Dominant-Satellite Relationships Between Live Cattle Cash and Futures Markets

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Considerable research exists in the area of price discovery in the beef complex. Most of the research has centered on temporal characteristics between cash prices at various levels of the marketing system and futures prices (see Purcell, Flood and Plaxico (1979), Weaver and Banerjee (1982), Oellerman and Farris (1985), and Hudson (1987)). The general conclusions of these studies are: that a high degree of interaction exists between prices, that the flows of information between the cash and futures markets are fairly rapid, and that the live cattle futures market performs an important price discovery function.

The spatial dimensions of the price discovery process in live cattle markets have received less attention (see Bailey and Brorsen (1985)). Examination of the extent to which prices at similar points in the marketing system reflect market information is important because it permits an assessment of the degree of market integration. Measurement of lead/lag relationships and identification of the most influential markets in the pricing process is also important because it may identify arbitrage opportunities and strategies to reduce risk. Further, examination of how price discovery has changed over time provides insight into the evolutionary nature of pricing mechanisms in agricultural markets (see Tomek (1983)).

The objective of this article is to determine the extent to which the spatial nature of the price discovery process has changed in the U.S. cattle slaughter market. The article identifies lead/lag relationships between major cash markets and between cash markets and the live cattle futures market. Dominant markets in the pricing discovery process are revealed using: lead/lag relationships, a strength of causality measure, and tests for sym-

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metry of feedback between markets. The use of the symmetry tests for strength of feedback relationships is important because previous research has noted a high degree of market interaction (see Purcell and Hudson (1985)). The linkages between price discovery and the changing structure of the U.S. cattle industry are examined through analysis of spatial prices over three time periods between 1973–84. The analysis focuses on four questions: (1) How have the spatial relationships and the relationship between the spatial cash market and futures prices changed over time?; (2) Are there subsets of live cattle markets that are most influential in the price discovery process?; (3) Have these subsets changed over time?; and (4) Are these pricing patterns related to changes in the industry?

THEORETICAL AND EMPIRICAL CONSIDERATIONS

The trading of similar commodities in different markets can arise because of positive transportation and communication costs. The degree to which these markets are interrelated depends largely on the costs of providing marketing services and the costs of information. At one extreme, prices in alternative markets may be independent when costs are sufficiently high to preclude almost all intermarket communication and speculation. A reduction in marketing costs and communication costs combined with efforts of arbitragers can reduce intermarket price differences, thereby integrating market prices across locations. In the limit, when costs are zero, prices should be identical across all markets. In equilibrium, a competitive marketing system with positive costs is characterized by price differences between markets over space consistent with the costs of marketing services. If price changes in one market are mirrored by price changes in other markets, the markets are perfectly integrated.

Introduction of new supply and demand information may disrupt a market equilibrium situation with reactions being directly related to the degree of market integration. In a perfectly integrated system, all markets assimilate new information at the same point in time and prices adjust simultaneously. If the markets are not perfectly integrated, one market may be more capable of registering the impacts of the new information. In such markets, the introduction of new information may result in price differences between markets which differ by more than the cost of marketing services for short time intervals. For example, due to the availability and cost of information, a futures market may gather and assimilate information more rapidly than other markets. Prices in secondary or localized markets without cost or informational advantages, will later mirror the price changes in the futures market.

Price differences in agricultural markets also can occur as markets perform their traditional role of guiding the flow of a product through the marketing system. Changes in the short-run supply and demand conditions can result in changing market signals, product flows, and a highly interactive situation. In this environment, markets which consistently lead others will likely be close to the center of market activities and hence reflect more closely the predominant changes in supply and demand conditions.[1]

The possiblity that one market leads others or is more influential in the price discovery process gives rise to a classification of dominant and satellite markets (see Garbade and Silber (1979)). Dominant markets are the closest to important activities and have the ability to assimilate information quickly; they are preeminent in the price discovery process and make little use of prices formulated elsewhere. Conversely, satellite markets

[1]As pointed out by a reviewer, price differentials can occur for a myriad of reasons. Focus here is on information assembly and price transmission which, in terms of the functions that these markets perform, are likely the most important.

rely on dominant markets as the primary source of information (lagging dominant markets and having limited influence on prices in dominant markets). Markets can also share information through a feedback process which may be either asymmetric or symmetric. Asymmetric feedback exists where market X follows changes in market Y closely, while having only a slight influence in the prices in market Y; here market Y tends to weakly dominate market X in the price discovery process. Symmetric feedback exists where the influence of price changes in market X on market Y is equivalent to the influence of market Y on market X; the two markets are of equal importance in the price discovery process.

The Granger causality method is used below to identify dominant-satellite relationships. This approach is well suited for the study of price discovery in agricultural commodities (see Bessler and Schrader (1980) and Bessler and Brandt (1982)). The initial focus is in establishing a temporal ordering of markets in price discovery. Dominant markets which are better able to interpret changes in information will lead price changes in satellite markets. Where lagged feedback exists, strength of causality measures and tests of their significance (both described below) are generated to clarify the feedback process.

Causality tests and strength measures are generated using an in-sample approach suggested by Geweke (1984), Tjosthiem (1981), and Hsiao (1982) and widely used in the literature (see Bessler and Brandt (1982), Geweke (1982) and Oellerman and Farris (1985)). In the strictest sense, the definition of Granger causality involves demonstrating improvement in out-of-sample forecast performance. However, the procedure used here has been shown to be a powerful approach in indentifying lead/lag relationships (see Guilkey and Salemi (1982), Geweke, Meese, and Dent (1983), Nelson and Schwert (1982), and Zapata, Hudson, and Garcia (1988)). Also, with appropriate model specification, the results of in- and out-of-sample procedures should differ only in the presence of structural change. Here, the changing nature of the price discovery process is assessed by selecting relatively homogenous periods for analysis and permitting the possibility of structural change through examining the dynamic relationships over time.

The tests and measures below are based on two specifications of the relevant time series. There are two series of interest, x_t and y_t, which are wide sense stationary. The first representation of the two series is purely autoregressive:

$$x_t = \sum_{s=1}^{p} D_{1s} x_{t-s} + u_{1t} \ \mathrm{var}(u_{1t}) = \sigma_1 \tag{1}$$

$$y_t = \sum_{s=1}^{p} F_{1s} y_{t-s} + v_{1t} \ \mathrm{var}(v_{1t}) = \omega_1. \tag{2}$$

The disturbance terms u_{1t} and v_{1t} are one-step-ahead errors when x_t and y_t are explained by their own past. The disturbance terms are each serially uncorrelated but may be contemporaneously correlated.

The second representation of the two series of a vector autoregression:

$$x_t = \sum_{s=1}^{p} D_{2s} x_{t-s} + \sum_{s=1}^{p} E_{2s} y_{t-s} + u_{2t} \ \mathrm{var}(u_{2t}) = \sigma_2 \tag{3}$$

$$y_t = \sum_{s=1}^{p} F_{2s} y_{t-s} + \sum_{s=1}^{p} G_{2s} x_{t-s} + v_{2t} \ \mathrm{var}(v_{2t}) = \omega_2. \tag{4}$$

These disturbance terms have similar properties as the pure autoregressive models with the covariance matrix defined as:

$$\Upsilon = \text{var}\begin{pmatrix} u_{2t} \\ v_{2t} \end{pmatrix} = \begin{bmatrix} \sigma_2 & \rho \\ \rho & \omega_2 \end{bmatrix}. \tag{5}$$

Based on these representations, Geweke (1982) defines three measures which represent the linear dependence between two series.

$$P_{y \to x} = \ln(\sigma_1/\sigma_2) \tag{6}$$

$$P_{x \to y} = \ln(\omega_1/\omega_2) \tag{7}$$

and

$$P_{x \cdot y} = \ln(\sigma_2 \cdot \omega_2 / |\Upsilon|). \tag{8}$$

Expressions (6) and (7) measure the strength of the linear causality from y to x and x to y, respectively. The instantaneous association between the series is measured by (8).[2] These strength measures equal zero if there are no causal flows and increase in magnitude as the causal flow becomes stonger. Interpretation of the strength measures is facilitated via a monotonic transformation of P proposed by Pierce (1982),

$$S = 1 - \exp(-P). \tag{9}$$

S, analogous to improvement in R^2 from a linear model, measures the percentage of the variation in the dependent series which is explained by introducing the exogenous series.

All parameters in eqs. (1)–(7) are estimated by maximum likelihood methods under the assumption the error terms are distributed normally. In this framework, large sample χ^2 tests can be conducted to ascertain the significance of the P-measures (see Geweke (1982)). These are analogs to the conventional small sample F-tests used to ascertain the significance of the reduction in error variance when exogenous variables are included. Where feedback relationships exist, a large sample test for symmetry of feedback can be conducted. If $P_{x \to y} = P_{y \to x}$, the asymptotic distribution of δ, defined as:

$$\delta = [nP_{x \to y}{*} - (p - 1)/3]^{1/2} - [nP_{y \to x}{*} - (p - 1)/3]^{1/2} \tag{10}$$

approximates a normal (0,2) where n is the number of observations in the sample, p is the dimension of the model, and the asterisks denote maximum likelihood estimates of the strength measures (6) and (7). The normal (0,2) distribution results from Sankaran's (1963) approximation of the noncentral chi-squared distribution which is necessary to permit the alternative hypothesis to include one-way causal flows (see Geweke (1982)).

The analysis that follows uses the more easily interpreted S measures, the results of the small sample F-tests of causality, and where feedback is present, the large sample tests of symmetry (δ).[3] If markets (X and Y) are highly integrated, there should be no leads/lags because all information is incorporated within the sampling interval (i.e., no significant lagged exogenous coefficients and significant instantaneous association). Where there is no association or causality between market prices in X and Y, the markets are independent. Where market X leads market Y, X is considered more dominant in the pricing process. Similarly, where lagged feedback exists but the symmetry test indicates

[2]The instantaneous measure of association merely measures concurrent association between two series. While it does not provide direct information about the lead/lag relationships between prices, its presence does suggest that markets are related within the temporal unit of observation.

[3]Findings of the more powerful small sample statistics are reported where possible: hence, the F-tests instead of the $\chi^2 s$. No small sample analog to δ currently exists.

the influence from X to Y is stronger, market X is viewed again as more dominant but in a weaker form. When lagged feedback is symmetric, the markets play an equivalent role in the pricing process and there no dominant-satellite relationship is suggested.

DATA

An important step in identifying lead/lag relationships between series involves the appropriate temporal specification of the unit of observation. Weekly prices are used here. Trading activity in many of these markets occurs on the first days of the week (e.g., Monday, Tuesday, and Wednesday). Weekly average prices therefore primarily reflect these early week activities. Also, the research on the spatial integration of livestock markets has focused on weekly prices (see Bailey and Brorsen (1985)). In a stochastic environment where uncertainty exists regarding the cause and duration of changing prices, firms may be reluctant to transport their cattle to alternative markets unless profitable marketing opportunities (as signaled by prices) persist over time. This uncertainty combined with the spatial nature of the analysis and the geographic separation of the markets which makes it physically impossible to move cattle between alternative markets within short periods of time suggests a weekly sampling interval to reflect the market environment.[4]

The data consist of weekly prices for fed cattle from January 1973 to December 1984. The cash prices represent the primary markets for cattle and markets on the fringes of the primary feeding areas.[5] Four terminal markets Omaha, Nebraska; Sioux City, Iowa; Greeley, Colorado; and Peoria, Illinois (referred to by the city name) are examined. Four direct market quotes are also used: Central Iowa; Nebraska District; Amarillo, Texas; and Illinois Direct (referred to by name of the state in which they are located). The terminal prices are arrived at by auction while the direct market quotes reflect prices for negotiated sales in each geographic area.[6]

Two truncated nearby CME live cattle futures contract prices are used in analysis.[7] One is a weekly average and the other is an early week average price. Two prices are used because cash cattle markets are early week markets with limited trade on Thursday and Friday; whereas, futures contracts are traded each day. Comparing weekly averages of futures prices and cash prices gives the futures market an implicit informational advantage since the weekly average futures price contains two extra days of information. Hence, an early week futures price series (a three day average, Monday–Wednesday) is used so that more informationally equivalent prices can be compared. The weekly average futures price also is examined to determine the role the futures market plays in price discovery when cash markets are inactive.

To examine structural influences on price discovery, the time period is divided into three subperiods: 1973 through 1976, 1977 through 1980, and 1981 through 1984. The overall time period was selected because it is sufficiently long to capture gradual evolu-

[4]Clearly, the inferences of the analysis are conditional on the temporal unit of observation.

[5]All cash prices are for choice yield-grade 3 steers (900–1100 lbs.) and are taken from the USDA Market News LS-214 forms.

[6]The decline in the importance (decreasing trade volume) of terminal markets has been widely discussed. The markets selected for analysis provide a cross-section of markets based on the relative volumes of steers slaughtered in the respective states and the perceived importance of the markets historically and today. Significant increases in the volume of direct trading in recent years have precipitated significant declines in trading volume for terminal markets, suggesting a less important role for these markets in price discovery. For further information on volumes of trade and changes in market composition and volumes (see Ward (1987)).

[7]The futures price series is made up of closing differenced prices of the contract nearest to delivery, prior to that contract's delivery month, and rolls to the next contract upon the entry into a delivery month.

tionary changes in the industry. The first subperiod reveals the price discovery process which persisted in the early 1970s through the herd liquidation of that period. By the beginning of the second subperiod the movement of cattle feeding to the highplains and the establishment of large boxed beef packing plants were complete. The second and third subperiods provide a perspective on price discovery during the recent industry evolution. In particular, across these two subperiods the volume sold in terminal markets has declined while direct buying and packer concentration have increased (see Ward (1987)). The periods do not represent mutually exclusive regimes but rather are used to capture the flavor of the changing market structure.[8]

EMPIRICAL RESULTS

All series were first-differenced to remove trends and facilitate examination of how price changes in one market are reflected in price changes in other markets (see Hudson (1987)). Prior to specification of the models, the series were examined and found to be covariance stationary. Bivariate models were fitted with a lag structure of two weeks ($p = 2$) and estimated via ordinary least squares. All estimates of error variance and covariance where calculated via maximum likelihood. Several information criteria were used to examine the lag structure for the models under consideration, including Schwarz's Bayesian Information Criterion, Akaike's (1974) Information Criterion, and Akaike's (1969) Final Prediction Error. This optimization was carried out for each time period. The consensus of the techniques suggested the VAR(2) specification as optimal. Q-statistics (Box-Ljung) for the error structures of the models revealed no significant serial correlation in the estimated models.

Conceptually, a complete multivariate representation of the market interactions would provide the richest framework for assessing the set of market relationships. The procedures and tests described above generalize to a multivariate setting. However, given the large number of markets examined, a complete representation is subject to severe collinearity difficulties often encountered in VARs. One procedure for mitigating the problem involves reducing the number of markets considered. The bivariate framework used here reflects a reluctance to specify *a priori* the most important markets in the pricing process over time and space. Rather the direction and strength of the bivariate relationships are compared with the changing structure of the industry to provide insight into the pricing process. Examination of several selected multivariate models which segmented the markets geographically provided qualitatively similar findings to the results presented below.

Consistent with previous research which identified a high degree of market interaction using weekly prices, the instantaneous association measures for all markets in all periods were significant.[9] As expected, there were no independent markets as strong information flows between markets within the week existed for all time periods.

Tables I and II provide information regarding lead/lag relationships and strength of lagged information flows. Specifically, Table I presents the strength of lagged flows for each of three time periods; asterisks indicate the level of significance of the small

[8]The three periods provide a cross section from which to draw inferences about patterns in price discovery while maintaining enough observations in each period to be confident in the time series results. The findings of the work are robust to moderate changes in the definition of the time periods. Two alternative specifications of the data, 6 months prior to and 6 months after the breaks reported herein, were used. The conclusions drawn with these alternative specifications were similar to those reported.

[9]The measures for instantaneous association were significant at the 0.01 percent level. They are not reported for purposes of brevity but can be obtained from the authors.

sample F-tests measuring the effects of lagged prices in one market on the other. For example, consider during the first period the relationship between the Omaha and Greeley markets. Lagged Omaha prices explain slightly more than 21 percent of the variation in the Greeley series. Not surprisingly, this is associated with a significant F-statistic of the lagged coefficients of the Omaha series in the Greeley equation. For the same period, lagged Greeley prices have a small and insignificant effect on the Omaha market, explaining only 1.6 percent of the variation in Omaha prices.

Table II provides an indication of the dominant markets based on lead/lags and calculations of δ which test for symmetry of information flow when lagged feedback exists. A market dominates another if it leads the other in the pricing process. Similarly, when lagged feedback is present, a dominant market relationship exists if lagged information flows are stronger in one direction as measured by the test for symmetry, δ. In the example above, the Omaha market leads and hence dominates the Greeley market in the first period. Next, consider the Nebraska and Greeley markets during the second period where lagged feedback exists. Here, the strength measures [S (Nebraska→Greeley, 23.93 percent), S (Greeley→Nebraska, 5.86 percent)] and the test for symmetry ($\delta = 4.03$) indicate that, although feedback is present, the information flows are significantly stronger from Nebraska to the Greeley market; the Nebraska market is dominant.

The results indicate that the dominant-satellite market relationships for the direct and terminal cash markets change over time. During the first period, two terminal markets (Omaha and Sioux City) and the Nebraska direct market are very influential in price discovery, with the Omaha market being dominant. The Texas market appears to dominate the Peoria, Greeley, and Illinois markets which are satellite markets in the price discovery process.

During the last two periods, the terminal markets lose importance in the pricing process. The Nebraska, Iowa, and Texas direct markets assume the dominant positions with Nebraska being the most influential. These three markets highly influence prices in all terminal markets. The Illinois direct market is dominated by the three other direct markets while its relationship with the terminal markets changes. Illinois dominates the terminal markets during the second period but during the last period is more interactive. In the last two periods, among the terminal markets, Greeley and Sioux City are the most influential. The influence of Omaha has steadily waned while the Peoria market had only a limited effect on prices in other markets throughout the study period.

The findings in the cash markets parallel the changes that have occurred in the cattle industry. In general, the higher volume markets and markets associated with preferred (direct) selling arrangments have assumed more importance in the price discovery process. In the first period, terminal markets which handled a large percentage of the cattle sold, played an important role in pricing. During the last two periods, with shifts in cattle feeding to the southwest and central highplains regions, a movement to larger feedlots, a localization of the packing industry in the producing areas, the terminal markets have become satellites; the seat of price discovery has shifted to the direct markets.

The relationship between the cash and futures markets further refines our understanding of the pricing process. The weekly average futures prices dominates all other markets in all time periods. Some lagged feedback exists between the smaller, less active cash markets but this effect is overwhelmed by the information flow from the futures market. The interactions of the early week futures prices and the cash price series are somewhat more subtle.

In the 1973–76 period, the early week average futures leads all cash markets, except the Omaha and Nebraska where symmetric feedback exists. During the second period, the early week futures leads Illinois and all terminal markets. However, Nebraska, Iowa,

TABLE I
PIERCE STRENGTH MEASURES (S) BETWEEN CATTLE PRICES, 1973–76, 1977–80, 1981–84

		Direct Markets				Terminal Markets				Futures	
		Texas	Nebraska	Iowa	Illinois	Greeley	Omaha	Sioux	Peoria	Early	Average
Texas	1[a]		.15[b]	4.35*	4.40*	8.66*	1.81	1.88	6.62*	.76	4.60*
	2		1.43	3.79*	4.25*	18.31*	17.38*	19.50*	15.35*	2.91**	1.01
	3		1.70	.01	5.72*	5.94*	11.22*	7.34*	10.39*	1.90	2.92*
Nebraska	1	15.18*		16.96*	20.90*	32.22*	2.12	11.70*	24.02*	4.33*	1.40
	2	9.99*		5.48*	14.20*	23.93*	31.92*	28.13*	26.20*	4.54*	.00
	3	7.08*		4.11*	16.26*	11.52*	22.42*	17.45*	20.91*	3.94*	.27
Iowa	1	2.76**	.86		4.61*	8.79*	.81	.69	13.95*	1.51	5.12*
	2	3.23*	.54		11.80*	12.69*	25.54*	24.52*	24.54*	3.63*	.04
	3	4.49*	1.47		20.49*	10.01*	25.33*	19.26*	19.95*	3.38*	.68
Illinois	1	2.32**	1.79	.39		8.57*	1.60	.31	8.23*	1.46	4.10*
	2	.72	1.26	1.30		2.11	6.47*	9.20*	12.23*	1.10	.61
	3	1.78	1.69	3.24*		.53	6.03*	2.82**	9.26*	.78	1.99
Greeley	1	1.05	1.53	2.16	2.94**		1.61	1.77	3.62*	1.30	6.32*
	2	2.31**	5.86*	3.72*	.34		1.99**	5.33*	5.37*	.97	2.60**
	3	.03	1.81	1.27	3.45*		9.50*	4.52*	8.03*	.70	1.52

Omaha	1	11.64*	5.14*	18.02*	19.52*	21.26*		11.13*	27.30*	2.90**	.08
	2	3.78*	6.13*	5.69*	.15	.55		2.48**	5.28*	.21	2.90*
	3	4.55*	5.68*	9.00*	.99	3.46*		.36	2.41**	.32	4.29*
Sioux	1	5.32*	.33	4.92*	9.82*	12.88*	1.93		14.36*	.73	5.05*
	2	5.32*	8.12*	7.49*	1.27	.23	.17		3.87*	.59	3.76*
	3	1.75	6.23*	5.02*	3.25*	1.02	5.17*		5.57*	.20	3.31*
Peoria	1	.71	3.54*	2.77*	1.16	.82	1.61	1.87		1.15	5.31*
	2	2.93*	4.17*	3.75*	.71	.72	.16	.49		.59	4.40*
	3	2.65**	6.05*	3.98*	2.97*	1.90	.35	.00		.36	2.68**
Early	1	6.62*	2.44**	5.24*	5.06*	10.03*	3.25*	2.88**	10.62*		
Futures	2	2.14	2.05	2.24	6.89*	9.24*	13.53*	13.76*	13.51*		
	3	1.24	.30	.61	2.99*	3.12*	3.20*	3.65*	4.93*		
Average	1	24.99*	14.55*	20.16*	21.71*	31.78*	12.06*	20.31*	28.41*		
Futures	2	19.99*	15.52*	16.81*	27.10*	29.43*	33.52*	33.76*	35.45*		
	3	14.98*	5.34*	9.93*	15.58*	18.91*	17.83*	20.01*	20.24*		

[a]The numbers in this column refer to the first (1973–76), second (1977–80), and third (1981–84) time periods.

[b]The numbers reflect the bivariate modeling of the series and represent the percent of the variation in prices from a given market (column) explained by including the lagged values of prices from another market (row). The asterisks indicate the level of significance (*, =, .05; **, = .10) of the *F*-test for the null hypotheses that the effect of the lagged exogenous variable is equal to zero.

Table II
DOMINANT CATTLE MARKET RELATIONSHIPS, 1973–76, 1977–80, 1981–84

		Direct Markets			Terminal Markets				Futures	
		Nebraska	Iowa	Illinois	Greeley	Omaha	Sioux	Peoria	Early	Average
Texas	1[a]	←--[b]	←--→ (.64)	←--→ (.87)	--→	←--	←--	--→	←--	←-- (−4.63*)
	2	←--	←--→ (.23)	--→	--→ (4.34*)	--→ (3.51*)	--→ (3.38*)	--→ (3.45*)	--→	←--
	3	←--	←--	--→	--→	←--→ (1.89)	--→	--→ (2.46**)	---	←-- (−3.38*)
Nebraska	1		--→	--→	--→	←--	--→	--→ (4.86*)	←--→ (.79)	←--
	2		--→	--→	--→ (4.03*)	--→ (5.35*)	--→ (4.12*)	--→ (5.02*)	--→	←--
	3		--→	--→	--→	--→ (3.81*)	--→ (2.68**)	--→ (3.41*)	--→	←--
Iowa	1			--→	--→	←--	--→	--→ (3.21*)	←--	←-- (−4.08*)
	2			--→	--→ (4.03*)	--→ (5.35*)	--→ (4.12*)	--→ (4.88*)	--→	←--
	3			--→ (4.34*)	--→	--→ (3.81*)	--→ (2.68**)	--→ (3.94*)	--→	←--
Illinois	1				←--→ (1.86)	←--	←--	--→	←--	←-- (−4.22*)
	2				---	--→	--→ (−.19)	--→ (2.03)	←--	←--
	3				←--	--→			←--	←--

Greeley	1	←---	←---	---→	←---	←--- (−5.26*)
	2	---→	---→	---→	←---	←--- (−6.24*)
	3	---→	---→	---→	←---	←---
Omaha	1		---→	---→	←---→ (−.15)	←---
	2		←---	---→	←---	←--- (−6.81*)
	3		←---	---→	←---	←--- (−3.41*)
Sioux	1			---→	←---	←--- (−3.62*)
	2			---→	←---	←--- (−6.49*)
	3			---→	←---	←--- (−4.22*)
Peoria	1				←---	←--- (−4.99*)
	2				←---	←--- (−6.54*)
	3				←---	←--- (−4.54*)

[a]The numbers in this column refer to the first (1973–76), second (1977–80), and third (1981–84) time periods.

[b]The arrows indicate the direction of dominant market relationships based on the bivariate analyses. The arrow ---→ alone represents a significant leading relationship from a given market (row) to a particular market (column). The arrow ←--- alone represents a significant leading relationship from a given market (column) to another market (row). --- denotes no significant lagged feedback. Parenthesis under arrows indicate initial lagged feedback. In these cases, the results of the symmetry test of the strength of information flows appear in the parentheses and determine the direction of the arrows. The asterisks indicate the level of significance consistent with Table I.

and Texas direct markets lead the early week futures series.[10] Note the strength measures between the early week futures and these markets are similar in magnitude, the symmetry tests (δ = 1.06, 0.62, and 0.37, respectively) indicate that it was not possible to reject the hypothesis of equal information flows between the markets in this period. During the last period, a somewhat similar pattern emerges. The early week futures dominates most of the cash markets, except Texas where no feedback exists and Nebraska and Iowa which lead the early week futures. Here, the strength measures and the symmetry test (δ = 2.30 significant at the 94.7% level) for Nebraska suggests that it is assuming a leading role in the price discovery process, nearly dominating an informationally equivalent futures price.

On balance, the seat of price discovery within the U.S. live cattle market appears to be in the direct cash markets, with the Nebraska market assuming the most important role. Over time, terminal markets have had much less influence in the process. The futures market plays an important, albeit somewhat reduced, function in price discovery. The findings suggest, especially in the later period, that the futures market is influenced by the Nebraska direct market which appears to dominate the early week price discovery process. However, the results of the whole week futures average emphasize that the futures market remains a viable price discovery force, particularly when the cash markets are inactive.[11]

SUMMARY AND IMPLICATIONS

The results presented here suggest that the relationships between terminal, direct and live cattle futures markets in the price discovery process have evolved over time to reflect changes in the cattle feeding industry. As the importance of direct selling has increased, so has the influence of direct prices. Also there has been a decline in the influence of terminal markets corresponding to the declines in volume moving through these outlets.

An observation supported by these results is that the cash markets have decreased their reliance on the futures market as an overall price discovery mechanism. However, the futures market is relied upon to register information which emerges late in the week which is reflected in the cash markets the following week.

The main finding of this study is that the price discovery process is dynamic and is dependent upon the structure of, and relationships among, the underlying markets. Futher, the emergence of a dominant market or a set of dominant markets with similar characteristics suggests that the prices discovered in these markets may be subject to shortcomings in the market structure. For example, in the last time period Nebraska emerges as the dominant market followed by several other direct market quotes. Terminal markets no longer appear to offer meaningful alternative reference prices. Hence, the effects of increased concentration in meatpacking and the emergence of power should remain important issues. Also, the issue of what types of information are reflected more efficiently by direct markets or by futures markets should be reexamined in a dynamic price determination framework.

[10]In general, the symmetry tests which examine the null hypotheses that the lagged feedback effects are equal, provide a consistent interpretation of the price relationships discussed here.

[11]It should be noted that the weekly average futures price implicitly includes additional information which cannot be registered by the early week cash markets. Therefore, this result suggests that the futures market is relied upon to register new information when the cash markets are not trading and that the cash market incorporates the information during the next trading period. Hence, an interactive environment exists between the cash and futures markets.

The results also have implications for the overall effectiveness of the evolving system in discovering the equilibrium prices. If the packing industry continues to become more concentrated and futures prices continue to exhibit an influence on all cash market prices, additional concern is likely to emerge over the representativeness of futures and direct market prices. In this environment, it becomes increasingly more important to detail the effects of heightened concentration in the meat packing industry on price discovery and efficiency in these markets. Such work needs to examine the relationships between the number and size of market participants in local markets and the size and ability of margins to reflect changing economic conditions. This will permit a more detailed and complete examination of the consequences of monopsony power in these important markets.

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