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Price Discovery in North and West Central Nebraska Livestock Auction Markets

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Summary

Price data from west central Nebraska livestock auction markets were used to determine the price discovery and information flow patterns between weight-gender cattle classes using time series analysis and directed acyclical graphs (DAG). Results indicated steers weighing 400-600 lb were the point of price discovery; the price change of each weight of steers impacted the price of the next heavier class of steers. Price movements for 600-700 lb heifers impacted prices of many other weight/gender classes including the price of heavier heifers and steers.

Introduction

The mechanics of how supply and demand work to set the price for a specific sale transaction is known as "Price Discovery." It involves several inter-related concepts including the relative power of buyers and sellers, how buyers decide their maximum bids, and how market information is transmitted.

Pricing decisions by buyers and sellers along the beef supply chain are made using available information about the current situation coupled with future expectations. Price information from these transactions are used by other buyers and sellers in their decision making process. It is this recursive process where market information impacts stakeholder's decisions that this study explores.

The purpose of this study was to determine which weight/gender classes of feeder cattle (calves between 300 and 999 lb) were the price leaders and which were market followers. The methodologies used in this study to determine causality and the direction of information flow were developed

by researchers in the field of artificial intelligence.

Procedure

The Agricultural Marketing Service (AMS), an agency in the USDA, publishes price data by sex and BW for individual livestock auction markets in Nebraska. Price data from the auction markets located in the Nebraska Sandhills and adjacent counties were collected beginning Aug. 1 and ending May 31 for the years 2003-4, 2004-5, and 2005-6. Livestock auction price data during June and July was sparse because sales were infrequent with few feeder cattle being sold during these months.

More than half the cattle marketed through these auctions were sold in the three months of October, January, and February. The largest numbers of cattle sold were in October (18.79%) followed by January (17.89%) and February (13.76%). This pattern was consistent over the three year period.

The weighted average BW of calves sold declined from 804 lb in August to 569 lb in October. Yearlings are generally sold directly off of grass in the fall and calves are sold later, after weaning. The decrease in average BW reflects fewer yearlings being sold as the fall season progresses. The weighted average BW of calves then increases to 693 lb in March, probably reflecting BW gains for calves over the winter. The weighted average BW drops to 664 lb in April and increases to 691 lb in May. Apparently producers begin holding their heavier calves in April.

The cattle were grouped by weight/gender using 100 lb increments. Calves weighing less than 300 lb or over 999 lb were not included in this study making a total of 14 groups. A weighted average price was calculated for each weight/gender class for each week.

The analysis was completed in two steps. First, a time series method was

employed to account for the dynamic relationships among the price series. Vector Auto Regression (VAR) analyses and an Error Correction Model (ECM) were run to determine which, if any, of the weight/gender classes were independent of the others. Second, a directed acyclical graph (DAG) as determined by TETRAD IV, software developed by researchers at in the area of artificial intelligence at Carnegie-Mellon University and located on the internet at www.phil.cmu.edu/projects/tetrad/, was constructed showing the causal relationships among the 14 price series. A DAG is a picture that uses arrows and lines that represent causal links between variables. Acyclical relationships are causal flows that do not feed back into themselves. The TETRAD IV program, mentioned above, uses a logical, step-by-step procedure and a strict set of assumptions for identifying these causal relationships. The data used in the TETRAD IV procedure was the residuals, or innovations, from the VAR/ECM models.

Results

Figures 1 and 2 show the historical plot of cattle prices in \$/cwt for the 14 weight/gender classes included in this study. The patterns of price movement among the different weight/gender classes were similar in appearance. Price level differences were not easily recognized because the scale used to chart these prices varied from one graph to another. The pattern of price movements was somewhat similar for calves weighing 600 lb or more. The pattern of price movements for calves less than 500 lb varied from the heavier animals price series. These observed differences in price patterns suggested there may be more than one price system.

Table 1 provides a list of the means and standard deviations of the prices for the different weight/gender

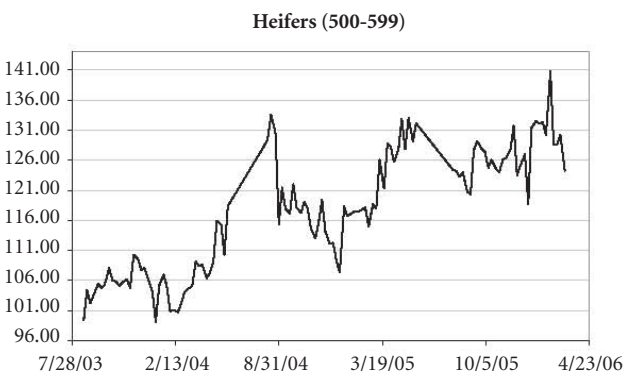
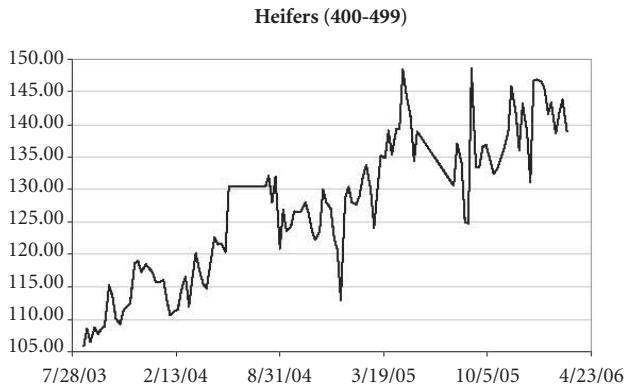
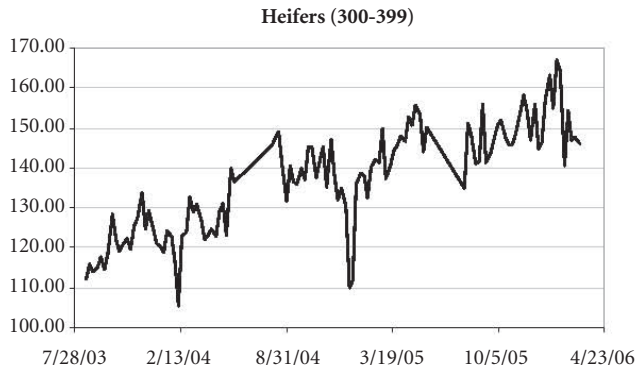


Figure 1. Plots of auction market prices by weight class, intact heifers and steers, weekly data August 2003 through April 2006.

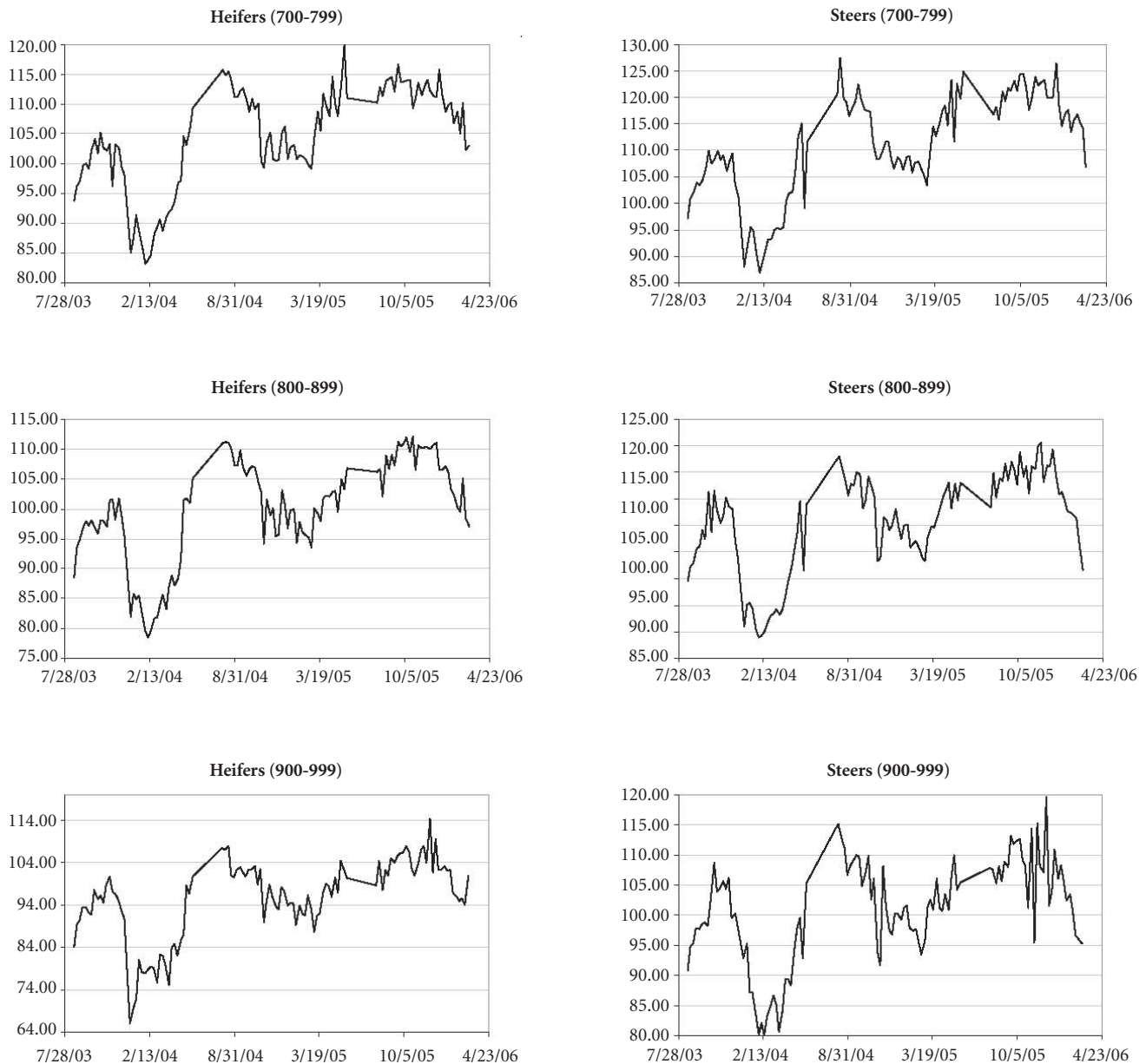


Figure 2. Plots of auction market prices by weight class, intact heifers and steers, weekly data August 2003 through April 2006.

groups. As expected, the average price per pound decreased as individual animal BW increased. Also, as expected, the average price for steers was higher than that of heifers for each weight category. Price variability, measured by standard deviation, generally followed the same pattern, lighter weight animals had higher standard deviation than their heavier contemporaries, with the exception that heifers weighing more than 900 lb had a larger standard deviation than heifers weighing 700-899 lb even though the

average price received was less.

The time-series analysis indicates that the prices for 400-500 and 500-600 lb steers did not follow the price changes of the other weight/gender classes. This indicates that they may have been the price leaders while the prices of the other weight/gender classes followed. These results were only marginally significant.

However, when these results were combined with the DAG, an interesting picture of causation between these weight/gender classes emerged.

Figure 3 shows the DAG created by the TETRAD IV program. Here a line drawn between two weight/gender classes represents existence of some type of relationship. If a line has an arrow, the price of the weight/gender class being pointed to is considered “caused” by the price of the weight/gender class from which the arrow is pointing. Information and causation flow in the direction of the arrow. When neither end of a line has an arrow, we can not say which weight/gender price was caused and which

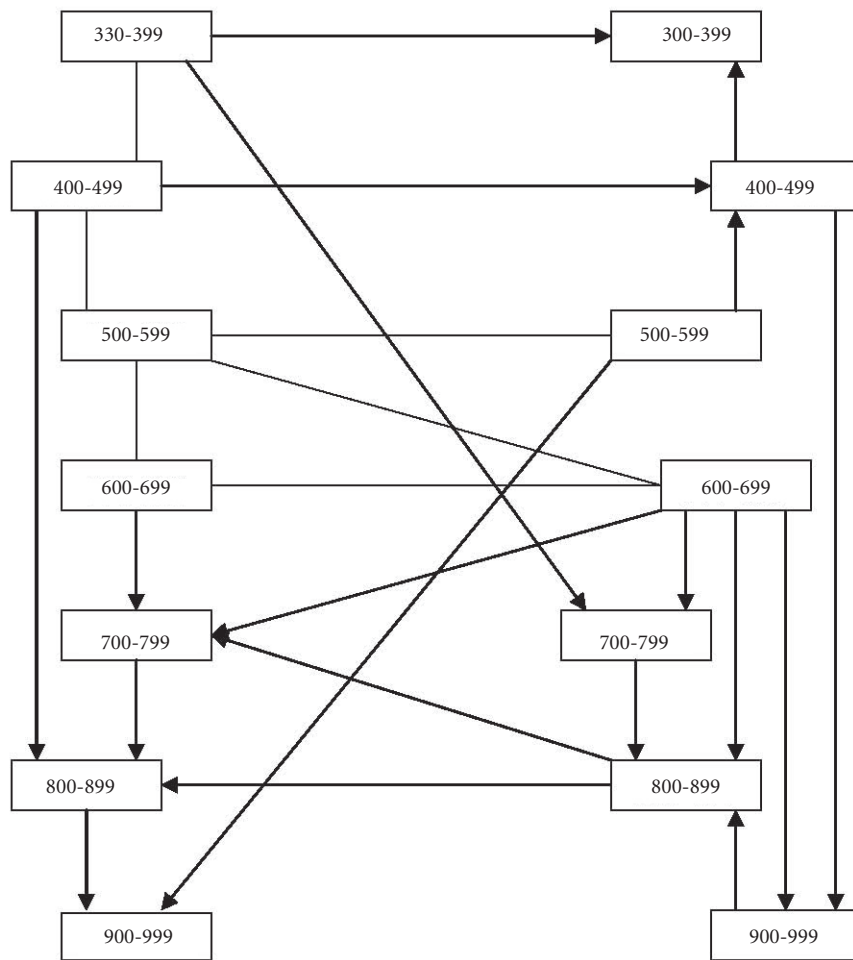


Figure 3. Pattern Found with GES Algorithm on Innovations from an Error Correction Model on Prices from Fourteen Feeder Cattle Market Classes, Weekly Data Aug. 6, 2003 - April 26, 2006.

Table 1. Means and standard deviations of heifer and steer prices by weight classes.

Market Class	Mean \$/CWT	Standard Deviation \$/CWT
Heifers		
300-399 lb	136.89	13.69
400-499 lb	126.75	11.41
500-599 lb	117.34	10.20
600-699 lb	109.61	9.39
700-799 lb	104.33	8.62
800-899 lb	99.80	8.65
900-999 lb	95.43	9.28
Steers		
300-399 lb	150.32	16.21
400-499 lb	138.41	13.27
500-599 lb	127.35	11.50
600-699 lb	118.05	10.32
700-799 lb	110.75	9.73
800-899 lb	105.48	9.24
900-999 lb	100.86	8.62

Note: Observed data are monthly average prices received in each market measured as *Dollars* per hundred pounds. Entries in the column labeled “Mean” refer to the simple mean price for the class listed in the far left-hand-most column of each row over the observation period August, 2003 through March, 2006. The columns headed by “Standard Deviation” give the standard deviation associated with observed prices from the class listed in the far left-hand-most column over the period listed in the row heading.

was causal. In Figure 4, the results from the VAR/ECM time-series analysis were used to direct some of the relationships in the DAG that the TETRAD IV program left undirected. These relationships are shown as heavy, dashed lines. Several generalizations from Figure 4 are noteworthy. First, no prices from weight/gender classes greater than or equal to 600 lb caused prices in classes less than 600 lb, while prices in classes less than 600 lb did cause prices in classes greater than 600 lb. Information of each weight/gender class price 600 lb or greater flowed to the next heavier weight class except information from 900-999 lb heifers which flowed to 800-899 lb heifers, which implied that information from the lighter classes of animals was being used in the discovery of price in the larger animals.

Another interesting note was prices for the cluster of steers weighing 700 lb or more did not cause any prices outside of this steer weight cluster. However the cluster of price classes of heifers weighing at least 500 lb or more were causal to heavy steers which made these heifers part of the price discovery of steers this size. This did not however hold for the light heifers. The prices of the two lightest weight steer classes caused the prices of the two lightest weight heifer classes. The prices of the two lightest weight heifer classes were also caused by the prices of heifers in the third lightest weight class 500-599 lb heifers. This could be interpreted that the two main factors that determined light heifer prices were heifers approaching breeding size and contemporary steers.

There were four unusual causal relationships that deserve note, two same sex causations and two cross sex relationships. The prices for both 400-499 steers and heifers caused prices of their respective sex in much heavier weight classes, 800-899 lb steer prices and 900-999 lb heifer prices respectively. The two extended cross sex effects were for the 300-399 steers which caused the price of 700-799 lb heifers and the 500-599 heifer prices

(Continued on next page)

which were causal to the price of 900-999 lb steers. Unfortunately three cross sex edges were left undirected, 600-699 lb heifers and steers, 600-699 lb heifers and 500-599 lb steers, and 500-599 lb heifers and steers making it impossible to determine conclusively whether heifer prices caused the prices in the other weight/gender classes. However, what is apparent from the graph was the 600-699 lb heifer price class has more edges and transfers more information than any other single weight/gender class. Ranked next was 800-899 lb heifers, with five edges, which made these heifers key in the determination of beef cattle prices.

Discussion

From casual observation and speaking with others involved in the feeder cattle market, one might assume that prices flow upstream with heavier BW steers and heifers leading the market and subsequent lighter BW animals following. However, this study suggests the opposite was true; prices for lighter BW steers were the market leaders and “caused” the prices of heavier BW cattle. It also suggests prices of middle and heavier BW heifers influenced the price of the heavier BW steers. The importance of heavier BW heifer prices was consistent with similar research conducted in Texas by David Bessler and Ernest Davis.

One possible explanation of why the light weight steer and middle weight heifer markets were so important in price discovery is because these are the points where new information enters the system. The question, “How many calves are available to be processed into beef,” is partially answered when calves are first

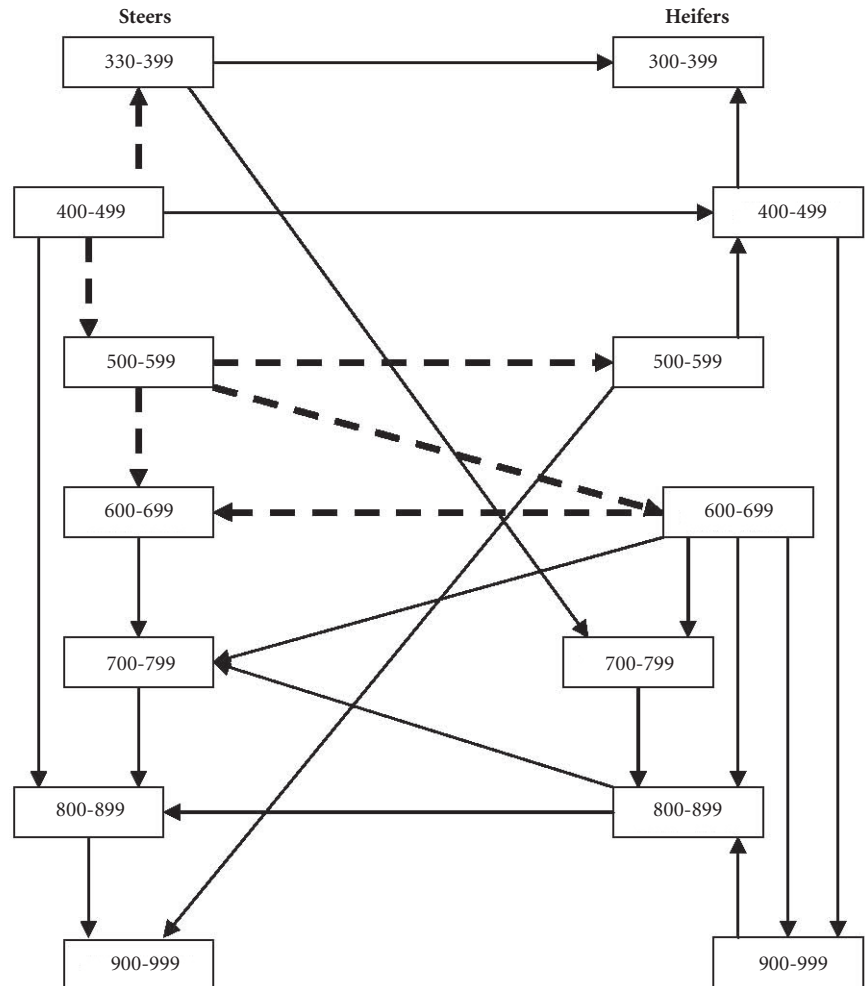


Figure 4. Added arrow direction to undirected edges by rank of the chi-squared test statistic critical values for exogeneity, to the Pattern Found with GES Algorithm on Innovations from an Error Correction Model on Prices from Fourteen Feeder Cattle Market Classes, Weekly Data Aug. 6, 2003 - April 26, 2006.

marketed. The prices paid for these calves affects the other markets as this information is dispersed through the system. The next critical point in the flow of information is how many heifer calves will be extracted from the system to be used in the breeding herd. This information becomes available when the middle weight heifers are sold and the information is transferred to the other heavier weight/gender classes.

These findings indicate that individuals interested in determining the direction of the market and the strength of the market would be best served to pay particular attention to the price of light weight steers and middle weight heifers.

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