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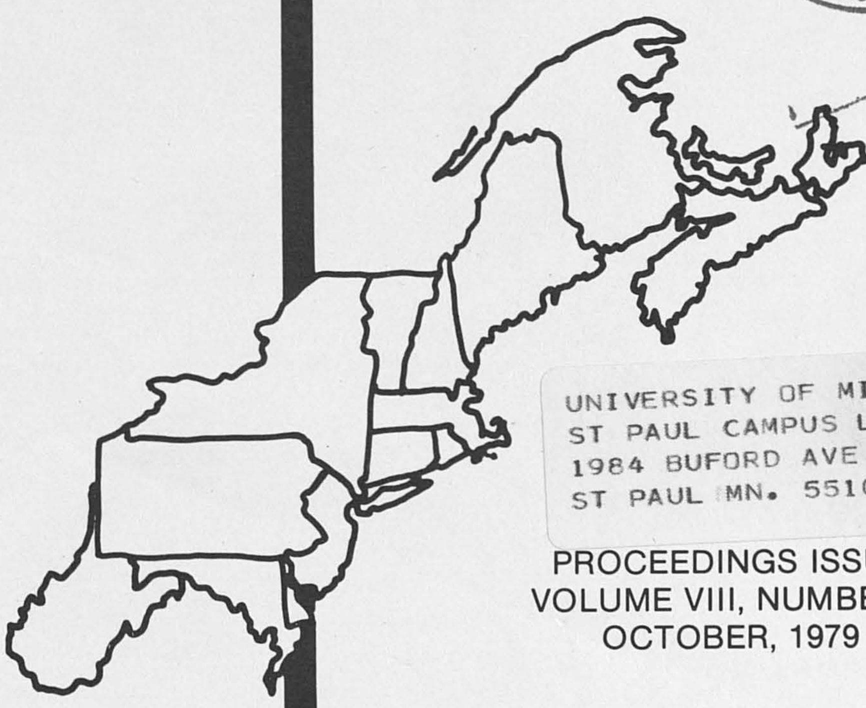

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COST STRUCTURES IN LIVESTOCK AUCTION MARKETS: AVERAGE VERSUS OPTIMAL EFFICIENCY

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The central role that local auction facilities play in the marketing of feeder, and in some areas slaughter, livestock has resulted in a large volume of literature relating auction costs to auction volume or size. Most auction cost studies have been based on statistical analyses of market accounting costs, although several have been based on synthetic construction of technically efficient market facility models. Studies of the former type include those by Lindberg and Judge (Oklahoma) and Wilson and Kuehn (West Virginia). Examples of the latter type are studies by Gibb and Riley (Michigan) and Kuehn (West Virginia).

It has been well established that statistically estimated cost functions, because they reflect "average" conditions in the industry, do not correspond to cost functions defined in economic theory [Johnston; French, pp. 55-58]. The precise manner in which statistical functions represent the average has been a subject of debate [Johnson; French]. Statistically-estimated unit total costs normally reflect sample average input price levels, accounting procedures, and managerial expertise. Although it is often possible to correct or account for sample variations in input prices, corrections for variatons in the latter two elements have proven elusive [French]. In the absence of an accurate management quality variable, statistical estimates of unit total costs are higher than minimum costs at any volume level because no manager can operate more efficiently than the optimum and some probably operate less efficiently.

In addition, regression of total costs or unit total costs against only a volume variable produces exaggerated estimates of size economics if sample average rates of capacity utilization increase with facility capacity [Johnston, pp. 188-192]. Understatement of size economies would then follow if average rates of capacity utilization decrease with facility capacity [Dean, p. 306]. One solution to this problem is to utilize a capacity explanatory variable in addition to a volume variable; a series of short run unit total cost functions are then calculated from which a long run envelope is subsequently derived [Stollsteimer, et. al; Dean]. This approach has the advantage that it enables estimation of the impacts of volume and capacity of short run marginal costs, and provides a clearer basis for comparing average industry efficiency levels with optimal tech-

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nical efficiencies indicated in synthetic analyses.

Despite the problems associated with excluding capacity measures, only Lindberg and Judge (1958) have utilized a capacity concept in statistical analysis of livestock auction market size economies. Inadequate attention has also been paid to comparison of statistical with synthetic auction cost analyses, especially regarding the behavior of marginal operating costs at various facility sizes [Kuehn]. The objective of the present paper is to evaluate alternative statistical cost models and to compare short and long run cost functions faced by auction markets operating at optimum and average managerial (technical) efficiency. The results should provide improved guidelines for management planning and a sounder basis for anticipating structural changes in the industry.

Statistical Analysis

Three alternative statistical models employed for comparison are:

$TC = f_1(V, T)$

$TC = f_2(V, K, T)$

$TC = f_3(V, K, V \cdot K, T)$

where TC = total annual auction market operating costs, in dollars;

V = total annual marketing unit volume, in marketing units;[1/]

K = total market pen space, in square feet;[2/] and

T = a time variable covering 1969-1976 (T = 1, 2, ..., 8).

The first model corresponds to that normally employed in auction market and other cost analyses, and assumes that neither fixed nor marginal operating costs are affected by facility capacity (K). Insofar as variable K acts as an intercept shifter, the second and third models allow fixed costs to be affected by capacity level. In the third model additionally, the partial derivative of total cost with respect to volume is, by virtue of cross-product term V·K, a function of capacity. Hence, with this model, both short run marginal costs and fixed costs may vary with capacity levels.

In models II and III, the effects of incremental changes in capacity on total cost should be positive because a unit of capacity has positive fixed cost. It is not obvious what should be the cost effect of incremental increases in the V·K term in Model III. The coefficient of V·K is the second derivative of TC with respect to V and K, and thus measures the effect of capacity increases on short run marginal costs. Increasing facility capacity may increase the cost of handling one more marketing unit because labor coordination becomes more difficult in larger facilities and because workers have farther to go to fetch livestock for sale or loading. However, when accompanied by stable increases in volume, increasing facility size may also encourage labor specialization and thus labor efficiency.

Results

Each statistical model was estimated using annual data from 30 Virginia auction markets during the period 1969-76.[3/] An error components

Table 1

Impacts of Selected Variables on Total Operating Costs, 30 Virginia Livestock Atuction Markets, 1969-76[a/]

	Intercept	Marketing Unit Volume (V)	V^2	Holding Capacity (K)	V·K	TIME	R^2 [b/]	df
Model I	-30,970.43 (-7.33)	4.316 (18.40)	-.0000338 (-10.60)			3,974.53 (7.03)	.78	236
Model II	- 2,210.78 (-.24)	1.065 (8.26)		0.600 (2.35)		4,772.56 (8.38)	.68	236
Model III	-25,098.80 (-2.39)	2.23 (7.09)		1.250 (4.24)	-.0000280 (-3.93)	4,508.14 (8.38)	.72	235
Variable Means		23,341 marketing units		34,107 square feet		4.5 Years		
Hypothesized Signs		+	-	+	+ or -	+		

[a/] t-values are in parentheses.

[b/] R^2 values were obtained from corresponding ordinary least squares regressions, which provide an upper bound for the amount of variation explained by the error components estimates.

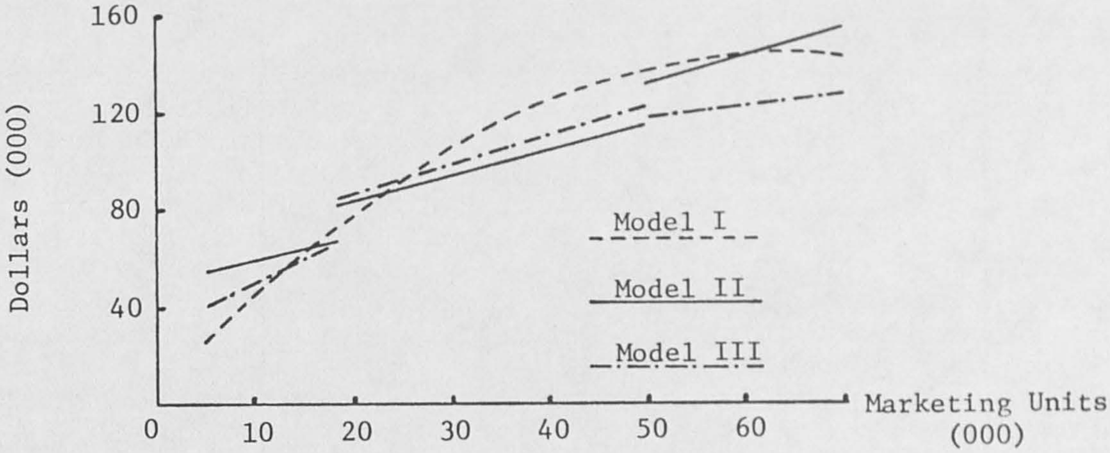

Figure 1. Total Auction Costs (Statistical Models I, II, and III).[a]

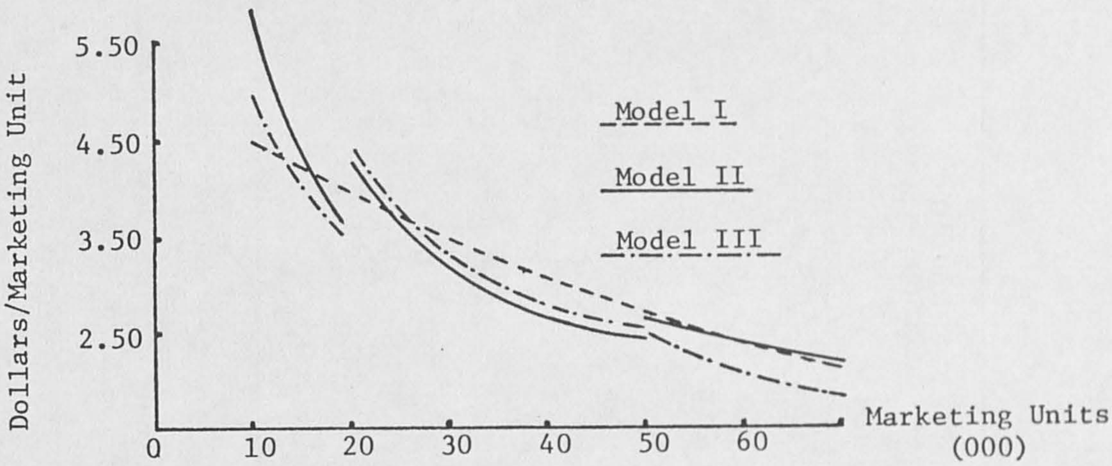

Figure 2. Short Run Unit Total Auction Costs (Statistical Models I, II and III).[a]

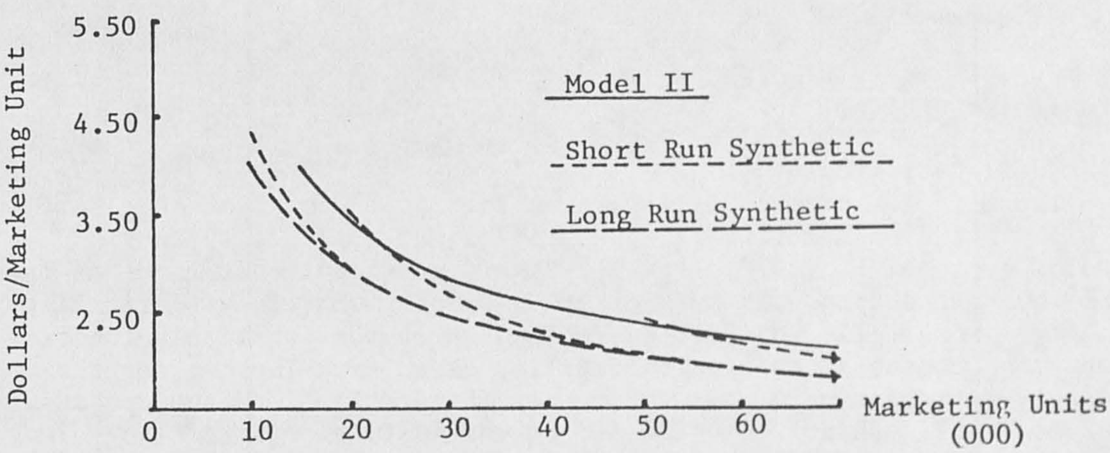

Figure 3. Short and Long Run Unit Total Auction Costs (Synthetic), and Long Run Unit Total Auction Costs (Statistical Model II).[a]

[a]Short run total and short run unit total costs correspond to 12,500, 37,500, and 62,500 square feet of penspace, respectively. These values are selected from the range of capacity observations utilized to estimate the regression model.

estimator was employed to correct for serial correlation and heteroskedasticity present in the time series, cross section sample [Fuller and Battese]. Linear, quadratic, and cubic transformations of the volume variable were tested in each equation; in addition, inverse and inverse-square transformations of volume were tested in model I. The quadratic form provided the best fit for model I, and linear forms provided the best fits for models II and III. Time trends, used to account for inflation-related or other secular increases in input prices, performed much better in this respect than did wholesale price indexes. Results of the selected equations are shown in Table 1.

Model I results imply that total costs increase with volume but at a continually diminishing rate. The corresponding unit cost function has the form $TC/V = 4.316 + (3974.53T - 30970.43)V - .0000338V$, in which the sign of the parenthesized term, and hence the concavity or convexity of the unit cost function, depends upon the time period selected for evaluation. Model II results support the hypothesis that increases in capacity shift short run total cost function intercepts upward. Furthermore, the superior statistical fit of the linear volume term over other volume transformations tested in models II and III indicates that marginal operating costs are invariant with respect to volume at each facility size; that is, short run marginal costs are constant and equal to unit variable costs at each size.[4/] Finally, the statistically significant negative t-value on the volume-capacity cross product term in model III suggests that larger Virginia markets have, on the average, incurred lower marginal costs than have smaller Virginia markets, implying that superior managerial ability and labor specialization in larger markets have outweighed the greater managerial problems these larger markets pose.

Interpretation of Results

We concur with Stollsteimer, Bressler, and Boles that estimation of true cost structural coefficients from statistical data must be approached with great care. Partly as a result of intercorrelation between volume and capacity variables, alternative functional forms providing equally good statistical fit may imply very different cost structures. This pitfall may only be avoided by paying close attention to theoretical implications of functional forms and to the range and quality of sample data, and by utilizing graphical analysis and informed judgment in conjunction with usual statistical tests.

Figure 1, for example, illustrates the manner in which models II and III explain the positivity and concavity of the total cost function revealed by model I. Model II allows short run total cost function intercepts to increase linearly but less than proportionately with facility capacity. Model III, in addition, allows short run total cost function slopes to decrease linearly with facility capacity. The two suggest considerably different unit cost structures (Figure 2). An envelope drawn under model II's short run unit cost curves would emphasize strong long run size economies up to 50,000 marketing units and weak size economies thereafter. These economies result from spreading such common fixed costs as management over a wider volume. Due to the added impact of marginal cost reductions with size increases, a similar envelope for model III would display strong long run size economies throughout the volume range observed.

Despite model I's superior R^2, and hence superior ability to predict observed total costs at each observed volume level, it provides insufficient information about the structure of livestock auction costs because it ignores the costs of capacity and underutilization of capacity. Model III has the higher R^2 of those remainig, but is also likely to produce misleading conclusions about auction market size economies. Larger auction markets in Virginia tend to be older ones that have achieved their size by gradual expansion; they generally report very low fixed (and thus total) costs because much of their fixed facilities have been fully depreciated. Since sample volume and capacity are positively correlated, model III generates unrealistically low marginal as qell as total cost estimates for large markets. The result is that it produces a long run unit cost function with an unrealistically negative slope. The fact that model II does not permit variations in marginal cost enable it to resist much of this understatement of total costs present in the data at high sample volume and capacity levels. Model II is, therefore, very likely a more accurate representative of long run cost conditons experienced in the industry than is model III.

Actual Versus Potential Cost Economies

Two approaches were taken to determine to what extent marginal costs at optimally efficient markets decline with market facility size, and to what extent long run unit costs faced by markets with average managerial efficiency approximate those faced by optimally efficient markets. Cost data reported on Packers and Stockyards Administration Forms 130 were first divided into those more closely associated with fixed costs and those more closely associated with variable costs.[5/] An estimate of the variable cost per marketing unit incurred by each market in 1976 was then plotted against its corresponding marketing unit volume, and the plots stratified into three facility size groups. These plots, subsequently repeated for several earlier years, suggested the following: (a) within each capacity category, per unit variable cost levels were not, on the average, related to volume; (b) within each capacity category, the lowest per-unit variable cost levels were not related to volume; (c) the lowest per-unit variable cost levels in each capacity category tended, in some years, to be equal across capacity categories and, in other years, to be lower in larger markets than in smaller markets. The first phenomenon corroborated the linear functional forms selected for the volume variable in models II and III. The second phenomenon suggested that such per-unit variable cost constancy would have been maintained even if only the most technically efficient markets had been selected for regression analysis. The third observation implied, although rather weakly, that the most efficient larger markdets tended to more efficiently utilize their variable inputs than did the most efficient smaller markets.

These conclusions were probed in a second approach by constructing synthetic models of livestock auction costs at three facility sizes (12,500, 37,500, and 62,500 square feet of pen space) which, assuming typical seasonal fluctuations in consignment volume, could be expected to accomodate 18,260, 54,780, and 91,300 marketing units per year, respectively. Floor plans for the markets were adapted from Brasington and from Kuehn, and annual investment costs estimated with the assistance of hardware suppliers, lenders and others. In the absence of resources for adequate time-and-motion studies, labor and utility requirements were determined from interviews with 25 market operators in which the lowest input levels per marketing unit were identified for each input category and facility size.[6/]

The short and long run unit cost curves generated by the above analysis (Figure 3) indicated, similar to statistical model II, significant size economies up to approximately 50,000 animal units annually and modest size economies thereafter. Particularly important is the fact that synthetically-derived marginal costs declined with facility capacity, from 1.65 1977 dollars in the lowest capacity group to .95 1977 dollars in the largest. This reduction, rather moderate considering the wide range in consignment volume involved, occurred mostly between small- and medium-sized facilities and was primarily due to decreases in animal handling time per marketing unit as facility size and volume grew.

Comparison of economies of size in average markets with those in optimally-efficient markets is also depicted in Figure 3, where the curve corresponding to statistical model II is an envelope drawn to its short run functions shown in Figure 2. The comparison suggests that markets with average managerial efficiency have been associated with a long run unit total cost curve that lies about 30 1977 cents per marketing unit above the minimum long run curve. Hence 30¢ per marketing unit appears to be a good estimate of average inefficiency in Virginia's livestock auction industry. This represents a noticeable though not drastic departure from optimal conditions.

Conclusions

Statistical and synthetic analyses of both short and long run livestock auction market cost functions provides a wealth of information about these markets. Part of the information is difficult to interpret due to data problems encountered in both analyses, but three important methodological conclusions emerge:

1. Statistical estimates of long run unit total cost curves which do not include a capacity variable may act as good predictors of total costs, but provide insufficient information about the cost structure of observed markets.
2. Inclusion of a capacity variable reduces the overestimation of long run unit total costs that result when no such variable is included. Furthermore, it serves to correct any over- or underestimation of size economies if the accounting data have been adjusted for correlation between facility age and size.
3. In the presence of positive age-size correlation, use of a volume-capacity cross product term considerably biases size economies in a positive direction. Exclusion of such a cross product reduces this bias to a great extent.

In addition, three conclusions emerge which illustrate the similarity of cost structure between average and optimally-efficient Virginia livestock auction markets. In both cases:

1. Short run marginal costs are essentially invariant with respect to volume, and hence equivalent to short run unit variable costs.

2. Short run marginal costs decline "to some extent" with increases in capacity, especially between small- and medium-sized markets, and even in the absence of age-size correlation.

3. The combined reduction in unit fixed and unit short run marginal costs as facility size increases results in a long run unit total cost curve which achieves most economies by the 50,000 marketing unit point.

A survey of the auction cost literature indicates that livestock auction markets differ just as much within as between states in such characteristics as layout and operating procedures. Thus, although the present study utilizes data from a single state, we believe it contains useful insights into cost structures one would expect to encounter in a wide number of auction markets in the country. Stated in a form in which long and short run cost economies are distinguished, and in which average and optimal cost levels are clarified, the results should provide an improved basis for auction cost research and management planning.

FOOTNOTES

[1]A previous regression of total costs on volumes of each livestock species handled indicated that the cost of marketing one head of cattle was, on average, equivalent to the cost of marketing 1.34 calves, or 2.01 pigs, or 2.61 lambs, or .49 horses. Volumes of each species were subsequently divided by their respective factor, resulting in a marketing unit equivalent in market cost to one head of cattle. The use of weighted average output regressors in multi-product situations is discussed in Johnston, pp. 185-6.

[2]Pen space is only one determinant of market facility capacity. However, it was correlated fairly strongly with other capacity determinants, such as number of loading chutes and munber of weighing stations, enumerated in market operator questionnaires. Hence it appears to be a good proxy for overall facility capacity. A capacity measurement in square feet may be converted to a measurement in animal units by assuming that each animal unit requires 25 sq. ft. of pen space. Further conversion may be made to an intensity-of-use variable by assuming that markets can hold a maximum of two sales per week.

[3]Volume and cost data were obtained from Packers and Stockyards Administration Forms 130. Facility capacity data (including pen space, numbers of pens, and numbers of loading chutes) were compiled from the author's questionnaire, which was completed by 30 of the 40 Virginia markets.

[4]Nonlinear volume terms may have been nonsignificant due to collinearity problems. However, models linear in volume continued to provide the best fit even in samples stratified by capacity group.

[5]The former included managers' salaries, taxes, and building and equipment depreciation and interest. The latter included wages, promotion and market support, maintenance and repairs, bonds and insurance, telephone, office and yard supplies, hauling, and miscellaneous expenses.

[6]Some quoted man-hour input levels were rejected as unreasonably low, and others were adjusted after consultation with the appropriate market operator.

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