Estimated Cost Functions For Oklahoma Livestock Auctions

R. C. Lindberg and G. G. Judge
Department of Agricultural Economics

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PREFACE

This study is concerned with the estimation of actual cost relationships from a sample of Oklahoma livestock auctions. For purposes of presentation the study is divided into two parts: (1) logic underlying firm operations and methodological approaches to cost measurement, and (2) analysis of plant costs for Oklahoma auctions. Appendix A discusses and describes the institutional environment within which Oklahoma auction firms operate. Those readers interested only in the institutional setting and results of the costs analysis should go directly to the section entitled "Data Generation."

Estimated Cost Functions For Oklahoma Livestock Auctions[1]

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Introduction

General Problem

Increasing the efficiency and lowering the costs of firms which provide the various marketing services offer one of the more important possibilities for improvement of our marketing system. As discussed by French, the problem areas delineated by firm efficiency research include: (1) Developing new production techniques and methods, (2) determining the relative efficiency of existing production methods, (3) indicating how changes in organization and operation will affect firm efficiency and costs, (4) ascertaining the influence of volume handled by a firm on costs and efficiency, (5) indicating the effect of firm capacity on cost and efficiency, and (6) from these developing a basis for reorganizing and improving the marketing facilities of an entire area or industry.[2] These interrelated problem areas pose questions for which the firm must find answers in order to make decisions and put these choices into action to provide marketing services. The economic efficiency achieved in providing marketing services will depend upon how successfully problems within these interrelated areas have been solved.

Specific Problem Area Investigated

Livestock auction markets over the past three decades have provided one of the most dynamic changes in our livestock marketing system and are today one of the most important market outlets for the nation's livestock. For example, it has been estimated that prior to 1930 less than 200 livestock auctions were in operation in the United States.[3] By 1937, the total had

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[1]The research on which this report was based is part of the Southern Regional Livestock Marketing Research Project SM-7, Oklahoma Agricultural Experiment Station Project Number 921, "The Efficiency of Marketing Livestock in Oklahoma."

[2]B. C. French, "New Techniques in Plant Efficiency Research," unpublished paper presented at the annual meeting of the Western Farm Economics Association, Lake Tahoe, Nevada, July, 1951.

[3]G. Engleman, "The American Livestock Auction Market—Its History, Importance and Problems," Mimeographed statement presented to the annual convention of the American National Livestock Auction Association, Denver, Colo., June 15, 1956.

reached 1,345, and by 1949 there were 2,472 auctions operating in the United States. The peak in the number of auctions was achieved in 1952 when over 2,500 livestock auction markets were holding sales. In 1955 the number of auctions had declined to 2,322. A similar pattern of growth also holds for Oklahoma auctions. For example, in 1932 there were 8 livestock auctions in operation in Oklahoma, while in August of 1955 there were a total of 100 livestock auctions serving the state. Thus, livestock auction markets have shown the typical growth pattern characteristic of most new industries.

The first sign of a new industry is its inception period followed by a period of rapid growth, both in numbers and capacity. Following this rapid expansion is the leveling off period as the demand for their services is fulfilled. Finally a decline in the number of firms materializes as low volume firms with high unit costs cease to exist as competition between firms for the available market increases. Given these institutional restrictions, the need for research into the efficiencies of operation that may be obtained by existing and potential livestock auction markets manifests itself.

If one could obtain a flashlight picture of the livestock auctions operating in Oklahoma and producing a marketing service, he would be instantly aware of the wide variation in both the scale and method of operation. For example, in Oklahoma one would find auction volumes varying all the way from 4,000 animal units annually to those handling over 100,000 animal units (see Page 15) during the same period. Many of these firms are of a size that is efficient for the particular conditions under which they must operate. Others are, of course, operating at considerably less than the efficiency that would be possible. In most cases, the inefficiencies are due to incomplete knowledge of cost relationships associated with alternative scale of plants, possible innovations, and unforeseen changes in the demand for their marketing services.

Within this setting, this study is concerned primarily with the economic aspects of the problem. However, it is related to physical efficiencies to the degree that costs are influenced by physical relationships and comparative costs are a measure of comparative physical efficiency. This provides a means of contrasting one firm's costs with anothers, lending additional information that the market operator may use in making decisions as to operational changes. The study reported herein was designed to present the physical and institutional environment within which livestock auction markets operate, determine the logic underlying firm operation, and develop information regarding volumes and costs of marketing livestock in auction firms selected to represent a large range of operating volume. As such, its specific objectives were: (1) To obtain a picture of the operations of existing livestock auction markets; (2) to review alternative methodological approaches to cost estimation; (3) to estimate the relationship between volume and costs for auction firms and to indicate the impact of certain factors on these costs; and (4) to use these estimates to determine the relationship between capacity and costs when the firms are operating at optimum volumes.

If the above objectives are realized, they should provide information which would be useful to present and potential auction firm operators in formulating decisions as to the scale of operations that may be most efficient for the individual conditions with which they are faced.

Basic Logic Underlying Firm Operation

The logical framework for firm cost and efficiency studies can be based, with some alterations, on the logical formulations of the conventional economic theory of production.[4] This section will present only a brief discussion of the logic necessary for evaluating the operation of firms and postulating models from which relevant economic relationships may be estimated.

In general, a firm may be defined as an institution which buys raw materials, transforms them in some manner, and then resells the new product or service with the purpose of making a profit from the transition. An operating firm is faced with prices for the resources it uses which are the cost of the inputs used in the transformation process. Also, there is given in the market a price for the firm's finished product or service. At different levels of output and the accompanying necessary amounts of inputs, the firm is faced with varying costs of production and subsequent revenue from its sale. If profit maximization is one of its major goals, the firm should erect the scale of plant which provides the greatest divergence of revenue over costs in conjunction with the demand for its product and the supply of its inputs.

In any particular firm there are technical restrictions which control and determine the relationship between the inputs of productive factors and the outputs of products or services. These physical restrictions in auctions may include, for example, the arrangement of pens and equipment, the integration of total operations, and the abilities of the manager and hired labor. Given these restrictions, the productive inputs may be partitioned into: (1) those inputs that are a function of time and therefore independent of the volume of products or services provided, and (2) those inputs that vary with the volume of products or services forthcoming. When these inputs are combined in the production process, a physical production function is obtained which describes the relationship between the level of inputs and level of outputs for a particular firm and time period.

Such physical production functions expressing the relationship between inputs and outputs are basic to the determination of cost relationships for the particular firm, since the cost of producing a given output is the quantity of in-

[4] For detailed discussions of this theory see:
Sune Carlson, *A Study on the Pure Theory of Production,* London: P. S. King and Son, Ltd., 1939.
P. A. Samuelson, *Foundations of Economic Analysis,* Cambridge: Harvard University Press, 1947.
B. C. French, et al, "Economic Efficiency in Plant Operations with Special Reference to the Marketing of Pears", *Hilgardia,* Vol. 24, 1956, pp. 544-78.

puts used times their respective prices. In this connection, the auction plant and equipment are fixed capital investments and thus, for the period of time considered, are fixed inputs or costs in the form of depreciation, interest, taxes, and insurance. Alternatively, inputs which vary with output, such as labor, appear as variable inputs or variable costs when the relevant prices are applied. Together, the fixed and variable inputs or costs reflect a relationship that describes the effect of output changes on inputs or costs of operation. A hypothetical relationship of this type is presented in Figure 1.

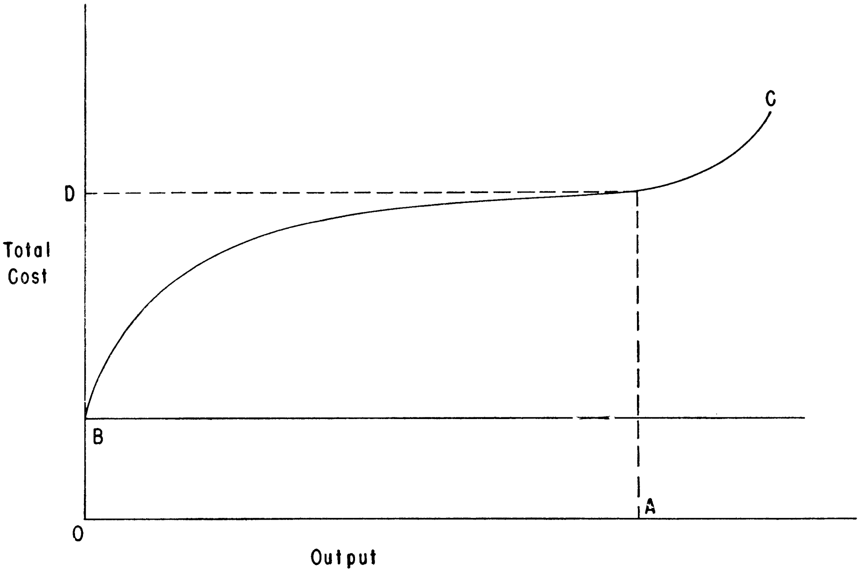

Figure 1—Hypothetical total cost relationship

The total cost of producing various outputs is traced out by the curve BC. This total cost curve is a direct reflection of the physical production function underlying the production process. As such, it traces out the area of, first, increasing returns to factors and then, constant followed by decreasing returns to factor inputs. Therefore, an alternative type of production function (e.g., linear) would generate alternative types of total cost curves. In the above figure, total fixed costs are represented by OB (constant), and total variable costs are shown as increasing first at a decreasing rate and then at an increasing rate. If this postulated firm, with the assumed physical production function and input prices, were operating at an output of OA, the total cost would be OD with fixed costs OB and variable costs BD. It should further be understood that alternative prices applied to the fixed and variable inputs would change the level and shape of the total cost curve. In addition, the total cost curve for this particular plant applies to the optimum combination of inputs for each particular output or, in other words, the least cost combination of inputs for each output. To be sure, other organizations of inputs or resource mixes are possible, but by definition they are inferior to the optimum organization.

Thus far, we have been concerned with a firm in the short-run—a case where many of the factors of production are fixed. It is now in order to consider the long-run situation where all factors are variable. This may be approached through the short-run analysis by considering the costs for a series of firms similar in type but differing in size or capacity. Since, in the long-run, it is possible to build firms of any given size, consider the family of total cost functions that would be generated by firms of alternative sizes. Given these individual plant total cost functions (short-run) we can then superimpose them on a graph and connect points on each one of the short-run, total cost curves by a long-run, total cost curve (Figure 2).

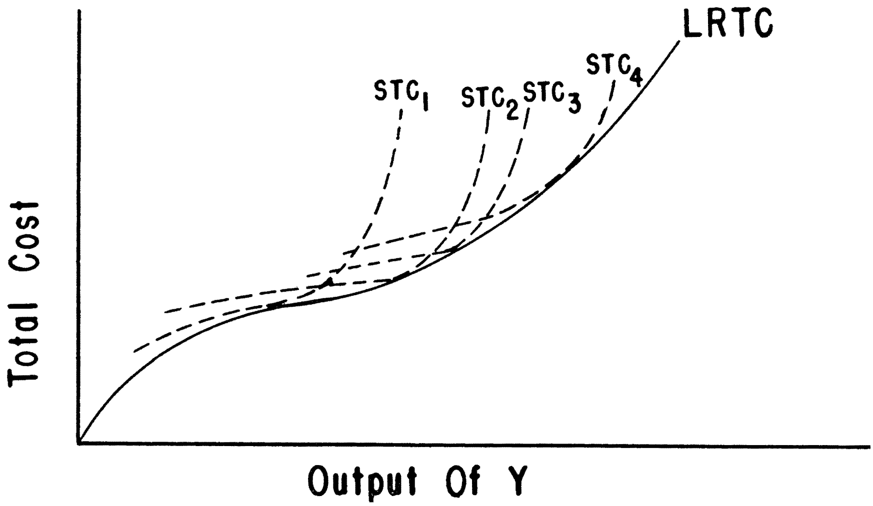

Figure 2—Hypothetical short- and long- run total cost relationships

These total relationships may be transformed into more familiar terms by expressing the total curves in terms of average or unit cost curves (Figure 3).

The broken lines in Figure 3 are average cost curves for the individual plants operating at various levels of capacity. They show the decreases in the average costs for a particular size firm when the output is increased to normal capacity, and the increase in cost as output

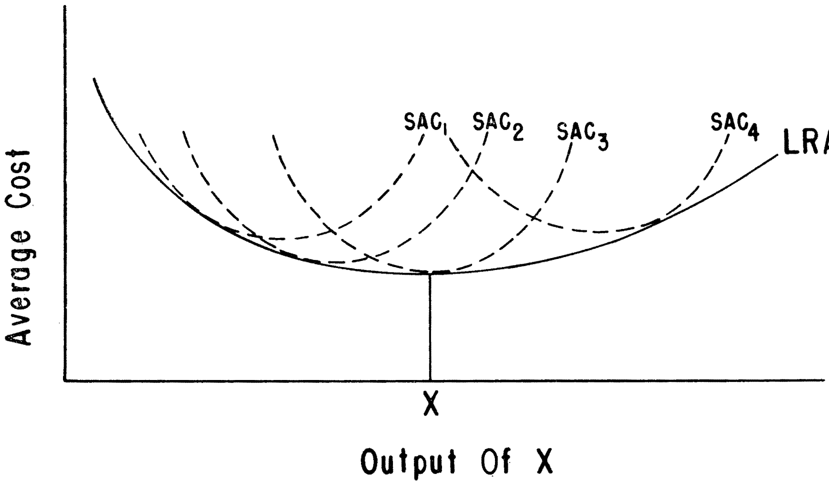

Figure 3—Hypothetical short- and long-run average cost relationships

is increased beyond normal capacity. If average costs at the most efficient outputs are lower for large plants than for small plants, a reduction in per unit costs or economies of large scale operation obtains. However, as size increases, diseconomies may occur. This is the situation portrayed in Figure 3.

Assuming it is possible to obtain short-run average cost curves for plants of many different sizes, an envelope curve could be drawn tangent to these individual plant curves as shown in Figure 3. This envelope or economies of scale curve shows the cost changes associated with changes in the size of plant under efficient plant operation and use of best known technology. Since this curve shows costs that may be achieved under optimum organizations, it may be called a planning curve.

In many production processes, there are variable factors which by nature are not freely divisible and must be bought or hired in large discrete units.[5] Imperfect divisibility of factors may then give rise to discontinuous cost functions yielding planning curves that consist of segments of the plant curves and thus will have a scalloped appearance. In all cases, however, the same economic interpretation applies to the discrete economies of scale curve.

Unfortunately, in making decisions on the size of plant that will prove most profitable, the operator is faced with incomplete information.[6] For example, he may have incomplete information as to: (1) future factor supply, (2) rates at which durable items deteriorate and new technology will become available, and (3) future demand for his product or services. Incomplete information of this type introduces expectations relative to

[5] Brems, Hans, "A Discontinuous Cost Function", *American Economic Review*, Vol. XLII, No. 4, September 1952, pp. 577-586.

[6] A. G. Hart, *Anticipation, Uncertainty and Dynamic Planning*, New York: Augustus M. Kelley, Inc. 1951.

the future path of these variables and interjects the element of subjective evaluation on the part of the firm into the responses to a given stimulus. Although the logic for choice or decision making without complete information will not be covered here, it should be remarked that the foregoing analysis would remain basically valid, although some modifications would be required to cover special cases. It should also be mentioned that consideration of the flexibility and adaptability of production processes for firm planning provides one form of insurance against incomplete knowledge.[7]

Inherent in the operational environment within which the firm must function are factors which tend to put an upper limit on the degree of efficiency that may be achieved. These factors, such as location, types of market configurations, etc., are in many cases beyond the control of any individual firm operator but are relevant if a total logical base for firm decisions is to be achieved.

This brief presentation concludes the discussion of the logic needed for the auction firm cost models to be presented. The task is now one of utilizing the logic presented as a tool in the analysis of structural economic relationships for auction firms. The following analysis attempts to derive cost relationships for a group of auction firms that possess a wide variation in capacity, and to construct from these a relationship estimating the economies of scale that currently obtains.

[7] G. Stigler, "Production and Distribution in the Short Run", *Journal of Political Economy* 47:305-327, 1939.

Conference on Price Research "Cost Behavior and Price Policy", New York: National Bureau of Economic Research, 1943.

Methodological Approaches to Cost Measurement

The problem of measuring and comparing firm costs may be approached in a number of alternative ways, the most efficient method depending on the specific objectives and the resources available. Two of the more frequently used methods are presented here in order to give the basic methodology, the relative merits of each, and the rationale for the method chosen in this study.

Synthetic Method of Cost Analysis[8]

The synthetic method of cost analysis, as an approach to the derivation of cost curves of various sized plants, is an outgrowth of industrial engineering. Basic to this method is a realization that a process of production generally lends itself to being broken down into its component parts of operation. As a raw material enters into the production process, each operation performed on the raw material may be separated into stages as it is transformed into its final form, with each stage being analyzed separately. This process of analyzing and summing these individual

[8] For a discussion of this method, see: G. Black, "Synthetic Method of Cost Analysis in Agricultural Marketing", *Journal of Farm Economics*, Vol. 37, 1955, pp. 270-79.

stages is commonly called the "building block" method.

Since each stage has its own input-output function, suitable prices and rates may be applied to derive a cost curve for each stage, and these when summed, result in an individual plant cost curve. Considering a series of alternative plant layouts or processes for a given product will give rise to a series of plant cost curves. As the plant size is increased, a family of short-run total cost curves will result, the composite of which will delineate the previously mentioned long-run total cost curve. Transforming these relations into short-run, average cost curves, and constructing a line tangent to this series of short-run, average cost curves, gives rise to the traditional envelope curve or what is commonly called the economies of scale or planning curve.

Accounting Records Method of Cost Analysis

The accounting records method of cost analysis differs substantially from the method outlined in the preceding section in that it employs as basic data the cost accounting records of existing firms. Basic to this method is the necessity of obtaining reliable cost records, covering a given period of time, from firms operating at a series of outputs. To generate this data, a stratified sample of firms operating at different levels of output must be drawn from the industry in question so that cost estimates for each volume of output will be represented. The total cost of each sample firm is treated as a single observation and a regression equation is fitted to the data to provide an estimated long-run total cost curve.

Although this method is much simpler and consumes fewer research hours than the synthetic method, it is subject to certain limitations.[9] For example, although a simple regression model has its uses in specifying the relationship between outputs and costs during the period studied, the result is not, in general, an appropriate estimate of the long-run, average cost function. This obtains since the size of plant and its position on its respective cost curve are not taken into consideration in the simple regression model. In the simple model an approximate estimate of the long-run, average cost function will be approached when the size of plant and plant output are perfectly correlated. To be specific, a long-run, average cost function will be correctly estimated only when the short-run average cost functions are tangent to the long-run, average cost curve.

One method of coping with this difficulty is to use a regression model with a measure of capacity utilization as a second explanatory variable.[10] The addition of this

[9] For example, relative to the basic data: (1) Accounting data do not provide a basis for comparing the relative efficiency of alternative methods of operations since the records do not reveal detailed information regarding stages of operation, (2) accounting records taken from plant operating statements contain many arbitrary valuations and allocations and may not be reliable measures of efficiency, (3) all methods employed by the low-cost plant may not be the most efficient, (4) proper account may not be taken of the effects on costs of operating at various levels of output in a particular plant, since the costs are an average for an entire season or period, and (5) the reported fixed costs reflect variation in such items as purchase date of plant and equipment and rates and method of depreciation. For a discussion of some of these limitations see B. C. French, *op. cit.*

[10] For a discussion of this method see: R. Phillips, "Empirical Estimates of Cost Functions for Mixed Feed Mills in the Midwest" *Agricultural Economics Research*, Vol. VIII, Jan. 1956, pp. 1-8.

variable permits the consideration of idle plant capacity as an output that affects production costs apart from the cost of producing the output of the product. The net result of this specification will be to shift each plant along its short-run average cost function to its optimum short-run output, and then the long-run average cost curve will pass through these points.

By using this modification, a careful analysis based on accounting data may yield a rough but useful approximation to economies of scale or variation in the relative efficiency among plants. Therefore, because the objectives of this study are broad and the resources limited, the accounting record approach with certain modifications has been chosen as a first approximation. It should, however, be kept clearly in mind that improved methods of performing particular operations or normative plant layouts will usually require detailed industrial analysis or time and motion studies.

Data Generation for This Study

Information for the major portion of this study was obtained from selected livestock auctions during the summer 1956 in the state of Oklahoma. Data from livestock auction markets were obtained by personal interview with each auction market operator. The schedule employed was designed to provide a descriptive picture of the over-all internal and external conditions and influences on the operational characteristics of the auctions.* In addition to the descriptive aspects, a portion of the schedule provided for a detailed breakdown of the expenses of maintaining and operating the physical auction plant.

The sample selected included 31 auction firms from a universe of approximately 100. In selecting the sample, considerations were given to (1) geographical location of the auction firms, (2) auction firms that possessed rather detailed cost records, and (3) auction firms that would yield a large range of operating volumes and conditions.

Because of the necessity of obtaining detailed cost records, a decision was made to use only those auctions listed under the Packers and Stockyards Act of 1921. This decision yielded auctions that were also consistent with the criteria of geographical location and large range of operating volumes. To insure a more complete representation of volumes, a judgment sample of four auctions not posted under the Act was also selected. No specific attempt was made to design the sample so as to be statistically representative of average conditions throughout the auction market industry. The geographical location of the auctions included in the sample is given in Figure 4.

* The institutional environment within which Oklahoma auction firms operate is described and discussed in Appendix A.

Analysis of Plant Costs

In this section, major attention is devoted to the production and overhead costs of auction operation. The end objective is an esti-

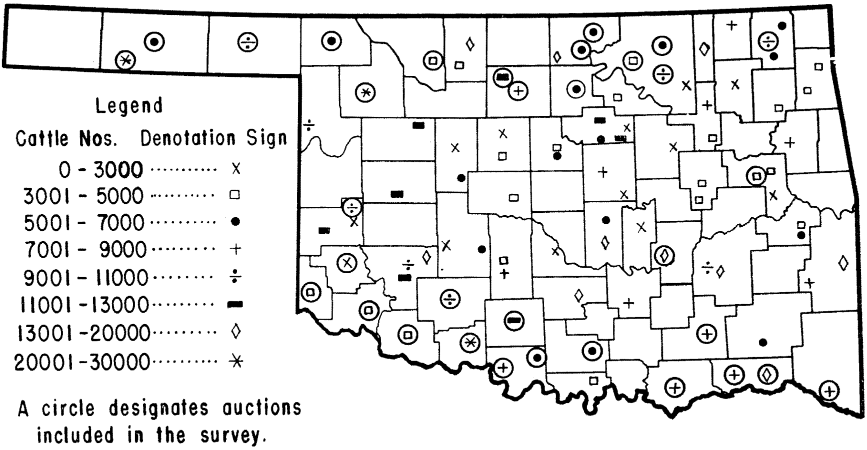

Figure 4—Location of state licensed community sales with annual cattle volumes handled, Oklahoma, 1954

mate of the relationship between livestock handled and cost efficiency when the degree of capacity utilized is taken into account. In this analysis of plant costs, the individual cost items are aggregated into the classifications discussed in the section pertaining to the logical framework underlying firm operations. As such, the breakdown includes total variable costs (those costs that are a function of output) and total fixed costs (those costs that are not a function of output, but of time). Each cost classification is first treated as a separate unit and then combined in the final over-all analysis. Economic interpretations and implications follow each postulated model.

Determination of Marketing Units

In order to put the auctions on a more homogenous basis for the purpose of cost analysis, the volume of livestock handled by each auction was converted to a market or animal unit base. The conversion rates for the various classes of livestock were broken down into animal units, with each of the following groups considered as being one unit: One horse; one head of cattle over 400 pounds; two calves, 400 pounds or less; two hogs; five sheep. Cattle are numerically the most important type of livestock handled by the auctions studied and for this reason were used as a base in developing the conversion rates. As a result of these adjustments, the volumes of the sample of auctions ranged from 4,354 to 77,572 animal units. The remaining volumes were fairly evenly distributed between these two limits.

Hired Labor Costs

In order to build up a more complete picture of auction operating costs, a separate analysis for hired labor was conducted, as this segment of total plant operating costs represents a large percentage of total variable costs. Labor costs are treated as variable, although operational labor requirements tend toward adding some fixity to them.

In most of the auctions studied, one or more persons performed a specific function. However, in some of the smaller auctions, one person in certain instances performed two or more jobs. The job listings included under the hired category were bookkeeper, auctioneer, ticket writer, clerk, weigher, yard labor (both full-time and part-time), and veterinarian.

In some instances, it was necessary to impute a cost for some of the labor categories. For example, when the bookkeeping duties were performed by the owner, who received no specific wage, the imputed value was estimated as the average wage paid other bookkeepers for comparable size auctions. A similar procedure was followed in situations where one person performed more than one job function or where the owner served in one of the other hired labor capacities. Except for these instances, all costs are actual hired labor expenses taken from the cost accounting records of the sample of firms. Of the 31 auctions included in the sample, one was omitted from the analysis because it conducted more than one sale per week, and as such was not homogenous with the other auctions. In addition, only hired labor costs were obtained from one of the auctions, and it was therefore omitted from all analysis other than that involving hired labor costs.

In order to derive a relationship between hired labor costs and the volume of animal units handled, both linear and quadratic regression models were postulated. Estimation of the postulated models resulted in the following regression equations:

$$Y = 4183.23 + \underset{(0.043)}{0.4646}X_1^*, \qquad R^2 = 0.80 \quad (1)$$

$$Y = 3024.71 + \underset{(0.15)}{0.5585}X_1^* - \underset{(1.94)}{1.28}X_2, \qquad R^2 = 0.81$$

where Y is the total hired labor costs, X_1, the number of animal units handled, and X_2 is the squared observations of the X_1 variable. Standard errors of estimate appear in parentheses below the coefficients. In all subsequent analysis, a single astrisk denotes statistical significance at or above the 95 percent probability level.

The linear model (equation 1) yielded a statistically significant coefficient connecting the variables Y and X_1. However, including the variable X_2 in the quadratic model did not result in a reduction in the error sum of squares of Y that was significant at the 95 percent probability level. Therefore, the linear model was accepted in this case as yielding the best approximated relationship between hired labor costs and volume. The large Y intercept value (4186.23) deserves comment since, logically, hired labor costs should be zero when no animal units are handled. However, for the auction to function, even at a low volume, a skeleton crew of workers is required even if their services are not completely utilized. The intercept value should therefore be loosely interpreted as the minimum hired labor cost for an auction to function. Therefore a discontinuity would occur in the cost function at the minimum volume level at which the firm will operate. Considering the total hired labor cost relationship as a continuous function, it may then be interpreted as follows: for an operating auction, a one animal unit increase in the number of animal units handled will bring about, on the average, an increase of 46 cents in hired labor costs.

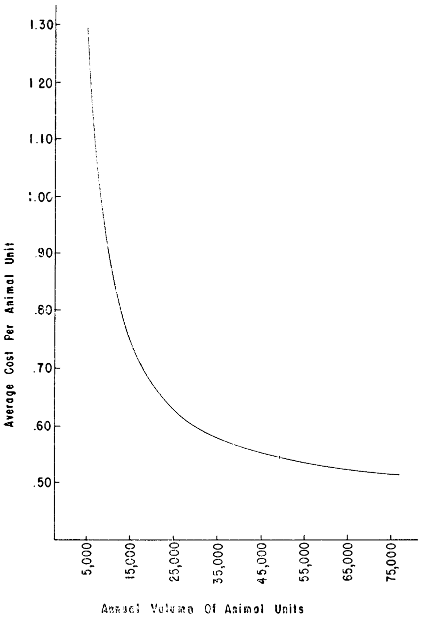

Figure 5—Average relationship between volume and hired labor costs

A graph of the relationship between the number of animal units handled and the average unit costs of hired labor is presented in Figure 5. This relationship depicts average hired labor costs as decreasing at a decreasing rate as the number of animal units increases. This average cost curve illustrates the economies that result from a more complete utilization of hired labor or, conversely, the diseconomies that result from a failure to completely utilize labor. It is interesting to note that for the firms under study most of the economies of scale are dissipated after a volume of 35,000 animal units is obtained.

As with any labor cost data obtained from accounting records, deviations occurred in the unit wage rates paid at the various auctions. It was postulated that these differences in unit wage rates were a partial influence in magnifying the deviations about the relationships fitted. As a means of testing this hypothesis, imputed hired labor costs were estimated for all job categories such that the unit labor costs of each auction were placed on the same basis. Linear and quadratic models utilizing the imputed hired labor values were then fitted. In terms of goodness of fit these relationships were inferior to equations 1 and 2 previously estimated using actual hired labor costs. The failure to increase the goodness of fit could possibly lie in differences of the various physical productivity of hired labor among auctions, i.e., workers may be paid different wages according to their productivity. To assign each type of worker an equal wage rate could distort the value of their services in the operation of the auction market.

Total Variable Costs

Variable costs as used in this study refer to those costs that are a function of output and as such, contain all costs associated with the operation of the auction minus all costs that would be incurred if the plant were left idle. No attempt was made to table all of the

Table 1—Components of fixed, variable and total costs for 31 Oklahoma livestock auctions, 1955

Total Fixed Costs	Total Variable Costs	Total Costs
Rent	Hired Labor	Hired Labor
Insurance	Office Expenses	Office Expenses
Taxes	Utilities	Utilities
Interest	Yard and Barn Expense	Yard and Barn Expense
Depreciation	Transportation	Transportation
	Advertising	Advertising
	Livestock Losses	Livestock Losses
	Miscellaneous	Miscellaneous
		Rent
		Insurance
		Taxes
		Interest
		Depreciation

separate variable cost items, as they are too numerous. Instead only the major categories are listed to give a general picture of the items included (Table 1). Data relating to total variable costs were obtained from 29 livestock auctions.

As has been noted, the major variable cost item is hired labor, which does not include supervisory personnel. Supervisory personnel are not included in the total variable costs as the owner in most cases performs two and sometimes three different positions at a single auction. Thus it was felt it would be extremely difficult, if not impossible, to arrive at any realistic estimate of the market value of the owner's services. Subsequent cost functions should be interpreted with this restriction in mind.

In order to derive a relationship between volume handled and total variable cost, linear and quadratic models were postulated. Estimation of these models resulted in the following regression equations:

$$Y = 5485.78 + \underset{(0.085)}{0.770} X_1^*, \qquad R^2 = 0.75 \tag{3}$$

$$Y = 2800.30 + \underset{(0.301)}{1.022} X_1^* - \underset{(0.005)}{0.004} X_2, \qquad R^2 = 0.75 \tag{4}$$

where Y represents total variable costs; X_1, the number of animal units handled and X_2, squared observations of the X_1 variable. Again, standard errors of estimate appear in parentheses below the coefficients.

Employing a linear model yielded a statistically significant coefficient connecting the variables Y and X_1. In the quadratic model the coefficient connecting Y and X_2 was not statistically significant. Based on statistical considerations, the linear model was chosen from the admissable models postulated to approximate the relationship between volume and total variable costs.

The non-zero Y intercept value is again due to the fact that many of the variable costs of an auction are necessary to handle any volume. This situation tends to make part of the variable costs similar to that associated with other fixed costs, i.e., one of spreading the overhead in order to attain a low average (per unit) cost. Assuming a continuous total variable cost function for an auction in operation, it is estimated that, on the average, a one animal unit increase in animals handled will bring about an increase of 77 cents in total variable costs.

The nature of the estimated linear total variable cost function defines an average variable cost function that decreases with volume at a decreasing rate. The resulting average variable cost function is shown in Figure 6. As was the case for the hired labor cost function, average variable cost decreases rapidly with increases in volume up to 35,000 animal units. A more complete utilization of variable resources, after a volume of 35,000 animal units is achieved, dissipates somewhat the economies of handling larger volumes.

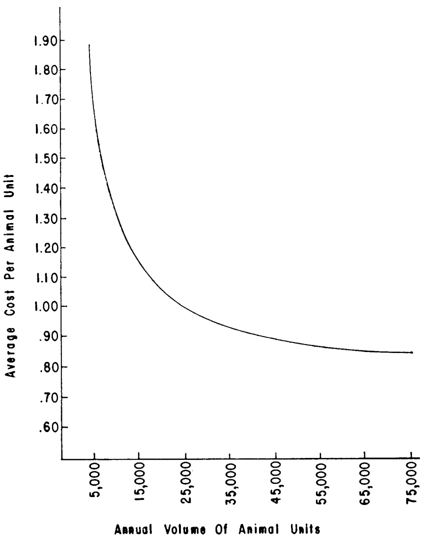

Figure 6—Average relationship between volume handled and variable costs

Total Fixed Costs

Fixed costs are defined as those costs which do not vary with volume changes within a plant. They obtain whether the auction is idle or in operation. Auction facilities and equipment are durable goods that are not completely used up in a single time period. As a result it becomes necessary to allocate investments over a number of time periods of useful life and to calculate fixed costs on the basis of depreciation rates based on the expected life. In addition to depreciation, fixed costs include interest, taxes, insurance, and repairs and maintenance. Annual fixed costs are a function of total investment and are estimated in each case by applying suitable rates to the investment data.

Buildings and yards were depreciated on a straight-line basis over a twenty-year period. A ten-year depreciation period was used for equipment. Interest charges were made at the rate of 3 percent. In each case the investments were based on the amount paid initially, plus an estimate of the value of improvements made.

Fixed costs are necessarily short-run costs since the short-run period permits only volume to change without changes in the physical plant and equipment capacities. Therefore, total fixed costs remain constant for a given plant and short-run period; and, because of this, average unit fixed costs will decrease rapidly as volume is increased. The relationship will then continue to decrease at a decreasing rate as volume is increased.

Fixed costs at auctions are a relatively small part of total costs. The estimated annual fixed costs for the auctions studied had a mean value of approximately 4,000 dollars and a range from 1,700 dollars to 13,000 dollars. In order to derive an approximation between size of auction and total fixed costs a linear model connecting auction capacity and total fixed costs was postulated.[11] Estimation of this linear model resulted in the following regression equation:

$$Y = 1440.0 + \underset{(0.004)}{0.032}X^{*}, \qquad R^2 = .62 \qquad (5)$$

where Y represents total fixed costs and X total capacity of the plant in animal units. The linear model yielded a statistically significant coefficient connecting Y and X. The sum of squares of error about the regression line are, to a large measure, due to the variation in the construction dates of the auctions (and thus reflect variations in the construction costs of labor and materials) and variations in the type of structure. The sign of the coefficient connecting Y and X is consistent with logic, as it depicts total fixed costs increasing as the size of plant increases.[12]

Tabular Breakdown of Costs

To give a more complete picture of the components of costs, the major items of auction operating costs are given in Table 2. Comparisons of the components of total costs, average costs and percent of capacity utilized are made for plants operating under four ranges of volumes. The largest component of total costs for all volumes was for labor. It accounted for 56.4 percent of total costs in auctions with the lowest volumes and 49.4 percent in those auctions with the highest volumes. Fixed costs varied from 23.7 percent of total costs in the low volume plants to 35.8 in those auctions with the highest volumes. Fixed cost varied from 19.6 percent of total costs in the low volume plants to 14.8 percent in the highest volume plants. It should be noted that for the 15,000 to 25,000 volume auctions, fixed costs accounted for only 12 percent of total fixed costs. However, this volume range group utilized 35.6 percent of the total capacity available—the highest utilization

[11]The capacity variable, as used in this study, refers to the number of each type of animal that each auction could accommodate during one sale day. This data was then placed on an animal unit basis. Since these auctions only operated one day per week, the potential capacity for each auction for one unit of time was multiplied by 52 to place the total potential capacity on an annual basis.

[12]Although size of plant and volume handled are not perfectly correlated, it was thought that the relationship connecting total fixed costs and volume handled might be of some interest. Estimation of a linear model relating total fixed costs (Y) and volume handled (X) resulted in the following regression equation:

$$Y = 770.42 + \underset{(0.018)}{0.155}X^{*}, \qquad R^2 = .73$$

This linear model also yielded a statistically significant coefficient connecting Y and X.

Table 2—Summary of component costs as a percentage of total costs for 29 Oklahoma livestock auctions, 1955

Operating Volume Ranges	Labor	Other Variable Costs	Fixed Costs	Average Total Unit Costs	Average Capacity Utilized
Animal Units	*Percent*	*Percent*	*Percent*	*Dollars*	*Percent*
4,000-15,000	56.40	23.70	19.60	1.64	16.11
15,001-25,000	55.40	32.60	12.00	1.24	35.64
25,001-40,000	50.50	32.60	16.90	1.19	33.29
40,000-over	49.40	35.80	14.80	1.17	21.37

of any of the volume range groups. Consistent with previous discussions, the average unit costs varied from 1.64 dollars for the lowest volume range group to 1.17 dollars for the highest volume range group. The greatest reduction in average unit costs occurred when going from the first to the second volume range group of auctions.

Although the average unit costs yield observations reflecting the level of costs for each volume group, there were, in most instances, large variations about the mean group value. For example, in the 4,000 to 15,000 volume range group, average cost per animal unit varied from 1.07 to 2.33 dollars. In the second range group unit costs varied from 0.94 to 1.55 dollars. These ranges spell out the pronounced differences in unit operating costs within volume groups and point up the differences in operating conditions that affect the major factors influencing these costs of operation, such as capacity and labor utilization. They also point up in part the possibilities for cost reduction for existing auction markets.

The Effect of Auction Volumes and Scale on Operating Costs

The final task is that of estimating a long-run cost function for auctions in order to ascertain the effect of volumes and scale on operating costs. One of the more common and simple procedures for doing this is to fit a model connecting total operating costs and volume. If correctly evaluated, a simple model such as this may be useful in that it estimates the relationship between volume and costs during the period studied. It is, however, not an appropriate estimate of the long-run average cost function as it does not take into account the size of plant which produces the output. Therefore it provides an approximate estimate of the long-run average cost function only when plant size and output are perfectly correlated. This type of analysis can estimate the long-run average cost function only when each plant studied is observed at a point on its short-run cost function that is tangent to the long-run average cost function.

These restrictions indicate the need for other methods of analysis. One alternative method is that of adjusting the cost data for each plant to correspond to a full utilization of plant capacity. A simple model connecting costs and volume might then provide an estimate of the long-run average cost function that passes through the low point on the short-run plant average cost function. This procedure, however, requires an accurate separation of costs and thus introduces a large amount of subjectivity into the data to be used.

To get around this difficulty, an alternative method of analysis has been suggested by Phillips.[13] Phillips suggests that by employing a model with some measure of capacity utilization as a second explanatory variable the same end can be achieved without adjusting the observed data. This model would then consider the maintenance of idle plant capacity as an output that affects operating costs over

[13] R. Phillips—*Op. Cit.*, pp. 4-6.

and above the other costs. By varying the level of plant utilization it is then possible to shift each plant along its short-run average cost curve to its optimum short-run output and thereby obtain an estimate of the long-run average cost function.

If the above logic is accepted and a model linear in the variables is postulated and a positive Y intercept value obtains, the resulting average cost function will be nonlinear, decreasing at a decreasing rate as volume increases. However, if a model linear in the variables is used and a negative Y intercept estimate obtains, then the corresponding average cost increases as output increases. As Phillips points out, the dependability of the results of this model depends heavily upon the accuracy of the observations at the lower end of the output range.

A total cost function non-linear in the volume variable and constrained to pass through the origin avoids this difficulty. However, the problem then encountered is one of selecting from the admissable possible models the one which will best reflect the data. For example, from the data obtained from the sample of livestock auctions, any one of the following might be considered as a plausible model.

$$Y=A+b_1X_1+b_2X_2, \quad (6)$$
$$Y=b_1X_1^{0.5}+b_2X_2, \quad (7)$$
$$Y=b_1X_1^{0.7}+b_2X_2, \quad (8)$$
$$Y=b_1X_1^{0.9}+b_2X_2, \quad (9)$$

where Y is the total annual cost of operating an auction, X_1, annual volume of animal units handled; and X_2, unused animal unit capacity on an annual basis.[14] Each of these possible models would probably result in a difference in the rate of decrease of the corresponding average cost functions. In addition, this model postulates that unused capacity is linearly related to the total cost of handling animal units. Obviously, other plausible variants of the models are possible. The models will generate short-run average cost functions that intersect the long-run average cost function at the volume equal to a particular plant's capacity. They will then differ substantially from the envelope curve as portrayed in conventional economic theory.

All of the above postulated models were estimated, using the sample of data from 29 livestock auctions. For purposes of discussion, only model 6 will be employed. All of the models fitted yielded approximately the same long-run average cost function and degree of explanation of the variation of Y. Fitting model 6 resulted in the following estimated equation:

$$Y=3510.23+\underset{(0.0729)}{0.9426}X_1^*+\underset{(0.021)}{0.049}X_2^*. \quad (10)$$
$$R^2=0.92$$

In the estimated relationship, the coefficients connecting the variables were statistically significant at or above the 95 percent probability level. The estimated long-run average cost curve reflected by equation (10) is given in Figure 7. The long-run average cost curve was computed by setting X_2 (unused capacity) equal to zero, and then solving for a series of total costs associated with a series of animal units handled. The result in each case was divided by the number of animal units handled to place it on an average unit cost basis. The short-run cost functions

[14]The observations which will be used to reflect unused capacity were obtained by subtracting the actual livestock marketings from the possible annual livestock marketings from each auction if operated at full capacity.

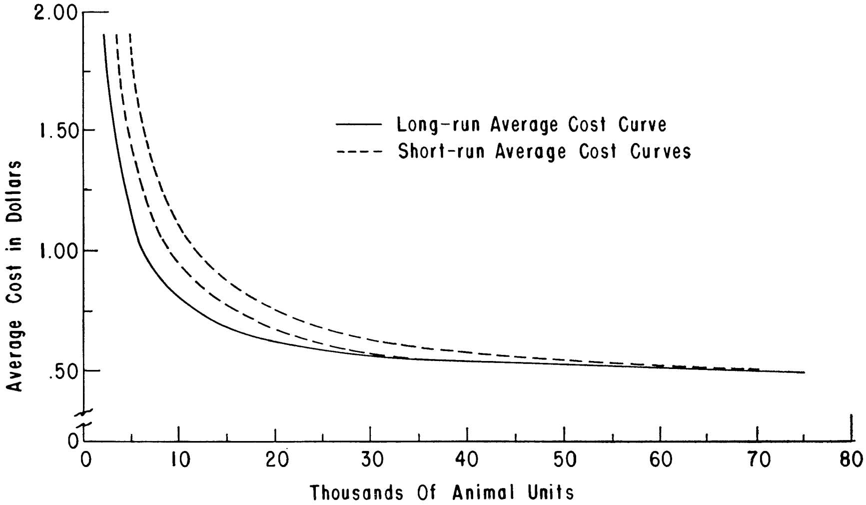

Figure 7—Estimated short- and long-run average cost functions for 29 selected Oklahoma livestock auctions, 1955

(dashed line curves) were computed by calculating the total cost of operation for an auction of a given size. From this point a series of total costs was computed for successive decreases in X_1 and corresponding increases in X_2. These observations were then divided by the value of X_1 in each case, and connecting the resulting points produces the continuous short-run cost curves.

Implications of the Results

The long-run average cost curve shown in Figure 6 represents the changes in average costs associated with change in livestock auction sizes when the capacity of each size plant is fully utilized. The estimated long-run average cost curve decreases rapidly at low volumes and then becomes more gradual with increases in size. Although increases in scale are accompanied by decreasing average costs throughout the range of the function, the rate of decrease is quite small after a volume of 35,000 animal units is obtained. For example, when operating at capacity, an increase in scale from 10,000 to 35,000 animal units will bring about a decrease of 25 cents per animal unit. On the other hand, an increase in the scale of auction from 35,000 to 70,000 animal units will bring about a decrease of only 5 cents per animal unit. It should be noted at this point that this long-run average cost curve pertains to what is, not what could exist or should exist under the optimum combination of the best technology available.

As noted earlier, the nature of the short-run average cost curves are not in the strictest sense like those of conventional economic theory since they terminate with the long-run average cost curve. Although these curves do not possess a range of costs that increase at an increasing rate beyond the optimum point, the derived curves lead to conclusions similar to those drawn from the more usual envelope curves. By the specification of the model, these short-run curves indicate that the lowest cost for any output can be obtained in the smallest plant capable of producing that output. They also indicate that a large plant can be operated at less than optimum output at a lower unit cost than a small plant at optimum output. For example, a large plant with an optimum annual output of 70,000 animal units can operate at 50,000 animal units annually at a lower average cost than a small plant which has an optimum output of 10,000 animal units annually. These individual short-run, average cost curves indicate the economies that result from a more complete utilization of any plant, or conversely, the uneconomical aspects resulting from a failure to completely utilize plant capacity. It should, however, be realized that even under the best conditions, seasonal or year to year variations in the number of animals consigned to an auction will make it impossible to operate without some excess capacity.

Knowledge pertaining to the short- and long-run cost functions for auctions should be useful to managers in showing the variation in operating costs that are primarily attributable to volume. A breakdown of these operating costs should also be useful since it permits managers to compare the operations of their plant with other operating establishments. It should also be important to potential auction owners and managers in making explicit the importance of potential volume to be handled and the influence of this volume on auction design and the per unit costs of operation.

The shape of the estimated long-run average cost function (one that flatens out rapidly as output is increased) probably explains part of the nature of the auction market environment. As indicated in a previous section, there are many auctions of various sizes distributed rather evenly throughout the state. The estimated economies of scale derived from building large auctions to serve a large geographical area appear to be limited. A small auction with a volume of 25,000 to 35,000 animal units annually can successfully compete with the larger size auction, thereby cutting down on the area served by a potentially large scale auction. This would tend to make the livestock auction marketing business a highly competitive one as, in reality, it is.

Although estimates of the relative costs of various size livestock auctions were obtained, one question that is important to the industry is still not answered: What is the most economical organization of auction firms in Oklahoma? This problem is really a combination of the problems involved in collecting and transporting animals and in auction operation. In the broad sense, the total solution is beyond the scope of the study reported here. The study does provide one part of the necessary information, i.e., the relationship between operation costs and size. Since there appears to be considerable overlapping of producers served by auctions, it is perhaps definitional that moderate amounts of consolidation would probably have little effect on transport costs.

Summary

The central problem area of this study involved the estimation of the actual cost relationships for a sample of Oklahoma livestock auctions. In order to provide a logical base for realizing this objective, a theoretical framework within which the problem is contained was formulated. Alternative methodological approaches to the estimation of cost relationships were examined. Given the broad objectives of the study and the restrictions on available resources, data generated from auction market cost accounting records were used. Methods consistent with this type of data were employed.

Alternative economic models were postulated for the generation of the data relating to long- and short-run average cost functions. By employing appropriate statistical techniques, estimates were obtained for the postulated models and the results were subjected to economic and statistical tests. These estimated relationships indicate important cost advantages to large auction markets. However, the economies of scale are most pronounced in the capacity ranges below 35,000 animal units per year. Under the operating conditions characterized by the plants included in this study, and assuming no excess capacity, it is estimated that operating costs per animal unit will decrease 25 cents in going from an annual volume of 10,000 animal units to one of 35,000. Beyond this volume, costs continue to decrease but at a more gradual rate. These results also emphasize the importance of excess capacity as a factor causing high operating costs per animal unit.

Inherent in the environment within which the auctions must function are institutional factors which tend to set limits to the degree of operational efficiency an auction market may obtain. Two of the more important institutional factors found as a cause of inefficiency were: (1) the present practice of operating the auctions with only one sale day per week, thus leaving the physical plant idle the major part of the time, and (2) the high degree of seasonality of livestock marketings during any one year. This phenomenon added an additional element to inefficiencies in the sense that it increased the uncertainty of the auction market owner's decision as to the correct scale of plant to build. The result of this inability to predict the number of cattle to be marketed in any one sale day led the owners, in many instances, to build a scale of plant overly large to handle their estimated volumes of cattle.

Appendix A—Descriptive Results of the Survey

In order to provide a foundation for the analysis of plant costs, a descriptive picture of the environment within which livestock auctions function is given in this appendix. This should do much to point up the institutional restrictions under which livestock auctions operate.

Geographical Location and Size

The Oklahoma State Board of Agriculture listed, as of August 15, 1955, a total of 100 auction sales that were state licensed or had a state license pending. In addition, thirty-two of these are posted under the Packers and Stockyards Act, 1921.

The geographical distribution and size of these livestock auctions are given in Figure 4 in the text. Auctions posted under the Act are distributed along the perimeter of the state, a fact which probably obtains due to their likelihood of engaging in interstate commerce. As seen in Figure 4 (in text), the auction markets are fairly evenly distributed throughout the state, although certain differences in density and size by areas are apparent.

The density of livestock production materially affects the type of marketing agency best suited for a given area and the location and operational efficiency of such agencies. As a means of reflecting the amount of services demanded of existing auction markets, the state has been arbitrarily divided into four regions and the number of cattle and calves on farms January 1, 1954, was obtained (Figure A-1). These data suggest that cattle numbers are fairly evenly distributed throughout the state and in turn probably account for the even geographical distribution of auction markets.

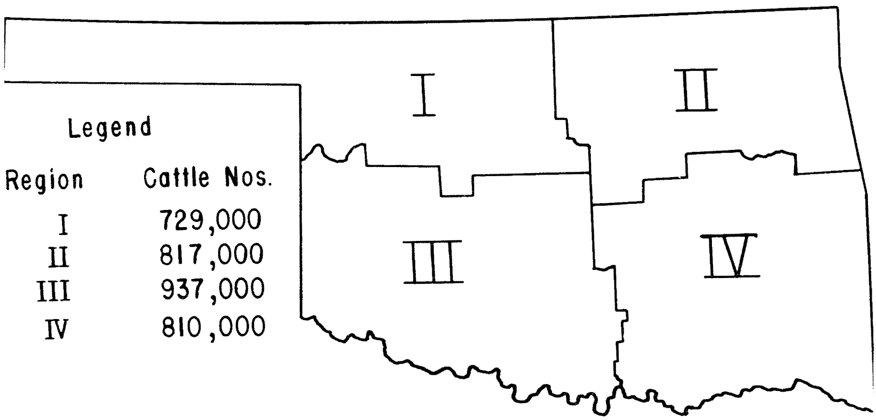

Figure A-1—Number of cattle and calves on farms by regions in Oklahoma, 1954

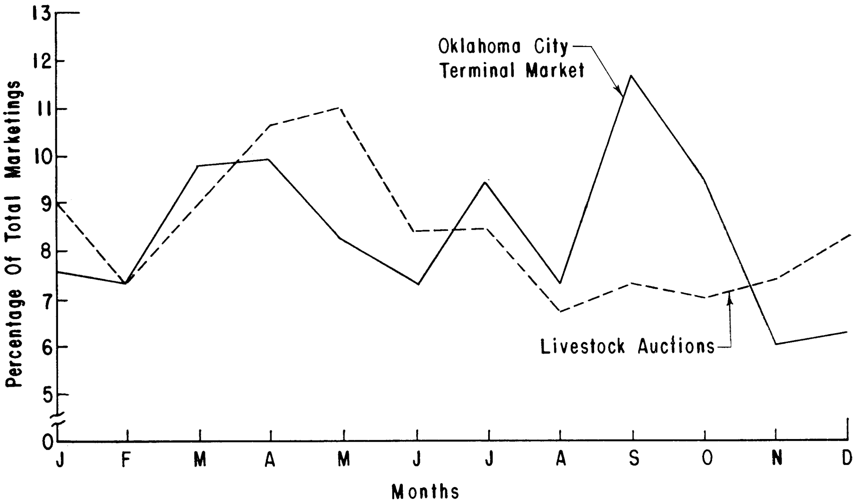

Figure A-2—Seasonal cattle marketing at selected Oklahoma livestock auctions for the state and the Oklahoma City terminal market, 1955

Seasonality of Auction Marketings

Seasonal variation in livestock marketings have a profound effect on the operational efficiency of the entire livestock system and in particular the livestock auction markets. Seasonality affects adversely the efficiency of labor and other resources used in the auction marketing process, especially during periods of low levels of marketing. Generated by this variation in marketings is the tendency for potential auction market owners to build a scale of plant larger than is necessary to handle the estimated peak loads of marketing within and between years. This creates an economic environment for the maintenance of excess capacity facilities during some periods of the year, causing average costs to be higher than they normally need to be. These considerations point up the fact that extreme caution in planning the layout of an auction market should be exercised in order to provide the needed range in cattle marketing facilities and keep excess capacity at a minimum.

Livestock received at the auctions included in the sample varied considerably from month to month during the year 1955. Volume during the heavy marketing season was approximately double that of the light marketing months. Of course, in addition to the monthly fluctuations, the marketings also vary from week to week and year to year.

Monthly variation in total cattle receipts at the auctions studied is depicted in Figure A-2. The seasonal pattern of marketings reveals that receipts of cattle in February were lower than for any

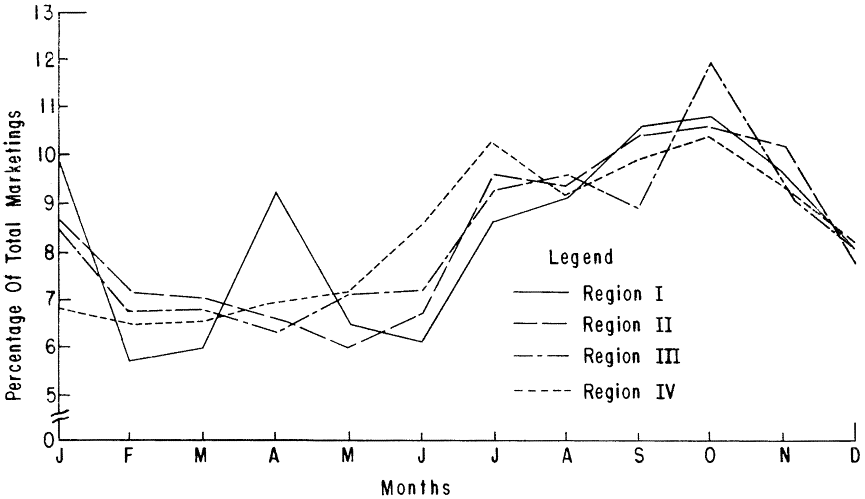

Figure A-3—Seasonal cattle marketings at selected Oklahoma livestock auctions by regions, 1955

other month of the year (6.4 percent). A two-month rise in marketings followed, reaching a high point in April. A second peak in cattle marketings occurred in July when 9.4 percent of the year's cattle were received. A slight drop in cattle receipts followed in August, but another peak in marketings occurred in October when they were over 11 percent greater than the low month of February.

As a basis of comparison, the monthly cattle receipts at the Oklahoma City terminal market have been included in Figure A-2. The most striking difference between the seasonal pattern of marketings of auctions and the terminal market was that the high point in marketings for the terminal market occurred in July when over 12 percent of the year's cattle were received. Seasonal variation in the receipts of the livestock auction market by areas is given in Figure A-3.

In Figures A-4 and A-5 an analogous group of comparisons is made for hog marketings. Hogs are generally marketed in large numbers in the spring and fall, chiefly because of present farrowing practices. An inspection of Figures A-4 and A-5 reveals that during the months of March, April and May, approximately one-third of the annual volume of hogs marketed was received at the auction markets. This phenomenon tends to offset the low marketings of cattle during the same months in which only one-fifth of the marketings occur. From the auction firm standpoint, this situation helps to use some of the available excess capacity as well as to increase the marginal productivity of resources that would otherwise be only partially used or left idle if hogs were not handled.

Livestock Consignments

Among the persons who demand the services of livestock auc-

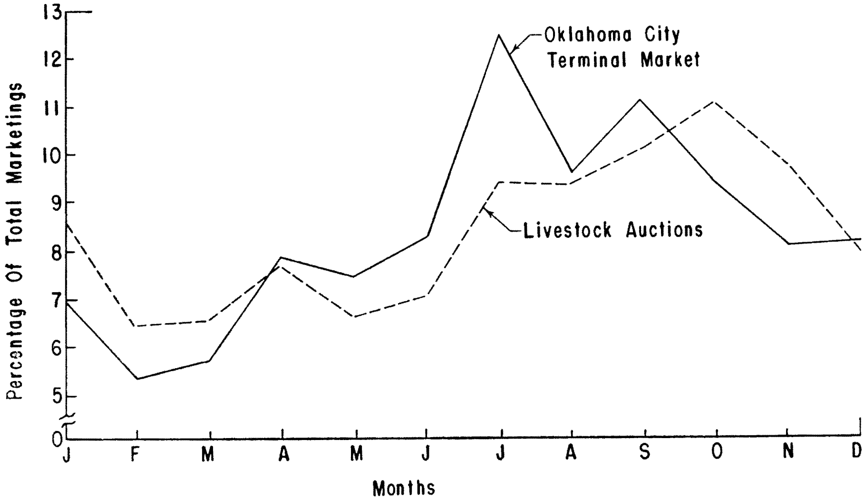

Figure A-4—Seasonal hog marketings at selected Oklahoma livestock auctions for state and the Oklahoma City terminal market, 1955

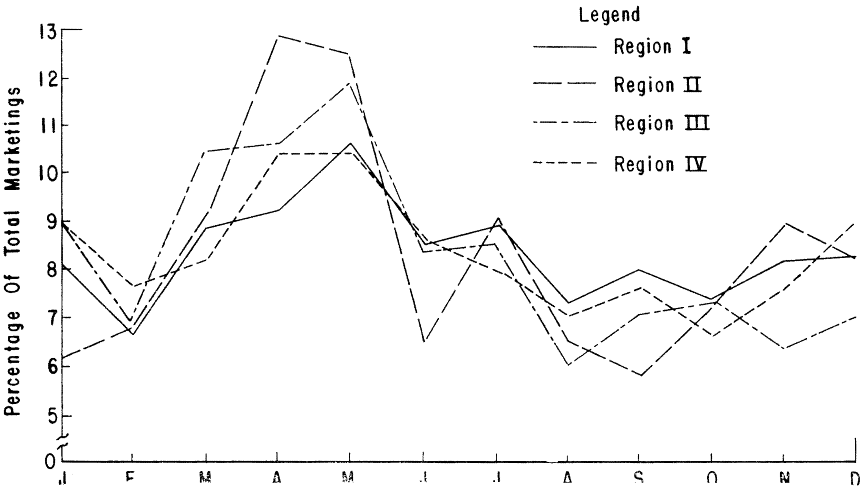

Figure A-5—Seasonal hog marketings at selected Oklahoma livestock auctions by regions, 1955

Table A-1—Percentage of cattle, calves and hogs consigned to 31 livestock auctions, by type of seller, 1955

Livestock Consigned by	Cattle	Calves	Hogs
Livestock producers	82.0	83.0	95.0
Dealers	15.0	14.0	4.4
Auction personnel	2.5	2.5	0.5
Others	0.5	0.5	0.1
Totals	100	100	100

tion markets are livestock producers, livestock dealers, and auction personnel. Among the producers are found ranchers specializing in livestock production, dairymen, farmers producing a few head of cattle in conjunction with other farm enterprises, and livestock feeders. Dealers include those individuals who make a practice of buying and selling animals for the purpose of profiting from differentials between markets or between prices at the farm and existing markets.

From this group, the livestock producer forms the backbone of the livestock auctions in terms of supplying the livestock for auctioning purposes. The importance of each of the individuals in demanding auction services for the various classes of cattle is shown in Table A-1.

These data reveal that, in these three classes of livestock, the livestock producer provides the major source of auction receipts. These observations emphasize the importance of making producers fully aware of all the services the auction market provides in order to continue to receive consignments from the producers. Dealers are relatively important as suppliers of cattle and calves but are of minor importance as to the consignment of hogs. Whether or not auction personnel should be permitted to buy and sell on their own markets has been a controversial subject over time. From the observations obtained from this sample of auctions, the auction personnel are relatively unimportant as a source of livestock receipts.

Size of Lots Consigned

The average size of lots brought to the auction market is shown in Table A-2. From these observations, it is apparent that auctions were the major outlet for farmers with small lots of livestock for sale. In many instances livestock producers would not market a carload of animals, even in a year's time, although they do have small numbers of livestock to sell at various times during the year. Dealers, on the other hand, usually

Table A-2—Average number of head per lot consigned by producers and dealers at 31 livestock auctions, 1955

Type of Consignor	Cattle	Calves	Hogs
Producers	9.9	10.8	7.8
Dealers	25.1	29.2	14.1

operate as livestock assemblers. Therefore, they usually consign in larger lots since it is necessary for them to obtain the economies of large volumes to realize a profit in their operations.

Method of Transportation and Distances Traveled

The density of livestock production in conjunction with the area served by a particular auction materially affects the scale of plant operations. The even distribution of auctions throughout the state results in most livestock auctions serving only limited areas. In this sense, the auctions studied may be classified as true community sales.

Because these auctions in the main serve limited areas, the method of transportation to and from auctions was predominantly by truck. Of the 31 auctions studied, only six had any consignments via rail transportation and these shipments comprised less than 10 percent of the total consignments in all cases.

The percentages of livestock received by specified distances from the auctions studied are given in Table A-3. Because most of these auctions are true community sales, approximately two-thirds of the cattle and calves come from within a radius of 24 miles of the auctions, and about 80 percent of the hogs were received from the same distance. Only a limited percentage of livestock was received from distances over 50 miles and most of these shipments were received at the larger auctions.

Livestock Purchasers

Livestock producers are an important source to whom cattle are sold as well as the main source of livestock consignments. The fact that farmers, along with ranchers and dealers, bought approximately 30 percent of the cattle and calves offered for sale suggests the importance of feeder and stocker cattle sold at many auctions (Table A-4).

The packer and order buyer furnished the major outlet for all types of livestock and bought over fifty percent of the total animals available in each case. In this respect, community livestock auctions provide a convenient source of animals for small slaughter firms

Table A-3—Percentage of livestock received at 31 Oklahoma livestock auctions, by specified distances, 1955

Distance Hauled in Miles	Cattle	Calves	Hogs
0 - 9	26[1]	25[1]	38[3]
10 - 24	38[1]	38[1]	43[4]
25 - 45	30[2]	30[2]	22[6]
50 and over	12[5]	12[5]	18[7]

[1]31 Auctions reporting
[2]30 Auctions reporting
[3]29 Auctions reporting
[4]28 Auctions reporting
[5]25 Auctions reporting
[6]23 Auctions reporting
[7]23 Auctions reporting

Table A-4—Percentage of the major classes of livestock purchased by type of buyer, 31 Oklahoma livestock auctions, 1955

Type of Buyer	Cattle	Calves	Hogs
Packer and order buyer	50.0	53.0	68.6
Dealers	20.4	18.0	8.4
Livestock producers	29.5	28.9	22.9
Auction personnel	0.1	0.1	0.1
Total	100.0	100.0	100.0

located at considerable distances from urban centers or terminal markets.

Although dealers purchased all types of livestock, their major purchases were cattle and calves. Auction personnel purchased a negligible number of the livestock consigned.

Of those cattle not immediately destined for slaughter, the auction market operators estimated that about 50 percent would be put on grazing, 29 percent into feed lots, and the remainder used for breeding stock.

Commission Charges

Auction income is derived mainly from the receiving, selling and loading of the livestock handled. In the auctions studied, the charges for these services were levied either on a per head or percentage basis. Commission charges are one way that the livestock operator may affect the quantity of livestock moving through his market, i.e., the level of commission charges may well affect the choice of market by the producer or dealer and thereby increase or decrease the area which a particular auction services.

Of those auctions sampled, 21 based their charge on a per head basis while 10 charged a fee based on a percentage of selling price. All auction markets not under the Packers and Stockyard Act may set their rates at any level, while those posted under the Act must have their rates approved. The rates on both a per head and percentage basis varied considerably among the auction firms studied and there are no logical groupings into which the charges could be categorized since they are so diverse. Percentage charges ranged from two to three percent, while per head charges ranged from \$1.00 to \$2.50 depending upon the weight of the animal.

1-58—2¼M