RESEARCH BULLETIN 1168 JANUARY 1985

Pricing Performance of an Electronic Slaughter Hog Market

W. TIMOTHY RHODUS
DENNIS R. HENDERSON
E. DEAN BALDWIN
C. S. THRAEN

The Ohio State University
Ohio Agricultural Research and Development Center
Wooster, Ohio

CONTENTS

** * **

AGDEX 440/842-848 1-85-2M

Pricing Performance of an Electronic Slaughter Hog Market

W. TIMOTHY RHODUS, DENNIS R. HENDERSON, E. DEAN BALDWIN, and C. S. THRAEN[1]

BACKGROUND, SITUATION, AND EXPECTATIONS

Introduction

The structure of the hog industry in the United States has experienced a great deal of change over the years, which has brought about significant changes in the marketing system for hogs. The purpose of this study is to identify these structural changes, determine their impact on market performance, and evaluate an alternative marketing system (the electronic market) regarding its potential to alter market behavior and improve performance. The objective is to report the impact of an experiment in the electronic marketing of slaughter hogs in Ohio (HAMS: Hog Accelerated Marketing System) on:

- Price levels paid to producers
- Pricing efficiency relative to other hog markets
- The behavior of daily prices and individual transaction prices.

Structural Change

At one time most hogs were either slaughtered on the farm or sold directly to butchers in town. With the introduction of railroads, hog production shifted with the farming population from the East to the Midwest and hogs were shipped by rail to the Eastern slaughtering establishments, which were located in the major population centers. Over time, cities such as Chicago and Omaha became centers of rail transportation and thus concentration points for livestock shipments, giving rise to the terminal livestock markets.

With the development of refrigerated railcars, fresh meat could be shipped long distances without loss of quality. This led packers to relocate slaughtering plants closer to the livestock marketing centers. By the mid-1920's, terminal markets at Kansas City, St. Louis, Omaha, Sioux City, and Chicago accounted for 75% of the volume of slaughter hogs (4).

Several developments during the 1930's and 1940's led farmers away from using terminal markets. These included the introduction of truck refrigeration and improvements in highways. As a result, producers turned to trucks rather than railroads to transport livestock to market. Thus, other marketing channels such as local auction markets and country buying stations became more important. Encouraged by economies in shipping meat rather than livestock, meat packers further decentralized their slaughtering plants, moving closer to producers and away from the central terminal market cities. As a result, direct sales between farmers and packers became increasingly feasible. Improved communications, such as the radio and telephone, and an expanded market information service also aided in the growth of alternative marketing channels (4).

There were additional reasons for the decline in the use of terminal markets. Both direct and auction selling permit producers to observe and participate in the selling process with the opportunity to decide on a "no sale" option. Consignment to distant terminal markets, on the other hand, represents a largely irreversible commitment to sell. In addition, producers who bypass public stockyard facilities, including auctions, can forego any selling commissions which may be assessed to them.

Consequently, the percentage of hogs moving through terminal markets decreased to less than 50% by 1940. By 1978, only 14.4% moved through terminals from hog operations with annual production of between 2,500 and 5,000 head, and 5.2% from hog operations which annually produced more than 5,000 head (13).

Structural change in the hog industry has also been occurring in the number and size of firms producing and processing hogs, which further facilitates the trend toward direct marketing. The number of medium (2,500-5,000 head) and large (>5,000 head) operations, average size, and percentage of U. S. marketings for the period of 1975-1978 are presented in Table 1.

As can be seen, both medium and large operations are increasing the number of hogs produced per operation, while at the same time increasing their share of the hog market from 17.4% in 1975 to 24.6% in 1978. In contrast, the number of firms slaughtering hogs decreased 41.3% between 1969 and 1978, while the total commercial slaughter decreased by 7.8% (Table 2). This leaves the remaining firms processing a larger number of hogs per year.

In conclusion, the structure of the hog industry today is such that the volume of both producers and processors is growing while their numbers are decreasing. Fewer and larger participants on both sides of the slaughter hog market enhance the opportunities for direct selling. Combined with other factors, this has caused direct sales to replace orga-

[1]Graduate Research Associate, Professor, Associate Professor, and Assistant Professor, respectively, Dept. of Agricultural Economics and Rural Sociology.

TABLE 1.—Number, Size, and Market Share of Medium and Large Hog Producers, U. S., 1975 and 1978.

Year	Number of Producers		Average Number of Hogs per Operation		Percent of U. S. Market	
	Medium	Large	Medium	Large	Medium	Large
1975	1,957	1,168	2,418	7,053	5.5%	11.9%
1978	1,661	1,340	3,196	10,192	6.9%	17.7%

Source: Rhodes, Stemme, and Grimes (13).

TABLE 2.—Number of Firms Slaughtering Hogs, U. S., 1969 and 1978.

	1969	1978	1978 as Percent of 1969
Number of Firms	709	416	58.7%
Total Commercial Slaughter (1,000)	83,838	77,315	92.2%
Average Slaughter per Firm (1,000)	118.2	185.9	157.3%

Source: U. S. Dept. of Agriculture (15).

nized sales at public terminal and auction markets as the dominant means of marketing.

Performance Implications

The decline in the use of organized markets has had several impacts on market performance.[2] One consequence is reduced competition among buyers. For individual producers, direct trading tends toward being oligopsonistic. As such, the producer is often in a position of "take it or leave it" regarding price and other terms of trade. In order to evaluate prices offered in direct trades, producers often look to price information from public markets as a value barometer. However, observations by the authors suggest that higher quality hogs tend to find a ready market among direct buyers, often leaving less desirable livestock to be traded at the public market. Also, the relatively low volume of sales and small number of participants indicate a lack of liquidity within the market. Thus, not only are prices in the organized market being determined by a small number of buyers or sellers based on a small volume, there are also few buyers waiting to enter the market on any given amount of change in price, making the market less sensitive to marginal changes in supply and/or demand conditions.

The combination of reduced competition, nonrepresentative quality, and lack of liquidity within the public markets creates a situation which allows prices to deviate from their competitive equilibrium levels. As such, what remains of the organized market has been termed a "thin" market. Where thin markets exist, both pricing and price reporting problems appear. For example, prices determined in these markets tend to be lower than those of a more competitive market because: 1) a lower quality of hog is sold, and 2) competition is reduced as the few buyers who do participate in the organized market typically acquire most of their supply elsewhere. Consequently, they stay in the market only as long as prices are attractively low. With small volumes of sales, it also becomes possible for a large volume buyer to unduly influence the price by abruptly entering or departing from the bidding. Additional concern arises when settlement prices in direct sales are "pegged" to a prevailing publicly reported "market price" (formula pricing), as the large buyer may be tempted to artificially inflate or deflate reported prices or price bids in reported public market sales, depending upon which benefits his privately negotiated deals. Consequently, there is some suspicion about the credibility of that reported price (5).

Thin markets may result in inaccurate price signals to producers, causing a misallocation of resources (inefficiencies). These inefficiencies result from the fact that formula pricing[3] potentially removes individual transactions from the organized competitive market which most accurately matches market supply and demand. Further inefficiencies may result because reported prices are often averages which do not reflect the quality differences of products.

In direct trading, the producer is often at a disadvantage relative to the buyer in obtaining up-to-date market information, such as total receipts and prices paid to other producers. This may occur for two reasons. First, buyers are normally engaged in daily acquisitions of large numbers of hogs while producers are in the market much less frequently and thus have less first-hand knowledge of market conditions. This provides a setting where the outcome of a transaction, which depends upon the relative bar-

[2]Market performance as used in this study is limited to price levels, pricing efficiency, and price behavior.

[3]Formula pricing is defined as a method of determining the price for a transaction through the use of some agreed upon formula, relative to a reference price.

gaining strength of the buyer and seller, favors the buyer. Second, because terms of sales are private and individual transactions are widely dispersed geographically, there are many problems associated with collecting accurate market information on direct sales. As a result, the seller often has less complete and accurate information at his disposal than the buyer.

Access to direct buyers is also of concern, particularly for smaller and geographically isolated producers. Due to high search, assembly, and transportation costs, buyers cannot efficiently purchase directly from smaller and/or geographically dispersed sellers. Thus, as organized markets decline in importance and attract fewer buyers, selling opportunities for the smaller and more dispersed traders become limited.

This limited market access has resulted in certain marketing inefficiencies. Brokers, agents, and other middlemen often assemble large numbers of animals from smaller and geographically dispersed sellers. However, this frequently results in excessive transportation and handling, cross hauling, on and off loading, and other activities which add stress to the livestock and costs to the marketing function (2).

Although marketing imperfections exist, direct marketing systems do provide many benefits to both buyers and sellers. These benefits include improved producer-packer coordination and a more orderly flow of product from seller to buyer. Frequently, standing agreements exist between producers and packers which normalize the marketing of hogs for the seller and the supply of hogs for the packer. Both parties improve their ability to make future production decisions since uncertainties regarding future supply and demand are reduced. Direct marketing also reduces handling costs because hogs are shipped directly from the farm to the packer without unnecessary delays and handling which occur in public markets. Also, it enables the producer of high quality hogs to establish a reputation with a buyer over time and this is translated into premium prices for that producer; this relationship is more difficult to develop in public markets.

The challenge to the slaughter hog marketing industry is to find ways to reduce the potential for pricing problems and allocation inefficiencies associated with a system dominated by direct trading, while maintaining the benefits of improved coordination and physical efficiency which result from such trading practices.

Electronic Marketing as an Alternative

Electronic marketing is a system of organized and centralized trading, remote access by buyers and sellers at locations distant from each other, with merchandising based upon product description rather than personal inspection. Translated, this means that buyers and sellers who are not at a common location interact with each other through the use of an electronic device (telephone, teletype, or computer terminal) for the purpose of buying and selling products, which conform to mutually agreed upon standards, in an organized manner. Conceptually, these markets offer the potential of combining the coordination and physical efficiency of direct marketing with the competition and pricing efficiency of organized, central markets. This is feasible since the product need not leave the farm before the trade is completed and all buyers are given the opportunity to bid on every trade. Sellers also benefit from a potential increase in accurate market information on prices paid for many grades or qualities of slaughter animals.

Performance Expectations

Relative to the direct market, producers who consign their hogs to an electronic market have the potential of facing a more competitive market with a greater number of traders In the direct market a transaction occurs between one seller and one buyer, while in the electronic market transactions can occur among all sellers and all buyers. To the extent that the lack of active competition among buyers in direct marketing may result in a less than competitive price to sellers, the increase in the number of competing buyers in an electronic market should lead to an increase in the average price level received by producers.

Empirical evidence on electronic selling in other markets supports this position. Results of research by Lu on prices of hogs in Ontario and Manitoba (11); Holder on prices for lambs in Virginia, West Virginia, and North Carolina (8); Ward on prices for lambs in Oklahoma (17); and Helmreich, Epperson, and Huang on prices of feeder cattle in Georgia (6) all provide evidence of increased price levels in electronic markets.

Because price negotiations within the electronic market occur in an organized, visible, and competitive arena, the ability of a dominant trader to unduly influence price is diminished. Also, to the extent that an electronic market captures a broader cross-section of total sales, it provides a more complete window to market price-quality relationships. As a result, it is reasonable to expect prices which are established within such a market to be more accurate reflections of true supply and demand conditions. This means that prices should be more efficient in their function of allocating resources and products among alternative uses (2).

An argument has been put forth by Henderson, *et al.* (7) that there is a relationship between price behavior and pricing efficiency. They suggest that within an efficient market, prices will most accurately adjust to ongoing changes in market conditions through frequent changes of small increments. These frequent but small price changes will, in time, facilitate more rapid and less discrete adjustments in allocation of resources to production. As a result, it is argued that increased pricing efficiency should lead to lower long-term price variability.

An extension of the Henderson, *et al.* rationale is that the level of pricing efficiency exhibited by different markets can be compared by measuring the relative impacts of previous price and changes in supply/demand conditions on current transaction price. Prices in a dynamic but price-inefficient market are expected to show a pattern of change which is relatively insensitive to minor changes in supply/demand conditions between successive trades and adjust by a greater amount to accumulated supply/demand changes over several transactions. In quantitative terms, the partial correlation coefficient between the previous transaction price and the current transaction price would be expected to be higher, and the partial correlation coefficients between shifts in supply/demand conditions and the current transaction price would be expected to be lower in the inefficient market, relative to the price efficient market.

Prices within a competitive electronic market are determined by the interaction of supply and demand. As the components of these functions fluctuate, prices within the market are expected to respond. An important characteristic of electronic markets is the high visibility of each transaction. Since the market is competitive in nature, buyers' preferences are conveyed through the higher or lower prices being bid for different lots. This differential pricing enables potential buyers and sellers, who have a clear view of the product characteristics and trading results, to adjust bids and offers to reflect premiums or discounts which they associate with those characteristics and changes perceived in market (supply/demand) conditions.

Additionally, a viable electronic market can handle a large number of transactions, all of which are tracked and recorded in the memory of a market computer. This facilitates compilation of continuously updated market information, which is available to all users and potential users (2). The result is more informed sellers who may be more able to accurately judge market conditions before making sales and production decisions.

Empirical evidence reported by Lu (10) and Helmreich, *et al.* (6) supports the hypothesis of improved pricing efficiency subsequent to the introduction of electronic sales mechanisms in other livestock markets.

In addition to potential benefits in terms of prices and pricing efficiency, other benefits are likely. Because electronic markets trade products based upon description, sales negotiations can be completed prior to physically moving products. This should allow the efficiencies associated with direct seller-to-buyer shipments to be achieved. These efficiencies can reduce marketing costs. Also, market access by the smaller and geographically dispersed sellers should be greatly improved within an electronic market due to the ease of communication with potential buyers via a computer terminal network. However, while these other potential benefits are expected to exist, they are left for future inquiry.

ORGANIZATION, DESIGN, AND OPERATION OF THE HAMS MARKET

HAMS was an experiment in electronic marketing of slaughter hogs conducted jointly by The Ohio State University (OSU), Ohio Dept. of Agriculture (ODA), and Producers Livestock Association (PLA), a livestock marketing cooperative headquartered in Columbus, Ohio. Partial funding and other assistance were provided by the Agricultural Marketing Service, U. S. Dept. of Agriculture (USDA). Actual sales were conducted for the period November 1980 through June 1981. HAMS featured a Hewlett-Packard 3000 mini computer located at The Ohio State University, connected to remotely located computer terminals via leased telephone lines. The computer was programmed to function as an auctioneer, accountant, communications manager, and market news reporter (1).

Computer terminals were located at 17 PLA stockyards in Ohio and eastern Indiana; 9 farms in Ohio; 17 packing plants in Ohio, Pennsylvania, New York, Maryland, Virginia, Tennessee, and Kentucky; and with PLA's order buying subsidiary, Eastern Order Buying Company (EOB) in Columbus, Ohio. Each participating seller had his hogs inspected by a PLA employee and the grade, weight, color, location, and number of hogs were entered into the system through a computer terminal at one of the PLA yards. The computer stored this information and made it available for inspection by potential buyers and other users. The computer also used this information in conducting auction bidding on the hogs listed for sale and for calculating settlement terms for completed sales.

Auctions were conducted at 30-minute intervals throughout the morning beginning at 9:30 a.m. and ending at 12:30 p.m. during the Nov. 10, 1980, to

TABLE 3.—Description of Average Transaction, Hog Accelerated Marketing System, Ohio, Nov. 10, 1980-June 12, 1981.

Measure	Average	Range	STD Deviation
Size of lot	36.6 hogs	1-222	30.7
Average weight	229 lb	190-275	16.8
Hogs graded 1+ (%)	11 8%	0%-100%	27.6
Hogs graded 1 (%)	68.1%	0%-100%	40.1
Hogs graded 1— (%)	10 9%	0%-100%	25 6
Hogs graded 2+ (%)	6 7%	0%-100%	21.3
Hogs graded 2— (%)	2.5%	0%-100%	14 5

March 27, 1981, period and at 10:00 a.m., 11:00 a.m., and 12:30 p.m. for the period March 30, 1981, to June 12, 1981. Bids on hogs were entered through terminals at packing plants, PLA yards, and EOB. The computer awarded the sale of each lot to the buyer making the highest bid during a specified bidding period. A record including the number of hogs traded, their location, price, and gross dollar outlay for each lot was available for both parties to the trade. Market news and information were collected and available to all users upon demand. A history of all transactions was also maintained and provides the basis for this analysis.

Results of Trading

During the period that HAMS was functional as an electronic slaughter hog market, 5,140 lots including 188,043 head of hogs were sold. This represented about 16.9% of the hogs reportedly sold in Ohio during the same period.[4] Information summarizing the transactions conducted through HAMS is presented in Table 3. Overall, the average lot of hogs traded on HAMS consisted of 36.6 head averaging 229 lb per head. In the average lot, 68.1% of the hogs graded No. 1, 11.8% graded No. 1+, 11% graded No. 1—, and 9.2% graded No. 2+ or 2—.[5]

A description of daily trading activity is presented in Table 4. Daily receipts on HAMS averaged 1,279 head, with 72% of all lots containing hogs commingled from more than one producer. On average, 5.9 different bidders were successful buyers each day, in addition to EOB. The four most active packer buyers, three in Ohio and one in Pennsylvania, purchased more than 25% of all hogs sold on HAMS and constituted the core of commercial support during the experiment. Purchases by EOB were made to fill orders from packers without termi-

[4]A complete description of the trading which occurred on HAMS is provided in a supplement to this research bulletin, HAMS An Experiment in Electronic Marketing — Description of Trading. Copies are available from the authors at The Ohio State University, 2120 Fyffe Rd., Columbus, Ohio 43210.

[5]The USDA grading system was modified by Dr Bobby Van Stavern, meat specialist, Ohio Cooperative Extension Service, for use in the HAMS experiment.

TABLE 4.—Description of Daily Activity, Hog Accelerated Marketing System, Ohio, Nov. 10, 1980-June 12, 1981.

	Average	Monday	Tuesday	Wednesday	Thursday	Friday
Daily receipts (head)	1,279	1,795	995	1,375	719	1,437
Percent commingled lots*	72	74	75	71	70	69
Number of active buyers†	6.9	8.4	6.2	6.3	4.5	7.9
Number of active packer buyers‡	3.4	4.1	3.1	3.5	2.5	3.5
Purchases by packers						
Share of all lots sold	34.8	35.6	29.1	32.3	29.9	30.6
Share of all hogs sold	41.9	42.2	34.5	38.2	35.4	35.8
Number of active yard buyers‡	2.5	3.3	2.1	1.8	1.0	3.4
Purchases at yards						
Share of all lots sold	9.4	12.9	14.5	8.1	4.8	15.8
Share of all hogs sold	10.5	15.0	18.1	9.4	5.3	19.1
Purchases by EOB						
Share of all lots sold	55.8	51.5	56.4	59.6	65.3	53.6
Share of all hogs sold	47.6	42.8	47.4	52.4	59.3	45.1

*Lots consisting of hogs from more than one consignor.
†Includes packer buyers, yard buyers, and EOB.
‡Active buyers making at least one purchase.

nals on the HAMS system, to fill out loads for packers who were active buyers on HAMS, and to provide market support on behalf of PLA, one of the sponsoring organizations.

ANALYSIS AND RESULTS

Impact of HAMS on Price Levels

Prior to the HAMS experiment, most hogs sold by farmers through PLA were bought by EOB and were resold to packers. During the experimental sales, EOB operations were altered as they became an active buyer on HAMS. At the termination of the experiment EOB reestablished its order buying operations. Since EOB was establishing the market for PLA prior to and after the HAMS experiment, prices paid to Ohio's farmers by EOB were compared to prices paid to farmers who sold hogs on HAMS in order to statistically identify the impact of HAMS on prices paid to farmers and to test the hypothesis that by facilitating increased market competition HAMS increased price levels.

To isolate the impact of the electronic market on prices (to eliminate the seasonal and annual impact of changing supply and demand relationships), price differentials were established between EOB and the Indiana direct market and the Peoria terminal market.[6] These differentials were established as norms which were compared with price differentials between HAMS and Indiana direct or Peoria. If HAMS enhanced price levels, then the price differential between Peoria and Indiana and HAMS would increase relative to the norm differentials.

An increase in prices paid to Ohio farmers relative to prices paid to farmers in neighboring states is measurable provided that the economic activity within the respective markets is relatively independent. Although price differentials among these markets in the long run should not vary by more than transportation costs, it is asserted that independence will prevail over a short time span because of the geographical differences among the three markets, imperfect market information, and the habitual nature of buyers and sellers. Thus, during a short time frame farmers would not change their marketing patterns and begin shipping hogs long distances to Ohio, even though prices were increasing in Ohio.

The statistical time series modeling technique known as ARIMA (Autoregressive Integrated Moving Average)[7] was used to determine whether a statistically significant change in prices occurred at either the Peoria terminal market or the Indiana direct market as of the initiation of the HAMS electronic market. Failure to detect such a change will be interpreted as evidence of independence among the markets during the 7-month time period. At the 95% confidence level, the hypothesis that independence existed was accepted (14).

In order to establish the impact of HAMS on the price levels paid to producers, a comparison of means was used. The time series of prices was broken down into four periods:

Period 1 = Nov. 12, 1979, to June 12, 1980 (pre-HAMS period, 1 year earlier)
Period 2 = June 15, 1980, to Nov. 9, 1980 (pre-HAMS)
Period 3 = Nov. 10, 1980, to June 12, 1981 (HAMS)
Period 4 = June 15, 1981, to Sept. 30, 1981 (post-HAMS)

Mean differences were computed from daily observations, for the periods 1-4, between EOB/HAMS and both the Peoria and Indiana markets. Duncan's multiple range test was applied separately to test for significant differences between the periods (14).

Results

The average price paid to farmers on HAMS was significantly higher, relative to both Peoria and Indiana, than EOB prices prior to and following the HAMS experiment (Table 5).

The results indicate that the average price during HAMS was $0.99/100 lb [($0.67) — (—$0.32)] higher than EOB prices a year earlier when compared to Indiana direct and $0 94/100 lb higher [(—$0.20) — (—$1.14)] when compared to Peoria. Following HAMS, prices paid to farmers by EOB returned to their previous levels.

TABLE 5.—Average Difference in Prices Between Peoria, Ill./Indiana Direct Markets and Eastern Order Buyers/HAMS Markets for the Period Nov. 1979-Sept. 1981 ($/100 lb).

Date Period	Market Comparison: Peoria vs. EOB	Peoria vs. HAMS	Indiana Direct vs. EOB	Indiana Direct vs. HAMS
Period 1	$—1.14*		$—0.32†	
Period 2	—1.28		—0 30†	
Period 3		$—0 20		$0.67
Period 4	—1.09*		—0.27†	

Source. Rhodus (14)
*Indicates that these mean differences are not significantly different at the 95 % level.
†Indicates that these mean differences are not significantly different at the 95 % level

[6]Prices paid to farmers on HAMS cannot be compared directly to other prices within Ohio due to the potential impact of HAMS on other Ohio markets.

[7]See Cook and Campbell (3, pp. 233-293) for a description of the ARIMA modeling technique.

TABLE 6.—Impact on Prices as of First Day of HAMS ($/100 lb).*

	Daily Average Prices as of			
	Nov 7, 1980		Nov. 10, 1980	
EOB	$47 50	$47 50		
HAMS			$47 79	$47 79
Peoria	48 75		48 25	
Indiana direct		48 00		47 37
Difference	$—1 25(a)	$—0 50(b)	$—0 46(c)	$ 0 42(d)
Impact of HAMS				
Change in difference from Peoria			$0 79 (c — a)	
Change in difference from Indiana direct			$0 92 (d — b)	

*Prices quoted are for U S grade 1 2, 200 230 lb, barrow or gilt.

From these results it can be inferred that HAMS increased prices by $0.94/100 lb to $0.99/100 lb relative to prices paid to farmers by Eastern Order Buying Company. This translates to an additional $2.15 to $2.27 gross revenue per head for a 229-lb hog.

The impact of HAMS on a producer's net sales revenue would have to include any marketing fees which the producer incurred by selling on the HAMS system. During HAMS, sellers were charged as much as $1.60 per head to market their hogs. This marketing fee was not directly related to the costs of the HAMS system; rather, it was set by Producers Livestock Association to offset income lost by diverting EOB sales to HAMS during the experiment.[8] Data on average marketing fees before HAMS and after HAMS are unavailable for comparison.

Analysis further indicated that the series of daily average price differences between EOB/HAMS and both the Peoria and Indiana markets were significantly affected as of the first day of activity on the HAMS market (Table 6). This provides some evidence that the basic difference between HAMS (electronic trading) and EOB (private trading), namely increased buyer competition, was translated into higher prices paid to the producer.

Impact of HAMS on Pricing Efficiency

The ability to allocate products and resources to their best use among alternatives is a necessary condition for a price efficient market. That is, when prices in the marketplace are such that they provide incentives for resources to be put to their best use, the market is considered to be efficiently pricing those resources or is "price efficient". Within a competitive market, this pricing efficiency is accomplished by buyers outbidding each other and sellers underbidding each other. The meeting of buyers and sellers then results in giving commodities certain values in exchange.

Given a competitive market, the economic theorist Leon Walras (16) has indicated that an equilibrium price will be established at the level where effective demand is equal to effective offer, which will result in the greatest possible satisfaction to each party of the exchange and essentially the best use of products and resources. However, if the utility of any product or resource increases or decreases for one or more of the parties, or if the quantity in the hands of one or more holders increases or decreases, the equilibrium price will change The price efficient market will proceed to establish a new equilibrium price through a groping or "tatonnement" process, whereby the price will rise for those products where the demand is greater than the offer, or the price will fall for those products where the offer is greater than the demand.

This newly formed equilibrium price would remain constant in a static market, where utilities and quantities possessed are expressed once and remain fixed thereafter. However, the real world is a dynamic market where the equilibrium price is constantly changing due to changing utilities and quantities possessed by the participants and potential participants. Such is a continuous market, perpetually tending towards equilibrium without ever actually attaining it.

Accepting this Walrasian explanation of the price formation process, the behavior of prices within a market should indicate the level of groping that is occurring within that market for the true equilibrium price. As such, it should also indicate the relative amount of pricing efficiency among different markets; *i.e.*, the greater the price "nervousness" (groping), the greater the efficiency with which resources are allocated. A corollary which may follow is that as pricing efficiency increases, less distortion in resource use should occur over the long run, thus resulting in lower long-run price variability.

[8]Total development costs and operating costs for different volumes of hogs are presented in Estimated Costs for Two Slaughter Hog Electronic Marketing Systems· HAMS and a Hypothetical Regional System. Copies are available from the authors, The Ohio State University, 2120 Fyffe Rd., Columbus, Ohio 43210.

The occurrence of greater price nervousness is put forth as evidence of increased pricing (or allocative) efficiency. This is measured by the frequency and magnitude of price change. Smaller, more frequent price changes are indicative of the groping or tatonnement process working. Likewise, relatively less sensitivity of current price to previous price indicates that through this groping process the price has adjusted to new and continually changing market conditions. The inefficient market may be characterized as one exhibiting less frequent price changes of a larger magnitude, increased stickiness of current price to previous price, and greater variability of prices over the long run due to allocation inefficiencies.

Statistical Evidence

Pricing efficiency in this study is operationally defined by comparing the daily average prices paid to farmers at the Peoria terminal and Indiana direct markets[9] with the prices paid to farmers on HAMS in terms of: 1) frequency and average amount of price change, 2) partial correlation coefficients associated with previous day's price and changes in supply/demand conditions,[10] and 3) long-run standard deviations in prices.

Given that the Peoria and Indiana markets have been shown to be statistically independent of changes in marketing options within Ohio, a Z test for differences between independent means of the above variables in each market was used as a test statistic.[11] To the extent that a market exhibits more or less of these attributes than do comparative markets, it is described as exhibiting more or less pricing efficiency.

Frequency of price change (FPC) was computed by dividing the total number of times that daily average price changed (up or down) from the previous day's average price by the total number of price quotes minus one.

Average price change (APC) was determined by computing the average amount of all non-zero changes in daily average price from one day to the next in absolute terms.[12]

The partial correlation coefficients associated with the previous day's price and changes in supply/demand conditions on current price were determined through multiple regression analysis. The following model was estimated separately for each of the three markets during period 3:

$$P(t) = A_0 + A_1P(t-1) + A_2R(t) + A_3R(t-1) + A_4TUE + A_5WED + A_6THU + A_7FRI + e(t)$$

where:

$P(t)$	= daily average price in each of the markets
A_0	= intercept*
$P(t-1)$	= previous day's average price
$R(t)$	= current receipts
$R(t-1)$	= previous day's receipts
TUE, WED, THU, FRI	= dummy variables for days of the week
$e(t)$	= random error

*Accounts for the effect of Monday, as this variable was dropped in order to avoid singularity. See Pindyck and Rubinfeld (12, pp. 111-116).

Within this theoretical model, days of the week and previous receipts are considered to impact upon average price. It is observed that most packers acquire the bulk of their weekly demand at the beginning of each week and attempt to minimize the amount of carryover from one week to the next. As a result, decreased buying activity on Tuesday through Friday (relative to Monday) should result in a negative impact on average price. In regards to previous receipts, it is expected that demand will decline following a day of large receipts and increase following a day of small receipts. Therefore, previous receipts should result in a negative impact on average price.

The long-run standard deviation in daily average prices (LRSD) was measured over the 7 months (Nov. 10, 1980, to June 12, 1981) for which HAMS was in operation. However, this measure is less than desirable for the pricing efficiency test as the long-run cycle for hogs is approximately 4 years in duration. Consequently, the results obtained for the 7-month period represent only partial evidence to answer the question about the long-run variability in prices within an electronic market. Firm conclusions are therefore not possible regarding this measure of pricing efficiency.

Based on previous evidence and theoretical reasoning, the following relationships were expected to occur within HAMS, relative to the comparative markets:

- Frequency of price change (FPC): HAMS > comparative markets
- Average amount of price change (APC): HAMS < comparative markets
- Partial correlation coefficient of previous price: HAMS < comparative markets
- Long run variability of prices (LRSD): HAMS < comparative markets

[9]This includes prices of hogs weighing 200-230 lb and graded U. S. 1-2, for the period Nov. 10, 1980, to June 12, 1981.

[10]This includes: current receipts, past receipts, and the day of the week.

[11]See Hopkins and Glass (9, pp. 234-236) for a description of the Z test.

[12]Only non-zero changes are examined because we are interested in determining the magnitude of change which occurs in response to changing market conditions.

TABLE 7.—Measures of Relative Pricing Efficiency Among HAMS, Peoria, and Indiana Direct Markets, Nov. 10, 1980-June 12, 1981.

Measure	HAMS	Peoria	Indiana
Frequency of price change (%)	98.6	88.4	85.0
Average price change ($/100 lb)	$ 0.5076	$ 0 658	$ 0.5475
Regression coefficient for previous price	0 9718	0.9846	0.9766
Long term variability	$ 2.818	$ 2.816	$ 2.827

Evidence supporting the above relationships was interpreted as improvement in pricing efficiency created by the HAMS electronic market.

Impact of HAMS on Pricing Efficiency — Results

Findings for the various efficiency measures are presented in Table 7. Results indicate that prices changed (either positively or negatively) from the previous day in 98.6% of the time on HAMS, 88.4% of the time at Peoria, and 85% of the time at Indiana direct. These findings support the expected relationships between the three types of markets. Prices do in fact change more often on the electronic market than in the other types of markets. This implies that day to day differences in market conditions are more readily being recognized by the price discovery process in the electronic market.

In order to test whether the average price change on HAMS was different from the average price change of the PLA direct market which HAMS substituted for, a Z test was conducted between HAMS and PLA (pre-HAMS). The data indicate that the average price change prior to HAMS was $0.63/100 lb, which is statistically different from the average price change during HAMS ($0.51/100 lb), and consistent with the hypothesis that the average price change within a direct market is greater than that of an electronic market.

The results also show that whenever average prices changed between days, they changed by an average amount of $0.66/100 lb at the Peoria terminal market, $0.55/100 lb at the Indiana direct market, and $0.51/100 lb on HAMS. In order to test for a significant difference in the average amount of price change (APC) between the markets, separate Z tests were applied. The first test indicates that the difference between HAMS and Peoria is significantly greater than zero at the 95% confidence level. The second test indicates that the difference between HAMS and Indiana direct is not significantly different from zero at the 95% confidence level but was significant at the 82% confidence level.

These results support the expected relationship between the electronic market and the terminal market, but fail to support the expected relationship between the electronic market and the direct market with a high degree of statistical confidence. While there is evidence that prices on the HAMS market do change in smaller increments than those of the Indiana direct market, given the standard deviation within each market there is an 18% chance that this difference is statistically no different from zero.

Nonetheless, the fact that whenever prices do change they change less in the electronic market implies that adjustments to market conditions are occurring in small rather than large increments. As a result, there is less uncertainty in terms of extreme price fluctuations associated with the electronic market relative to the other markets.

Summarizing the results of this measure of pricing efficiency, it is apparent that prices on the electronic market change more frequently than those of the direct or terminal markets and by smaller amounts than those of the terminal market. As such, this lends support to the hypothesis that prices on the electronic market are more efficient guides to resource allocation decisions than are prices in the comparable terminal and direct markets.

Multiple regression analysis was used to determine the relative impact of both previous price and market conditions on current price within each of the three markets (HAMS, Peoria terminal, and Indiana direct). The estimated models for each of the markets are presented in Table 8.

The results reveal partial correlation coefficients associated with previous prices of 0.9718 for HAMS, 0.9766 for Peoria terminal, and 0.9846 for Indiana direct (Table 8). Using a Z test for independent means, the differences between HAMS and both Peoria and Indiana are significantly greater than zero at the 95% confidence level. This supports the expected relationship between the electronic market and the terminal and direct types of markets. The fact that current price is less completely explained by previous price in HAMS than in the other two markets means that other information (changes in supply and/or demand conditions as represented by daily receipts and days of the week) had a more significant impact on transaction prices in the electronic market. Thus, the electronic market also met this

TABLE 8.—Relative Impacts of Previous Price and Market Conditions on Current Prices in HAMS, Peoria Terminal, and Indiana Direct Markets, Nov. 10, 1980-June 12, 1981.

P(t)†	Intercept	P(t — 1)‡	R(t)††	R(t — 1)‡‡	Tuesday	Wednesday	Thursday	Friday
HAMS	2.436**	0.9718**	—0.000458**	0.000278	0.067	—0.423*	—0.614*	—0.218
t =	(2.63)	(51.44)	(—2.76)	(—1.70)	(—0.30)	(—2.33)	(—2.5)	(—1.11)
R^2 =	0.9546	F = 412						
INDDIR	2.488**	0.9846**	0.0000171	—0.0000125**	—0.08	—0.262	—0.425**	—0.407**
t =	(3.39)	(66.35)	(1.08)	(—7.09)	(—0.59)	(—1.9)	(—2.93)	(—2.63)
R^2 =	0.9699	F = 634						
PEORIA	1.744*	0.9766**	—0.000375**	0.000201**	—0.021	—0.107	—0.253	—0.139
t =	(2.0)	(51.17)	(—5.89)	(3.07)	(—0.13)	(—0.65)	(—1.43)	(—0.82)
R^2 =	0.9505	F = 378						

*Significant at 95% confidence level.
**Significant at 99% confidence level.
†Daily average price.
‡Previous day's average price.
††Current daily receipts.
‡‡Previous day's receipts.

test for pricing efficiency relative to the direct and terminal markets.

Because HAMS trading was limited to 7 months and the long-run cycle for hogs is approximately 4 years, data on HAMS trading is not sufficient for testing relationships concerning long-run variability of prices. Consequently, the results obtained (Table 7) represent very imperfect evidence of the impact of electronic marketing on the long-run standard deviation in prices. The results achieved over the 7-month period indicate that there were some differences among the three markets but these differences are fairly small. They suggest support for the expected relationship between the electronic market and the direct market, but not so in regard to the terminal market. However, no conclusions can be drawn regarding the long-term price variability of the electronic vs. conventional markets due to limitations on the data available for analysis.

Summarizing the findings of this section, it appears that the electronic market is generally more pricing efficient than either the terminal or direct markets based upon the measures of frequency and average amount of price change and the impact of previous price on current price with one exception. When measured in terms of long-run price variability, results are inconclusive.

Impact of HAMS on Price Behavior

As a competitive market, prices on HAMS were determined by the interaction of supply and demand. As the components of these functions fluctuate, prices within the market are also expected to change, thus revealing the preferences of the buyers and reservations of sellers. Such diffferential pricing enables potential buyers and sellers, as they view product characteristics and changes in market conditions, to adjust bids and offers to reflect premiums or discounts which they assess as being associated with those characteristics and changing conditions. Therefore, price is a function of conditions in the market and the characteristics of the products in individual sales lots.

Multiple regression analysis was used to judge the effect of market conditions on daily HAMS prices, and to gain an improved understanding of how well the electronic market generated daily average prices which represent the collective impacts of both supply and demand forces at work in the market place. The following model was estimated in the analysis:

$$\begin{aligned} HAMS(t) = {} & B_0 + B_1 HAMS(t-1) + B_2 PCENTPAC \\ & + B_3 PCENTYD + B_4 NTYPE1D + \\ & B_5 NTYPE3D + B_6 RECEIPTS + B_7 TUE \\ & + B_8 WED + B_9 THU + B_{10} FRI + e(t) \end{aligned}$$

where:

$HAMS(t)$ = daily average price on HAMS
B_0 = intercept*
$HAMS(t-1)$ = previous day's average price
PCENTPAC = percentage of lots per day purchased by packers
PCENTYD = percentage of lots per day purchased by yard buyers
NTYPE1D = number of active packer buyers per day
NTYPE3D = number of active yard buyers per day
RECEIPTS = total receipts per day

*Accounts for the effects of sales on Mondays and the percentage of lots/day purchased by EOB, as these variables were dropped in order to avoid singularity.

TUE, WED, THU, FRI = dummy variables for days of the week
e(t) = random error

These independent variables were used because of their theoretical impact on supply and demand and data availability. It is assumed that as the percentage of lots purchased by either packers or yard buyers increases relative to EOB, prices will move upward since EOB was generally considered the "buyer of last resort". As the number of competing buyers (yard and/or packer) increases, it is assumed that prices will increase. As explained previously, the days of the week are also expected to affect prices by affecting demand, while supply effects are represented by receipts. There may have been other variables which would influence the daily supply or demand of hogs but these were not included in the analysis because of data limitations.

Multiple regression analysis was used to judge the effect of qualitative differences among sales lots on the amount of price difference between individual price and daily average price. Once again, these variables were chosen because of their theoretical impact on value and data availability. Round 1 was chosen to be represented by the intercept since it is theoretically assumed that prices determined at the beginning of the day set the "tone" of the market, and comparisons between time periods within a day should be done relative to the beginning of the day. As a result, rounds 2 and 3 are assumed to have negative impacts on price as the buyers with high reservation prices complete transactions and drop out of the bidding. The variables representing size and quality of the lot are expected to positively impact price due to conventional expectations. Once again, lots purchased by packers or yard buyers are anticipated to receive higher prices since EOB was generally considered the "buyer of last resort". Variables representing commingling of lots, distance to buyer, average weight, weight range, and number of Duroc (red) hogs per lot are all anticipated to react negatively with prices paid because increases in these characteristics typically lower the desirability of a given lot. Supply effects are represented by receipts per location. The following model was estimated:

$$PDIF = C_0 + C_1ROUND\ 2 + C_2ROUND\ 3 + C_3SIZE + C_4SIZESQ + C_5COMNG + C_6DISTANCE + C_7DISTANCESQ + C_8PBUYER + C_9YARD + C_{10}AWT + C_{11}AWTSQ + C_{12}WTRANGE + C_{13}WTRANGSQ + C_{14}WTAVGR + C_{15}WTAVGRSQ + C_{16}REDS + C_{17}REC\ (1 - 17) + e(t)$$

where:

PDIF = price difference between individual sale lots and daily average price
C_0 = intercept*
ROUND 2 = dummy variable for lots sold between 10:30 a.m. and 11:30 a.m.
ROUND 3 = dummy variable for lots sold at 11:30 a.m. and later
SIZE = number of head per lot
SIZESQ = square of SIZE†
COMNG = dummy variable for commingled lots
DISTANCE = distance from lot to buyer in miles
DISTANCESQ = square of DISTANCE†
PBUYER = dummy variable for packer buyer
YARD = dummy variable for yard buyer
AWT = average weight of hogs in lot
AWTSQ = square of AWT†
WTRANGE = weight range of hogs per lot
WTRANGSQ = square of WTRANGE†
WTAVGR = weighted average quality grade of each lot‡
WTAVGRSQ = square of WTAVGR†
REDS = number of Duroc hogs per lot
REC (1-17) = daily receipts for each PLA location
e(t) = random error

*Accounts for the effects of lots sold at 10:00 a.m. or earlier and lots purchased by EOB, as these variables were dropped in order to avoid singularity.

†Squared terms were used in order to improve the fit of the model and better describe the underlying relationships.

‡Calculated as follows: 100% grade 1+ = 500, 100% grade 1 = 400, 100% grade 1 — = 300, 100% 2+ = 200, or 100% grade 2 — = 100.

The expected directions of impacts for both the market condition variables and the qualitative characteristics are presented in Table 9.

Impact of HAMS on Pricing Behavior — Results

The estimated model, which represents the effects of market conditions on daily average price, is presented in Table 10.[13]

These results show that the most important variable explaining current daily average price is previous price (HAMS (t— 1)). This is consistent with results of previous research in other markets. The regression coefficient of 0.96 implies that current price was typically 96% of the previous price, with other factors explaining any difference from this value.

As the percentage of lots purchased by packers

[13]To aviod any effects from pre-test estimation, the initial estimation of the model was used.

TABLE 9.—Expected Direction of Impact on Price of Market Conditions and Qualitative Variables.

Market Conditions		Qualitative Characteristics	
Variable	Direction of Impact	Variable	Direction of Impact
HAMS (t — 1)	Positive	ROUND2‡	Negative
PCENTPAC*	Positive	ROUND3‡	Negative
PCENTYD	Positive	SIZE	Positive
NTYPE1D	Negative	COMNG	Negative
NTYPE3D	Positive	DISTANCE	Negative
RECEIPTS	Negative	PBUYER**	Positive
TUE†	Negative	YARD**	Positive
WED†	Negative	AWT	Negative
THU†	Negative	WTRANGE	Negative
FRI†	Negative	WTAVGR	Positive
		REDS	Negative
		REC	Negative

*Relative to the percentage of lots purchased by EOB.
†Relative to Monday.
‡Relative to Round 1.
**Relative to lots purchased by EOB.

TABLE 10.—Effect of Market Conditions on Daily HAMS Prices, Regression Results.

Variable	Parameter Estimate	T Ratio
Intercept	2.2453	2.63**
HAMS (t — 1)	0.9617	52.81**
PCENTPAC	0.0112	3.30**
PCENTYD	0.0334	2.56*
NTYPE1D	—0 0447	—0.94
NTYPE3D	—0.1854	—2.51*
RECEIPTS	—0.000357	—1.88
TUE	—0.3417	—1.73
WED	—0.4106	—2.33*
THU	—0.7665	—3.08**
FRI	—0.0363	—0.22

*Significant at the 95% confidence level.
**Significant at the 99% confidence level.
R Square = 0.9596. F = 321.

(PCENTPAC) increased by 10%, average price increased by $0.112/100 lb. However, this increase was less than that associated with an equal increase in the percentage of lots purchased by yard buyers (PCENTYD), which was $0.33/100 lb.[14] Combining these, if packers and yard buyers both increased their purchases by 10% on any given day, relative to PLA/EOB, the daily average price would increase by $0.44/100 lb. This is consistent with the expectations for these three types of buyers.

The middle days of the week had negative impacts on price, as expected. Of these, Wednesday decreased prices $0.41/100 lb and prices on Thursday were down by $0.77/100 lb relative to Monday, holding all other factors constant.

The negative relationship between average price and number of yard buyers each day (NTYPE3D) is not consistent with prior expectations. Statistically, the results indicate that the daily average price on HAMS decreased as the number of yard buyers participating on the system increased. A possible explanation for this may be that EOB either stayed out completely or failed to compete against the yard buyers after their opening bid, because EOB had prior knowledge as to the lots in which yard buyers were interested.

The negative relationship of current price to total receipts (RECEIPTS) is consistent with the concepts of supply and demand. However, this variable was not found to be a significant explanatory variable when combined with the other variables in the model. When the variables representing the number of packer or yard buyers per day and their corresponding percentage of purchases were not included, current receipts were found to be statistically significant (Table 8). This indicates that supply (RECEIPTS) is an important variable within the market when referring to the market in general, but is not as important within any specific segment of the market. In this case, variables which capture specific buyer behavior are relatively more important.

The number of packer buyers who were successful bidders on any given day (NTYPE1D) was not a statistically significant determinant of average price. A possible explanation is that there were only a few packer buyers participating on any given day and their bidding success did not conform to any specific behavior in prices. However, data on the number of packers active as bidders but unsuccessful as buyers on any particular day were not available for analysis. Thus, empirical evaluation of this explanation is not possible.

In summary, the highest price on HAMS was associated with sales on Monday. When packers or yard buyers were expanding their share of purchases, prices increased. However, an increase in the number of yard buyers decreased prices.

The estimated model which represents the effects of the qualitative characteristics on price differences for individual sales is presented in Table 11.[15]

The variables representing time of sale, commingling of a lot, and daily receipts for locations 2-15 were found not to be statistically significant at the 95% confidence level.

These results show that not all of the relation-

[14]Yard buyers were agents of Producers Livestock Association who made purchases (from the collection yards) on behalf of a local buyer who did not have access to a HAMS computer terminal.

[15]To avoid any effects from pre-test estimation, the initial estimation of the model was used.

ships are linear. The variables average weight, weighted average grade, size of lots, weight range, and distance from lot to buyer exhibit a quadratic impact on price over certain ranges for each variable.

The price of a lot, relative to the daily average price, increased as the average weight (AWT) of the hogs in the lot increased up to 222 lb. Beyond this weight, price decreased. Approximately 63% of all lots sold on HAMS averaged more than 222 lb per hog. Thus, producers who postponed marketing their hogs in anticipation of higher prices were assessed a discount if their hogs averaged more than 222 lb.

The price of a lot increased with an increase in the weighted average grade of the lot but at a decreasing rate, thus implying a diminishing marginal return to quality.[16] Therefore, upgrading the quality of hogs sold on HAMS from mostly grade 2+ to mostly grade 1 resulted in a $0.536/100 lb improvement in price, while upgrading from mostly grade 1 to mostly grade 1+ resulted in only a $0.077/100 lb improvement.

As the number of head in the lot increased, price per lot also increased, but only up to 135 head per lot. Price decreased with additional increases in size. Only 1.4% of the lots sold on HAMS exceeded 135 head per lot; thus, 98.6% of trades could have achieved a higher price if sold in larger lot sizes.

Results pertaining to the weight range are not completely consistent with prior expectations. These indicate that buyers were willing to increase price as the weight range increased up to 28.7 lb per lot, but decreased price thereafter.[17] Prior reasoning assumed that, holding lot size constant, a narrowing of the weight range would be preferred by buyers. The results do, however, conform to the average weight range of 30 lb typically used in reporting daily prices of hogs by market news services and independent buyers.

The positive signs on the type of buyer, YARD or PBUYER, indicate that these buyers paid premiums over prices paid by EOB, which was generally considered the "buyer of last resort". Therefore, the successful buyer had to outbid EOB on any given lot. The relative magnitudes of the two buyer types are consistent with expectations. Yard buyers paid an average of $0.19/100 lb more than EOB and packer buyers paid an average of $0.11/100 lb more. Yard buyers should be able to pay more than packer buyers because of transportation cost differences and because they are buying a set of hogs selected specifically for a buyer who has instructed them on what he needs.

[16]The weighted average grade of a lot was determined by the percentage of the different grades within a lot, where 100% grade 1+ = 500, 100% grade 1 = 400, 100% grade 1— = 300, 100% grade 2+ = 200, and 100% grade 2— = 100. Grade 1+ is considered the highest grade.

[17]Buyers were aware of the weight range before bidding on any lot.

TABLE 11.—Effect of Qualitative Differences Among Sales Lots on Price Difference, Regression Results.

Variable	Parameter Estimate	T Ratio
Intercept	—57.202	—86.87**
ROUND 2	— 0.0162	— 0.67
ROUND 3	0.0206	0.85
SIZE	0.00566	13.56**
SIZESQ	— 0.0000209	— 7.76**
COMNG	— 0.00499	— 0.50
DISTANCE	— 0.000397	— 2.54*
DISTANCESQ	0.000000603	2.14*
PBUYER	0.111	9.33**
YARD	0.186	11.58**
AWT	0.498	87.43**
AWTSQ	— 0.00112	—91.67**
WTRANGE	0.01	6.53**
WTRANGSQ	— 0.000174	— 7.24**
WTAVGR	0.00649	21.10**
WTAVGRSQ	— 0.000000635	—13.53**
REDS	— 0.00285	— 2.57*
REC1	— 0.000166	— 2.25*
REC2	0.000124	1.31
REC3	— 0.0000635	— 0.94
REC4	0.0000563	0.62
REC5	0.0000947	0.70
REC6	— 0.00014	— 1.93
REC7	0.000015	0.24
REC8	— 0.000023	— 0.23
REC9	0.0000977	0.59
REC10	— 0.000083	— 1.25
REC11	0.000104	1.41
REC12	— 0.000099	— 1.47
REC14	0.000037	0.29
REC15	0.000027	0.39
REC16	0.00025	2.36*
REC17	0.00045	3.00**

*Significant at the 95% confidence level.
**Significant at the 99% confidence level.
R Square = 0.8396. F = 567.

Price also increased as the daily receipts of either the Woodville (REC17) or Wilmington (REC16) location increased. As daily receipts at Woodville increased by 100 head, price increased by $0.045/100 lb, and an equal increase in receipts at Wilmington increased price by $0.025/100 lb. The results also show that as receipts at Bath (REC1) increased by 100 head, the price decreased by $0.017/100 lb. For whatever reason, buyers perceived a greater value to hogs from the two former locations relative to all other locations and a lower value for hogs at the latter location.

The price of a lot decreased by $0.0285/100 lb as the number of Duroc hogs per lot increased by 10 head. This is consistent with the added costs of processing at certain times.

The DISTANCE variable indicates that prices

decreased per lot as the distance from the lot to the buyer increased, but only up to 329 miles. Thereafter, price increased with additional increases in distance. Overall, 92.8% of all trades occurred within the 329-mile limit. This accounted for 100% of the yard purchases, 100% of the EOB purchases, and 75.8% of the packer purchases. As a result, as the distance from the lot to the buyer increased from zero to 100 miles, the price decreased by $0.034/100 lb. This is consistent with the fact that buyers within Ohio have a greater number of alternative sources of supply and will offer less as the distance increases, while Eastern buyers have no alternatives but the Midwest for their supply of hogs. As a result, competition among Eastern buyers for Midwest hogs results in higher prices for these "long distance" buyers. However, the decrease in prices offered by Ohio buyers did not cover the added fuel costs required for transporting hogs additional distances.[18] Thus, it appears that buyers who competed for hogs on HAMS did not cover fuel costs, let alone the other expenses of operating a truck.

An examination of the beta coefficients[19] was made to examine the relative importance of the various independent variables in the model (Table 12). As can be seen, a one-standard deviation change in the average weight of a lot led to a much greater change in the price of the lot than a one-standard deviation change in the number of head per lot or any of the other independent variables. This implies that even though the average grade, size, and weight range of a lot of hogs is important when hogs are sold either by individual producers or commingled from several producers, it is the average weight of the lot which most favorably or adversely affected the sale price.

[18]Based upon a load of 200 hogs, weighing 220 lb each, with fuel costs of $1.00/gallon and an average of 4.75 miles per gallon.

[19]Beta coefficients are determined by a linear regression in which each variable is normalized by subtracting that variable's mean and dividing by its standard deviation. See Pindyck and Rubinfeld (12, pp. 90-91).

TABLE 12.—Beta Coefficients Associated with Price Difference per Lot, Significant Variables Only.

Variable	Coefficient
Average weight	11.011
Weighted average grade	0.644
Size of lot	0.229
Weight range	0.145
Yard buyer	0.079
Packer buyer	0.068
Receipts location 17	0.032
Receipts location 16	0.015
Distance from lot to buyer	—0.064
Receipts location 1	—0.016
Reds	—0.016

Summarizing the results pertaining to the price differences per lot, the optimum price on HAMS was achieved with high quality hogs, no heavier than 222 lb in lots of 135 head and with a weight range not greater than 29 lb.

CONCLUSIONS AND IMPLICATIONS

Impacts of Electronic Trading on Price Levels

A significant improvement in the average price paid to farmers for their hogs was observed on the HAMS electronic market. This improvement amounted to $0.94 to $0.99/100 lb in gross price and would be expected to occur as a market becomes less oligopsonistic and more competitive. Reports of higher prices subsequent to the introduction of an electronic market mechanism were also found by other researchers in markets for hogs, lambs, and feeder cattle. As a result, this improvement in price levels should be a strong incentive for the industry to try electronic marketing since any gains in price levels within the electronic market will most likely be matched by the industry to preserve existing trade patterns. However, marketing agents who advocate electronic marketing should look carefully at their tariffs in order not to discourage electronic marketing by appropriating most of the price gain through higher tariffs.

Pricing Efficiency

In addition to improved price levels, electronic marketing has also resulted in pricing behavior which generates an improvement in pricing efficiency relative to private treaty markets. Since the electronic market is highly visible and competition occurs among numerous buyers, pricing inaccuracy problems should be minimized due to the fact that potential entrants can freely enter the market and take advantage of situations in which the commodities being traded within the market inaccurately reflect existing supply and demand relationships.

In order to quantify pricing efficiency exhibited by the electronic market relative to a terminal and direct market, three measures of efficiency were used. These included: 1) increased frequency and diminished magnitude of price changes, 2) increased correlation between price and market conditions, and 3) decreased long-term price variability. When viewed in total, the results of these measures are consistent with what has been put forward as evidence of an improvement in efficiency within the electronic market; *i.e.*, measures 1 and 2 provide positive evidence while measure 3 does not provide negative evidence.

Market Information

An additional impact of the electronic market is the improvement in the quantity, quality, and availability of market information to both current and

potential users. As evidenced on the HAMS market, the average weight of the hogs had a significantly greater impact on price, relative to average grade, number of head, weight range, type of buyer, and other explanatory variables. The ability to determine these factors which most favorably affect price can be very beneficial to the profit maximizing producer. From the buyer's point of view, even though the packer may pay a higher average price, identification of factors which add value to hogs allows him to correlate price and quality better; thus, he can discount for poor quality and/or not buy it or pay more for desired quality. Overall, the buyer pays more but he stands to receive more in terms of desired products and less in terms of undesired products.

Regarding "thin" markets and market access concerns, there is no direct evidence on the impact of the HAMS electronic market on these problems. However, given the results concerning price levels, pricing efficiency, and factors affecting prices, logic suggests that these problems have been lessened. For example, increased buyer competition may indicate less thinness, while sales of relatively small lots with fairly small price discounting may indicate better market access for the small producer.

Implications to Market Performance

As a result of the HAMS experiment, it appears that electronic marketing provides a competitive arena within which price formation can occur. As a result, markets which are characterized as oligopsonistic can be transformed into more competitive markets as electronic marketing replaces private treaties among buyers and sellers.

Improvement in the allocative efficiency of a market may also be expected following the adoption of an electronic marketing mechanism. This occurs because prices are matched with products under existing supply and demand conditions, as opposed to prices determined under a standing formula arrangement which is based on averages relative to some other reference market. Since electronic marketing facilitates fine tuning of prices to specific products, resource misallocation should be minimized.

With the improvement in quality and availability of market information, the electronic market should enable producers to improve their marketing decisions by being better informed as to their available opportunities. This would include not only when to sell (time of day), but also which day of the week and what composition of hogs earns the highest return. Such information could also be used by producers to improve their marketing/bargaining power relative to the buyers. This would lead to a market in which pricing decisions are based upon product characteristics and more equal bargaining strengths.

Design and Operation of a Future Electronic Hog Market

Due to the high start-up costs and the need to attract a steady supply of hogs, some market support may be necessary for the successful operation of an electronic market. But this support should be minimized relative to the level of commercial buying. This implies that market support buying should not be used as a substitute for commercial buying, but only to supplement it. While development and operating costs have not been analyzed herein relative to the (price-related) benefits, these costs (particularly start-up/development) were high and are the subject of another report.

Data from the HAMS market has indicated that buyers are willing to pay a premium for hogs which are sold in lots of up to 135 head. Since this corresponds to roughly a half-truck load, it suggests that 1/2TL may be the appropriate listing when offering hogs for sale. The data also indicate that buyers prefer hogs which average 222 lb and are sold in lots where the weight range per lot does not exceed 29 lb.

Marketing Policy

Electronic marketing has several implications in regard to public policy. First, it may simplify the task of market reporting. Resources which are currently being used to monitor private treaty markets could be reduced as the number of transactions occurring within an electronic market increased, since it is much easier and consequently cheaper to obtain the same information when transactions do not occur behind a veil of private negotiations. Furthermore, as the number of transactions within the electronic market increased, it might be possible to scale back publicly funded market news, since market information could be offered on the electronic market to all current and potential users.

Second, electronic marketing may be an effective antitrust policy. Legislation could be considered in which electronic markets are prescribed rather than monopolies being proscribed. As such, electronic marketing may represent a desirable alternative to an undesirable situation.

Third, electronic marketing is able to provide an "audit trail" which can facilitate post facto analysis (such as this study), whereas terms of trade or trading conditions are seldom recorded on a trade by trade basis in existing markets. Because trading is highly visible, undesirable market behavior such as price discrimination or price collusion may be discouraged.

Given the potential impact of electronic trading on allocative efficiency which results in public as well as private benefits, there is an appropriate public in-

terest in the rules of conduct established within an electronic market. First, the integrity of the system needs to be protected; *e.g.*, who establishes or modifies the grades and standards to be employed, who can modify information stored within the computer, who can set pricing procedures etc. Second, adequate protection of the privacy of the buyers and sellers who participate on the system needs to be provided; *e.g.*, who has access to what information during actual trading, what information is retained for analytical purposes, who has access to this information and when, etc. Third, rules need to be established which insure that producers receive their fair share of price gains relative to the marketing agents.

Market Researchers

This study of electronic marketing has developed and utilized three measures of pricing efficiency. But there exists a need to develop and further test methods for measuring the level of pricing efficiency exhibited within a market. The three measures used have led to certain conclusions concerning the relative efficiency of electronic markets, but further evaluation is desirable. Additionally, researchers need to identify other performance measures for evaluating electronic markets relative to other markets and how to generate the appropriate data. Furthermore, continued effort is necessary for the development of theory and logic dealing with price behavior and allocative efficiency within a commodity market; *e.g.*, the need to update the work of earlier economists in terms of the modern market environments. Finally, there is a need to further evaluate the benefits of electronic marketing (pricing, allocative, physical efficiency) relative to its costs (public, private, direct, and indirect).

REFERENCES

1. Baldwin, E. Dean. Oct. 1978. A Proposed Pilot Project for Computerized Electronic Marketing of Slaughter Hogs. The Ohio State Univ., Dept. Agri. Econ. and Rural Sociol. (mimeo).
2. Baldwin, E. Dean. March 1981. Electronic Marketing of Agricultural Products with Examples f rom HAMS. Paper presented at Amer. Pork Congress, Kansas City, Mo.
3. Cook, Thomas D. and Donald T. Campbell. 1963. Quasi-Experimentation: Design and Analysis Issues for Field Settings. Rand McNally and Co., Chicago, pp. 233-293.
4. Engleman, Gerald and Betty Sue Pence. March 1958. Livestock Auction Markets in the United States. U. S. Dept. of Agriculture, Agricultural Marketing Service, Marketing Research Division, MRR No. 223.
5. Hayenga, Marvin L. March 2-3, 1978. The Concept of a Thin Market. *In* Pricing Problems in the Food Industry (with Emphasis on Thin Markets). Washington, D. C.
6. Helmrich, Dennis P., James E. Epperson, and Chung-Liang Huang. July 1980. The Value of Electronic Marketing—Some Empirical Evidence. Paper presented at annual meeting, Amer. Agri. Econ. Assoc., Urbana, Ill.
7. Henderson, Dennis R., Lee F. Schrader, Thomas L. Sporleder, and E. Dean Baldwin. July 29-August 1, 1979. The Economic Feasibility and Impacts of Electronic Markets: A Tentative Appraisal. Paper presented at annual meeting, Amer. Agri. Econ. Assoc., Washington State Univ.
8. Holder, David L. Feb. 1979. Benefits of a Sheep and Lamb Teleauction in Virginia and West Virginia. Paper presented at Southern Agri. Econ. meeting.
9. Hopkins, Kenneth D. and Gene V. Glass. 1978. Basis Statistics for the Behavioral Sciences. Prentice-Hall Inc., New Jersey, pp. 234-236.
10. Lu, Chang-Mei. 1969. Effect of Teletype Auction on Hog Price Variation in the Short Run. University of Manitoba, Unpublished M.S. Thesis.
11. Lu, Wen-Fong. 1968. Effect on Regional Price Levels of Selling Hogs by Teletype. University of Manitoba, Unpublished M.S. Thesis.
12. Pindyck, Robert S. and Daniel L. Rubinfeld. 1981. Econometric Models and Economic Forecasts, 2nd. Ed. McGraw-Hill Book Co., New York.
13. Rhodes, V. James, Calvin Stemme, and Glenn Grimes. Feb. 1979. Large and Medium Volume Hog Producers: A National Survey. Univ. Missouri-Columbia, Agri. Exp. Sta., SR 223.
14. Rhodus, W. Timothy. 1982. Pricing Performance of an Electronic Slaughter Hog Market. The Ohio State Univ., Unpublished M.S. Thesis.
15. U. S. Dept. of Agriculture. Sept. 24, 1979. Concentration in the Meat Packing Industry—National and Local Procurement Levels. Agricultural Marketing Service, Packers and Stockyards Programs, presented to Committee on Small Business, U. S. House of Representatives.
16. Walras, Leon. 1954. Elements of Pure Economics. W. Jaffe, trans. George Allen and Unwin, London.
17. Ward, Clement E. Feb. 1980. Marketing Lamb and Wool for Greatest Profit. Paper presented at sheep short course in Tonkawa and Woodward.

The Ohio State University
Ohio Agricultural Research and Development Center