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James R. Nichols, Director

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The Virginia Agricultural Experiment Station dedicates Bulletin Number 81-1 to Coyt T. Wilson, director of the station from 1964 to 1978.

Abstract

A model is developed of the costs of operating a time-shared computerized livestock auction system. Computerized auction sales are more expensive to conduct than are conventional ones. However, when the total costs of marketing are considered, including buyers' time and transportation costs as well as selling costs, the computerized system is less costly than the conventional system. The sensitivity of computerized sale costs to changes in important operating parameters is demonstrated.

Key words: computerized auctions, electronic marketing, livestock marketing costs, livestock auctions

THE COSTS OF MARKETING SLAUGHTER CATTLE BY COMPUTERIZED AND CONVENTIONAL AUCTION SYSTEMS

by

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I. INTRODUCTION

In Virginia, as in most other areas of the United States, slaughter beef and dairy cows are sold primarily through livestock auction markets. Forty-one Virginia auction markets, representing an average of nearly one market for every two counties in the state, currently sell slaughter cattle. A major problem with localized cattle auction sales is that the small number of cattle attracted to each sale tends to attract a small number of buyers. This contributes to a "thin" market situation in which "reservation supply and demand values of only a small proportion of all traders are represented" and, therefore, discovered prices inaccurately reflect true market value (Raikes).

Computerized Auction Procedure

Potential improvements in both pricing and technical (cost) efficiency of the auction marketing system may be obtained by selling livestock by means of a remote electronic device; the telephone, telegraph, or computer provide an example of such devices. Through a grant from the U.S. Department of Agriculture, a computerized version of a progressive livestock auction has been developed in Virginia in an attempt to achieve some of these efficiency improvements. The auction program was originally designed for slaughter cows and finished cattle, but it is currently being employed for other classes of livestock as well. An independent, non-profit corporation, named the Eastern Electronic Marketing Association (EEMA), has been organized to operate the computerized auction sales and to work with buyers and sellers in establishing operating procedures and policies.

The computerized sales conducted by the EEMA operate on a time-sharing basis with the Computer Sciences Corporation. At portable computer terminals, buyers obtain printed descriptions of lots offered for sale. Bidding is initiated when the EEMA representative enters an initial asking price at a central terminal. During the bidding process, buyers automatically receive, at preset intervals, a display of the currently high-bid and the number of seconds left in which to raise this bid. Bids are raised a preset increment by pushing a particular key on the terminal. A sale is terminated when no

buyer has raised the currently high bid in the time alloted to do so. "No-Sales" are declared if the high price falls short of the seller's reservation price.

Conventional auction market facilities participate in this system by assembling, weighing, and grading the animals and by sorting them into homogeneous lots before a sale. Descriptions of lots to be offered for sale are entered in a computer terminal at the EEMA office or at terminals located at participating auction markets.

Previous Work and Objectives of This Study

At present, little empirical work is available which compares electronic and conventional livestock marketing systems in terms of technical or cost efficiency. In a 1972 report, Johnson compared total marketing costs of selling finished slaughter cattle directly to packers with the costs of conventional auctions, with telephone and teletype auctions, and with four other sale methods. In a 1979 appraisal of the feasibility of electronic markets, Henderson, Schrader, Sporleder, and Baldwin provided preliminary cost estimates for selling hogs by computerized auctions in Ohio. And a 1979 Texas study by Glazener included cost estimates for a computerized progressive auction for feeder cattle, involving remotely-located computer terminals connected to a central computer through dedicated lines.

The present study compares the costs of marketing slaughter cattle by computerized and conventional auction systems in Virginia. Specific objectives of the study are:

(1) to develop synthetic or engineering cost functions of computerized and conventional livestock marketing systems (Chapter II),

(2) to compare total per-head costs of computerized and conventional livestock marketing systems as computerized cattle sales are progressively substituted for conventional cattle sales (Chapter III, part one), and

(3) to compare cash costs incurred by the EEMA and participating auction markets in the conduct of computerized sales with the cash costs at conventional livestock auction sales (Chapter III, part two).

The analysis is designed to provide a more detailed model of computerized marketing costs than has heretofor been available and to offer additional evidence of the relative costs of computerized and conventional marketing. The analysis is developed in such a way that estimated costs can easily be updated as factor prices and market operating procedures are altered. As such, the model may be useful for determining fee schedules at computerized sales similar to those in Virginia.

II. MODELS OF SLAUGHTER CATTLE MARKETING COSTS: COMPUTERIZED AND CONVENTIONAL

The first part of this chapter is devoted to those costs associated with the computerized selling process. The second part of the chapter is devoted to farm-to-market and market-to-plant transportation costs and to order-buyer and company-buyer costs. The third part includes an analysis of handling, weighing, and grading costs for computerized and conventional auction systems.

Computerized Selling- and Buying-cost Functions

The computerized sales in Virginia operate through shared access to the INFONET system, a division of Computer Sciences Corporation (CSC). Information on the lots of cattle for sale is assumed to be entered either at a computer terminal at the EEMA office or at terminals located at auction markets that agree to participate as assembly points. Each buyer is assumed to have a portable terminal from which he can receive printed descriptions of lots of cattle for sale and at which he can participate in the auction. The EEMA office is assumed to have two terminals. One terminal will be used by the EEMA manager to coordinate and monitor auctions. The other terminal at the EEMA office is, as a precaution in case a buyer is unintentionally disconnected during a sale, assumed to be logged on as a "buyer" to enable the EEMA manager, if necessary, to enter bids.

Total weekly cost functions are defined in this section for costs directly associated with the computerized auction sales. These cost functions have been divided into three categories: (1) INFONET system usage, (2) terminals, modems, and terminal paper, and (3) auction market time, buyer time, and the EEMA management. All terms used in cost functions below are defined in table 2.1 along with values for those parameters that are not changed in this study. Non-dollar-denominated values given in table 2.1., such as the amount of time for which lot information is stored, were derived from our initial experience with computerized auctions. Dollar-denominated values are either observed factor prices or cost estimates that are discussed below.

Table 2.1. Definitions of term used in the cost model of the computerized auction system

		Parameter value
AU_L	= number of head per lot offered for sale.	---
AU_w	= number of head per week offered for sale.	---
BD_{bt}	= average number of bids per connected buyer-terminal per lot.	2
BD_{et}	= average number of bids at the EEMA terminal per lot.	0
$BPAC_w$	= total cost of paper, all buyer-terminals, in dollars per week.	---
$BTIM_w$	= total cost of buyers' time, in dollars per week.	---
BT_s	= number of buyer terminals connected per sale.	---
BW_m	= buyer's wage, in dollars per minute.	$0.166
C_m	= undiscounted cost of connect time, in dollars per minute per terminal.	$0.158
C_{sru}	= undiscounted cost of computer processing time, in dollars per SRU.	$0.36
CC_b	= total connect cost during the auction bidding process, all buyer-terminals, in dollars per week.	---
CC_{eL}	= total connect cost for entering lots of cattle, all auction market terminals, in dollars per week.	---
CC_{Lf}	= total connect cost for buyers' listing of cattle files, in dollars per week.	---
CCE_b	= total connect cost during the auction bidding process, the EEMA terminals, in dollars per week.	---
CCE_{eL}	= total connect cost for entering lots of cattle, the EEMA terminals, in dollars per week.	---
CCE_{Lf}	= total connect cost for listing of cattle files, the EEMA terminal, in dollars per week.	---
D	= discount received under normal INFONET connect and processor rates, in percent.	---
DEP_{bt}	= depreciation cost of one buyer-terminal or auction-market terminal, in dollars per week.	$6.284
$EPAC_w$	= total cost of the EEMA terminal paper, in dollars per week.	---

		Parameter value
ET_{eL}	= number of the EEMA terminals used to enter lots.	1
EFC	= fixed costs at the EEMA office (terminal and modem depreciation and maintenance, manager, rent, utilities), in dollars per week.[a/]	$463.55
IB_w	= total invoice charge, all buyer-terminals, in dollars per week.	---
IE_w	= total invoice charge, all the EEMA terminals, in dollars per week.	---
IM_w	= total invoice charge, all market terminals, in dollars per week.	---
INV_{id}	= invoice cost per user I.D., in dollars per week.	$0.69
L_{Ld}	= number of long lot-descriptions, in minutes per lot per terminal.	10
M_{LLd}	= connect time for a list of long lot-descriptions, in minutes per lot per terminal.	---
M_{Lsd}	= connect time for a list of short lot descriptions, in minutes per lot per terminal.	---
M_{tL}	= connect time for auction bidding process, in minutes per lot per terminal.	---
MK_w	= number of auction markets entering lots for computerized sales.	---
MPAC	= total cost of paper, all auction market terminals, in dollars per week.	---
MT_{bt}	= maintenance cost of one buyer-terminal or auction-market terminal, in dollars per week.	$2.96
$MTIM_w$	= total cost of time at auction markets used to enter lots, in dollars per week.	---
MW_m	= auction market terminal operator's wage, in dollars per minute.	$0.066
PA_b	= total amount of paper used during the bidding process, all buyer-terminals, in inches per week.	---

[a/] Cost items in dollars per week were, for depreciation and maintenance of printer terminal, $12.91, for cathode ray tube, $4.77, for two modems, $8.36, for manager's salary, $384.62, for rent, $11.54, for telephone, $34.62, and for other utilities, $6.73.

		Parameter value
PA_d	= total amount of paper used to obtain descriptions of lots, all buyer-terminals, in inches per week.	---
PAC_{in}	= cost of paper used for buyer or auction market terminals, in dollars per inch.	$0.00375
PAC_s	= cost of paper used for the EEMA terminal, in dollars per inch.	$0.0059
PC_b	= total computer processing cost during auction bidding, all buyer-terminals, in SRU's per week.	---
PC_{eL}	= total computer processing cost for entering lots, all auction-market terminals, in dollars per SRU.	---
PC_{Lf}	= total computer processing cost for listing cattle files, all buyer-terminals, in dollars per SRU.	---
PCE_b	= total computer processing cost during auction bidding process, the EEMA terminals, in SRU's per week.	---
PCE_{eL}	= total computer processing cost for entering lots, the EEMA terminal, in dollars per SRU.	---
PCE_{Lf}	= total computer processing cost for listing cattle files, the EEMA terminal, in dollars per SRU.	---
S_w	= number of computerized auction sales held per week.	---
SC_f	= total fixed cost of data storage for cattle trading programs, in dollars per week.	$20.71
SC_{Lw}	= unit variable cost of data storage, in dollars per week.	$0.189
SC_w	= total cost of data storage, in dollars per week.	---
SEC_{bL}	= elapsed time after a lot has been sold and before another lot is offered for sale, in seconds.	30
SEC_{dp}	= elapsed time between displays of current high bid, in seconds.	20
SH_L	= amount of the EEMA terminal paper used, in sheets per lot.	1.5
W_L	= amount of storage time for information on a particular cattle lot, in weeks.	2

		Parameter value
Y_1	= the ratio of the number of lots per week entered at auction market terminals to the total number of lots offered for sale per week.	.75
Y_2	= number of lots per sale divided by the number of lots in a list of short lot-descriptions.	1
Y_3	= number of lots per sale divided by the number of long lot-descriptions requested.	1
Y_4	= average number of buyer terminals connected per lot divided by the total number of buyer terminals connected for all or part of a sale.	1

INFONET System Usage

The major costs of INFONET system usage are for terminal connect time and interactive usage (processor time). The CSC's unit of billing for processor time is called an SRU (System Resource Unit). Other costs are for system storage and a monthly invoice charge per user I.D. A representative of the CSC furnished estimates of input prices and input requirements for the auction program discussed here. The input requirements were then checked against information from sample runs and, in some cases, modified to show fixed and variable components. Improvements in the auction program that would lower costs were still being undertaken at the time of this study. If the monthly bill for INFONET services is less than $10,000, a 25% discount is applied to all factor prices; otherwise, a 30% discount is applied.[1/] The term D in the cost equations below represents the percentage discount in effect.

In this section, total weekly connect-cost functions and processor-cost functions are defined for: (1) entering lots at auction market terminals, (2) obtaining descriptions of cattle lots at buyer terminals, (3) bidding at buyer terminals, (4) entering lots at the EEMA terminal, (5) obtaining descriptions of cattle lots at the EEMA terminal, and (6) monitoring the auction at the EEMA terminals. In addition, total weekly

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[1/] As a consequence of receiving a federal grant for this project, there is no surcharge for INWATS usage, and a discount is received on CSC's published prices. These price reductions may be unavailable in the future when the EEMA becomes a more commercial entity.

cost functions are included for system storage cost and for the invoice charge to buyer, auction market, and EEMA user I.D.'s.

Entering Lots at Auction Markets: Connect Cost. Equation (2-1) was used to calculate the total weekly connect-cost (CC_{eL}) for entering information at auction market terminals on cattle lots to be offered for sale:

$$(2\text{-}1) \quad CC_{eL} = [1.2MK_w + 2.3Y_l(AU_w/AU_L)]C_m(1 - D).$$

The term in the square brackets represents the total minutes of connect time per week for entering lots at auction market terminals. The portion of connect time per terminal per sale that is fixed with respect to volume is 1.2 minutes; this is multiplied by the number of markets participating in computerized sales per week (MK_w). The number of head offered for sale in a week divided by the average number of head per lot is the total number of lots offered for sale in a week. The ratio of the number of lots per week entered at auction market terminals to the total number of lots per week entered in computerized sales is represented by Y_l; this, when multiplied by the total number of lots offered for sale in a week (AU_w/AU_L), gives the number of lots entered per week at auction market terminals. An additional lot entered would add 2.3 minutes of auction market connect time. Notice the potential exists to decrease connect time for a given volume by reducing the number of lots through increased lot size. The discounted cost per minute of connect time is represented by $C_m(1 - D)$.

Entering Lots at Auction Markets: Processor Cost. Equation (2-2) was used to calculate total weekly processor cost for entering information at auction market terminals on cattle lots to be offered for sale (PC_{eL}):

$$(2\text{-}2) \quad PC_{eL} = 4Y_l(AU_w/AU_L)C_{sru}(1 - D).$$

An average of four SRUs are required per lot entry, and the ratio (AU_w/AU_L) multiplied by Y_l is the number of lots entered per week by all market terminals. Hence the number of SRUs per week for entering lots at auction market terminals is $4Y_l(AU_w/AU_L)$. The term $C_{sru}(1 - D)$ represents the discounted cost per SRU.

Obtaining Descriptions of Lots at Buyer Terminals: Connect Cost. Two types of descriptions of a set of cattle lots can be obtained: (1) short descriptions, which give grade, average weight, location, size of the lot, and, if a lot has already been sold, its selling price, and (2) longer descriptions, which provide, in addition to the information in the short description, total weight of the lot, the weight range, estimated quality and yield grade for finished slaughter cattle and estimated grade and dressing percentage for slaughter cows, dominant breeds in a lot, and information on when the animals were weighed and how long they were off feed or water before weighing time.

When obtaining descriptions of lots, the buyer first indicates whether he (also read she) wants descriptions of lots to be sold at the present sale or descriptions of lots sold on the previous sale day, or both. Then he must indicate whether he is interested in obtaining information on finished slaughter cattle, on slaughter cows, on both finished slaughter cattle and cows, or on some specific lot. If the buyer designates that he wishes to see information on a specific lot, he receives the longer type of description for that lot. Otherwise, the buyer receives a list of the shorter type of descriptions for the lots which he delineated. For example, he might receive a list of the shorter type of descriptions for all finished slaughter cattle and slaughter cows for sale.

Equation (2-3) represents minutes of connect time per buyer-terminal per sale for obtaining a list of short descriptions (M_{Lsd}), and equation (2-4) represents minutes of connect time per buyer-terminal per sale for obtaining the longer descriptions for specific lots (M_{LLd}):

$$(2\text{-}3) \qquad M_{Lsd} = 1.4 + .06Y_2(AU_w/AU_L S_w)$$

$$(2\text{-}4) \qquad M_{LLd} = \begin{bmatrix} .68 + .60Y_3(AU_w/AU_L S_w) \\ .68 + .60L_{Ld} \end{bmatrix}$$

In equation (2-3), the term $Y_2(AU_w/AU_L S_w)$ represents the number of lots in a list of short descriptions, which is a function, linear from the origin, of the number of lots per sale ($AU_w/AU_L S_w$). The time required to log on and log off is represented in the intercept of (2-3). Equation (2-4) was used to calculate minutes of connect time per terminal per sale

for obtaining the longer descriptions. Assuming that a buyer first obtains a list of short descriptions of a category of lots and then requests long descriptions of specific lots, about 0.68 minutes elapse between the last short lot description and the first long lot-description. In the first form of the equation, the number of longer descriptions specified by a buyer is a function of the number of lots offered for sale on that day; in the second form, the number of lots for which longer descriptions are requested is constant with respect to the number of lots offered. The appropriate form to use would depend upon buyer practice. In the remainder of this analysis, the second form of equation (2-4) is used.

Multiplying the sum of equations (2-3) and (2-4), which is the total minutes of connect time per buyer-terminal per sale for obtaining descriptions of lots, by the number of buyer-terminals per sale (BT_s), by the number of sales per week (S_w), and by the discounted cost per minute of connect time [$C_m(1 - D)$], yields the total weekly connect cost for obtaining descriptions of lots at buyer terminals (CC_{Lf}):

$$(2\text{-}5) \quad CC_{Lf} = [(2.08 + .60L_{Ld})BT_s S_w + .06Y_2 BT_s (AU_w/AU_L)]C_m(1 - D).$$

Here, $(2.08 + .60L_{Ld})$ is an estimate of the fixed component of connect time per terminal per sale for obtaining both short and long descriptions where the number of long descriptions requested is constant with respect to volume. When multiplied by the number of buyer terminals per sale (BT_s) and the number of sales per week (S_w), an estimate is provided of the fixed component of total connect time per week for obtaining both short and long lot-descriptions for all buyer-terminals. For each additional lot offered for sale, connect time would increase by $.06Y_2 BT_s$ minutes. The number of lots in a list of short descriptions is assumed to be a function, linear from the origin, of the number of lots per sale, and Y_2 represents the slope of that function. The quantity Y_2 may be greater than, less than, or equal to one, depending upon the set of cattle lots for which the buyer has requested a listing of short descriptions. For example, the quantity Y_2 would be greater than one (equal to two), if a buyer requested a listing of short descriptions of all cattle which

either have been sold on the previous sale-day or which are to be sold at the present sale. The quantity Y_2 would be less than one, if a buyer requested a listing of short descriptions of only slaughter cows to be sold at the present sale (assuming both slaughter cows and finished slaughter cattle are to be sold at the present sale). And Y_2 would be equal to one, if a buyer requested a listing of short descriptions of all lots to be sold at the present sale. The term in the brackets of (2-5), then, represents the total weekly minutes of connect time used by all buyer-terminals to obtain short and long descriptions of lots; this term is then multiplied by the discounted cost per minute of connect time, $C_m(1 - D)$.

Obtaining Descriptions of Lots at Buyer Terminals: Processor Cost. Equation (2-6) was used to calculate total weekly processor cost for obtaining descriptions of lots (PC_{Lf}), where it is assumed that the number of long descriptions requested is fixed with respect to volume:

$$(2\text{-}6) \quad PC_{Lf} = [(3 + .65L_{Ld})BT_s S_w + .03Y_2 BT_s (AU_w/AU_L)]C_{sru}(1 - D).$$

The term in the first set of parentheses of (2-6) represents the number of SRUs per terminal per sale which are constant with respect to volume. Three SRUs are used for logging on and off and requesting a list of short descriptions. An average of 0.65 SRUs is used per long lot-description. When multiplied by the number of buyer terminals per sale (BT_s) and by the number of sales per week (S_w), this provides an estimate of the fixed number of SRUs required per week for obtaining descriptions of lots. For an additional lot description in a listing of short descriptions, 0.03 of an SRUs would be expended per terminal.

Bidding at Buyer Terminals: Connect Cost. The equation used to calculate the total weekly connect cost of buyer terminals during the course of bidding (CC_b) is shown below:

$$(2\text{-}7) \quad CC_b = [5BT_s S_w + M_{tL} Y_4 BT_s (AU_w/AU_L)]C_m(1 - D).$$

It was assumed that the average buyer would log off after obtaining lot descriptions, but log on again shortly before the bidding on the lots began. Above, five minutes per sale represents the time for a buyer to log on, wait for the sale to begin, and to log off when the sale is over.

The average number of buyer terminals connected per lot is represented by Y_4BT_s. To take into account that all buyers may not stay connected for the entire length of a sale, the term Y_4 is included, which is the ratio of the average number of buyer terminals connected per lot to the total number of buyer terminals connected for all or part of a sale. Minutes of connect time per terminal per lot (M_{tL}) multiplied by the number of buyer terminals connected per lot (Y_4BT_s) then results in the total number of minutes of connect time per lot. Multiplying this by the number of lots per week (AU_w/AU_L) gives the component of total weekly connect time for buyer terminals during the course of bidding that is variable with respect to volume.

Bidding at Buyer Terminals: Processor Cost. Equation (2-8) was used to calculate total weekly processor cost for buyer terminals during the course of bidding (PC_b):

$$(2\text{-}8) \quad PC_b = \{3.8BT_sS_w + [.063(60M_{tL} - SEC_{bL})/SEC_{dp} + .091BD_{bt}]Y_4BT_s(AU_w/AU_L)\}\, C_{sru}(1 - D).$$

It was estimated that 3.8 SRUs, for logging on and off and accessing the auction program, would be fixed with respect to volume. As the bidding proceeds on a particular lot, the currently highest bid is displayed at predetermined intervals at each buyer's terminal. The function $(60M_{tL} - SEC_{bL})/SEC_{dp}$ is the average number of high bid displays per lot per terminal which, when multiplied by .063, yields the number of SRUs per lot per connected terminal that is required for this display service. The term $.091BD_{bt}$ represents the average number of SRUs required for bidding per terminal per lot. The entire term in square brackets, then, is the average processor time or number of SRUs required during bidding per connected buyer-terminal per lot. The number of SRUs per connected terminal per lot multiplied by the number of buyer terminals connected per lot (Y_4BT_s) and by the number of lots offered per week (AU_w/AU_L) results in the component of total SRUs per week required during the bidding process which is variable with respect to volume.

The EEMA Terminals: Connect Cost and Processor Cost. Before the auction, the EEMA manager may enter some of the lots to be offered for sale.

The total weekly connect cost for entering lots at the EEMA terminal (CCE_{eL}) is obtained by adjusting equation (2-1) as follows:

$$(2\text{-}9) \quad CCE_{eL} = [1.2ET_{eL}S_w + 2.3(1 - Y_1)(AU_w/AU_L)]C_m(1 - D).$$

As in equation (2-1), 1.2 minutes is the portion of connect time per terminal per sale which is fixed with respect to volume; this represents the time required for logging on and off and accessing the program to enter lots. Unlike in equation (2-1), equation (2-9) involves only one terminal for entering lots. The term ET_{eL} is set equal to one when lots are entered at the EEMA office and set equal to zero when all lots are entered at auction-market terminals. The ratio of the number of lots per week entered by the EEMA manager to the total number of lots per week entered for computerized sales is represented by the term $(1 - Y_1)$.

The total weekly processor cost for entering lots at the EEMA terminal (PCE_{eL}) is obtained by substituting $(1 - Y_1)$ for Y_1 in equation (2-2), where Y_1 was the ratio of the number of lots per week entered at auction market terminals to the total number of lots per week entered for computerized sales:

$$(2\text{-}10) \quad PCE_{eL} = 4(1 - Y_1)(AU_w/AU_L)C_{sru}(1 - D).$$

After all the lots have been entered, the EEMA manager requests a listing of short descriptions in order to check that all the lots to be offered at the present sale had been entered properly. Multiplying the number of minutes of connect time per terminal for obtaining a list of short descriptions [equation (2-3)] by the number of sales per week (S_w) and by the discounted cost per minute of connect time $[C_m(1 - D)]$, and then setting Y_2 equal to one, results in the total weekly connect cost for listing the lot descriptions at the EEMA office (CCE_{Lf}):

$$(2\text{-}11) \quad CCE_{Lf} = [1.4S_w + .06(AU_w/AU_L)]C_m(1 - D).$$

The estimated fixed connect time per terminal per sale for obtaining a list of short descriptions is 1.4 minutes; this includes time for logging on and off. An additional lot offered would increase connect time

by an average of 0.06 minutes.

By subtracting from equation (2-6) the number of SRUs per week used by buyers to obtain long descriptions of lots,[1/] and by setting Y_2 and the number of terminals obtaining lot descriptions (BT_s) equal to one, the total weekly processor cost for obtaining a listing of short descriptions at the EEMA terminal (PCE_{Lf}) is generated:

$$(2\text{-}12) \quad PCE_{Lf} = [3S_w + .03(AU_w/AU_L)]C_{sru}(1 - D).$$

During the auction, two terminals are connected at the EEMA office. One terminal is logged on such that the manager can monitor the sale - watch as buyers log on and see which buyer makes which bid. The other terminal is logged on as a "buyer" to enable the manager to enter bids for a buyer if necessary. Setting the number of terminals connected per sale (BT_s) in equation (2-7) equal to two, the ratio of terminals connected per average lot to the total number of terminals connected per sale (Y_4) equal to one, and assuming ten minutes of connect time to be fixed with respect to volume for the EEMA terminals, yields the total weekly connect cost for EEMA terminals during the course of bidding (CCE_b):

$$(2\text{-}13) \quad CCE_b = [20S_w + 2M_{tL}(AU_w/AU_L)]C_m(1 - D).$$

The total weekly processor cost for the EEMA terminals during the course of bidding (PCE_b) was estimated by setting the number of terminals per sale (BT_s) in equation (2-8) equal to two and setting the ratio of terminals connected per average lot to the total number of terminals connected per sale (Y_4) equal to one. It was assumed that no bids were entered by the EEMA manager.

$$(2\text{-}14) \quad PCE_b = \{7.6S_w + 2[.063(60M_{tL} - SEC_{bL})/SEC_{dp} + .091BD_{et}](AU_w/AU_L)\} C_{sru}(1 - D).$$

[1/] This is $0.65L_{Ld}BT_sS_w$ if the number of long descriptions requested by buyers is assumed to be fixed with respect to volume.

When the sale is over, the manager performs a routine which stores, for each lot sold, the price for which the lot was sold together with other information obtained on the lot when it was entered for sale. The manager also obtains a printed "journal" that provides information on the time each bid was made and by whom it was made. Separate cost estimates for the above activities, along with a few other routines which the manager may use, could not be obtained. However, the CSC representative believed that a reasonable estimate for all the activity of the EEMA terminals was included in the processor cost and connect cost for two buyer terminals during the course of bidding.

System Storage Cost. Disc- or tape-storage costs fall into two categories: fixed and variable. The portion of storage cost that is fixed with respect to volume of lots traded is for storage of the computer trading program itself. The variable portion of storage cost is associated with storage of information on each lot entered for sale. Equation (2-15) was used to model total weekly storage cost (SC_w) for the entire system:

$$(2\text{-}15) \quad SC_w = [SC_f + SC_{Lw} W_L (AU_w/AU_L)](1 - D).$$

Storage cost per lot per week (SC_{Lw}) is the product of disc space per lot (one page) and the charge per page for one week. This is multiplied in turn by the number of weeks for which information is stored on each lot (W_L) and by the number of lots offered for sale per week to give total weekly variable storage cost. The sum of the total weekly variable storage cost and total weekly fixed storage cost (SC_f), multiplied by (1 - D), yields the discounted total weekly storage cost.

Invoice Charge. There is a monthly invoice charge per user I.D. Each terminal was assumed to be associated with one user I.D. Equations (2-16), (2-17), and (2-18) were used to calculate the total invoice charge on a weekly basis for buyer terminals (IB_w), market terminals (IM_w), and the EEMA terminals (IE_w), respectively:

$$(2\text{-}16) \quad IB_w = BT_s INV_{id}(1 - D)$$
$$(2\text{-}17) \quad IM_w = MK_w INV_{id}(1 - D)$$
$$(2\text{-}18) \quad IE_w = 2INV_{id}(1 - D).$$

Terminals, Modems, and Terminal Paper

Weekly buyer terminal depreciation and maintenance costs were determined by multiplying weekly depreciation and maintenance costs per terminal by the number of buyer terminals participating in computerized sales per week, which was assumed to be equivalent to the number of buyer terminals participating per sale. Likewise, total weekly auction market terminal depreciation and maintenance costs were determined by multiplying weekly depreciation and maintenance costs per terminal by the number of auction markets per week assumed to be participating in computerized sales. The same terminal model was assumed to be used by buyers and by auction markets. For the EEMA, total weekly depreciation and maintenance costs were estimated for two terminals, one with a printer and the other with a cathode ray tube, and for two high-speed modems.

Buyer Terminal Paper. The buyer terminals utilize heat sensitive paper which comes in rolls. Equation (2-19) was used to estimate the number of inches of paper used per week by buyer terminals to obtain both long and short descriptions of lots (PA_d), and equation (2-20) was used to estimate the total number of inches of paper used per week by buyer terminals during the bidding process (PA_b):

$$(2\text{-}19) \quad PA_d = (4 + 4L_{Ld})BT_s S_w + .50BT_s Y_2 (AU_w/AU_L)$$

$$(2\text{-}20) \quad PA_b = 4BT_s S_w + 3Y_4 BT_s (AU_w/AU_L).$$

In equation (2-19), four inches of paper per terminal are assumed to be used in logging on and off, four inches per terminal for a long lot-description, and one-half inch per terminal for a short lot-description. In equation (2-20), four inches of paper per terminal are assumed to be used in logging on and off, and three inches per lot per terminal are assumed to be used during the auction bidding process. Term $Y_4 BT_s$ represents the number of connected buyer-terminals per lot.

The sum of PA_d and PA_b, multiplied by cost per inch of paper for each buyer terminal (PAC_{in}), results in the total weekly cost of paper for all buyer-terminals ($BPAC_w$):

$$(2\text{-}21) \quad BPAC_w = [(8 + 4L_{Ld})BT_s S_w + (.50Y_2 + 3Y_4)BT_s (AU_w/AU_L)]PAC_{in}.$$

Auction Market Terminal Paper. The same type of rolled paper used at buyer terminals is used at auction market terminals. The total weekly cost of terminal paper for auction markets ($MPAC_w$) is the cost of paper used at auction markets for entering lots at computerized sales:

$$(2\text{-}22) \quad MPAC_w = [4MK_w + 6Y_1(AU_w/AU_L)]PAC_{in}.$$

Here, four inches of paper are assumed to be used for logging on and off and six inches of paper are assumed to be used to enter a lot. The term, Y_1AU_w/AU_L represents the number of lots per week entered at auction market terminals.

The EEMA Terminal Paper. Equation (2-23) was used to calculate total weekly cost of paper used for the EEMA terminal equipped with a printer ($EPAC_w$):

$$(2\text{-}23) \quad EPAC_w = 1.5(AU_w/AU_L)PAC_s$$

Unlike the buyer terminals and auction market terminals, 14.875 inch by 8.5 inch standard computer paper is used by the EEMA printer model. The amount of terminal paper assumed to be used at the EEMA terminal is 1.5 sheets per lot. The term PAC_s represents the cost per sheet of computer paper.

Auction Market Time, Buyer Time, and the EEMA Management.

The total weekly cost of entering information at auction markets on lots of cattle to be offered for sale is equivalent to the time used to enter lots per week at auction markets multiplied by the terminal operator's wage or implicit wage rate. In order to represent this cost of data entry, the discounted cost per minute of terminal connect time in equation (2-1), $C_m(1 - D)$, was replaced with the terminal operator's wage rate per minute (MW_m). The result, the total weekly cost of time at auction markets used to enter lots to be offered for sale ($MTIM_w$), is represented by equation (2-24):

$$(2\text{-}24) \quad MTIM_w = [1.2MK_w + 2.3Y_1(AU_w/AU_L)]MW_m.$$

The total weekly cost of buyers' time ($BTIM_w$) is equivalent to the sum of the total minutes of buyer connect time per week for obtaining descriptions of lots and the total minutes of buyer connect time per week to participate in or observe the bidding process, multiplied by the cost per minute of a buyer's time (BW_m). The total cost can be derived from equations (2-5) and (2-7) as follows:

$$(2\text{-}25) \quad BTIM_w = [(7.08 + .60L_{Ld})BT_s S_w + (M_{tL} Y_4 + .06Y_2)BT_s (AU_w/AU_L)]BW_m.$$

The first term in the bracket of (2-25) is derived from the first term in the bracket in equation (2-5), which assumes that buyers' connect time to observe long lot-descriptions is invariant with respect to the number of lots offered for sale, and from the first term in equation (2-7). The addition to the total time for all buyers to list short descriptions that is attributable to an additional lot offered for sale is $.06Y_2 BT_s$. The addition to the total time for all buyers to participate in or observe the bidding process that is attributable to an additional lot offered for sale is $M_{tL} Y_4 BT_s$.

The costs of the EEMA manager and of the EEMA office expenses were assumed to be fixed with respect to volume of animals or of animal lots offered for sale. The primary expenses for the EEMA office are for office rental, telephone usage, and other utilities.

Cattle Transportation and Procurement Cost Functions

The following relationship was used to calculate the per-head cost (TRUTC) of assembling cattle from farm to market:

$$(2\text{-}26) \quad TRUTC = \frac{(FC_{yr})(1/365) + (VC_{mi})(RMI)}{AU_{trp}}$$

where

FC_{yr} is the fixed cost of owning a truck, in dollars per year,

VC_{mi} is the variable cost of operating a truck, in dollars per mile,

RMI is the round trip distance between producer location and assembly point, in miles, and

AU_{trp} is the number of animal units hauled per trip, in cow equivalents.

Use of the fraction (1/365) implies that only one day of the truck's annual fixed cost is apportioned to hauling cattle to an assembly point. In addition, it is assumed that a farmer makes only one trip in one day to an assembly point.

Fixed and Per-mile Variable Costs of Farm-to-market Assembly

Operating costs were estimated for a 3/4-ton pickup truck and a 1 1/2-ton truck. The similarity of road conditions in Virginia and West Virginia justified use of information from two West Virginia livestock transportation studies that employed an engineering approach to estimate efficient costs for 3/4-ton and 1 1/2-ton trucks (Nor and Kuehn; Lin and Kuehn). In the present study, depreciation was recalculated for new 1979 trucks, while all other fixed costs given in the West Virginia studies were replaced with 1980 cost estimates. In calculating annual depreciation costs and for tax purposes, a depreciation schedule developed by Capstick was employed which represented, for 3/4-ton and 1 1/2-ton farm trucks and for truck ages ranging from zero to sixteen years, the percent of new cost depreciated each year.

For most of the variable cost items, input prices given in the West Virginia studies were replaced with 1980 prices. Only for those variable cost items for which the West Virginia study did not specify input requirements were cost estimates inflated by price indexes (Agricultural Prices, USDA). The resulting estimates of annual fixed cost (FC_{yr}) and variable cost per mile (VC_{mi}) for the two truck-sizes are shown in table 2.2.

Table 2.2. Annual fixed costs and per-mile variable costs of farm-to-market cattle assembly, 3/4-ton and 1 1/2-ton trucks, West Virginia and Virginia, 1980

Item	3/4 ton truck	1 1/2 ton truck
	Dollars	
Annual fixed cost	$1338.12	$1391.92
Variable cost per mile	0.24	0.30

Delineation of fixed and variable transportation costs on the basis of truck size enabled estimates to be made of the transportation cost differential by farm size. Generally, larger farms haul a larger number of cattle to the market at one time and thus employ larger trucks, which according to table 2.2, involve larger fixed and variable expenses. However, since these larger trucks have carrying capacities that are proportionately larger than their operating costs, transportation costs per head were lower for larger farms.

Data on farm sizes and corresponding numbers of head hauled per trip to the auction market were obtained for twelve finished slaughter-cattle producers and sixty-six slaughter cow producers interviewed for Russell and Purcell's report. Shown in table 2.3 are the cattle type and farm size groups with corresponding average numbers of head per trip, truck sizes, and weighting coefficients used in the calculation of a weighted average unit transportation cost.

Table 2.3. Parameters used in estimating weighted average farm-to-market costs of cattle assembly in Virginia

Cattle type	Farm size[a/]	Truck size	Head per trip[b/]	Weighting coefficient
	--head--	--tons--	--number--	--percent--
Finished Slaughter-cattle	3-240	1 1/2	10	13
Slaughter cows	21-100	1 1/2	6	12
Slaughter cows	11- 20	1 1/2	3	23
Slaughter cows	1- 10	1 1/2	2	26
Slaughter cows	1- 10	3/4	2	26

a/ Number of cattle sold per year at all auction markets.

b/ Capacity for the 3/4-ton truck is defined by Nor and Kuehn as two animal units; capacity for the 1 1/2-ton truck is defined by Lin and Kuehn as ten animal units, where one animal unit is equivalent to one head of cattle, two calves, four hogs, or four sheep or lambs.

Distances of Farm-to-market Assembly

When estimating road mileages from producer locations to auction markets for "conventional" auction sales, all forty-one of the livestock auction markets in the state that currently sell slaughter cattle were used. The distance in miles from each of seventy-eight randomly selected producer locations in the state to the nearest of the forty-one auction markets was determined using mileages printed on service station road maps; then an average was taken of the seventy-eight mileages.[1/]

Although it is conceivable that in computerized auction sales the assembly function could be bypassed and animals hauled directly to the slaughter plant, in this study it is assumed that all cattle are first assembled at auction market facilities before transfer to plant. Three scenarios were employed in modeling the operation of computerized auctions. The first scenario assumes that nine markets, the second that sixteen markets, and the third that forty-one markets have agreed to participate in assembling and handling for computerized sales. Criteria used in selecting the auction market locations for the nine-market and sixteen-market scenarios were the likelihood that these markets would in fact agree to participate in computerized sales and the provision of a fairly uniform distribution of markets throughout the state.[2/]

For the nine-market scenario, mileages were measured from each of the seventy-eight sample producer locations to the nearest of the nine auction markets identified; for the sixteen-market scenario, mileages were measured to the nearest of sixteen markets identified; for the forty-one-market scenario, mileages were measured to the nearest of the forty-one markets in the state which currently sell cattle. Estimates for average round-trip mileage from producer locations to auction markets were: nine-market scenario, sixty-two miles; sixteen-market scenario, thirty-eight miles; forty-one-market scenario, twenty-six miles.

It had initially been hypothesized that cattle feeders would be located closer to main highways than would beef cow-calf producers and

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[1/] Producer locations were obtained from the survey responses used by Russell and Purcell.

[2/] Obtained from conversation with K. C. Williamson, Department of Animal Science, Virginia Tech.

dairymen. Under this assumption, separate average assembly mileages were calculated for finished cattle and for slaughter cows. The results, shown in table 2.4, indicate no important difference in assembly mileages. As a consequence, averages of these distances, weighted by the sample numbers of each type of producer, were utilized instead.

Table 2.4. Average two-way mileages from sample farm locations to livestock auction markets in Virginia

	From farm producing ...	
Auction markets	Slaughter cows	Finished-slaughter-cattle
numbers	miles	
9	62	64
16	40	32
41	26	26

Accounting for the Cost of Repeated Cattle-sales

Buccola and Polishuk note that in the conventional auction marketing system in Virginia "slaughter cattle appear to be resold, often by 'traders' taking advantage of price differentials across markets," but that "there are no precise data on the average frequency with which a single [head of] cattle ... is marketed in a given year in Virginia." It was felt that the reselling of cattle occurs often enough in the conventional auction marketing system in Virginia to justify the inclusion of some estimate for the cost of reselling, despite the lack of certainty regarding the frequency with which animals are resold. The following equation was used to adjust equation (2-26) to provide a net estimate of the unit total cost of assembling cattle in the conventional auction marketing system:

$$(2\text{-}27) \quad TRUTC_{conv} = TRUTC_{wa1} + (FREQ - 1)(TRUTC_{wa2})$$

where

$TRUTC_{conv}$ is the average total cost of assembling cattle for the conventional auction marketing system, in dollars per head,

FREQ is the average number of times an animal is sold before arriving at a slaughter plant,

$TRUTC_{wa1}$ is the average total cost of assembly the first time an animal is hauled to an auction market, in dollars per head, and

$TRUTC_{wa2}$ is the average total cost of hauling an animal from one auction market to another, in dollars per head.

Three values were sequentially assigned to FREQ: 1.5, 1.25, and 1.00. Thus, assembly costs corresponding to the conventional auction system were first estimated under the assumption that the average cow is sold 1½ times before delivery to a slaughter plant, then under the assumption that it is sold 1¼ times before delivery to a plant, and finally under the assumption that the average cow is sold only one time before delivery to a slaughter plant.

$TRUTC_{wa1}$ was determined, as explained above, as a weighted average of the hauling costs for different farm sizes and cattle types. The estimate utilized the round-trip mileage calculated for the forty-one auction market scenario, $TRUTC_{wa2}$, was determined similarly, except that the round-trip distance from producer point to assembly point (RMI) in equation (2-26) was replaced with the average one-way distance in miles between two adjacent auction markets.

The average one-way distance between adjacent markets was estimated by averaging the mileages printed on service station road maps between every pair of markets not separated by more than forty miles. Using this rule, mileages between forty-two pairs of auction markets were calculated, the average of which was twenty-five miles.

Cost of Shipping Cattle from Market to Plant

Estimating the average distance Virginia cattle are shipped from auction market to slaughter plant proceeded as follows: first, auction market-to-plant mileages were estimated from each sample-plant location to Lynchburg, which is the most centrally-located market site in the state; then, the mileage from each sample-plant location to Lynchburg

was weighted by an estimate of the percent of total Virginia slaughter cattle purchased by that packer, and these weighted mileages were summed. A 340-mile weighted average market-to-plant distance was estimated. This distance was heavily influenced by the northern plants located in Pennsylvania, New York, and New Jersey, which together purchased approximately 66.5% of all Virginia slaughter cattle.[1/]

Representatives of two Virginia livestock trucking firms contacted said they charged $1.50 and $1.60, respectively, per truckload-mile for one-way trips, regardless of the length of haul. Assuming 37 head of cattle per truckload, $1.50 and $1.60 per truckload-mile are equivalent to $0.041 and $0.043 per head-mile, respectively. Multiplying $0.041 per head-mile by 340 miles resulted in an estimated per-head market-to-plant transportation cost of $13.94.

Cost of Order-buyer or Company-buyer Time

To procure cattle from conventional auction sales held in Virginia, slaughter plants hire either their own company buyers or order buyers or a combination of these. In order to estimate buyer costs incurred by slaughter plants, cost estimates of using an order buyer and a company buyer had to be obtained.

An average of order buyers' per-head charges for obtaining slaughter cows from conventional auction sales, as reported by seven packers interviewed for Russell and Purcell's study, was used to approximate order-buyer costs. The sample average order buyer's charge was $2.54 per head purchased.

Most company buyers work full-time, although some are employed by the packer in other capacities during a portion of the week. The average wage paid to company buyers in 1979 was approximately $10.00 per hour. These buyers travel about 1000 miles per week in the course of their work and spend about two nights per week on the road. Itemized weekly costs are shown in table 2.5. All costs in table 2.5 are assumed to be fixed with respect to the number of head purchased. Thus, the per-head

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[1/] The remainder were purchased by packers in Virginia (27.3%) and in Georgia, North Carolina, Tennessee, and West Virginia (6.2%).

cost of using a company buyer decreases asymptotically as the number of head purchased increases.[1/]

Table 2.5. Itemized weekly costs of a meat packing company's livestock buyer, East Coast, 1980

Cost item	Cost per week
Meals (5 days at $6/day)	$ 30.00
Car expense (1000 mile/week at $0.15/mile)	150.00
Buyer's time	
Travelling (25 hrs./week at $10/hr.)	250.00
At market and meals (15 hrs./week at $10/hr.)	150.00
Motel (2 nights/week at $20/night)	40.00
	$620.00

Using these estimates for per-head order-buyer costs and per-head company-buyer costs, a weighted average per-head buyer cost for the conventional system (BC_{conv}) was calculated. Precise data on the percentages of Virginia slaughter cattle purchased by order buyers and by company buyers from conventional auction sales were not available. So, two sets of weights were sequentially applied: per-head buyer costs were first estimated under the assumption that 50% of Virginia slaughter cattle sold at conventional auctions were purchased by order buyers and 50% by company buyers, then under the assumption that 80% of the cattle were bought by order buyers and 20% by company buyers.

[1/] Using the above estimate of total weekly company buyer cost ($620), a buyer would have to purchase about 244 head of cattle per week to result in the order buyer per-head figure of $2.54.

Handling, Weighing, and Grading Cost Functions

Derivation of Fixed and Variable Cost Estimates

At conventional sales held in livestock auction markets, animals are weighed, graded in some cases, penned, and afterwards driven through the sales ring and sold by the auctioneer present. Auction market facilities were assumed to be used also for weighing and grading cattle destined for computerized auction sales. In a 1977 study of the operating costs of Virginia livestock auction markets, Polishuk and Buccola synthesized efficient short run curves for three model-auction markets: "small" markets with maximum daily capacity of 500 animal units, "medium" markets with maximum daily capacity of 1500 animal units, and "large" markets with maximum daily capacity of 2500 animal units.[1/] The total variable cost function for each market size was assumed to be linear through the origin. Thus, to derive the corresponding unit variable cost functions, total variable cost had to be estimated at only one volume level for each market size, namely the maximum feasible animal unit volume for that size.[2/] Unit fixed cost functions were estimated over a range of volumes for each of the three market-sizes. For use in our study, itemized handling, weighing, and grading costs reported by Polishuk and Buccola were inflated from 1977 dollars to 1980 dollars with appropriate price indexes. Hourly wages and salaries employed by Polishuk and Buccola were replaced with 1980 quotes from Farm Labor (USDA).

In table 2.6 are shown, for each market size, the weekly total fixed costs and unit variable costs for handling, weighing, and grading cattle at computerized auction sales and for handling, weighing, grading, and selling cattle at conventional auction sales. Of the 35 Virginia livestock auction markets used in the Polishuk and Buccola study, 23% were classified as "small", 43% as "medium", and 34% as "large" markets.

[1/] Animal unit equivalents used in Polishuk and Buccola's study (p.14) were: 1 head of cattle = 1.34 calves = 2.01 hogs = 2.61 sheep or lambs = 0.49 horse.

[2/] Maximum feasible animal unit volume is the largest possible annual marketing volume given the capacity (defined by pen-space) of the market and given the normal seasonality of marketings by animal types.

Table 2.6. Livestock markets' fixed and variable costs, computerized and conventional auction sales, Virginia, 1980

Market size	Unit variable costs: Computerized sales[a]	Unit variable costs: Conventional sales[b]	Weekly total fixed cost[c]
	Dollars		
Small	1.81	2.06	$523.16
Medium	1.14	1.31	953.93
Large	1.03	1.21	1367.87
Weighted averages	1.26	1.45	

[a] The costs of computerized auction sales that must be covered by either sellers or auction markets are excluded here.

[b] The costs of the auction itself, that is, the cost of the auctioneer and ringmen, are included here with the other costs for handling, weighing, and grading.

[c] These are the same for computerized and conventional sales.

Using these percentages and the data shown in table 2.6, weighted averages were obtained for unit total variable costs and unit total fixed costs for computerized and conventional sales. The weighted average unit variable costs are also shown in table 2.6. The information used to obtain the unit fixed cost functions is discussed below.

Development of Unit Fixed Cost Functions

The weighted average unit fixed cost function for markets which participate in computerized as well as in conventional sales ($HUFC_{comp}$) is shown in equation (2-28). In contrast, the unit cost function shown in equation (2-29) is a weighted average for all forty-one markets in the state which handle cattle. Some of these markets, (MK_{comp}), hold both conventional and computerized auctions and some, ($41 - MK_{comp}$), hold only conventional auctions.

$$(2\text{-}28)\quad HUFC_{comp} = \sum_{i=1}^{3} W_i \frac{TFC_i}{[MFV_i - (V_{cat}FREQ/41)] + (V_{conv}FREQ/41) + (V_{comp}/MK_{comp})}$$

$$(2\text{-}29)\quad HUFC_{conv} = (MK_{comp}/41)HUFC_{comp} + [(41 - MK_{comp})/41] \sum_{i=1}^{3} W_i \frac{TFC_i}{[MFV_i - (V_{cat}FREQ/41)] + (V_{conv}FREQ/41)}$$

where

W_i is the ratio of the number of markets of the ith size to the total number of auction markets in the state which handle cattle,

TFC_i is the total fixed cost for a market of the ith size, in dollars per week,

MFV_i is the weekly maximum feasible animal unit volume for a market of the ith size, in cow equivalents (MFV = 351 for a "small"-sized market, 1053 for a "medium"-sized market, and 1756 for a "large"-sized market),

V_{cat} is the total weekly volume of cattle sold at all 41 markets in either conventional or computerized auction sales,

V_{conv} is the total weekly volume of cattle sold at conventional auction sales,

V_{comp} is the total weekly volume of cattle sold at computerized auction sales, and

MK_{comp} is the number of markets which hold computerized auction sales in addition to conventional auction sales, and

FREQ is the average number of times a head of cattle is sold at conventional auctions before arriving at a slaughter plant.

Weekly maximum feasible volume (MFV_i) less 1/41 of total weekly cattle volume (V_{cat}), multiplied by the average number of times (FREQ) a head of cattle marketed through conventional auctions is assumed to be sold before being shipped to a slaughter plant, represents the fixed

volume of all animals, other than cattle, sold at a market of a given size. The volume of cattle sold conventionally at any market is represented by 1/41 of the total volume of cattle sold at conventional auctions (V_{conv}), multiplied by FREQ. Similarly, the volume of cattle sold in computerized auction sales at any market (V_{comp}) is represented by 1/41, or 1/16, or 1/9 (depending upon whether the forty-one-market, the sixteen-market, or the nine-market scenario is being examined) of the total volume of cattle sold at computerized auctions. Recall that only conventionally-sold cattle are assumed to be resold before arrival at the plant.

In the next chapter, the cost functions presented in this chapter are used to compare costs of the computerized and conventional marketing systems.

III. RESULTS OF COMPARATIVE MARKETING COST ANALYSIS

The discussion of results consists of two parts: (1) an analysis of aggregate total costs of computerized and conventional systems and (2) an analysis of cash costs of computerized and conventional sales. First, each analysis is described for a specific set of parameters; then, the effect of parameter changes is discussed.

Aggregate Total Costs of Computerized and Conventional Systems

In this first analysis, a fixed volume of cattle is assumed to be sold at all auction markets in the state. Per-head total costs of the computerized system are compared with those of the conventional system as the proportion of cattle sold through computerized sales is increased and the proportion sold through conventional sales is decreased. Included are costs of farm-to-market transportation, market-to-plant transportation, handling, weighing, and grading at auction markets, cattle buyer time and expenses, and the cattle sale process itself.

In the three scenario discussions immediately below, it is assumed for computerized sales that the average lot size is twenty head, that the average time to complete the auctioning of a lot is three minutes, that five sales are held per week, and that participating markets have terminals at which lots offered for computerized sales are entered. For conventional sales, it is assumed at the outset that a head of cattle is sold an average of 1.5 times before delivery to a slaughter plant and that 80% of the cattle are bought by order buyers and 20% by company buyers. For both computerized and conventional sales, it is assumed that there is a total of twenty cattle-buyers and that 4400 head of cattle are offered for sale each week to the twenty cattle-buyers.

Nine-market Scenario

In this scenario, nine auction markets are used to handle, weigh, and grade cattle and enter lot information at terminals for computerized sales. All forty-one markets in the state are assumed to hold conventional auction sales of cattle. Figure 3.1 shows the unit total costs of cattle marketed

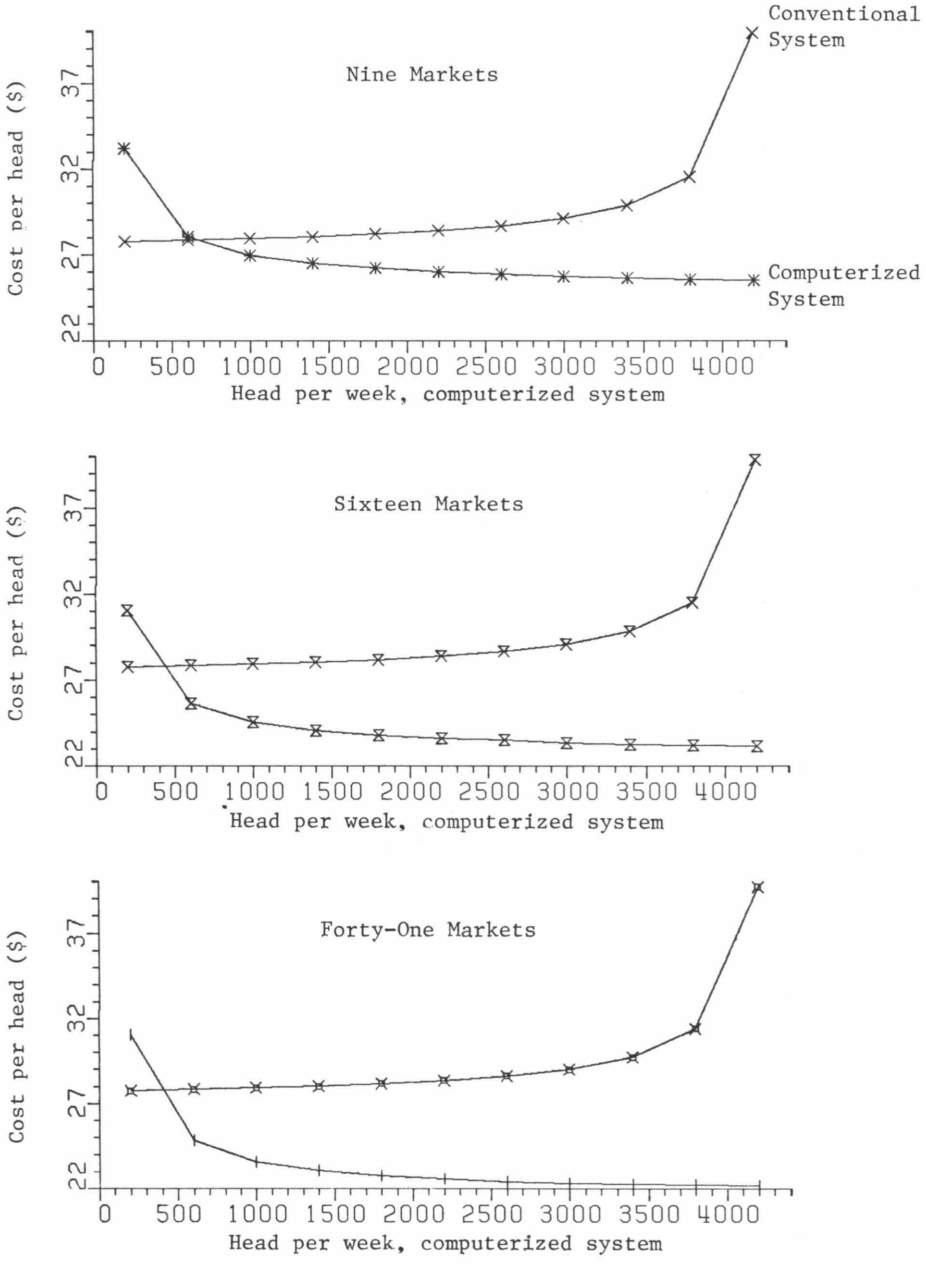

Figure 3.1. Unit total costs of computerized and conventional auction systems, FREQ = 1.50, 1980.

under each system as computerized sales are progressively substituted for conventional sales. Cost parameters employed are those shown in table 2.1. The per-head cost of the computerized system equals the per-head cost of the conventional system when about 600 head per week are sold at computerized sales and 3800 head per week are sold at conventional sales. The total per-head cost at this point is about $28.00 (costs of shrinkage and mortality are excluded). Only when more than 600 head per week are sold at computerized sales (and as a consequence, fewer than 3800 head per week are sold at conventional sales) are the per-head costs of the computerized system less than those for the conventional system.

If none of the costs varied with total volume sold per week at computerized or conventional sales, we could interpret figure 3.1 on a strictly percentage basis. That is, we could assert that the results are also applicable when the volume sold through both types of auctions is something other than 4400 head per week. However, the unit fixed costs for handling, weighing, and grading cattle at auction markets, which are included in each cost line in figure 3.1, are a function of total volume handled [see equations (2-28) and (2-29)]. Fortunately, the effect of a change in total cattle volume on handling, weighing, and grading unit fixed costs is small enough relative to other per-head costs that we can ignore this effect. Thus, it can be said as an approximation that, given the cost parameters employed here, the computerized system is less costly than the conventional system when at least 14% of the cattle in the state are sold at computerized sales.

Table 3.1 gives in detail the costs corresponding to the conventional system's cost function of figure 3.1. Notice that the slope of the conventional unit cost curve is primarily determined by the per-head cost of buyer time. Per-head buyer cost ranges from $2.62, when all 4200 head per week are bought at conventional sales, to $14.43, when only 200 head are assumed to be bought at conventional sales. On the other hand, auction market per-head fixed costs associated with conventional sales increase relatively slightly, from $1.50 to $1.81, as volume sold at conventional sales is decreased from 4200 to 200 head per week. This is because other classes of livestock continue to be sold in conventional auctions, and unit fixed costs at markets can be allocated over all livestock handled.

Table 3.1 Unit costs of the conventional auction marketing system for Virginia slaughter cattle, assuming the cattle are sold 1.5 times, nine-market scenario, 1980

Head per week	Unit total cost[a/]	Buyer time and expenses	Unit fixed cost of handling, weighing, grading, and selling[b/]
Numbers	- Dollars -		
200	$39.89	$14.43	$1.81
600	31.56	6.16	1.76
1000	29.86	4.51	1.71
1400	29.11	3.80	1.67
1800	28.68	3.40	1.63
2200	28.40	3.15	1.60
2600	28.20	2.98	1.57
3000	28.05	2.85	1.55
3400	27.93	2.76	1.53
3800	27.83	2.68	1.51
4200	27.76	2.62	1.50

[a/] Includes handling, weighing, grading, and selling variable cost ($2.18), farm-to-market unit transportation cost ($7.52), and market-to-plant unit transportation cost ($13.94).

[b/] Selling costs, that is, the cost of the auctioneer and ringmen, amount to $0.19 per head.

These estimates of both variable and fixed costs per head for handling, weighing, grading, and selling cattle at conventional sales assume that cattle are sold an average of 1.5 times before arriving at a slaughter plant. The per-head cost of transporting Virginia slaughter cattle from farm to market is about $4.16 if all 41 markets conduct sales. But taking into account the per-head cost for hauling cattle between two typical markets ($6.69), and the frequency with which reselling is assumed to occur in conventional sales, results in a per-head cost of hauling cattle to auction markets of $7.51. This transportation cost, in addition to the market-to-plant transportation cost of $13.94 per head, accounts for the largest portion of total per-head costs shown in figure 3.1 and table 3.1.

Table 3.2 details the costs involved in the cost function for the computerized system in figure 3.1. The market-to-plant transportation cost was assumed to be the same, $13.94 per head, for both computerized and conventional sales. But the cost of hauling cattle to market when only nine markets participate as assembly points for computerized sales is $7.96 per head. As a consequence of assuming that some cattle sold conventionally are resold before arrival at a slaughter plant, this $7.96 is not much greater than the $7.51 per head for conventional sales even though the farm-to-market mileage is less for conventional sales. Lower handling, weighing, and grading variable costs for computerized sales than for conventional sales can be accounted for largely by the assumed reselling of cattle in the conventional sales system. The per-head fixed cost of using auction market facilities for computerized sales ranges from $0.97 to $0.70 as the number of head sold by computer is increased from 200 to 4200 head per week.

Buyer costs shown here include the cost of the buyer's time and only those other costs for the computerized sale which the buyer is at present expected to pay. (These include his terminal and requested lot descriptions; see Appendix A.) Buyer costs range from $4.45 per head to $0.71 per head as the number of head sold at computerized sales is increased from 200 to 4200 per week.

Selling costs shown in table 3.2 include all costs of operating the computerized sale that are presently chargeable to the EEMA and producers.

Table 3.2. Unit costs of the computerized auction marketing system for Virginia slaughter cattle, nine-market scenario, 1980.

Head per week	Unit total cost[a/]	Buyer time and expenses	Computer selling costs	Unit fixed cost of handling, weighing, and grading
Numbers			Dollars	
200	$33.20	$4.45	$4.61	$0.97
600	28.02	1.84	2.07	0.93
1,000	26.95	1.32	1.57	0.90
1,400	26.48	1.09	1.35	0.86
1,800	26.21	0.97	1.23	0.83
2,200	26.02	0.89	1.15	0.81
2,600	25.89	0.83	1.10	0.78
3,000	25.72	0.79	1.00	0.76
3,400	25.64	0.76	0.97	0.74
3,800	25.57	0.73	0.95	0.72
4,200	25.52	0.71	0.93	0.70

[a/] Includes handling, weighing, and grading unit variable cost ($1.26), farm-to-market unit transportation cost ($7.96), and market-to-plant unit transportation cost ($13.94).

These include costs of the EEMA and auction market terminals, the EEMA manager and office expenses, auction market terminal operator, connect and processor time for all terminals (including buyer terminals), and system storage. Such selling costs range from approximately $4.61 to $0.93 per head. Although the buyer costs shown here are less for computerized sales than for conventional sales, the selling costs in computerized sales are clearly greater than those in conventional sales, which only involve the use of an auctioneer and ringmen.

Sixteen-market Scenario

In the present scenario, shown also in figure 3.1 and detailed in Appendix tables B and C, sixteen markets are assumed to handle, weigh, and grade cattle for computerized sales. The cost breakeven-point occurs where about 400 head per week are sold at computerized sales and about 4000 head per week are sold conventionally, at which point the total per-head cost of marketing is about $28.00. The breakeven cost is approximately the same in both the nine, sixteen, and forty-one market scenarios because no significant shift in the unit total cost function for the conventional system occurs across scenarios and because this curve is relatively flat where low volumes of cattle are sold at computerized sales (high volumes sold conventionally). Given the price structure assumed here, per-head costs under computerized sales are less than those under conventional sales when at least 9% of the slaughter cattle moving through auction markets are sold at computerized sales.

The decrease in computerized marketing costs in the sixteen-market compared to the nine-market scenario is solely a consequence of the lower average farm-to-market mileage and, therefore, lower transportation cost, when sixteen markets participate in computerized sales. These farm-to-market costs drop from $7.96 to $5.43 per head between the two scenarios. The full impact of such a downward intercept shift of the computerized market's unit total cost function is dampened by slight cost increases resulting from an increase in unit selling costs when the number of auction market terminals is increased and from an increase in handling, weighing, and grading unit fixed costs when the volume of cattle sold at computerized sales is divided among sixteen instead of nine markets.

Forty-one-market Scenario

In the forty-one-market scenario, unit total cost functions, which are shown in figure 3.1 and detailed in Appendix tables B and D, for all forty-one Virginia auction markets are assumed to participate in computerized as well as in conventional sales. In this scenario, the intersection of the unit total cost curve for the computerized system with the cost curve for the conventional system occurs where about 400 head per week are sold at computerized sales and 4000 head per week are sold at conventional sales. Thus, marketing costs associated with computerized sales would just equal those associated with conventional sales, if about 9% of the state's slaughter cattle were sold by computer. Beyond approximately this proportion, costs of computerized marketing would fall below those in conventional sales.

Because of the shorter farm-to-market mileage in the forty-one-market case compared to the sixteen-market case, the intercept of the computerized market's unit total cost function is lowered once again. Per-head farm-to-market transportation costs drop from $5.43 for the sixteen-market scenario to $4.16 per head in the present scenario. As before, this decrease is dampened by cost increases resulting from an increase in unit selling costs when the number of auction market terminals are increased and from an increase in handling, weighing, and grading unit fixed costs when the volume of cattle sold at computerized sales is divided among forty-one instead of sixteen markets. The decrease in per-head total cost from the sixteen to the forty-one market scenario ranges from nearly zero when 200 head are sold at computerized sales to $0.98 when 4200 head are sold at computerized sales. Compared to total per-head costs, this decrease is small and as a consequence does not have much of an effect on the cost breakeven point.

Repeated Cattle-sales

Because there is some uncertainty associated with the number of times slaughter cattle are currently sold before delivery to a plant, we have examined the sensitivity of solution results to this assumption. The effect on the weekly per-head total cost for the conventional system

(UTC_{conv}) of a change in the average number of times a head of cattle is sold before delivery to slaughter plant is

$$(3\text{-}1) \quad \partial UTC_{conv}/\partial FREQ = TRUTC_{bm} + HUVC_{conv} + HUFC_{conv} + HUFC'_{conv}(FREQ)FREQ$$

where

$TRUTC_{bm}$ is the average cost of hauling a head of cattle from one market to another, in dollars per head,

$HUVC_{conv}$ is the unit variable cost of handling, weighing, grading, and selling cattle in the conventional auction system, in dollars per head,

$HUFC_{conv}$ is the unit fixed cost of handling, weighing, grading, and selling cattle in the conventional auction system, in dollars per head per week,

FREQ is the average number of times a head of cattle in the conventional system is sold before delivery to a slaughter plant, and

$HUFC'_{conv}(FREQ)$ is the reduction in handling, weighing, grading, and selling unit fixed cost for the conventional system caused by increased volume when FREQ rises.

Both the cost of hauling from one market to another ($6.69 per head) and the variable cost at the auction market ($1.45 per head) are invariant with respect to volume, whereas the unit fixed cost incurred at auction markets in the conventional system is assumed to be a function of volume, as shown in equation (2-29). Thus, $HUFC_{conv}$ is also a function of frequency of sale.

Figure 3.2 contains a reproduction of figure 3.1 in which cattle sold conventionally are assumed to be sold an average of 1.5 times. Superimposed on this are unit total cost functions for the conventional system when cattle are assumed to be sold an average of 1.25 times and when cattle are assumed to be sold only once before delivery to a slaughter plant. Table 3.3 shows (1) the unit total costs for the conventional system corresponding to the nine-market scenario in figure 3.2, (2) the differentials between unit costs when cattle in the conventional system are sold 1.5 times and when they are sold only one time, and (3) the differentials

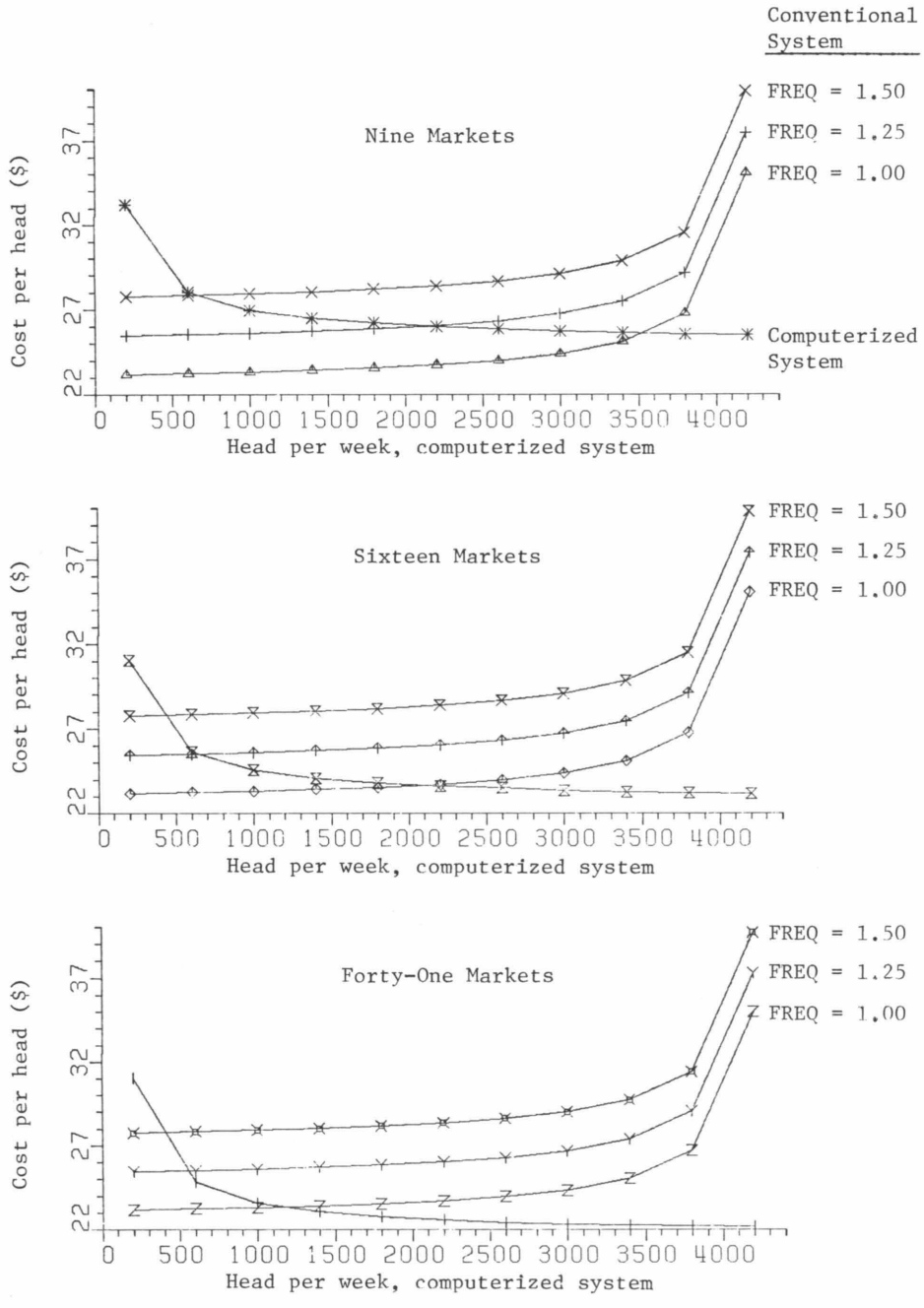

Figure 3.2. Unit total costs of computerized and conventional auction systems; FREQ = 1.50, 1.25, and 1.00; 1980.

Table 3.3. Unit total costs of selling slaughter cattle conventionally: differences resulting from alternative assumptions on frequency cattle are sold before slaughter, nine-market scenario, Virginia.[a/]

Head per week	Unit total cost			Increase in cost	
	FREQ=1.00	FREQ=1.25	FREQ=1.50	col (4) minus col (2)	col (4) minus col (3)
Numbers	- -			Dollars	- - - - - - - - - - - - - - - - - - - -
200	35.07	37.45	39.89	4.82	2.44
600	26.79	29.16	31.56	4.77	2.40
1,000	25.12	27.48	29.86	4.74	2.38
1,400	24.40	26.75	29.11	4.71	2.36
1,800	24.00	26.33	28.68	4.68	2.35
2,200	23.74	26.06	28.40	4.66	2.34
2,600	23.56	25.87	28.20	4.64	2.33
3,000	23.42	25.73	28.05	4.63	2.32
3,400	23.32	25.62	27.93	4.61	2.31
3,800	23.24	25.54	27.83	4.59	2.29
4,200	23.18	25.47	27.76	4.58	2.29

[a/] FREQ=1.00 denotes that cattle are sold only once, FREQ=1.25 that cattle are sold an average of 1.25 times, and FREQ=1.50 that cattle are sold an average of 1.50 times before delivery to a slaughter plant.

between unit costs when cattle are sold 1.5 times and when they are sold 1.25 times.

In the nine-market scenario, if cattle in the conventional system are sold an average of 1.25 times, the cost breakeven-point occurs where about 2000 head (45%) are sold at computerized sales and 2400 are sold conventionally. At this point, the total marketing cost is $26.00 per head. If cattle are assumed not to be resold (FREQ = 1), the intersection occurs where 3500 head (80%) are sold by computer and 900 head are sold conventionally, at a cost of about $25.60 per head. Recall that the breakeven point when FREQ = 1.5 occurred where approximately 600 head (14%) were sold by computer and 3800 head were sold conventionally.

If cattle are sold 1.25 times in the sixteen-market scenario, the breakeven point between the unit total cost curve for the conventional auction system and for the computerized auction system occurs where about 600 head, or 14%, are sold by computer and 3800 head are sold conventionally. If cattle are assumed to be sold only once in the sixteen-market scenario, the breakeven point occurs where about 2000 head, or 45%, are sold by computer and 2400 head are sold conventionally.

In the forty-one-market scenario, if cattle marketed conventionally are resold 1.25 times before delivery to plant, the breakeven point occurs where about 500 head (11%) are sold by computer and 3900 head are sold conventionally. If cattle are sold only once before delivery to a slaughter plant, the intersection of conventional and computerized cost curves occurs where 1200 head (27%) are sold by computer and 3200 head are sold conventionally.

Analysis of Cash Costs in Computerized and Conventional Sales

This section compares those cash costs of computerized and conventional auctions that would likely be passed on to consignors. The cost curve fixed at $1.45 per head in figure 3.3 is the weighted average per-head variable cost incurred at auction markets for conventional sales (not including additional costs of cattle resale). The downward sloping curve in figure 3.3 contains the weighted average per-head cost of handling, weighing, and grading cattle for computerized sales ($1.26) plus

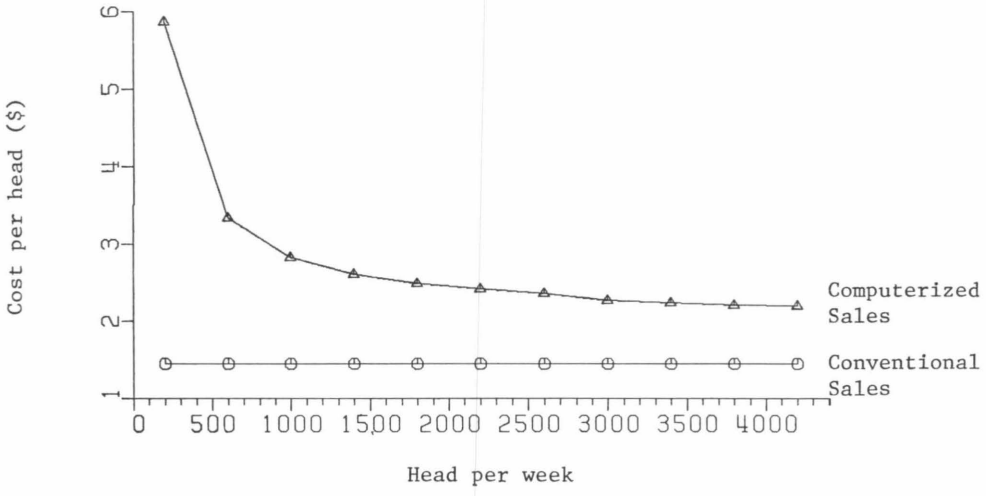

Figure 3.3. Unit cash costs at computerized and conventional slaughter cattle sales, parameter set no. 1, 1980.

the per-head costs at computerized auctions which would be expected to be covered by the seller. It is assumed here that five sales are held per week, that twenty buyer-terminals are connected for the length of each sale, that lots are entered at nine auction-market terminals as well as at the EEMA office, that each lot is sold in an average of three minutes, and that the average lot size is twenty head. Fixed cost components of the computerized sales process (such as terminal hardware costs) have been included in this analysis because at present such fixed costs are paid out-of-pocket.

The computerized selling cost function in figure 3.3 is, in fact, the same as that included in the preceding analysis. Thus, the per-head computerized selling costs given for volumes ranging from 200 to 4200 head per week in table 3.2 correspond also to figure 3.3 above. In table 3.4 are shown the sum of handling, weighing, and grading costs and computerized selling costs corresponding to figure 3.3. Table 3.4 also includes, at selected volume levels, the amounts by which costs for computerized sales exceed those for conventional sales. At a volume of 200 head per week, cash costs for computerized sales exceed those for conventional sales by \$4.42. At the highest volume shown here, 4200 head per week, cash costs for computerized sales exceed those for conventional sales by \$0.74. Notice that the total per-head selling cost in computerized sales would have to drop to around \$0.19 per head (\$1.45 minus \$1.26) before it would equal the conventional selling costs of auctioneer and ringmen labor.

Number of Sale Days per Week

The partial derivative of per-head weekly selling cost for computerized sales (SUTC) with respect to the number of sales held per week (S_w) is shown in general form as:

$$(3\text{-}3) \quad \partial SUTC/\partial S_w = [(21.4 + 1.2ET_{eL})C_m + 10.6C_{sru} + (5C_m + 3.8C_{sru})BT_s](1 - D)/AU_w.$$

Setting the number of buyer terminals per sale (BT_s) equal to twenty and the number of the EEMA terminals entering lots (ET_{eL}) equal to one (in order

Table 3.4. Unit cash costs of handling, weighing, grading, and selling at computerized slaughter cattle sales, and comparisons with such costs at conventional sales[a/]

Head per week	Per-head cash costs at computerized sales[b/]	Col (2) minus per-head cash costs at conventional sales[c/]
Number	Dollars	
200	5.87	4.42
600	3.33	1.88
1000	2.83	1.38
1400	2.61	1.16
1800	2.49	1.04
2200	2.41	0.96
2600	2.36	0.91
3000	2.26	0.81
3400	2.23	0.78
3800	2.21	0.76
4200	2.19	0.74

[a/] Costs for computerized sales are estimated assuming five sales per week, nine auction-market terminals, twenty buyer-terminals connected for each sale, three minutes to sell one lot, and twenty head per lot.

[b/] Selling costs include all costs of operating the computerized sale that are presently chargeable to the EEMA and producers: the EEMA and auction market terminals, the EEMA manager and office expenses, auction market terminal operators, connect and processor time for all terminals (including buyer terminals), and system storage.

[c/] The weighted average handling, weighing, grading, and selling (that is, the auctioneer and ringmen) unit variable cost for conventional sales is $1.45 (1980).

to correspond with the selling function in figure 3.3) and substituting the assumed cost per SRU (C_{sru}) and cost per minute of terminal connect time (C_m) from table 2.1, equation (3-3) becomes:

$$(3\text{-}3)' \quad \partial SUTC/\partial S_w = 50.588(1 - D)/AU_w.$$

As can be seen from the above equation, a change in the number of sales per week would elicit a greater per-unit cost change in the lower range of volumes than in the higher range of volumes. At a weekly volume of 200 head per week, decreasing the number of sale days per week from five to one would result in a variable cost decrease of $0.75 per head. At a weekly volume of 4200 head, the variable cost decrease would be only $0.03 per head. The INFONET discount is 25 percent in the former case and 30 percent in the latter case.

Minutes per Lot.

Equation (3-4) is the partial derivative of per-head weekly selling costs at computerized sales (SUTC) with respect to the number of minutes of connect time per terminal per lot during the bidding process (M_{tL}):

$$(3\text{-}4) \quad \partial SUTC/\partial M_{tL} = [2C_m + 7.56C_{sru}/SEC_{dp} + (Y_4C_m + 3.78Y_4C_{sru}/SEC_{dp})BT_s](1 - D)/AU_L.$$

Setting the number of buyer terminals per sale (BT_s) equal to twenty, the average number of head per lot (AU_L) equal to twenty, and the other parameters equal to the values shown in table 2.1, we have:

$$(3\text{-}4)' \quad \partial SUTC/\partial M_{tL} = 0.324(1 - D).$$

A decrease of one minute in terminal connect time per lot during the bidding process would decrease per-head selling cost by $0.24, if the INFONET discount is equal to 25 percent.

Average Number of Head Per Lot

The partial derivative of weekly per-head selling costs for

computerized sales (SUTC) with respect to the average number of head per lot (AU_L) is represented as:

$$(3\text{-}5)\quad \partial SUTC/\partial AU_L = -\{[2.36C_m + (4.03 - .126\,SEC_{bl}/SEC_{dp} + 0.091BD_{et})C_{sru} + W_L SC_{Lw}](1 - D) + (6Y_1 PAC_{in} + 1.5PAC_s + 2.3Y_1 MW_m) + (-0.063SEC_{bL}Y_4/SEC_{dp} + 0.091BD_{bt}Y_4)C_{sru}(1 - D)BT_s + (2C_m + 7.56C_{sru}/SEC_{dp})(1 - D)M_{tL} + (Y_4 C_m + 3.78Y_4 C_{sru}/SEC_{dp})(1 - D)M_{tL}BT_s\}/AU_L^2.$$

Setting the number of buyer terminals per sale (BT_s) equal to twenty, setting the number of minutes of connect time per terminal per lot during the bidding process equal to three, and substituting for the remaining parameters those values shown in table 2.1, equation (3-5) becomes:

$$(3\text{-}5)'\quad \partial SUTC/\partial AU_L = -[21.4473(1 - D) + 0.14]/AU_L^2.$$

This version shows the effect on the computerized selling cost curve in figure 3.3 of a change in the average number of head per lot. Increasing the number of head per lot from the twenty head used in figure 3.3 to forty head would decrease computerized selling costs by about $0.40 per head, assuming a 25 percent discount rate.

Number of Buyer Terminals Used Per Sale

The partial derivative of per-head selling costs at computerized sales (SUTC) with respect to the number of buyer terminals used per sale (BT_s) is given in general form as:

$$(3\text{-}6)\quad \partial SUTC/\partial BT_s = [(5C_m + 3.8C_{sru})(1 - D)S_w]/AU_w + [(-0.063SEC_{bl}Y_4/SEC_{dp} + 0.091BD_{bt}Y_4)(1 - D)C_{sru} + (Y_4 C_m + 3.78Y_4 C_{sru}/SEC_{dp})(1 - D)M_{tL}]/AU_L.$$

Equation (3-6) may be evaluated using the same parameter values as employed in the computerized unit selling cost equation of figure 3.3, that is five sales per week, three minutes of connect time per terminal per lot during bidding, and twenty head per lot. The result shows the effect on the unit selling cost function shown in figure 3.3 of a one-terminal increase in the number of buyer terminals connected per sale:

$$(3\text{-}6)' \quad \partial SUTC/\partial BT_s = 10.80(1 - D)/AU_w + 0.044(1 - D).$$

Decreasing the number of buyer terminals per sale from twenty to ten would decrease the per-head computerized selling cost by $0.73 at 200 head per week or by $0.32 at 4200 head per week. The INFONET discount is 25 percent in the former case and 30 percent in the latter case.

Weekly Volume

The partial derivative of per-head selling costs at computerized sales (SUTC) with respect to the number of head offered for sale each week (AU_w) is represented as:

$$(3\text{-}7) \quad \partial SUTC/\partial AU_w = -\{EFC + (SC_f + 2INV_{id})(1 - D) + [DEP_{bt} + MT_{bt} + (INV_{id} + 1.2C_m)(1 - D) + 1.2MW_m + 4PAC_{in}]MK_w + (21.4C_m + 1.2ET_{eL}C_m + 10.6C_{sru})(1 - D)S_w + (5C_m + 3.8C_{sru})(1 - D)BT_sS_w\}/AU_w^2.$$

Here, EFC represents the EEMA office terminal and modem depreciation and maintenance cost, expenses in the EEMA office, and the EEMA manager's salary. The other terms have been defined in table 2.1. Equation (3-7) may now be evaluated by substituting into it the parameter values given in table 2.1, by setting the number of buyer terminals used per sale (BT_s) at twenty, setting the number of auction markets with terminals (MK_w) at nine, and setting sales per week (S_w) at five. The result, given in equation (3-7)', shows the effect of a change in the number of head offered for sale each week (AU_w) on the per-head selling cost in computerized sales:

$$(3\text{-}7)' \quad \partial SUTC/\partial AU_w = -[547.61 + 282.94(1 - D)]/AU_w^2.$$

Equation (3-7)' is illustrated in figure 3.3, where an increase in weekly volume from 200 to 600 head results in a decrease in selling costs of about $2.54 per head. In contrast, an increase in weekly volume from 3800 to 4200 head per week results in a decrease in selling costs of about $0.02 per head.

IV. SUMMARY AND CONCLUSIONS

Summary

In this study, costs of marketing slaughter cattle through computerized auction sales were compared with costs of marketing cattle through conventional sales. Two analyses, each concentrating on Virginia, were undertaken to illustrate the cost relationships involved: (1) an analysis of aggregate total slaughter cattle marketing costs and (2) an analysis of cash costs incurred during computerized and conventional sales. The first or aggregate analysis included costs of farm-to-market transportation, market-to-plant transportation, handling, weighing, and grading at auction markets, cattle buyer time and expenses, and the cattle sale process itself. This analysis provided information appropriate to government and industry decisions regarding the future of computerized and conventional cattle auction sales. The second or cash cost analysis was concerned only with out-of-pocket expenses of operating computerized and conventional sales. The latter provided information appropriate to the establishment of fee schedules at computerized sales and to other short-term management decisions at auction markets.

Three scenarios were employed to implement the aggregate cost analysis. In the first scenario it was assumed that nine markets, in the second scenario that sixteen markets, and in the third scenario that forty-one markets have agreed to participate in assembling and handling cattle for computerized sales. For each scenario, per-head costs were compared for computerized and conventional sales as the proportion of cattle sold through computerized sales was increased and the proportion sold through conventional sales was decreased.

In the nine-market scenario, the point at which total per-head costs of computerized and conventional auction marketing systems becomes equal occurs where about 14.0% of the State's cattle are sold by computer. In the sixteen-market scenario, this cost breakeven-point occurs where 9.0% of the State's cattle are sold by computer; and in the forty-one-market scenario, it occurs where 9.0% are sold by computer. The total per-head cost of marketing at the breakeven point is $28 for all three scenarios. For the purpose of these estimates, it was assumed that in the conventional auction system cattle are sold an average of 1.5 times before delivery to a packing

plant. If, for example, cattle are sold an average of only 1.25 times before delivery to plant and only nine markets participate as assembly and handling points, the cost breakeven point between computerized and conventional systems does not occur until approximately half the State's cattle are sold by computer.

Comparison of out-of-pocket expenses at computerized and conventional auctions depended upon a large number of assumptions regarding the organization of computerized sales. Assuming that 200 head per week are sold at computerized sales, that there are five sale days per week and nine market terminals at which lots are entered, that there are three minutes of connect time per lot during the bidding process and an average lot size of 20 head, and that 20 buyer terminals are connected per sale, the combined selling, handling, weighing, and grading cash costs at computerized sales exceed those at conventional sales by $4.42 per head. Assuming that 4200 head per week are sold at computerized sales and that all other parameters are the same as the above, per-head cash costs are only $0.74 greater at computerized than at conventional sales. There is potential for decreasing the cost of computerized relative to conventional sales by decreasing the number of sale days per week, the average number of minutes of bidding per lot, or the number of buyer terminals connected per sale. But the most effective method by which to reduce computerized sales expenses on a per-head basis is by increasing the number of head offered per lot and thereby reducing the computer connect time per head sold.

Conclusions

This analysis has shown that, at present factor prices in Virginia, total per-head costs associated with marketing cattle by computer are less than those associated with marketing cattle in the conventional auction system, provided a minimal volume of cattle are sold by computer. The conclusion that the computerized marketing system is cheaper, in a total cost sense, than the conventional system serves to complement arguments made by other researchers that electronic markets encourage competition and access to market information and, hence, promote pricing accuracy (Henderson, et al.).

However, the fact that computerized marketing is relatively inexpensive when all costs are considered does not necessarily imply that computerized sales will be immediately beneficial to all parties involved in the marketing process. Most of the cost savings in computerized sales accrue to buyers, who avoid the expensive travel involved in the conventional auction system. The auction sales process itself is more expensive when conducted by computer than it is when conducted in the barn, and auction market operators will have to pass on these higher costs in the form of higher marketing charges. What should be the allocation of these higher charges between animal producers and packers is not the subject of the present report. Clearly, all marketing costs must in the long run be passed on to consumers. But packers should be able to ultimately absorb much of the expense of computerized selling without increasing meat prices to retailers, because computerized sales represent such a large saving of the buyer's (or his agent's) own time.

A significant advantage of the computerized over the conventional auction system is that considerably less fuel is utilized in the computerized system. Fuel savings come in two forms: (a) buyers or their agents need not travel to sale sites, and (b) cattle are not as likely as in the conventional system to be marketed several times, at different market sites, before delivery to packers. Thus, any increase in the real cost of fossil fuels would increase the relative cost advantage of the computerized over the conventional marketing system.

The comparison of conventional and computerized marketing arrangements in this report has centered on prospects for computerizing slaughter cattle sales. This emphasis is justified given the degree of market imperfection usually ascribed to markets for cull cows in the United States. But the small numbers of cows sold by individual farmers and the large number of quality categories necessary for describing live cows mean that lot sizes in which cows are sold will normally be small. This in turn implies that computerized selling costs per cow will be greater than would, for example, be the case for feeder pigs or lambs. Comparison of computerized and conventional marketing costs for these latter animal types would, both on a

total and cash cost basis, likely favor computerized sales much more than was the case for slaughter cattle. Furthermore, the marketing of pigs and lambs by computer in addition to cattle will, by increasing total lot volume, reduce per-head fixed costs of computer use below levels shown in this report.

APPENDICES

Appendix Table A. Itemized buying and selling costs, Virginia computerized livestock auction sales. 1980[a/]

Costs charged to buyers (dollars per week, all buyers)	
Terminal depreciation, maintenance, and invoice charge	$ 195.27
Obtaining descriptions of lots, connect time	110.20
Obtaining descriptions of lots, processor time	272.70
Terminal paper	44.25
Buyer's time	1,238.00
Costs charged to markets and the EEMA (dollars per week, all markets)	
Markets:	
Terminal depreciation, maintenance, and invoice charge	87.87
Entering lots, connect time	21.76
Entering lots, processor time	81.00
Terminal paper	1.82
Operator's time	12.22
EEMA:	
Terminal depreciation, maintenance, and invoice charge	27.09
Entering lots, connect time	7.54
Entering lots, processor time	27.00
Bidding, connect time	83.12
Bidding, processor time	61.29
Obtaining descriptions of lots, connect time	1.54
Obtaining descriptions of lots, processor time	4.86
Terminal paper	0.88
Manager and office expenses	437.50
Buyers:	
Bidding, connect time	771.87
Bidding, processor time	771.18
Other:	
Auction program storage	15.53
Lot description storage	28.35
GRAND TOTAL	$4,242.88

[a/] These costs were calculated for a volume of 2,000 head per week under the assumptions that five sales were held per week, twenty buyer terminals were connected for the length of each sale, lots were entered at nine auction market terminals as well as at the EEMA office, each lot was sold in an average of three minutes, and the average lot size was twenty head. All other parameters were assigned values shown in table 2.1.

Appendix Table B. Unit total costs of the conventional auction marketing system for Virginia slaughter cattle, assuming cattle are sold 1.5 times, sixteen- and forty-one-market scenarios, 1980.

Head per week	Unit total cost[a/]		Unit fixed cost of handling, weighing, grading, and selling[b/]		Buyer time and expenses
	Forty-one markets	Sixteen markets	Forty-one markets	Sixteen markets	
Numbers	- -		Dollars	- - - - - - - - - - - - - - - - - - - -	
200	39.69	39.81	1.62	1.74	14.43
600	31.41	31.50	1.61	1.70	6.16
1,000	29.74	29.81	1.59	1.66	4.51
1,400	29.02	29.07	1.58	1.63	3.80
1,800	28.62	28.65	1.57	1.60	3.40
2,200	28.35	28.38	1.55	1.58	3.15
2,600	28.17	28.18	1.54	1.56	2.98
3,000	28.03	28.04	1.53	1.54	2.85
3,400	27.92	27.92	1.52	1.52	2.76
3,800	27.83	27.93	1.51	1.51	2.68
4,200	27.76	27.76	1.50	1.50	2.62

a/ Includes handling weighing, grading, and selling unit variable cost ($2.18), farm-to-market unit transportation cost ($7.52), and market-to-plant unit transportation cost ($13.94).

b/ Selling costs, that is, the cost of the auctioneer and ringmen, amount to $0.19 per head.

Appendix Table C. Unit total costs of the computerized marketing system for Virginia slaughter cattle, sixteen-market scenario, 1980.

Head per week	Unit total cost[a/]	Buyer time and expenses	Computer selling costs	Unit fixed cost of handling, weighing, and grading
Number	- Dollars -			
200	$31.03	$4.45	$4.96	$0.98
600	25.64	1.84	2.19	0.97
1,000	24.55	1.32	1.64	0.96
1,400	24.08	1.09	1.40	0.94
1,800	23.81	0.97	1.27	0.93
2,200	23.63	0.89	1.18	0.92
2,600	23.51	0.83	1.13	0.90
3,000	23.34	0.79	1.02	0.89
3,400	23.27	0.76	0.99	0.88
3,800	23.21	0.73	0.97	0.87
4,200	23.16	0.71	0.95	0.86

[a/] Includes handling, weighing, and grading unit variable cost ($1.26), farm-to-market unit transportation cost ($5.43), and market-to-plant unit transportation cost ($13.94).

Appendix Table D. Unit total costs of the computerized marketing system for Virginia slaughter cattle, forty-one market scenario, 1980.

Head per week	Unit total cost[a/]	Buyer time and expenses	Computer selling costs	Unit fixed cost of handling, weighing, and grading
Number	- Dollars -			
200	$31.03	$4.45	$6.21	$1.00
600	24.83	1.84	2.61	1.00
1000	23.59	1.32	1.89	1.01
1400	23.07	1.09	1.58	1.02
1800	22.78	0.97	1.41	1.03
2200	22.60	0.89	1.30	1.03
2600	22.41	0.82	1.16	1.04
3000	22.32	0.79	1.11	1.05
3400	22.26	0.76	1.07	1.06
3800	22.21	0.73	1.03	1.07
4200	22.18	0.71	1.01	1.08

[a/] Includes handling, weighing, and grading unit variable cost ($1.26), farm-to-market unit transportation cost ($4.16), and market-to-plant unit transportation cost ($13.94).

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Coyt T. Wilson

Coyt T. Wilson, a native of Fulton, Mississippi, came to Virginia Tech in 1964 as associate director of the Virginia Agricultural Experiment Station. In 1965 he became the station's director, and in 1966 he was also named associate dean of the research division.

Before coming to Tech, Wilson was the assistant dean of the School of Agriculture and associate director of the Agricultural Experiment Station at Alabama Polytechnic Institute. He received both his undergraduate and master's degrees from Alabama Polytechnic Institute. Wilson received his doctoral degree in plant pathology from the University of Minnesota.

Wilson's list of accomplishments include being named in the *American Men of Science, Who's Who in America* and *Who's Who in American Education.* While in Alabama, he served on a gubernatorial committee on development and use of nuclear energy in Alabama. In 1965-66 he served as a representative to the USDA-State Agicultural Experiment Stations Joint Committee on Long-Range study of agricultural research. Wilson also served as USAID consultant on agricultural research administration to the Ministries of Agriculture in Iran, Turkey, and Bangladesh. He has also served as the division of agriculture's representative to the Senate of the National Association of State Universities and Land-Grant Colleges, and is a member of the executive committee of the division of agriculture for NASULGC.

Since his retirement in 1979, Wilson has lived in Blacksburg with his wife, Alma Inez Brackeen.