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A Note on Exogeneity and Endogeneity of Prices in Selected Cattle Markets

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A Note on Exogeneity and Endogeneity of Prices in Selected Cattle Markets.

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A Note on Exogeneity and Endogeneity of Prices in Selected Cattle Markets.

Abstract

Lead/lag relationships were identified for six cattle classes using Cattle-Fax data, for twelve markets. The relationships were either endogeneity/endogeneity (feedback), endogeneity/exogeneity (unidirectional), and exogeneity/exogeneity (no causality) relationships. Feedback relationships were the most common, while only one case of no causality was identified. The long-run equilibrium was mainly driven by prices with a feedback relationship with all or most of the prices. Generally, markets with large cattle numbers led the others, and had more influence on the long-run equilibrium with a few exceptions.

Key words: Exogeneity, endogeneity, price equilibria, cattle

Introduction

Prices play a major role in balancing trade, especially in spatially separated markets. The relationships of prices between spatial markets have serious implications for market performance. Improper price transmission, coupled with other market failures, can lead to scarcity in some regions and surpluses in others. The importance of price information in spatially separated commodity markets increases as spatial trade increases both domestically and internationally.

The question of spatial markets and price transmission between spatially separated markets has been the subject of several studies including Blyn (1973), Roll (1979), Monke and Petzel (1984), Ravallion (1986), Stock and Watson (1988), Blank and Schmiesing (1988), Ardeni (1989), Faminow and Benson (1990), Ellis et al (1991), Baffes (1991), Goodwin and Schroeder (1991), Goodwin (1992), Mundlak and Larson (1992), William and Bewley (1993), Gardner (1994), Alexander and Wyeth (1994), and McNew (1996). The primary focus of these studies has mainly been the existence of market integration and/or the law of one price and related issues. It is generally accepted that two or more markets are integrated if a long-run equilibrium exists in the sense that the prices in these markets are “tied together” and cannot drift from each indefinitely. A model based on such prices will always attain this long-run equilibrium and can thus be used to predict the individual prices included in the system.

However, such a long-run equilibrium could be driven equally by all prices or more by some prices than others—raising the question of exogeneity and endogeneity of the individual elements that make up an integrated system. Muwanga and Snyder (1997a, 1997b) reported that cattle prices of selected western and central states of America were integrated basing on cointegration, correlation and causality approaches. It is the objective of this study to identify which of those prices are exogenous and which are endogenous to the system of integrated prices.

Theoretical Model

The Granger-causality model described below measures the precedence and information content in the independent variable for purposes of predicting the dependent variable, but not the "effect or cause" of the independent variable as would be the case if the error correction Granger-causality model was applied (Granger 1969; Ravallion 1986; Alexander and Wyeth 1994).

Bivariate Granger-causality investigates the question whether a scalar x_t is useful in forecasting another scalar y_t or put differently, whether a scalar, x_t, has explanatory power in a regression of a variable y_t on lagged values of y_t and x_t (Greene 1990). Specifically, x_t Granger-causes y_t if for s > 0, the mean square error (MSE) of a forecast of y_{t+s} based on $(y_t, y_{t-1}, \ldots)$ is less than the mean square error of a forecast of y_{t+s} based on both $(y_t, y_{t-1}, \ldots)$ and $(x_t, x_{t-1}, \ldots)$. For linear functions, x_t Granger-causes y_t if

$$(1) \qquad MSE\ [\hat{E}(y_{t+s}|y_t, y_{t-1}, \ldots)] > MSE\ [\hat{E}(y_{t+s}|y_t, y_{t-1}, \ldots, x_t, x_{t-1}, \ldots)]$$

If the alternative specification is also true, i.e., y_t Granger-causes x_t, then a feedback relationship exists. On the other hand, if x_t fails to Granger-cause y_t, then the MSE of a forecast of y_{t+s} based on lagged values of y_t is less than or equal to the MSE of a forecast of y_{t+s} based on lagged values of both y_t and x_t. In this case, y_t is said to be exogenous in a time series sense with respect to x_t or, equivalently, x_t is not linearly informative about future values of y_t. To implement the test, the autoregressive specification of Granger-causality is estimated assuming a p^{th} order autoregressive model using OLS, (Hamilton 1994).

(2) $$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \ldots + \alpha_P y_{t-p} + \beta_1 x_{t-1} + \beta_2 x_{t-2} + \ldots + \beta_p x_{t-p} + \upsilon_t.$$

An F-test is then conducted on the null hypothesis of lack of Granger-causality (H_o: $\beta_1 = \beta_2 = \ldots = \beta_p = 0$) against the alternative of the existence of Granger-causality (H_1: $\beta_1 \neq \beta_2 \neq \ldots \neq \beta_p \neq 0$). The F-test is implemented by calculating the sum of squared residuals (RSS_1) from equation (2) and comparing it with the sum of the squared residuals (RSS_0) of a univariate autoregressive model, which constitutes the restricted model for the F-test, i.e.,

(3) $$y_t = \alpha_0 + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \ldots + \alpha_P y_{t-p}$$

If the F statistic is greater than the 5% critical value for an $F(p, T\text{-}np\text{-}1)$ distribution, the null hypothesis is rejected, implying that x Granger-causes y.

Data

The data used for this study were average weekly cattle price series from Cattle-Fax. The study was limited to cattle sold in the nineteen states, covering twelve markets. Each individual region included one to three states as specified by Cattle-Fax, i.e., Washington/ Oregon/Idaho (WOI), Montana/Wyoming (MW), California (CA), Nevada/Utah (NU), Arizona/New Mexico (ANM), Colorado (CO), Iowa (IO), Kansas/Missouri (KM), North/ South Dakota (NSD), Nebraska (NE), Oklahoma (OK), and Texas (TX). For purposes of this study, the data were transformed by computing the simple arithmetic mean of the lower and upper price series for each region. Six cattle classes were selected, i.e., utility slaughter cows, 800-, 600-, and 400-pound feeder steers, and 700- and 400-pound feeder heifers.

Results

Granger-causality tests were performed on the feeder cattle data as described in the model outlined above. There were three possible outcomes, i.e., bidirectional causality (feedback), unidirectional causality and lack of causality. Unidirectional causality indicates an exogeneity/endogeneity relationship whereby one of the elements (x) is exogenous while the other (y), is endogenous to the bivariate system—implying that y is endogenous to x while x is exogenous to y. A feedback relationship indicates an endogeneity/endogeneity relationship implying that both the elements of the bivariate system are endogenous to each other. Lack of causality indicates an exogeneity/exogeneity relationship whereby both elements of the system are exogenous to each other.

The F-test was used to test for Granger-causality in all cases. All the price series had a trend but were all cointegrated within each class, Muwanga and Snyder (1997a, 1997b). As a result, the tests were performed on the price levels rather than the differences. There was no need to detrend the series because the trend is adjusted for in the long-run equilibrium relationship. More specific results are presented in tables 1 through 6, inclusive. Two asterisks imply bidirectional causality (feedback relationship) existed, whereby prices in market *a* had predictive power for prices in market *b* at the 5% level of significance, and vice versa. The letter "*a*" implies that unidirection causality existed whereby prices in market *a* had predictive power for prices in market *b* but prices in market *b* did not have predictive power for prices in market *a* at the 5% level of significance. The letter "*b*" implies that unidirectional causality existed whereby prices in market *b* had predictive power for prices in market *a* but prices in market *a* did not have predictive power for prices in market *a* at the 5% level of significance.

Utility Slaughter Cows

T.1

Exogeneity/endogeneity occurred for 25.8% of the pairs, a feedback occurred for 72.7% of the pairs, while exogeneity/exogeneity occurred for 1.5% of the pairs (table 1). Prices in Colorado were endogenous to prices in Montana/Wyoming, Arizona/New Mexico, Iowa, Kansas/Missouri, North/South Dakota and Nebraska. Prices in Nebraska and Oklahoma were endogenous to prices in Kansas/Missouri and North/South Dakota while prices in Washington/Oregon/Idaho were endogenous to prices in Arizona/New Mexico and Kansas/Missouri.

Prices in California and Montana/Wyoming were endogenous to prices in Arizona/New Mexico while prices in Iowa, Nevada/Utah and North/South Dakota were endogenous to prices in Kansas/Missouri. Prices in Oklahoma and Nebraska were exogenous to each other. A feedback relationship existed for all the other pairs. Prices in Texas had a feedback relationship with prices from all regions. Prices in Texas, Arizona/New Mexico and Kansas/Missouri were the major determinants of the long-run equilibrium.

800-Pound Steers

Exogeneity/endogeneity occurred for 51.5% of the pairs, while a feedback relationship occurred for 48.5% of the pairs (table 2). Prices in Nevada/Utah were endogenous to prices in all regions, while those in Washington/Oregon/Idaho were endogenous to prices in all regions except California, Iowa and Nevada/Utah. Prices in California were endogenous to prices in Arizona/New Mexico, Kansas/Missouri, North/South Dakota, and Oklahoma, while those in Arizona/New Mexico were endogenous to prices in Montana/Wyoming, Colorado, Kansas/Missouri, and North/South Dakota.

Prices in Iowa were endogenous to prices in Kansas/Missouri, North/South Dakota, Nebraska, and Oklahoma, while those in Nebraska were endogenous to prices in North/South Dakota and Oklahoma. Prices in Montana/Wyoming were endogenous to those in Colorado. All the other pairs had a feedback relationship. Prices in Texas had a feedback relationship with prices in all regions except Washington/Oregon/Idaho and Nevada/Utah. Prices in Colorado, Kansas/Missouri, North/South Dakota, Oklahoma, and Texas were identified as the major determinants of the long-run equilibrium.

600-Pound Steers

Exogeneity/endogeneity occurred for 21% of the pairs while a feedback relationship existed for 78.8% of the pairs (table 3). Prices in Nevada/Utah were found to be endogenous to prices in Washington/Oregon/Idaho, Montana/Wyoming, Arizona/New Mexico, Colorado, North/South Dakota, and Nebraska, while those in California were endogenous to prices in Arizona/New Mexico, North/South Dakota, and Nebraska.

Prices in North/South Dakota were identified as endogenous to prices in Kansas/Missouri and Oklahoma, while those in Colorado and Nebraska were endogenous to prices in Montana/Wyoming and North/South Dakota, respectively. All the other pairs had a feedback relationship. Prices in Texas and Iowa had a feedback relationship with prices in all regions. Prices in Washington/Oregon/Idaho, Montana/Wyoming, Arizona/New Mexico, Iowa, Kansas/Missouri, Oklahoma, and Texas were found to be the major determinants of the long-run equilibrium.

400-Pound Steers

Exogeneity/endogeneity occurred for 4.6% of the pairs, while feedback relationships occurred for 95.5% of the pairs (table 4). Prices in California, Colorado, and Nevada/Utah were endogenous to prices in Oklahoma, Montana/Wyoming, and Oklahoma, respectively. All the other pairs had a feedback relationship. Overall, the long-run equilibrium was mutually driven by all prices.

700-Pound Heifers

Exogeneity/endogeneity occurred for 42.4% of the pairs, while a feedback relationship occurred for 57.6% of the pairs (table 5). Prices in Nevada/Utah, Iowa and Washington/Oregon/Idaho, were found to be endogenous to prices in Arizona/New Mexico, Colorado, Kansas/Missouri, North/South Dakota, Nebraska, and Oklahoma. Prices in Iowa and Washington/Oregon/Idaho were also endogenous to prices in Montana/Wyoming. Prices in California were endogenous to prices in Arizona/New Mexico, Kansas/Missouri, North/South Dakota, and Oklahoma, while prices in Montana/Wyoming, North/South Dakota, Nebraska, and Oklahoma were endogenous to prices in Nevada, Oklahoma, Oklahoma, and Texas, respectively. A feedback relationship occurred for all the other pairs. Prices in Arizona/New Mexico, Colorado, Kansas/Missouri and Texas were the major determinants of the long-run equilibrium.

400-Pound Heifers

Exogeneity/endogeneity occurred for 31.8% of the pairs, while a feedback relationship occurred for 68.2% of the cases (table 6). Prices in California and Nevada/Utah were found to be endogenous to prices in Montana/Wyoming, Arizona/New Mexico, Kansas/Missouri, North/South Dakota, Nebraska, and Oklahoma. Prices in Nevada/Utah were also endogenous to prices in Colorado. Prices in Washington/Oregon/Idaho were endogenous to prices in North/South Dakota, Nebraska, and Oklahoma, while those in North/South Dakota were endogenous to prices in Montana/Wyoming, Nebraska, and Oklahoma. Prices in Arizona/New Mexico and Nebraska were endogenous to prices in Montana/Wyoming. A feedback relationship occurred for all the other pairs. Prices in Montana/Wyoming, Colorado, Iowa, Kansas/Missouri, and Texas were the major determinants of the long-run equilibrium relationship.

Conclusions

Exogeneity/endogeneity relationships were identified basing on whether lagged values of prices in one market Granger-caused prices in another market using the F-test. The long-run equilibrium for 400-pound steers was basically driven by all prices. The long-run equilibria for other classes of cattle were driven by prices from different markets. As calves become larger, they become less mobile in a trading sense. Hence, one would expect to see less bidirectional causality for the heavy-weight classes. Prices in California, Nevada/Utah, Iowa, Texas and Washington/Oregon/Idaho were generally found to be endogenous to the system, while prices in Kansas/Missouri, North/South Dakota, Oklahoma, Arizona/New Mexico, Montana/Wyoming and Colorado were exogenous to the system more often than others.

Generally, prices in Kansas/Missouri, Texas, Arizona/New Mexico and Colorado had more influence on the long-run equilibrium relationships than others. The states generally found to be in the most influential position are typically those with the larger cattle numbers. Most of the bivariate systems had a feedback relationship, although endogeneity/exogeneity relationships were also common. The exogeneity/exogeneity relationship was identified in only one case for prices of utility slaughter cows in Oklahoma and Nebraska. Though it varies by cattle type, it does appear that cattle prices in one (or more) market areas follow prices in other market areas. This also suggests that the leading markets may be useful in predicting price movements in trailing markets.

The question of endogeneity/exogeneity has been addressed by testing two elements of the overall integrated system but is yet to be extended to a multivariate setting where more than two elements of the integrated system are simultaneously tested for endogeneity and exogeneity. Also, the speed of adjustment, in terms of the number of periods necessary to achieve the total long-run adjustment, for a given integrated bivariate system needs to determined. Such empirical work would be very useful in further identifying the nature and extent of these cattle markets.

References

Alexander, C., and J. Wyeth. 1994. "Cointegration and Market Integration: An Application to Indonesian Rice Market" *The Journal of Developmental Studies* 30: 303-328.

Ardeni, P.G. 1989. "Does the Law of One Price Really Hold for Commodity Prices ?" *America Journal of Agricultural Economics* 71:661-69.

Baffes, J. 1991. "Some Further Evidence on the Law of One Price: The Law of One Price Still Holds." *American Journal of Agricultural Economics* 73:1264-73.

Blank, S., and B. Schmiesing. 1988. "Modeling of Agricultural Markets and Prices Using Causality and Path Analysis." *North Central Journal of Agricultural Economics* 10:35-48.

Blyn, G. 1973. "Price Series Correlation As a Measure of Market Integration." *Indian Journal of Agricultural Economics* 28:56-9.

Cattle-Fax. A Marketing Tool for the Cattle Man. Englewood, Colorado. Englewood, Colorado. January 1989 to July 1996.

Ellis, Magrath F.P., and B. Trotter. 1991. *Rice Marketing in Indonesia: Methodology, Results and Implications of a Research Study*. Chatham. Natural Resource Institute, Marketing Series 4(1991).

Faminow, M.D., and B. L. Benson. 1990. "Integration of Spatial Markets." *American Journal of Agricultural Economics* 72:49-62.

Gardner, B.L., and K.M. Brooks. 1994. "Food Prices and Market Integration in Russia: 1992-1993." *American Journal of Agricultural Economics* 76:64-46.

Goodwin, B.K. 1992. "Multivariate Cointegration Tests and the Law of One Price in International Wheat Markets." *Review of Agricultural Economics* 14:117-24.

Goodwin, B.K., and T.C. Schroeder. 1991. "Cointegration Tests and Spatial Price Linkages in Regional Cattle Markets." *American Journal of Agricultural Economics* 73:452-64.

Granger, C.W.J. 1969. "Investigating Causal Relationships by Econometric Models and Cross Spectral Methods" *Econometrica* 37:424-438.

Greene. H.W. 1990. *Econometric Analysis*. New York: Maxwell Publishing Company.

Hamilton, J.M. 1994. *Time Series Analysis*. Princeton: Princeton University Press.

McNew, K. 1996. "Spatial Market Integration: Definition, Theory and Evidence." *Agricultural and Resource Economics Review* 25(1):1-11.

Monke, E., and T. Petzel. 1984. "Market Integration: An Application to International Trade in Cotton." *American Journal of Agricultural Economics* 66:481-87.

Mundlak, Y., and D. Larson. 1992. "On the Transmission of World Agricultural Prices." *World Bank Economic Review* 6:399-422.

Muwanga, S.G., and D.L. Snyder. 1997a. *Market Integration and the Law of One Price: A Case Study of Selected Cattle Markets*." Economic Research Institute Study Paper ERI #97-11.

______. 1997b. *Error Correction Models and Market Integration: Evidence for Cattle Markets in the United States.* Economic Research Institute Study Paper ERI #97-19.

Ravallion, M. 1986. "Testing Market Integration." *American Journal of Agricultural Economics* 68:102-9

Roll, R. 1979. "Violation of Purchasing Power Parity and Their Implications for Efficient International Commodity Markets." *In International Finance and Trade*. (ed. M. Sarnat and G.P. Szego. Cambridge, Mass.: Ballinger) 1:133 - 76.

Stock, J.H. and M.W. Watson. 1988. *Testing for Common Trends', Price and Quality of Rice in Java: An Investigation into the Demand for Closely Related Goods.* Amsterdam: Free University Press.

Williams, C., and R. Bewley. 1993. "The Transmission of Price Information of Queensland Cattle Auctions." *Australian Journal of Agricultural Economics* 37: 33-55.

Table 1. Granger-Causality Relationships for Utility Slaughter Cows

	Mkt (a)										
Mkt (b)	MW	CA	NU	AN	CO	IO	KM	NSD	NE	OK	TX
WOI	**	**	**	a	**	**	a	**	**	**	**
MW		**	**	a	b	**	**	**	**	**	**
CA			**	a	**	**	**	**	**	**	**
NU				**	**	**	a	**	**	**	**
AN					b	**	**	**	**	**	**
CO						a	a	a	a	**	**
IO							a	**	**	**	**
KM								b	b	b	**
NSD									b	b	**
NE										NS	**
OK											**

A statistical significance of 5% was applied for all parameters. ** denote bidirectional causality, letter *a* denotes unidirectional causality from market *a* to market *b*, while letter *b* denotes unidirectional causality from market *b* to market *a*.

Table 2. Granger-Causality Relationships for 800-Pound Steers

	Mkt (a)										
Mkt (b)	MW	CA	NU	AN	CO	IO	KM	NSD	NE	OK	TX
WOI	a	**	b	a	a	**	a	a	a	a	a
MW		**	b	b	a	**	**	**	**	**	**
CA			b	a	**	**	a	a	**	a	**
NU				a	a	a	a	a	a	a	a
AN					a	**	a	a	**	**	**
CO						**	**	**	**	**	**
IO							a	a	a	a	**
KM								**	**	**	**
NSD									b	**	**
NE										a	**
OK											**

A statistical significance of 5% was applied for all parameters. ** denote bidirectional causality, letter *a* denotes unidirectional causality from market *a* to market *b*, while letter *b* denotes unidirectional causality from market *b* to market *a*.

Table 3. Granger-Causality Relationships for 600-Pound Steers

	Mkt (a)										
Mkt (b)	MW	CA	NU	AN	CO	IO	KM	NSD	NE	OK	TX
WOI	**	**	b	**	**	**	**	**	**	**	**
MW		**	b	**	b	**	**	**	**	**	**
CA			**	a	**	**	**	a	a	**	**
NU				a	a	**	**	a	a	**	**
AN					**	**	**	**	**	**	**
CO						**	**	**	**	**	**
IO							**	**	**	**	**
KM								b	**	**	**
NSD									b	a	**
NE										a	**
OK											**

A statistical significance of 5% was applied for all parameters. ** denote bidirectional causality, letter *a* denotes unidirectional causality from market *a* to market *b*, while letter *b* denotes unidirectional causality from market *b* to market *a*.

Table 4. Granger-Causality Relationships for 400-Pound Steers

	Mkt (a)										
Mkt (b)	MW	CA	NU	AN	CO	IO	KM	NSD	NE	OK	TX
WOI	**	**	**	**	**	**	**	**	**	**	**
MW		**	**	**	b	**	**	**	**	**	**
CA			**	**	**	**	**	**	**	a	**
NU				**	**	**	**	**	**	a	**
AN					**	**	**	**	**	**	**
CO						**	**	**	**	**	**
IO							**	**	**	**	**
KM								**	**	**	**
NSD									**	**	**
NE										**	**
OK											**

A statistical significance of 5% was applied for all parameters. ** denote bidirectional causality, letter *a* denotes unidirectional causality from market *a* to market *b*, while letter *b* denotes unidirectional causality from market *b* to market *a*.

Table 5. Granger-Causality Relationships for 700-Pound Heifers

	Mkt (a)										
Mkt (b)	MW	CA	NU	AN	CO	IO	KM	NSD	NE	OK	TX
WOI	a	**	**	a	a	**	a	a	a	a	**
MW		**	a	**	**	b	**	**	**	**	**
CA			**	a	**	**	a	a	**	a	**
NU				a	a	**	a	a	a	a	**
AN					**	b	**	**	**	**	**
CO						b	**	**	**	**	**
IO							a	a	a	a	**
KM								**	**	**	**
NSD									**	a	**
NE										a	**
OK											a

A statistical significance of 5% was applied for all parameters. ** denote bidirectional causality,letter *a* denotes unidirectional causality from market *a* to market *b*, while letter *b* denotes unidirectional causality from market *b* to market *a*.

Table 6. Granger-Causality Relationships for 400-Pound Heifers

	Mkt (a)										
Mkt (b)	MW	CA	NU	AN	CO	IO	KM	NSD	NE	OK	TX
WOI	**	**	**	**	**	**	**	a	a	a	**
MW		b	b	b	**	**	**	b	b	**	**
CA			**	a	**	**	a	a	a	a	**
NU				a	a	**	a	a	a	a	**
AN					**	**	**	**	**	**	**
CO						**	**	**	**	**	**
IO							**	**	**	**	**
KM								**	**	**	**
NSD									a	a	**
NE										**	**
OK											**

A statistical significance of 5% was applied for all parameters. ** denote bidirectional causality, letter *a* denotes unidirectional causality from market *a* to market *b*, while letter *b* denotes unidirectional causality from market *b* to market *a*.