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by

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Introduction

Marketing of agricultural products has evolved from the days when commodities were traded at centralized terminal auction markets to a system where products move directly from producer to processor through the use of direct marketing contracts, formula prices, or in some cases vertical integration. Unlike the competitive auctions markets of the past, direct marketing tends to restrict information to those participants not directly involved.

While these direct transactions increase spatial efficiency, it can be argued that they tend to decrease pricing efficiency. Only those agents directly involved in a given transaction receive the information it generates. Moreover, the resulting reduction in volume traded in centralized markets increases the probability that they will become "thin", so that the information they generate may not accurately represent the market. Because certain types of information may not be available to all potential participants, competitiveness of the marketing system is likely to be reduced, and may result in inequity, misallocation of resources, or both. Hayenga summarizes this issue as follows:

> "The great concerns seem to be associated with markets which once were broadly traded, but which changed when vertically integrated systems or longer term contracts, especially reference or formula price contracts, became dominant. As the residual market decreased, insecurity increased regarding the representativeness of transacted and reported prices, the potential ease of price manipulation, the adequacy of market information, and the risk of having sufficient buyers or sellers available at any time to insure an equitable price" [p. 1].

Electronic markets have been promoted as a way to recover the pricing efficiency of centralized markets while retaining the spatial efficiency of direct transactions. Traders at remote locations are brought together via an electronic medium (e.g. telephones, teletypes or computers) and interact through a central clearing mechanism. Electronic markets

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thereby recentralize the price discovery process, increasing the number of potential market participants while continuing to decentralize product transfer; both are important factors in decreasing transactions costs [Purcell]. In addition, the evolution of computerized trading systems offers the potential for efficiency superior to that of other electronic marketing systems because of their greater ability to convey vast amounts of information about the commodity being traded [Hamm, Purcell, and Hudson].

The use of computerized trading systems, however, raises a number of questions with regard to the types of information provided to system users and the implications for the price discovery process. The purpose of the paper is to present the results of an initial experimental investigation of the impacts of information on prices in a computerized auction. By comparing the results of live experimental auctions with those of the computerized auction and varying the levels of information provided in each setting, measures of the relative efficiency of the two systems are generated. The results provide insight into the impacts of information on competitive bidding processes and suggests directions for further research.

The history of electronic trading systems for agricultural commodities is briefly summarized in the next section. Section three details the problem and objectives of the research. Experimental procedures are summarized in the fourth section of the paper. Section five presents a brief discussion of the measures used to examine the efficiency of the experimental markets. The results are presented and discussed in section six. The paper concludes with a discussion of the implications of the results and suggestions for further research.

Background

Electronic marketing of agricultural products was first introduced in the 1940's for Florida citrus. Despite the initial success of the "Selevision" system, the concept did not gain much attention until the 1960's when a teletype auction for slaughter hogs was started in Canada. Interest in electronic trading continued to grow during the 1960's with the development of various types of systems (e.g., tele-auctions, video auctions, etc.) for livestock. In 1968, the first computerized trading system for an agricultural commodity was proposed by Schrader, Heifner, and Lazelere for eggs.

In the mid-1970's continued interest in electronic marketing led to the funding of a number of pilot projects by the USDA Agricultural Marketing Service. These developmental efforts included a number of livestock trading systems: CATTLEX (an exchange for feeder and stocker cattle), HAMS (a computerized trading system for hogs), and NEMA (a computerized trading system for slaughter lambs). The AMS project also provided for the testing of the CATS system for meat products at the wholesale level. Concurrent with the pilot tests of these markets, the use of electronic markets for cotton (TELCOT) and eggs (ECI) continued to generate interest.

As a result of the AMS project on electronic marketing, a number of research studies have been conducted examining the pricing efficiency of electronic systems (see, for example, Forster and Roberts; Russell and Purcell; and Hamm, Purcell, and Hudson). In addition, continued interest in new forms of trading has led to recent efforts in the area of fresh produce (the CAMP system) and grains (the GEM system).

Despite the widespread and continuing interest in electronic marketing of agricultural products, a number of problems have emerged limiting the adoption of the tool. In fact, of the systems developed under the original AMS project, only the NEMA system has been adopted by the private sector.[1] Nonetheless, the obstacles related to high cost of computer equipment, communication linkage problems, and private sector interest appear to be diminishing. It is, therefore, expected that the demand for electronic trading systems will continue to expand in the years to come.

In light of this continuing interest, several researchable issues related to the design and performance of such systems emerge. In particular, the emergence of the microcomputer and its ability to efficiently handle vast amounts of information raises a number of interesting questions related to the use of computerized trading system, including: What types of information are most important to the price discovery process? Does the order of presentation of the information on the computer screen affect the outcomes of the bidding process? Can pricing efficiency be improved through control of information among traders using the trading system?

Although initial assessments of the performance of electronic trading systems have been completed with data from actual auctions, the answers to the above questions require a more controlled environment. The use of experimental methods can provide this type of control. By accounting for the issues noted above in the design of trading experiments, measures of the efficiency of various trading systems under controlled conditions can be generated. This information will then provide a basis for the design and development of new electronic trading systems for use in agricultural markets.

Objectives

As noted above, computerized trading systems have a tremendous capacity for disseminating market information. Summarizing and presenting that information to market participants in a usable form is a critical design issue for computerized trading systems. Consider, for example, an electronic market for livestock. One drawback of a computerized trading system is the inability of potential buyers to visually inspect the product. Traders must, therefore, rely on summary descriptions based on a careful evaluation according to grading standards.

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1 It should be noted that development of the HAMS project provided in part the impetus for the development of a private sector system which continues to operate in the Midwest.

If trading is to occur, with remote traders operating through a central electronic exchange, accurate descriptions of the commodity are essential. It is here that an important and researchable question emerges: What is the minimum amount of information required by the participants in order for the market to efficiently reach equilibrium?

To examine this issue, an experimental framework is set up using procedures summarized by Plott [1982]. The economic experiments allow a researcher to control for many of the factors that cannot be controlled in field sample data, thus allowing a more precise assessment of the issue being investigated.

The general objective of the investigation described here is to examine and test the effect of additional information on market efficiency. By controlling the access of market participants to information about the commodity being traded, the benefits of information can be assessed. It should be noted that traders may prefer to have certain kinds of information for reasons other than those which affect market efficiency and that the investigation will not address this issue.

The secondary objective of the research effort is to examine the usefulness of recently developed microcomputer-based network for simulated trading. The network system, developed under a grant from the IBM Corporation, is described in detail in Hudson et. al.[2] The system allows the researcher to control the information flows to participants in the simulated auction and is designed to mirror traditional livestock auctions.

Most centralized livestock markets use a multiple-bid single-sided auction mechanism, wherein a live auctioneer calls out prices, usually in ascending order, and sells to the person accepting the highest price called. Much of the experimental research on homogeneous commodities has discovered substantial inefficiencies associated with the single-sided mechanism [e.g. Plott, 1982, and Frahm and Schrader, 1970]. Following the finding by Forster and Roberts that an electronic double-sided auction system was more efficient than an oral double-sided auction, the efficiency of the single-sided trading system was examined and compared to a live trading mechanism.[3]

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2 The network system was developed through IBM's support of Project EXCEL. Additional support comes from the College of Agriculture and Department of Agricultural Economics at the University of Illinois at Urbana-Champaign. The network consists of 2 IBM PC/AT's as servers with 1 Meg RAM and 30 Meg fixed disk drives. These are connected through the IBM PC Network Adapters and Cabling to 16 IBM PC/XT's with 512K and dual 360K 5 1/4" disk drives. All of the computers are equipped with IBM's Enhanced Graphic Adapters (EGA) driving Enhanced Color Displays (EDC). The network operates under IBM PC DOS 3.2 and Version 1.12 of the PC Network Program. The network trading simulation was developed using Microsoft's C language compiler (Ver. 3.0) along with Windows for Data (Vermont Creative Software Ver. 1.0), Lattice dBCIII ISAM, and dBase III+ from Ashton-Tate. It was written by Paul Magelli (MS 1986) at the University of Illinois.

3 A double-sided auction is one where both buyers and sellers make and accept offers; an example is the trading of future contracts on a commodity exchange floor.

Experimental Procedures

Using the interactive microcomputer network for the electronic auction, and a professional auctioneer for the live auction, experiments were conducted in a single-sided English (ascending bid) auction format on theoretical lots of heterogeneous slaughter cattle. The rules for each system were as similar as possible.

A non-equivalent control group quasi-experimental design was used to control for selection, maturation, history, instrumentation, test sensitivity, and mortality. The interaction of these variables was not controlled. The design assures internal validity so that group results are consistent [Campbell and Stanley]. Table 1 depicts the experimental design. The words live and electronic refer to the trading mechanism used in the simulation. The treatment in this experiment is providing market information to the participants prior to bidding.

To facilitate the analysis, a number of assumptions must be made regarding the commodity being traded and the participants in the experiments. This study relaxes two of the most common assumptions used in such efforts: (1) that participants have no prior attitude toward the commodity which they are trading, and (2) that the commodity traded is homogeneous.

The assumption of no prior attitudes is a bit unrealistic for markets where actual products are traded which differ by breed, grade, and other factors. In addition, any biases related to prior attitude can only be explored by measuring these attitudes and then observing their impacts on the trading process. Further, while it is likely that the participants in the experiment conducted here possessed prior attitudes toward the commodity traded, such attitudes would be expected to affect the live and electronic trading equally.

The assumption that the commodity traded is homogeneous is too limiting for the study of agricultural markets. Limited evidence exists regarding trading outcomes with heterogeneous commodities such as livestock [Frahm and Schrader]. Participants in our experiments were told that they would be bidding on two types of sale lots, one type containing Angus cattle and one containing mixed-breed cattle, but that the cattle were homogeneous with respect to all other characteristics. They were also told that each lot of Angus cattle was worth four dollars per hundredweight more upon resale than the mixed-breed lots, and that the two types of lots were distributed randomly throughout each trading schedule.

To examine for prior attitudes, the participants completed an elicitation survey designed to assess their beliefs about slaughter cattle prior to the trading sessions. Each participant was asked to rank the interval according to his or her belief about the average price of slaughter cattle in 1986. The average price of slaughter cattle in 1986 was chosen in order to assess the degree of participants' familiarity with the cattle markets. Figure 1 aggregates the rankings for each interval. The $60 to $65 interval was considered most likely by the participants, with deviations following an approximately normal pattern.

An alternative method of eliciting prior price expectations, involved the use of the standard logarithmic scoring rule [see Appendix A]. Each participant was asked to distribute 20 stars among the intervals, based on his or her belief about the most likely interval for the average price of slaughter cattle during 1986. Summing the stars in each interval over all participants created the frequency distribution shown in Figure 2. Again, the $60 to $65 interval was ranked most likely.

These results suggest that the participants had a strong belief about the price of slaughter cattle. Indeed, the true average price for 1986 was in the $60 to $65 interval. If transaction prices in the experiment are traded at or near this price range, one may suspect that prior attitudes affected the results. No such tendency was detected in the experiments.

In the pre-treatment phase of the experimental design, participants were not told which kind of lot they were bidding on until the lot had been sold. In the post-treatment phase, the information was provided before bidding on each lot. Standard experimental procedures as outlined by Plott were followed for the experiments. Excess demand equaled zero in all trading schedules. No monetary rewards were provided to the traders, who were undergraduate students in a senior level agribusiness management course; credit for quiz grades in the class was provided as an incentive to trade.[4] Competition was encouraged by announcing each trader's profit or loss following the completion of each trading schedule. Since this was the first time any of them had taken part in such an experiment, the students enjoyed the competition, and, we believe, acted as though real money was involved.

Table 2 shows a typical demand schedule given to the student participants. The demand schedules (negatively sloped) were set up as if they were to be used in an experimental double auction, with equilibrium at the intersection of the demand curve and the highest horizontal supply curve (See Figure 3). Buyers in each trading session traded two schedules, plus a practice schedule the first time they traded. Although each schedule defined a different equilibrium price and quantity, the fixed costs listed at the bottom were the same for each schedule. This is analogous to the fixed costs a cattle buyer may incur in attending an auction and transporting potential purchases back to the processing facility. Each buyer calculated his or her profit by summing the profits from each purchase and subtracting the fixed costs to get the net profit.

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[4] Most economics experiments use monetary rewards to participants to induce demand. Smith [1976], however, identified several conditions under which grade points may be used as an inducement. We believe these were met in this experiment.

Table 2. Representative Demand Schedule

Name ____________
Date ____________

Units Bought	Resale Value	Purchase Price	Profit
1	$130.00	______	______
2	$129.00	______	______
3	$126.00	______	______
4	$121.00	______	______
5	$113.00	______	______
6	$103.00	______	______
7	$91.00	______	______
8	$77.00	______	______
9	$58.00	______	______
10	$39.00	______	______
11	$35.00	______	______
12	$33.00	______	______
13	$31.00	______	______
14	$29.00	______	______
15	$27.00	______	______

Gross Profit ______

Fixed Cost $369.00
Net Profit ______

To more realistically model a real livestock auction, opening prices for each lot were set at random intervals between 15 and 25 percent below the equilibrium. In effect, this lower bound (the lowest horizontal line in Figure 3) becomes the reservation price for a given lot, corresponding to a reservation price a cattle producer might set, below which he will not allow the cattle to be sold. A producer usually sets this reservation price below the expected price since, if the animals are not sold, additional selling, transportation, and feed costs are incurred. As Smith observed in a similar experiment (where excess demand equaled zero), the sellers' minimum price is the (new) equilibrium price, and by purchasing cattle at that price, buyers capture all available economic rent. The shift downward in the supply curve in this experiment was not sufficient to increase equilibrium quantity because of the discrete nature of the lots of cattle; for the example shown in Figure 3, equilibrium quantity is nine units.

Similarly, the shift upward in the demand curve for Angus cattle induced by the premium was not sufficient to change the equilibrium quantity; equilibrium price was effectively increased by the amount of the premium. Buyers could afford to pay more for an Angus lot because the quantity they were able to purchase did not change. One of the rules of the auction stated that if more than one lot in a schedule failed to sell for lack of a bid at least as high as the opening price, trading for that schedule was stopped and buyers lost any further chance for profit on that schedule.

Measuring Market Efficiency

Market efficiency is measured using a market efficiency index (MEI) developed by Rhodus in response to problems encountered with other commonly used measures, namely insensitivity to price variability and inability to measure the speed at which equilibrium prices are achieved. The index is comprised of two factors; a weighted price deviation index (WPD) and a quantity deviation index (QDI), each of which ranges between 0 and 1. The WPD is a weighted sum of absolute deviations of transaction prices from equilibrium, with proportionally more weight given to those transactions occurring late into the trading schedule.[5]
The WPD and QDI are calculated as:

$$WPD = \Sigma (1 - (|p_i - p^e| / p^e) \times i) / \Sigma i, \text{ and}$$

$$QDI = 1 - |n - q^e| / q^e,$$

where,

i = transaction number (1, 2, 3, ...),
p_i = transaction price,
p^e = equilibrium price,
n = number of lots sold and,
q^e = equilibrium quantity.

The QDI is simply the quantity traded divided by the equilibrium quantity when actual quantities are below or equal to the equilibrium quantities. Multiplying the price and quantity indices together gives the market efficiency index. The value of this index is higher if transaction prices are closer to the competitive equilibrium price, if observed price instability occurs relatively early in a trading schedule, and if quantities actually traded are near competitive equilibrium quantities.

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5 Since equilibrium quantity was traded in all sessions, QDI = 1 and WPD = MEI. Since average opening price was below the expected double-auction price, the participants maximized their profits by purchasing all of the cattle they could at the opening price (equivalent with reservation price in this experiment).

Experimental Results

Pre- and post-treatment WPD efficiency measures for the two groups of participants are presented in Table 3 and plotted in Figure 4. The values presented in the table are presented in the order of occurrence in the experiment. The first two values for group 1 are observations from a live auction simulation, the next two are from an electronic simulation, and so on. The opposite is true for group 2; the first two are for an electronic simulation. It is apparent that increased efficiency was associated with increased market information. To test the statistical significance of the difference between pre- and post-treatment observations and to verify that the difference does not result from learning by the participants, multiple regression analysis is used.

Table 3. Market Efficiency Index for All Trading Sessions

	Group 1	Group 2	
Live	.9201	.9612	Electronic
	.9301	.8764	
Electronic	.9243	.8969	Live
	.9406	.9057	
Treatment			
Live	.9744	.9866	Electronic
	.9548	.9489	
Electronic	.9841	.9563	Live
	.9702	.9760	

Table 4 shows the results of regressing the WPD measures on the following independent variables:

(GROUP2) - 1 if Group 2 was trading, 0 if Group 1

(LOG_TIME) - represents learning between trading sessions -- this variable is the natural logarithm of the number which represents the order in which each schedule was traded by a group. The logarithmic specification allows for learning at a decreasing rate.

(LIVE) - 1 if live auction, 0 if electronic

(INFO) - 1 if post-treatment, 0 if pre-treatment

All but LOG_TIME are qualitative variables. 16 observations are included in the analysis.

Table 4. Regression Analysis of Factors Affecting Market Efficiency Measure in Experimental Auctions

$$Y = \beta_0 + \beta_1(\text{GROUP2}) + \beta_2(\text{LOG\_TIME}) + \beta_4(\text{LIVE}) + \beta_5(\text{INFO})$$

Independent Variable	Estimated Coefficient	Standard Error	P-Value
GROUP2	-0.0111	0.0104	0.310
LOG_TIME	-0.0137	0.0134	0.330
LIVE	-0.0100	0.0104	0.360
INFO	0.0638	0.0176	0.004
INTERCEPT	0.9411		

R^2= 0.70 Adj. R^2= 0.59 F= 6.4

The significant positive coefficient for INFO, which represents the effect of added information, indicates that the difference between pre- and post-treatment efficiency shown in the graph was indeed statistically significant. Although there appears to be a slight learning effect (uptrend) in the pre-treatment phase on the graph, the insignificant coefficient on LOG_TIME indicates that there was no significant learning effect between schedules (the WPD measure accounts for learning within a trading schedule). This supports the results obtained by Forster and Roberts for a double-sided auction mechanism using an identical measure of market efficiency.

There was no significant difference between the groups of participants, as shown by the insignificant coefficient of GROUP2. Finally, the insignificant coefficient on LIVE indicates that the electronic system was just as efficient as the live system. Somewhat contrasting results were reported by Forster and Roberts, who found the electronic system statistically more efficient than the live system in a double-sided mechanism. They attributed the increased efficiency of the electronic system to reduced personality interactions between passive and dominant traders. Apparently, the personality interactions in a single-sided mechanism are not as important as in a double-sided mechanism.

Consistent, however, with previous experimental examinations of the single-sided mechanism [Plott, 1982; Frahm and Schrader; Smith, 1965], prices converge to equilibrium from above in each trading session (a representative price track is shown in Figure 5). Smith [1986] explained that prices tend to converge from above when surplus available to the buyer is greater than that available to the seller. This price track is an example of a group's first trading session. The wide fluctuations in price occurred only in the first trading session. After the initial period of uncertainty the curves become much flatter and the buyers become more adept at capturing all of the surplus available to them. The buyer's surplus is defined as the area below the demand curve and above the equilibrium price. The seller's surplus is the area above the supply curve and below equilibrium price. Further support for this experimental evidence comes from Buccola's 1982 empirical examinations of single-sided cattle auctions which found a slight downtrend in prices throughout the auctions.

Implications and Suggestion for Further Research

The results of this initial experimental investigation of the impacts of information on competitive bidding processes in a computerized auction have several implications. First, the finding that the computerized trading system is no less efficient than the live auction suggests that such systems will be useful for further research. Second, the result that information improves market efficiency, although not surprising, suggests the potential of and need for continued experimental research related to the types of information presented and the order of its presentation in computerized trading systems. Development of hedonic pricing models may indicate the appropriate values to impute to various pieces of information about such commodities for future experiments. The amount of information provided to market participants about other participants on the system may also affect market efficiency, and should also be considered [Colling and Sporleder].

The microcomputer network allows each trader to have different information from the other traders; an extension of the investigations suggested above is to test the effect on market efficiency when traders possess asymmetrical market information about the commodity, other traders, or both. The theoretical literature has dealt with this issue [e.g., Engelbrecht-Wiggans, Milgrom and Weber; Milgrom; Schwartz and Wilde; and Hughart], although we are not aware of any experimental work in this area, particularly for heterogeneous commodities.

Finally, as the theory and techniques of experimental economics are applied to issues in electronic markets for agricultural commodities, further attention should be given to assessment of traders' prior beliefs and attitudes in order to ensure reliability and replicability of experimental results. Experimental economics promises to be a valuable tool in examining some of the issues surrounding electronic marketing, but sound justification must be provided as traditional assumptions are relaxed.

Table 1. Non-equivalent Control Group Quasi-experimental Design

Group 1	Live	Electronic	Treatment	Live	Electronic
Group 2	Electronic	Live		Electronic	Live

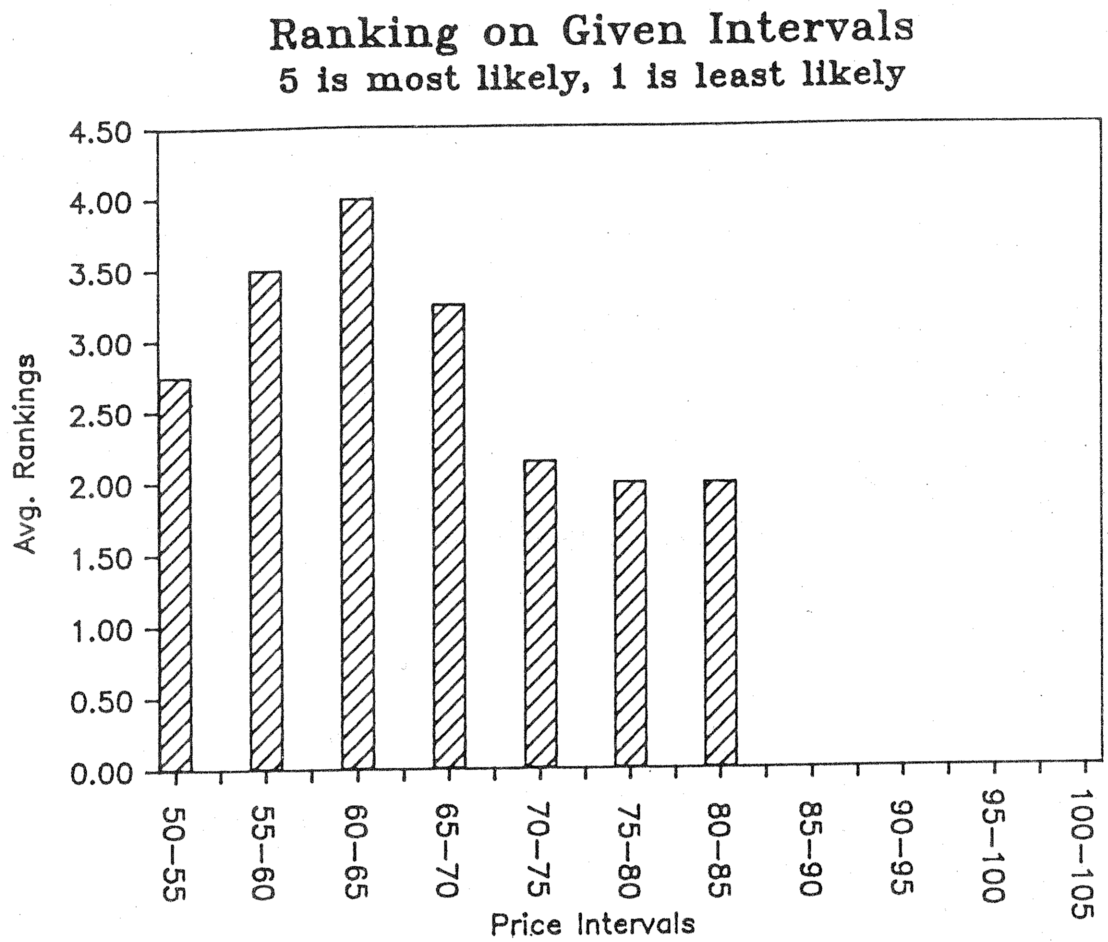

Figure 1. Distribution of Prior Attitudes Toward Cattle Prices

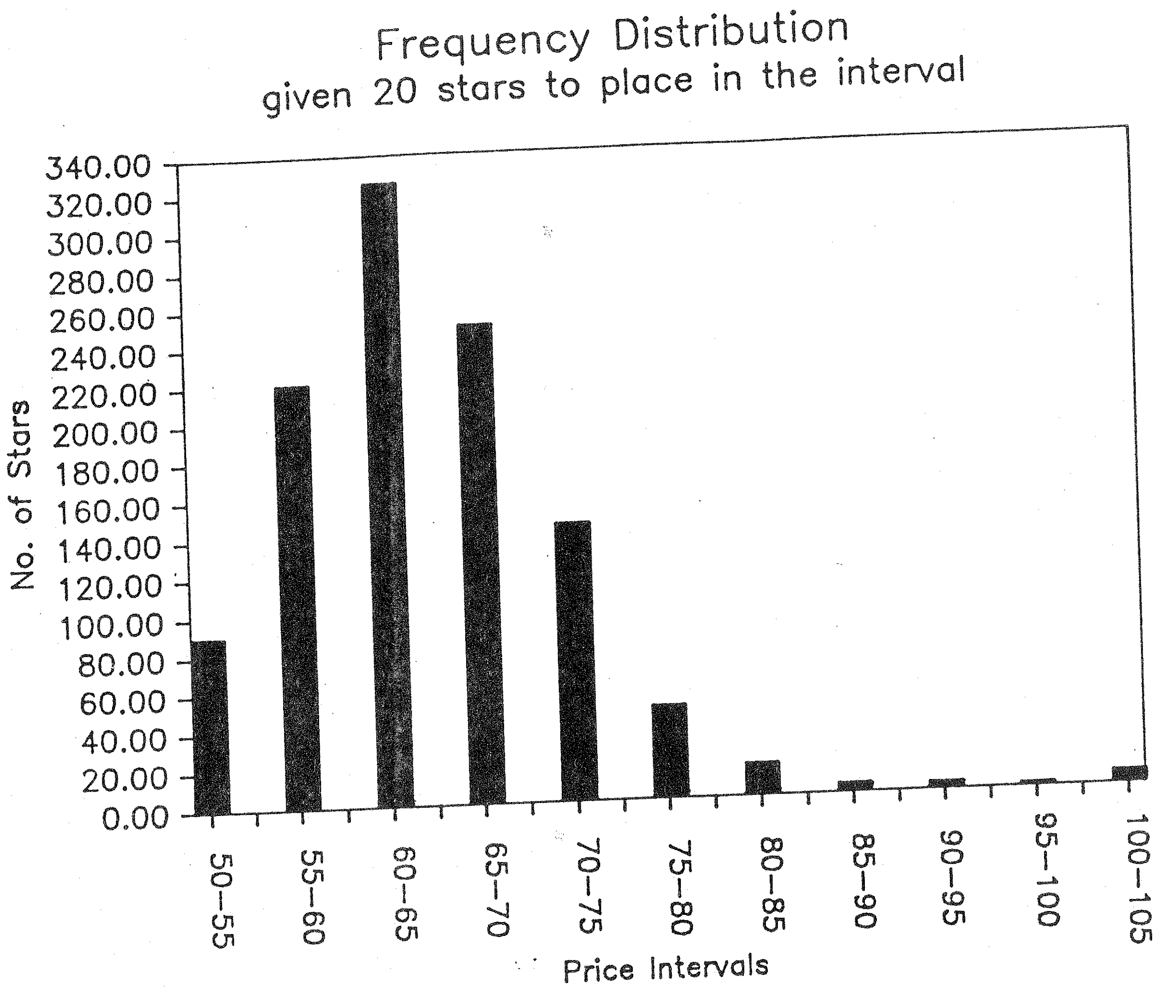

Figure 2. Distribution of Prior Attitudes Toward Cattle Prices Using Logarithmic Scoring Rule

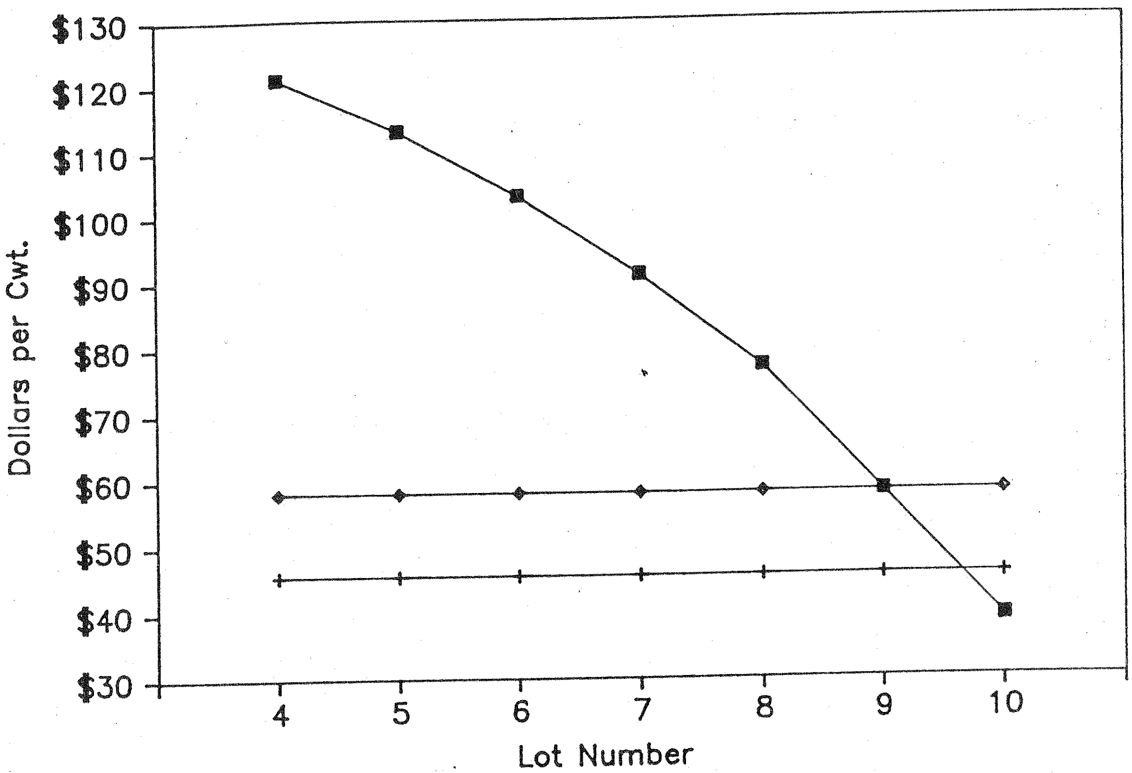

Figure 3. Sample Demand and Supply Relationships

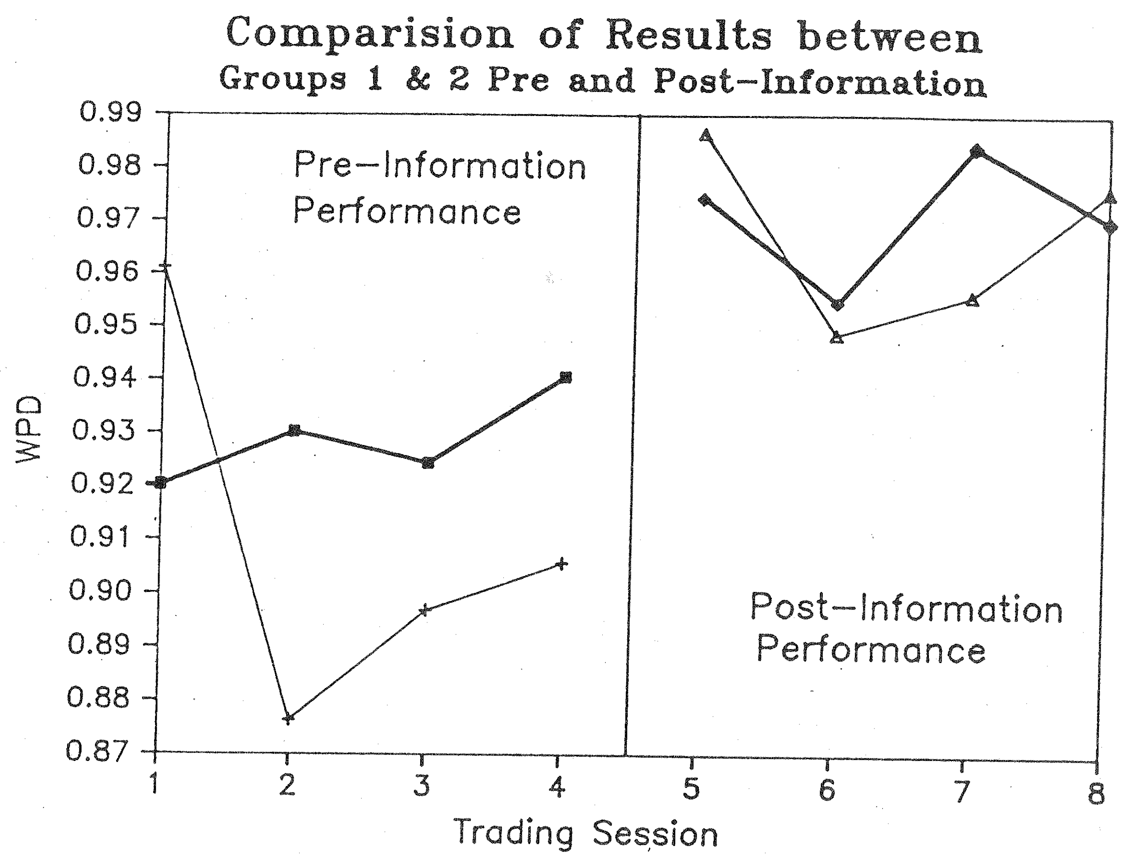

Figure 4. Market Efficiency Measures for Each Group During All Trading Sessions

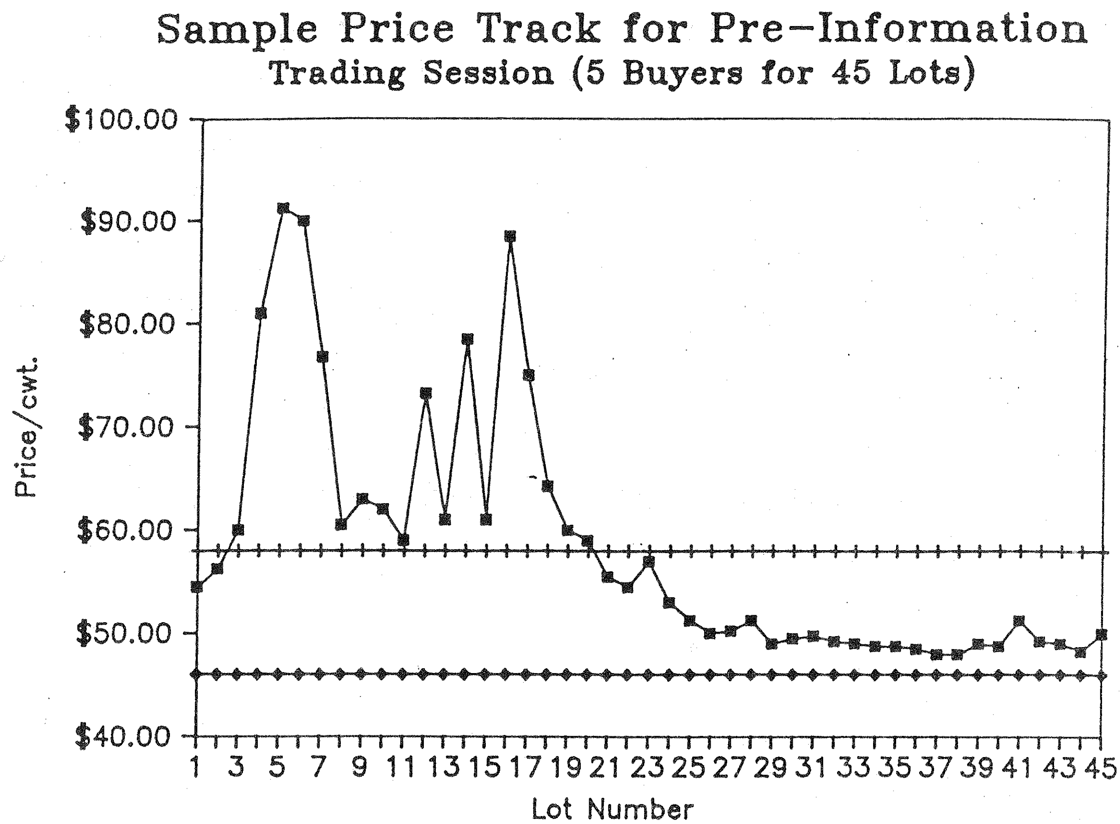

Figure 5. Results: A Representative Price Track for a First Trading Session

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