773	.3324	.7458	.6094	.7629	.5242
Fentress	Jamestown	19,177	.8268	.7117	.7629	.9931	1.0698	.8822	.9291	.9590	.4219	.5498	.4944	.6350
Franklin	Winchester	36,491	.3579	.3366	.5839	.6691	.5668	.3622	.5412	.8311	.6180	.6052	.5540	.5839
Giles	Pulaski	25,459	.4219	.5199	.5285	.4858	.2983	.3494	.3537	.7245	.7970	.6990	.7373	.6137
Grundy	Altmont	11,245	.5285	.3579	.6308	.7970	.7373	.5327	.6649	.8098	.5327	.5583	.4560	.5668
Hickman	Centerville	30,559	.5370	.6606	.4517	.2642	.4517	.5540	.3537	.4901	.8013	.6649	.8183	.5796
Houston	Erin	3,638	.7032	.7757	.4944	.4730	.7032	.8055	.6052	.3409	.8439	.7075	.8609	.6222
Humphreys	Waverly	18,658	.6776	.7501	.4986	.4475	.6222	.7501	.5796	.4219	.8481	.7117	.8652	.6265
Jackson	Gainesboro	16,919	.6393	.6265	.5455	.7842	.8822	.7714	.7416	.7416	.3111	.3324	.4176	.4176
Lawrence	Lawrenceburg	21,963	.4986	.5967	.5370	.4517	.2642	.4262	.3622	.7203	.8695	.7714	.8140	.6649
Lewis	Hohenwald	5,728	.5412	.6649	.5327	.3068	.3665	.5583	.3579	.5753	.8652	.7458	.8311	.6649
Lincoln	Fayetteville	30,384	.3324	.3921	.5540	.5540	.4262	.2642	.4219	.7501	.6819	.6393	.6094	.5540
Macon	Lafayette	7.546	.5796	.6563	.4816	.7117	.7970	.6904	.6563	.5924	.4688	.3324	.5498	.3579

TABLE 23 (continued)

Origins		Estimated no. of hogs sold	Destinations (potential market sites)											
County	City		Shelbyville	Manchester	Nashville	Centerville	Lawrence-burg	Fayetteville	Columbia	Clarksville	Cookeville	Carthage	Sparta	Lebanon
			Dollars per head											
Marshall	Lewisburg	17,158	.3153	.4389	.4432	.4432	.4048	.3324	.3111	.6308	.6904	.5924	.6563	.5071
Maury	Columbia	26,793	.4048	.5285	.3963	.3537	.3622	.4219	.2642	.5924	.7288	.6308	.6945	.5242
Montgomery	Clarksville	26,698	.6435	.6904	.4176	.4901	.7203	.7501	.5924	.2642	.7672	.6308	.7842	.5455
Moore	Lynchburg	8,597	.2897	.3281	.5157	.5881	.4901	.2855	.4730	.7117	.6222	.6052	.5455	.5199
Overton	Livingston	16,605	.7075	.6649	.6521	.8737	.9505	.7629	.8098	.8481	.3025	.4304	.3750	.5242
Perry	Linden	15,375	.6222	.7458	.5711	.3452	.4475	.6521	.4389	.5967	.9206	.7842	.9632	.6990
Pickett	Byrdstown	12,433	.8226	.7799	.7672	.9888	1.0655	.8567	.9036	.9632	.4176	.5455	.4944	.6308
Putnam	Cookeville	32,877	.6308	.5114	.5711	.8013	.8695	.6819	.7288	.7672	.2642	.3579	.2940	.4432
Robertson	Springfield	29,212	.5668	.6137	.3409	.5668	.6563	.6734	.5157	.3579	.6393	.5029	.6734	.4347
Rutherford	Murfreesboro	39,111	.3324	.3579	.3579	.5583	.5753	.4432	.4347	.5540	.5157	.4176	.4816	.3409
Smith	Carthage	43,483	.5285	.4901	.4347	.6649	.7714	.6393	.6308	.6308	.3579	.2642	.4347	.3068
Stewart	Dover	15,419	.7672	.8140	.5412	.5626	.7927	.8950	.6947	.3452	.8908	.7544	.9505	.7117
Sumner	Gallatin	27,638	.5242	.5498	.3452	.5753	.6606	.6350	.5199	.4901	.5071	.3707	.5412	.3025
Trousdale	Hartsville	4,919	.5157	.5626	.4219	.6521	.7373	.6264	.5967	.5626	.4304	.2940	.5071	.2940
Van Buren	Spencer	10,642	.5327	.4091	.6180	.8183	.7842	.5796	.6734	.8140	.3579	.4901	.2770	.5157
Warren	McMinnville	38,129	.4432	.3196	.5285	.7288	.6947	.4901	.5839	.7245	.4134	.4389	.3409	.4517
Wayne	Murfreesboro	18,852	.6222	.7203	.6521	.4262	.3452	.5498	.4773	.6606	.9846	.8652	.9377	.9121
White	Sparta	45,438	.5626	.4389	.5881	.8183	.8140	.6094	.6947	.7842	.2940	.4347	.2642	.4603
Williamson	Franklin	30,979	.4048	.4773	.2983	.4389	.4603	.4773	.3196	.3944	.6350	.5114	.6009	.4262
Wilson	Lebanon	36,786	.4432	.4688	.3494	.5796	.6649	.5540	.5242	.5455	.4432	.3068	.4603	.2642

TABLE 24

ESTIMATED NUMBER OF SHEEP SOLD BY COUNTIES AND TRANSPORTATION COSTS IN DOLLARS PER HEAD FROM 41 POINTS OF ORIGIN TO 12 DESTINATIONS, MIDDLE TENNESSEE, 1968

Origins		Estimated no. of sheep sold	Destinations (potential market sites)											
County	City		Shelbyville	Manchester	Nashville	Centerville	Lawrence-burg	Fayetteville	Columbia	Clarksville	Cookeville	Carthage	Sparta	Lebanon
			Dollars per head											
Bedford	Shelbyville	3,375	.1312	.1714	.2222	.2666	.2476	.1650	.2010	.3195	.3111	.2624	.2793	.2179
Cannon	Woodbury	909	.2052	.1629	.2179	.3153	.3428	.2476	.2518	.3153	.2306	.1904	.2095	.1968
Cheatham	Ashland City	0	.2645	.2878	.1523	.2370	.3089	.3174	.2391	.1756	.3259	.2581	.3343	.2158
Clay	Celina	65	.3661	.3280	.3195	.4359	.4761	.4126	.4063	.4105	.1925	.2137	.2328	.2560
Coffee	Manchester	487	.1714	.1312	.2454	.3280	.2962	.1947	.2624	.3428	.2539	.2433	.2179	.2328
Cumberland	Crossville	260	.3386	.2772	.3513	.4656	.4634	.3619	.4042	.4486	.1798	.2603	.1693	.2878
Davidson	Nashville	260	.2222	.2454	.1312	.2243	.2666	.2751	.1968	.2074	.2835	.2158	.2920	.1735
DeKalb	Smithville	682	.2603	.1989	.2476	.3576	.3703	.3047	.3005	.3449	.1756	.1798	.1544	.1841
Dickson	Charlotte	292	.2857	.3216	.1968	.1714	.2857	.3216	.2370	.1650	.3703	.3026	.3788	.2603
Fentress	Jamestown	130	.4105	.3534	.3788	.4931	.5312	.4380	.4613	.4761	.2095	.2730	.2454	.3153
Franklin	Winchester	487	.1777	.1671	.2899	.3322	.2814	.1798	.2687	.4126	.3068	.3005	.2751	.2899
Giles	Pulaski	552	.2095	.2581	.2624	.2433	.1481	.1735	.1756	.3597	.3957	.3470	.3661	.3047
Grundy	Altmont	0	.2624	.1777	.3132	.3957	.3661	.2645	.3301	.4021	.2645	.2772	.2264	.2814
Hickman	Centerville	454	.2666	.3280	.2243	.1312	.2243	.2751	.1756	.2433	.3978	.3301	.4063	.2878
Houston	Erin	0	.3492	.3851	.2454	.2349	.3492	.3999	.3005	.1693	.4190	.3513	.4275	.3089
Humphreys	Waverly	130	.3365	.3724	.2476	.2222	.3089	.3724	.2878	.2094	.4211	.3534	.4296	.3111
Jackson	Gainesboro	325	.3174	.3111	.2708	.3894	.4380	.3830	.3682	.3682	.1544	.1650	.2074	.2074
Lawrence	Lawrenceburg	227	.2476	.2962	.2666	.2243	.1312	.2116	.1798	.3576	.4317	.3830	.4042	.3301
Lewis	Hohenwald	0	.2687	.3301	.2645	.1523	.1820	.2772	.1777	.2857	.4296	.3703	.4126	.3301
Lincoln	Fayetteville	1,525	.1650	.1947	.2751	.2751	.2116	.1312	.2095	.3724	.3386	.3174	.3026	.2751
Macon	Lafayette	1,201	.2878	.3259	.2391	.3534	.3957	.3428	.3259	.2941	.2329	.1650	.2730	.1778

TABLE 24 (continued)

Origins		Estimated no. of sheep sold	Destinations (potential market sites)											
County	City		Shelbyville	Manchester	Nashville	Centerville	Lawrence-burg	Fayetteville	Columbia	Clarksville	Cookeville	Carthage	Sparta	Lebanon
			----------Dollars per head----------											
Marshall	Lewisburg	1,331	.1566	.2179	.2201	.2201	.2010	.1650	.1544	.3132	.3428	.2941	.3259	.2518
Maury	Columbia	3,343	.2010	.2624	.1968	.1756	.1798	.2095	.1312	.2941	.3619	.3132	.3449	.2603
Montgomery	Clarksville	227	.3195	.3428	.2074	.2433	.3576	.3724	.2941	.1312	.3809	.3132	.3894	.2708
Moore	Lynchburg	325	.1439	.1629	.2560	.2920	.2433	.1417	.2349	.3534	.3089	.3005	.2708	.2581
Overton	Livingston	0	.3513	.3301	.3238	.4338	.4719	.3787	.4021	.4211	.1502	.2137	.1862	.2603
Perry	Linden	97	.3089	.3703	.2835	.1714	.2222	.3238	.2179	.2962	.4571	.3894	.4783	.3470
Pickett	Byrdstown	0	.4084	.3872	.3809	.4910	.5291	.4253	.4486	.4783	.2074	.2708	.2454	.3132
Putnam	Cookeville	195	.3111	.2539	.2835	.3978	.4317	.3386	.3619	.3809	.1312	.1777	.1460	.2201
Robertson	Springfield	292	.2814	.3047	.1693	.2814	.3259	.3343	.2560	.1777	.3174	.2497	.3343	.2158
Rutherford	Murfreesboro	2,077	.1650	.1777	.1777	.2772	.2857	.2201	.2158	.2751	.2560	.2074	.2391	.1693
Smith	Carthage	2,337	.2624	.2433	.2158	.3301	.3830	.3174	.3132	.3132	.1777	.1312	.2158	.1523
Stewart	Dover	0	.3809	.4042	.2687	.2793	.3936	.4444	.3449	.1714	.4423	.3746	.4719	.3534
Sumner	Gallatin	779	.2603	.2730	.1714	.2857	.3280	.3153	.2581	.2433	.2518	.1841	.2687	.1502
Trousdale	Hartsville	1,882	.2560	.2793	.2095	.3238	.3661	.3111	.2962	.2793	.2137	.1460	.2518	.1460
Van Buren	Spencer	0	.2645	.2031	.3068	.4063	.3894	.2878	.3343	.4042	.1777	.2433	.1375	.2560
Warren	McMinnville	130	.2201	.1587	.2624	.3619	.3449	.2433	.2899	.3597	.2052	.2179	.1693	.2243
Wayne	Waynesboro	227	.3089	.3576	.3238	.2116	.1714	.2730	.2370	.3280	.4888	.4296	.4656	.4529
White	Sparta	97	.2793	.2179	.2920	.4063	.4042	.3026	.3449	.3894	.1460	.2158	.1312	.2285
Williamson	Franklin	1,980	.2010	.2370	.1481	.2179	.2285	.2370	.1587	.2454	.3153	.2539	.2984	.2116
Wilson	Lebanon	4,511	.2179	.2328	.1735	.2878	.3301	.2751	.2603	.2708	.2201	.1523	.2285	.1312

ION COSTS IN DOLLARS PER HEAD
T TENNESSEE, 1968

otential market sites)

	Chattanooga	Dandridge	Knoxville	Loudon	Athens	Johnson City
rs per head						
15	3.3529	2.1448	1.4575	1.9157	2.4573	3.5612
86	2.1657	3.8320	3.1446	2.5406	2.4989	5.2484
98	3.1446	2.0199	1.4148	1.7074	1.9990	3.3529
62	1.6866	3.5196	2.8322	2.1448	1.6241	4.9359
39	3.7903	2.6239	1.9366	2.6239	2.9363	4.0194
81	5.6858	2.7457	3.3321	3.9986	4.4152	1.2284
00	4.3527	2.1657	1.9990	2.6864	3.2279	3.0197
92	4.2277	1.3950	2.0407	2.7281	3.0821	2.2698
25	4.1028	1.6450	1.7491	2.4365	2.9780	2.8322
74	4.7276	2.0407	2.5614	3.3113	3.6029	1.7074
09	4.2902	1.4367	1.9366	2.6239	3.1655	2.3323
02	1.2909	4.1236	3.4362	3.7457	2.2282	5.5400
91	4.8526	2.1240	2.4989	3.2488	3.7487	2.6864
41	4.7485	1.9990	2.3948	3.0821	3.6237	2.1865
67	4.1236	1.2909	1.7699	2.4573	2.9363	2.6031
46	6.3523	3.4154	3.9986	4.6651	5.0817	1.8949
66	3.4362	1.7699	1.2909	1.7699	2.3115	3.1863
39	2.7457	2.4573	1.7699	1.2909	1.6241	3.8528
93	1.5616	4.6027	3.9153	3.2279	2.7072	6.0190
55	2.2282	2.9363	2.3115	1.6241	1.2909	6.0190
21	2.0824	3.1655	2.4781	1.8949	1.3950	4.5818
22	2.5614	2.6031	1.9782	1.4158	3.0405	3.9361
30	3.0613	2.6864	1.9990	2.1240	3.7070	4.4152
37	1.9990	3.2696	2.6447	2.0824	1.5408	4.6027
20	1.8324	3.4154	2.7281	2.2073	2.3115	4.8318
64	2.7281	2.5198	1.8324	1.6241	3.2071	3.9361
55	3.7487	2.9988	2.3115	2.8114	4.2277	4.4777
60	1.7283	4.2694	3.5820	3.0197	1.6866	5.7899
16	3.7278	1.4367	1.6241	2.3115	4.2069	2.7697
97	5.8732	3.1030	3.5196	4.2069	4.7485	1.5200
31	5.3733	2.6864	3.2071	3.9570	4.2486	1.3950
15	3.9361	2.1240	1.5825	2.2698	4.4152	3.3321
23	5.5400	2.6031	3.1863	3.8528	6.0190	1.2909

ION COSTS IN DOLLARS PER HEAD
T TENNESSEE, 1968

otential market sites)

	Chattanooga	Dandridge	Knoxville	Loudon	Athens	Johnson City
rs per head						
55	.9944	.6361	.4323	.5682	.7288	1.0562
59	.6423	1.1365	.9326	.7535	.7411	1.5565
32	.9326	.5991	.4199	.5064	.5929	.9944
32	.5002	1.0438	.8400	.6361	.4817	1.4639
82	1.1241	.7782	.5743	.7782	.8709	1.1921
50	1.6863	.8153	.9882	1.1859	1.3095	.3643
49	1.2909	.6423	.5929	.7967	.9573	.8956
46	1.2539	.4137	.6052	.8091	.9141	.6732
93	1.2168	.4879	.5187	.7226	.8832	.8400
64	1.4021	.6052	.7597	.9821	1.0685	.5064
28	1.2724	.4261	.5743	.7782	.9388	.6917
24	.3828	1.2230	1.0191	.8153	.6608	1.6430
87	1.4392	.6299	.7411	.9635	1.1118	.7967
17	1.4083	.5929	.7102	.9141	1.0747	.6548
61	1.2230	.3828	.5249	.7288	.8709	.7720
26	1.8840	1.0129	1.1859	1.3836	1.5071	.5620
43	1.0191	.5249	.3828	.5249	.6855	.9450
82	.8153	.7288	.5249	.3828	.4817	1.1427
45	.4631	1.3650	1.1612	.9573	.8029	1.7851
88	.6608	.8709	.6855	.4817	.3828	1.2662
82	.6176	.9388	.7350	.5620	.4137	1.3589
00	.7597	.7720	.5867	.4199	.4199	1.1674
61	.9079	.7967	.5929	.6299	.7473	1.3095
76	.5929	.9697	.7844	.6176	.4570	1.3650
24	.5435	1.0129	.8091	.6546	.6299	1.4330
67	.8091	.7473	.5435	.4817	.6052	1.1674
88	1.1118	.8894	.6855	.8338	.9512	1.3280
56	.5126	1.2662	1.0624	.8956	.8523	1.7172
73	1.1056	.4261	.4817	.6855	.7720	.8214
14	1.7419	.9203	1.0438	1.2477	1.4083	.4508
79	1.5936	.7967	.9512	1.1735	1.2600	.4137
14	1.1674	.6299	.4693	.6732	.8338	.9882
17	1.6430	.7720	.9450	1.1427	1.2662	.3828

COSTS IN DOLLARS PER HEAD
TENNESSEE, 1968

tential market sites)

	Chattanooga	Dandridge	Knoxville	Loudon	Athens	Johnson City
rs per head						
)	.6862	.4389	.2983	.3921	.5029	.7288
5	.4432	.7842	.6435	.5199	.5114	1.0741
5	.6435	.4135	.2897	.3494	.4091	.6862
4	.3452	.7203	.5796	.4389	.3324	1.0101
)	.7757	.5370	.3963	.5370	.6009	.8226
L	1.1636	.5626	.6819	.8183	.9036	.2514
2	.8908	.4432	.4091	.5498	.6606	.6180
3	.8652	.2855	.4176	.5583	.6308	.4645
3	.8396	.3366	.3579	.4986	.6094	.5796
4	.9675	.4176	.5242	.6776	.7373	.3494
2	.8780	.2940	.3963	.5370	.6478	.4773
)	.2642	.8439	.7032	.5626	.4560	1.1337
9	.9931	.4347	.5114	.6649	.7672	.5498
4	.9718	.4091	.4901	.6308	.7416	.4475
)	.8439	.2642	.3622	.5029	.6009	.5327
5	1.3000	.6990	.8183	.9547	1.0400	.3878
5	.7032	.3622	.2642	.3622	.4730	.6521
)	.5626	.5029	.3622	.2642	.3324	.7885
)	.3196	.9419	.8013	.6606	.5540	1.2319
3	.4560	.6009	.4730	.3324	.2642	.8737
9	.4262	.6478	.5071	.3878	.2855	.9377
5	.5242	.5327	.4048	.2897	.2897	.8055
9	.6265	.5498	.4091	.4347	.5157	.9036
)	.4091	.6691	.5412	.4262	.3153	.9419
.	.3750	.6990	.5583	.4517	.4347	.9888
3	.5583	.5157	.3750	.3324	.4176	.8055
3	.7672	.6137	.4730	.5753	.6563	.9163
3	.3537	.8737	.7331	.6180	.5881	1.1849
7	.7629	.2940	.3324	.4730	.5327	.5668
3	1.2019	.6350	.7203	.8609	.9718	.3111
3	1.0996	.5498	.6563	.8098	.8695	.2855
9	.8055	.4347	.3238	.4645	.5753	.6819
5	1.1337	.5327	.6521	.7885	.8737	.2642

TABLE 28

ESTIMATED NUMBER OF SHEEP SOLD BY COUNTIES AND TRANSPORTATION COSTS IN DOLLARS PER HEAD FROM 33 POINTS OF ORIGIN TO 12 DESTINATIONS, EAST TENNESSEE, 1968

Origins		Estimated no. of sheep sold	Destinations (potential market sites)											
County	City		Pikeville	Maryville	Cleveland	Tazewell	Greeneville	Morristown	Chattanooga	Dandridge	Knoxville	Loudon	Athens	Johnson City
			Dollars per head											
Anderson	Clinton	162	.3068	.1841	.3259	.2137	.2984	.2349	.3407	.2179	.1481	.1947	.2497	.3619
Bledsoe	Pikeville	130	.1312	.3132	.2814	.4126	.4698	.4063	.2201	.3894	.3195	.2581	.2539	.5333
Blount	Maryville	130	.3132	.1312	.2581	.2349	.2772	.2306	.3195	.2052	.1439	.1735	.2031	.3407
Bradley	Cleveland	0	.2814	.2581	.1312	.3809	.4190	.3746	.1714	.3576	.2878	.2179	.1650	.5015
Campbell	Lafollette	0	.3492	.2137	.3513	.1968	.3301	.2666	.3851	.2666	.1968	.2666	.2984	.4084
Carter	Elizabethton	260	.5481	.3555	.5163	.3216	.1883	.2518	.5777	.2793	.3386	.4063	.4486	.1248
Claiborne	Tazewell	0	.4126	.2349	.3809		.2433	.1798	.4423	.2201	.2031	.2730	.3280	.3068
Cocke	Newport	0	.4211	.2201	.3682	.2222	.1671	.1523	.4296	.1417	.2074	.2772	.3132	.2306
Grainger	Rutledge	0	.3872	.2116	.3555	.1756	.2243	.1608	.4169	.1671	.1777	.2476	.3026	.2878
Greene	Greeneville	162	.4698	.2772	.4190	.2433	.1312	.1735	.4804	.2074	.2603	.3365	.3661	.1735
Hamblen	Morristown	65	.4063	.2306	.3746	.1798	.1735	.1312	.4359	.1460	.1968	.2666	.3216	.2370
Hamilton	Chattanooga	0	.2201	.3195	.1714	.4423	.4804	.4359	.1312	.4190	.3492	.2793	.2264	.5629
Hancock	Sneedville	0	.4634	.2878	.4317	.1650	.2179	.1777	.4931	.2158	.2539	.3301	.3809	.2730
Hawkins	Rogersville	130	.4571	.2772	.4211	.1947	.1671	.1650	.4825	.2031	.2433	.3132	.3682	.2222
Jefferson	Dandridge	97	.3894	.2052	.3576	.2201	.2074	.1460	.4190	.1312	.1798	.2497	.2984	.2645
Johnson	Mountain City	130	.6370	.4275	.6052	.3788	.2560	.3195	.6454	.3470	.4063	.4740	.5163	.1925
Knox	Knoxville	130	.3195	.1439	.2878	.2031	.2603	.1968	.3492	.1798	.1312	1.1798	.2349	.3238
Loudon	Loudon	97	.2581	.1735	.2179	.2730	.3365	.2666	.2793	.2497	.1798	.1312	.1650	.3915
Marion	Jasper	0	.2158	.3682	.2201	.5079	.5290	.4846	.1587	.4677	.3978	.3280	.2751	.6116
McMinn	Athens	0	.2539	.2031	.1650	.3280	.3661	.3216	.2264	.2984	.2349	.1650	.1312	.4338
Meigs	Decatur	0	.2243	.2349	.1735	.3449	.4021	.3386	.2116	.3216	.2518	.1925	.1417	.4656

TABLE 28 (continued)

Origins		Estimated no. of sheep sold	Destinations (potential market sites)											
County	City		Pikeville	Maryville	Cleveland	Tazewell	Greeneville	Morristown	Chattanooga	Dandridge	Knoxville	Loudon	Athens	Johnson City
			----------Dollars per head----------											
Monroe	Madisonville	130	.2581	.1693	.1989	.2941	.3365	.2878	.2603	.2645	.2010	.1439	.1439	.3999
Morgan	Wartburg	65	.2708	.2370	.2878	.2793	.3534	.2899	.3111	.2730	.2031	.2158	.2560	.4486
Polk	Benton	0	.3132	.2370	.1417	.3619	.4042	.3555	.2031	.3322	.2687	.2116	.1566	.4677
Rhea	Dayton	0	.1481	.2793	.2285	.3703	.4275	.3640	.1862	.3449	.2772	.2243	.2158	.4906
Roane	Kingston	0	.2391	.2116	.2391	.2793	.3365	.2730	.2772	.2560	.1862	.1650	.2074	.3999
Scott	Huntsville	130	.3407	.2666	.3936	.2624	.3851	.3216	.3809	.3047	.2349	.2857	.3259	.4550
Sequatchie	Dunlap	97	.1650	.3576	.2370	.4571	.5142	.4507	.1756	.4338	.3640	.3068	.2920	.5883
Sevier	Sevierville	0	.3724	.1693	.3174	.2581	.2179	.1841	.3788	.1460	.1650	.2349	.2645	.2814
Sullivan	Blountville	357	.5671	.3915	.5354	.3089	.2179	.2814	.5968	.3153	.3576	.4275	.4825	.1544
Unicoi	Erwin	0	.5354	.3428	.4846	.3089	.1756	.2391	.5460	.2730	.3259	.4021	.4317	.1417
Union	Maynardville	0	.3703	.1883	.3322	.1481	.2751	.2095	.3400	.2158	.1608	.2306	.2857	.3386
Washington	Johnson City	0	.5333	.3407	.5015	.3068	.1735	.2370	.5629	.2645	.3238	.3915	.4338	.1312

APPENDIX B

METHOD USED TO DERIVE THE AVERAGE WEIGHTS OF CATTLE AND CALVES MARKETED IN TENNESSEE, 1968

METHOD USED TO DERIVE THE AVERAGE WEIGHTS OF CATTLE AND CALVES MARKETED IN TENNESSEE, 1968

The average weight of cattle or calves recently marketed in Tennessee is not available. Only the combined weight of 671,340,000 pounds for the 598,100 cattle and the 439,000 calves sold in 1968 is available.[1] The average weight of calves calculated by Malphrus, et al.,[2] from a 1962 sample of all major livestock market outlets in the South (except farmers) is used in this study. They found the average weight of all calves, including vealers, originating in Tennessee that year to be 273.4 pounds.[3] Using this average weight for calves sold in 1968 means that the total weight of all calves sold was 120,032,258 pounds (273.4 pounds per head times 439,000 head). Thus, the total weight of all cattle sold was 551,307,742 pounds (671,340,000 pounds of cattle and calves marketed - 120,032,258 pounds of calves marketed). Therefore, the average per head weight of cattle sold in 1968 is estimated at 921.9 pounds (551,307,742 pounds ÷ 598,000 head).

Since there could have been a substantial change in the average weight of calves marketed in Tennessee between 1962 and 1968, an

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[1] United States Department of Agriculture. Livestock and Meat Statistics, Supplement for 1968 to Statistical Bulletin 333 (Washington: Government Printing Office, July, 1969), pp. 30-31.

[2] L. D. Malphrus, C. Y. Liu, and R. J. Freund. Cattle and Calf Movement in the South. Southern Cooperative Series Bulletin 134 (Knoxville: The University of Tennessee Agricultural Experiment Station, March, 1968).

[3] Ibid., Statistical Supplement Table 1.

independent check on the reliability of the estimated average weight of cattle and calves is needed. The method selected to do this is: (1) to calculate a dollar value for the estimated marketings derived in this study of 551,307,742 pounds of cattle and 120,032,258 pounds of calves, and (2) to compare the resulting dollar value with the known value of the combined weight of 671,340,000 pounds of cattle and calves marketed.

In 1968, the average price received by producers in Tennessee was $20.70 per hundredweight for cattle and $28.00 per hundredweight for calves.[4] Thus, the calculated value of the 1968 marketings of cattle and calves is $147,729,735 (551,307,742 estimated pounds of cattle marketed x $.2070 + 120,032,258 estimated pounds of calves marketed x $.2800 = $147,729,735). In 1968, the total cash receipts received from the sale of 671,340,000 pounds of cattle and calves are $147,684,000.[5] Thus, with a difference of only $45,735, or an error of .03 percent, the calculated weights are highly acceptable.

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[4] Livestock and Meat Statistics, Supplement for 1968 to Statistical Bulletin 333, p. 31.

[5] Ibid.

VITA

Billy G. Hicks, son of Amy Lee Hicks and the late J. E. Hicks, was born on December 11, 1932. A native of West Tennessee, Hicks was reared on a farm in Obion County near Reelfoot Lake. He received his high school training at Dixie High School, graduating in 1950.

Hicks worked in Union City, Tennessee, for three years before entering the U. S. Army in 1953. After being released from active duty in 1955, he enrolled in general agriculture at The University of Tennessee at Martin and in 1959 graduated with a Bachelor of Science degree. He continued his studies at The University of Tennessee, Knoxville, earning his Master of Science degree in agricultural economics in 1961.

Hicks was appointed assistant agricultural economist with The University of Tennessee Agricultural Extension Service in June, 1961. He took a one-year study leave in 1966-67 to complete the residence requirements for his doctorate in Agricultural Economics at The University of Tennessee, Knoxville. His doctorate was awarded in June, 1970. He is a member of the American Agricultural Economics Association and the Southern Agricultural Economics Association. Hicks is also a member of Phi Kappa Phi, Alpha Zeta, and Gamma Sigma Delta.

He was married in 1950 to the former Ann Elizabeth Maupin, and is the father of a son, Terry.