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PRICE TRANSMISSION BETWEEN U.S. GRAIN AND KOREAN IMPORT GRAIN

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ABSTRACT

This study examines the price transmission between U.S. farm level grain prices and Korean imported grain prices. Price transmission results for corn, soybeans, and wheat indicate that the policy of liberalizing of imported grain markets in Korea has been progressing relatively well. This is important for Korean grain importers and livestock producers who rely heavily on international price signals.

I. Introduction

Price transmission can be described as the co-movement of prices between two markets over time. In the Korean context, agricultural policy makers are faced with the goal of improving agricultural competitiveness while at the same time ensuring food security and farmer welfare. Over the past number of years, Korean feed grain import markets have been liberalized, with one reason being

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to assist livestock producers in becoming more competitive, and improving resource allocation. Since feed grains are mostly imported, it is important to have accurate and timely international price signals to help ensure competitiveness of the livestock sector.

Price transmission also has important implications for liberalization of trade and markets. If a country's trade is liberalized, then international price signals would be expected to transmit more efficiently. Price transmission is one way to measure trade liberalization, as it can account for non-tariff barriers such as food labeling regulations, food safety and sanitary requirements, distribution systems, and other restrictions and regulations that can reduce trade.

A first measure of price transmission is the price transmission elasticity. It is the percentage change in price in one market given a one percent change in another market. A higher price transmission elasticity coefficient indicates more efficient pricing in markets. If markets are fully liberalized and integrated, then a one percent change in world farm price should be met with the same corresponding one percent change in Korea and other countries, assuming no rigidities in the market. This would imply a price transmission elasticity coefficient of one and fully integrated markets. However, real world economics dictates that this may not hold, due to imperfections in markets and rigidities (Goodwin and Schroeder, 1991).

A second measure of price transmission is the direction and speed of price transmission, e.g the time it takes for prices to be transmitted from the U.S. to Korea. A faster speed of price transmission also indicates more efficient pricing in markets. Under fully liberalized trade, it would be expected that prices would be quickly transferred from one country to another. However, factors such as poor information flows, distance between markets, and trade restrictions may result in a number of time lags before price information is transferred from one country to another.

Recent research has been conducted on price transmission by Chavas and Mehta (2004), and Miller and Hayenga (2001),

though both these studies have focused on domestic price transmission and asymmetry, rather than international price transmission. Some research has been conducted on agricultural price transmission in Korea including Sung's (1996) study of beef price transmission. Sung (1999) later studied the impact of Korean exchange rates and Korean import prices on Korean consumer prices. Sung (1999) found that changes in exchange rates had a greater impact on consumer prices and feed mixture prices, compared to the impacts from changes in grain import prices. This paper seeks to expand price transmission research for Korea, and examine price transmission and pricing efficiency for the grain imports. A background section is included next, followed by a methodology section, a results section, and then a summary section.

II. Background on the Grain Sector in Korea

After the Uruguay Trade Agreement in 1994, the Korean government opened several agricultural commodity markets to imports. Liberalization policies were implemented for feed grains so that markets would be driven by price competition. Corn imports have tariff rate quotas (TRQ), while wheat imports are subject to relatively small tariffs. Demand for feed grains is tied closely with the Korean livestock industry. With the exception of rice bran, most of the feedstuffs used for livestock and dairy farming are supplied by imports. The feed grain market is highly price sensitive with high positive cross-price elasticities. So the market prices of competing feed grains will dictate the level of substitution among imported feed grains.

1. Corn and Soybeans

Corn production in South Korea is very limited, with about 73,000 MT produced annually, between 1996 and 2003 (Table 1). This is partially due to the MAF's agricultural policy promoting rice production for the past two decades. Almost 99% of corn requirements for feed and processing is supplied with imports.

Corn makes up the largest proportion in feedstuffs (Table 2), and almost 75% of imported corn is used to produce feedstuffs. Thus demand for imported corn is highly influenced by the production of livestock in South Korea. International food safety issues such as BSE has decreased imported beef consumption, while demand for domestic beef has increased. This also increased the demand for feed grains that are used in the Korean livestock industry. Most soybeans in Korea are imported as well. Soybeans are used primarily as a feed ingredient, though soybeans quantities for feed use have been dropping in recent years. In terms of comparison, corn use for feed ingredients in 2003 was about 7,000,000 MT, followed by corn at 2,200,000 MT and followed by wheat at 1,500,000 MT (Table 2).

TABLE 1. Corn Supply and Consumption, South Korea (1000 MT)

	1996	1997	1998	1999	2000	2001	2002	2003
Domestic Production	72	87	80	82	64	57	73	70
Total Imports	8,336	7,700	7,514	8,691	8,723	8,602	8,900	9,200
Total Supply	9,374	8,877	8,826	9,873	10,033	10,076	10,314	10,611
Feed Consumption	6,296	6,200	5,560	6,541	6,460	6,584	6,700	7,000
Total Consumption	8,284	8,074	7,526	8,640	6,584	8,735	8,973	9,270

Source: NLCF (National Livestock Cooperative Federation), Livestock Price and Supply Data.

TABLE 2. Korean Feed Ingredient Use for Compound Feed Production (1000 MT)/a

	1999	2000	2001	2002	2003
Wheat	2,014	1,000	1,100	1,500	1,500
Corn	6,543	6,600	6,800	6,700	7,000
Rye	407	200	200	100	100
Barley	2,131	2,200	2,200	40	40
Soy meal and others	5,041	5,000	5,000	2,100	2,200

/a FAS/ Seoul forecast.
Source: Korea Feed Association (KFA)

2. Wheat

Very little wheat is produced in Korea and nearly all wheat is imported, with imports averaging around three to four million metric tonnes annually (Table 3). Human consumption of wheat in Korea has been fairly stable around two million metric tonnes per year in recent years. Wheat quantities for feed use have ranged widely, often from around zero to two million metric tonnes annually. There are three major exporters of wheat to South Korea. The U.S. market share of total Korean wheat imports stood at 53.2 percent, Australia at 40.8 percent and Canada at 10.0 percent in 2002 (KOFMIA).

Wheat imports to South Korea were privatized in 1990. An import quota was replaced with a tariff. Trade liberalization for milling wheat imports began in 1983 and was completed by 1990. During this liberalization period, the wheat import quota gradually increased from 2.28 MT in 1989 to 2.3 MT in 1990. In 1990, the fixed import quota of 2.3 MT was eliminated and replaced with a 5% tariff on imported wheat. The wheat tariff is to be reduced to 1.8% by 2004. Following trade liberalization, South Korean millers have used two routes to import wheat. Millers can negotiate directly with exporters; or wheat can be purchased by tender from the Korean Flour Mills Industrial

TABLE 3. Import Quantity of Wheat (1000 MT)

Year	Imports
1993	4,500
1994	6,100
1995	2,800
1996	3,100
1997	3,400
1998	4,300
1999	4,100
2000	3,100
2001	3,600
2002	4,000

Source: Estimates by Korea Customs Service and Other Sources

Association (KOFMIA) which was formerly a Korean government central buying agency.

III. Data and Methodology

1. Data

Data is for corn, soybeans, and wheat prices, and is converted to US dollars when comparing across countries. Monthly data is used, and U.S. farm prices are from U.S. Department of Agriculture, while Korean import prices are obtained from KREI and KATI (Korean Agricultural Trade Information). The data period covers 1996-2002, and. U.S. dollars are used as the base currency. This allows for consistent comparison of international commodity prices across different countries, by eliminating exchange rate effects.

2. Price Transmission Methodology

2.1. Method One: Price Transmission Elasticity

Method one examines the price transmission elasticity between U.S. farm prices and Korean import prices. Similar price transmission models include and Mundlak and Larson (1992), Goodwin and Schroeder (1991), and Gardner and Brooks (1994). Others studies include Goodwin and Holt (1999), Goodwin and Grennes (2002), Baulch (1997), and Asche, Bremnes, and Wessells (1999), Boyd and Brorsen (1985, 1986, 1988), Colman (1985), Ravillion (1986), and Ardeni (1989).

Prices between free and competitive markets should differ only according to transportation cost and transaction cost, because of arbitrage. If the price in one market increases by one percent, then the price for the same commodity in another market should also increase by one percent, and markets would be defined as fully integrated. This corresponds to a price transmission elasticity of one, which represents a market with highly efficient pricing.

If prices are not fully transmitted between markets, then markets are considered to be to be at least partially segmented and not fully integrated. This may occur for a number of reasons,

including: (1) Producer subsidies, consumer subsidies, or other internal policies (2) Trade policies and industry protection (e.g. quotas, tariffs, non-tariff barriers) (3) Imperfect competition (4) Administrative mark up pricing/vertical integration (5) Distance related to transportation and shipment (6) Poor information flows.

An econometric model is used to estimate the price transmission elasticity coefficient, and model specification assumes there is a market where price is first determined and then passed on to another market. This can be summarized as a log-log model in time t:

$$log(P^K) = a_1 + b_1 log(P^U) + e \quad (1)$$

where: P^K=*Korea Import Price*
P^U=*U.S. Farm Price*
b_1=*price transmission elasticity coefficient*
e=*error term*

Equation (1) is estimated for corn, soybean, and wheat prices. The main result of equation (1) is that b1 is the price transmission elasticity coefficient. If b_1=1, then a one percent change in U.S. farm price results also in a one percent change in Korean import price, indicating fully integrated and efficient markets. But if b_1 is zero, this indicates that there is no relationship between U.S. farm and Korean import prices.

2.2. Method Two: Causality and Time Lags (Speed of Price Transmission)

Method two uses causality and time lag procedures to examine the direction and speed of price transmission between price changes in the U.S. and Korea. Methods are based on those such as Granger (1969), Boyd and Brorsen (1985, 1986, 1988), Coleman (1996), Copeland and Copeland (1998), Frino, Walters, and West (2000). A series of bivariate autoregressive (AR) models are constructed, and percentage price changes are used rather than price levels. This is because price change data is needed to study the short-run price dynamics for the speed of price transmission,

as price change data better reflects short-run dynamics than does price level data. The use of price changes also makes the data stationary and removes autocorrelation problems. The number of lags included or price transmission time is determined using Akaike's Information Criterion (AIC) (Akaike, 1976).

The bivariate model can be written as:

where

$$P_t = \begin{bmatrix} P_{1t} \\ P_{2t} \end{bmatrix}, \quad A = \begin{bmatrix} a_{11}(i) & a_{12}(i) \\ a_{21}(i) & a_{22}(i) \end{bmatrix}, \quad and \; e_t = \begin{bmatrix} e_{1t} \\ e_{2t} \end{bmatrix} \tag{2}$$

and P_{1t} and P_{2t} are the Korean import price and the U.S. farm price for grain, the e_t's are residuals, and the a's are coefficients to be estimated. If residuals of the bivariate autoregressive models are found to be white noise, then consistent and asymptotically efficient estimates of the parameters and standard errors are obtained by least squares techniques.

The concept of Granger (1969) causality is used to determine the direction of dynamic price adjustments. If U.S. farm grain prices are found to cause Korean import grain prices, then it would imply that prices are first discovered in the U.S. farm market. The test for direction of causality is performed by testing the significance of the coefficients as a group rather than individually. This test is conducted with the Wald F statistic. This test procedure is a variant of Granger's test which Monte Carlo studies have shown to be more powerful than the causality tests of either or Haugh or Sims. Two equations are used for the bivariate models, with variables being U.S farm price and Korean Import Price. Two lags are used for illustration purposes in this example:

$$K\ Import\ Price_t = f(K\ Import\ Price_{t\text{-}1},\ K\ Import\ Price_{t\text{-}2},\ US\ Farm\ Price_{t\text{-}1},\ US\ Farm\ Price_{t\text{-}2}) \tag{3}$$

$$US\ Farm\ Price_t = f(K\ Import\ Price_{t\text{-}1},\ K\ Import\ Price_{t\text{-}2},\ US\ Farm\ Price_{t\text{-}1},\ US\ Farm\ Price_{t\text{-}2}) \tag{4}$$

For example, if adding the past US farm corn prices adds significant explanatory power to the Korean import corn price in equation (3), as measured by the use of the F-test, then the US farm corn market is said to "cause" or lead the corresponding Korean import corn market. Likewise, if the past Korean import corn price adds significant explanatory power to US farm corn price in equation (4), as measured by the use of the F-test, then the Korean import corn price is said to "cause" or lead the corresponding US farm corn price. However, the Korean import corn market leading the US farm corn market would be unlikely, given the relatively large size of US corn market and its influence on world price and Korean price.

IV. Results

1. Method 1: Price Transmission Elasticity Results

Equation (1) was estimated using ordinary least squares and autocorrelation was addressed by using the Newey and West procedure to adjust the standard errors. Results from models show reasonable price transmission from U.S. farm prices to Korean import prices (Table 4). This indicates relatively efficient

TABLE 4. Monthly Price Transmission Elasticity from U.S. Farm Price to Korean Import Price, 1996–2002, Prices in $US /a

	Constant	β^a	R^2
Corn	1.54 (7.61)	0.74* (12.70)	0.76
Soybeans	1.15 (6.14)	0.82* (19.64)	0.87
Wheat	2.20 (13.67)	0.62* (12.54)	0.81

/a β is the price transmission elasticity, since the model is in log-log form. T-values are in parentheses.
* Indicates significance at 5 percent level.

markets for grain imports, with price transmission elasticity coefficients .74, .82, and .62 for corn, soybeans, and wheat, respectively. For example, if U.S. farm price for wheat increases by one percent, then Korean import wheat price is likely to increase by about .62 percent. These results show reasonable level coefficients, given that there is a relatively large physical distance and long transportation time between the U.S. and Korea. A coefficient of one would indicate full integration or perfect price transmission.

The R^2 statistic explains the model fit, and .76 for corn indicates that 76 percent of the corn import price variation is explained by the variation in U.S. corn farm price. Tests found no cointegration for corn, soybean, and wheat equations. These results indicate that error terms are non-stationary, autocorrelated, and under these conditions parameter estimates will be remain consistent, but standard errors may not be consistent (Goodwin and Schroeder, 1991). Therefore, standard errors were adjusted as mentioned above for autocorrelation, to improve standard error estimates.

Korean grain import prices appear to have converged to closer U.S. levels, indicating relatively effective liberalization of the markets. In fact, by mid 2002 Korean import and U.S. farm

FIGURE 1. Corn: US Farm vs. Korea Import Price

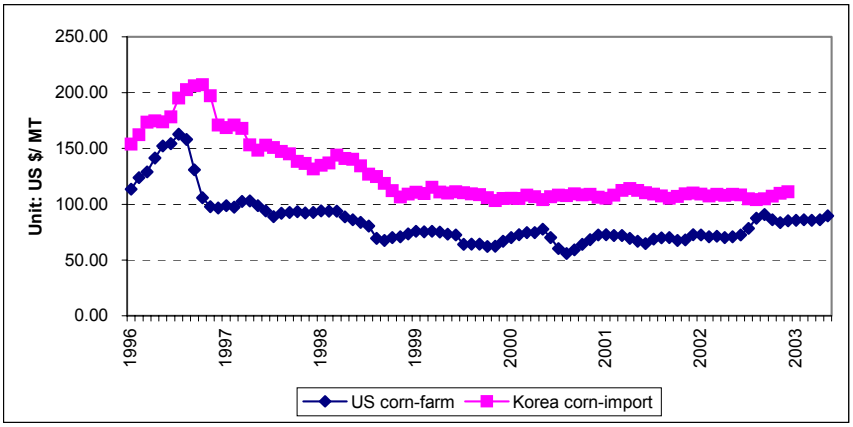


FIGURE 2. Soybeans: US Farm vs. Korea Import Prices

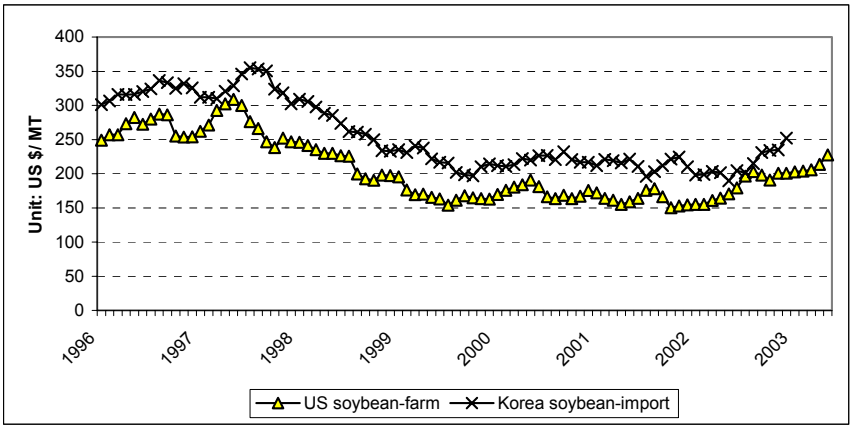
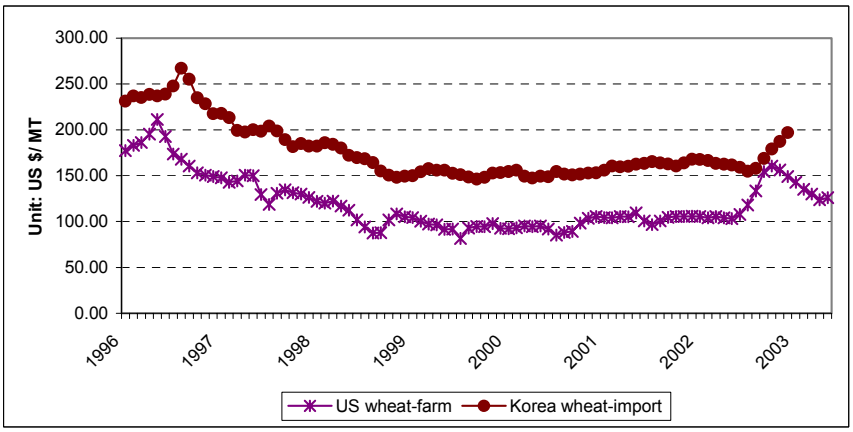


FIGURE 3. Wheat: US Farm vs. Korea Import Prices



prices were at about the same level during mid 2002 (Figures 1, 2, and 3). With the Korean government relaxing border measures for several commodities under the Uruguay Round Agreement in 1994, the impacts of market liberalization are revealed in this price comparison.

2. Method 2: Causality and Time Lag Results (Speed of Price Transmission)

Both Fishers Kappa and Bartlett's Kolmogorov-Smirnov tests failed to reject the null hypothesis of white noise in all six equations as shown in Table 5 below, indicating that all statistically important information has been captured by the model and only white noise remains in the residuals. The causality F-statistics, equation F-statistics, and R^2 values are shown in Table 6. All of the six equations show significant equation F-statistics at the five percent level, indicating significant explanatory power for the equations.

U.S. farm price is found to lead or "cause" Korean import price for all three commodities, according to the significant Wald F-Statistics from the Granger causality tests (Table 6). These results indicate that price is determined primarily on the export side, the U.S. market, and then price information is transmitted to Korea. This is consistent with the structure of the world grain market, where the U.S. is a large grain exporting country and plays a large role in world price determination. In contrast, Korea's grain imports are much smaller than U.S. total grain exports, and so world market price changes would be passed on to Korea.

TABLE 5. White Noise Tests of the Residuals from Causality Equations, 1996-2002

Commodity	Barrletts's K-S Statistic /a	Fisher's Kappa Statistic /a
US Corn Farm → Korea Corn Import	.0754	2.96
Korea Corn Import → US Corn Farm	.0859	3.74
US Soybean Farm → Korea Soybean Import	.0952	3.03
Korea Soybean Import → US Soybean Farm	.1766	4.08
US Wheat Farm → Korea Wheat Import	.0910	4.85
Korea Wheat Import → US Wheat Farm	.1901	4.03

/a Tests failed to reject the null hypothesis of white noise residuals at the ten percent level of significance in all 6 equations.

TABLE 6. Monthly Price Causality Lead-Lag Relationships and Equation Results for Corn, Soybeans, and Wheat, 1996-2002

Commodity	Causality Wald F-Statistic	Equation F-statistic	R^2
US Corn Farm → 2 Korea Corn Import /a	8.81*	7.86*	.29
Korea Corn Import → 2 US Corn Farm	.08	9.35*	.32
US Soybean Farm → 2 Korea Soybean Import	5.93*	3.44*	.15
Korea Soybean Import → 2 US Soybean Farm	.46	2.73*	.13
US Wheat Farm → 2 Korea Wheat Import	8.67*	9.87*	.34
Korea Wheat Import → 2 US Wheat Farm	1.16	3.25*	.15

* Indicates significance at 5 percent level.
/a For example, US corn farm price leads or "causes" Korean corn import price by 2 months, as evidenced by the significant causality Wald F-statistic

All three grains were found to have a two month lag between the U.S. farm price and the Korean import price (Table 6), according to the AIC procedures used for identification of the equations. The lag time between markets provides an estimate of relative pricing efficiency between two markets. A shorter lag time would indicate higher price efficiency between markets. The Table 6 results show that prices take two months to be transmitted from U.S. farm level to Korean import level, and this is reasonably efficient, given the large physical distance. It is also close to the range of results of Boyd and Brorsen (1986) who found that international price transmission between the U.S. and Europe typically takes between about three and nine weeks. One reason for the lag time between markets may be long shipping and transportation distance. The two month price transmission period appears to be a reasonable length of time to transport grain from U.S. farms to end users in Korea. Some pricing rigidities may also account for the two month lag in prices. For example, merchants in the Korean import market may be reluctant to change their prices until they are certain that the shift in supply or demand is justified. Overall, with a two month lag, the Korean grain import market appears to have reasonable

pricing efficiency, given the relatively long physical distance from the U.S.

V. Summary

Over the past number of years, Korean grain import markets for corn, soybeans, and wheat have been liberalized, beginning with the 1994 Uruguay Trade Agreement. One reason this was undertaken was to make the Korean livestock sector more competitive. After trade is liberalized, international price signals between countries would be expected to transmit efficiently. Price transmission is one way to measure trade liberalization, as it can account for non-tariff barriers such as food labeling, food safety and sanitary requirements, distribution systems, and other regulations and restrictions that can reduce trade.

A first measure of price transmission is the price transmission elasticity. The price transmission elasticity coefficients for corn, soybeans, and wheat were found to be .74, .82, .62., using monthly prices for corn, soybeans, and wheat. A price transmission elasticity coefficient of .74 for corn import price means that when U.S. farm corn price increases by one percent, then Korean import corn price increases by .74 percent. These results indicate relatively efficient pricing in grain import markets, given the relatively long transportation distance from the U.S. to Korea. These results are consistent with markets that have been liberalized and graphical analysis of Korean grain import prices support that they have converged to closer U.S. levels as well.

A second measure of price transmission is the direction and speed of price transmission. U.S. farm price was found to lead or "cause" Korean import price for all three commodities. All three grains were found to have a two month lag between the U.S. farm price and the Korean import price. Results show that prices take two months to be transmitted from the U.S. farm level to the Korean import level, and this is reasonably efficient, given the long physical distance between the countries. Overall, results show that Korean grain import markets have reasonable

pricing efficiency following the liberalization from the Uruguay Trade Agreement in 1994. This is important for the Korean livestock sector which relies heavily on price signals of imported grains.

REFERENCES

Akaike, H. 1976. Canonical Correlations Analysis of Time series and the Use of An Information Criterion. In R.Mehra and D.G. Lainiotis (eds.) *Advances and Case Studies in System Identification*. Academic Press, New York.

Ardeni, P.G. 1989. "Does the Law of One Price Really Hold for Commodity Prices?" *American Journal of Agricultural Economics* 71: 661-669.

Asche. F., H. Bremnes and C.R. Wessells. 1999. "Product Aggregation, Market Integration, and Relationships between Prices: An Application to World Salmon Markets." *American Journal of Agricultural Economics* 81: 610-622.

Baulch. B. 1997. "Transfer Costs, Spatial Arbitrage, and Testing for Market Integration." *American Journal of Agricultural Economics*. 79: 477-487.

Boyd, M.S. and B.W. Brorsen. 1985. "Dynamic Relationship of Weekly Prices in the U.S. Beef and Pork Marketing Channels." *Canadian Journal of Agricultural Economics* 33: 331-442.

_____. 1986. "Dynamic Price Relationships for US and EC Corn Gluten Feed and Related Markets." *European Review of Agricultural Economics*, 13: 199-215.

_____. 1988. "Price Asymmetry in the U.S. Pork Marketing Channel." *North Central Journal of Agricultural Economics* 10: 103-110.

Chavas, Jean-Paul and Aashish Meta. 2004. "Price Dynamics in the Vertical Sector: The Case of Butter." *American Journal of Agricultural Economics* 86: 1078-1093.

Coleman, W. 1996. "Money and Output: A Test of Reverse Causation." *American Economic Review* 86: 90-111.

Colman, D. 1985. "Imperfect Price Transmission Policy and Prices." *European Review of Agricultural Economics* 12: 171-186.

Copeland, M. and T. Copeland. 1998. "Leads, Lags, and Trading in Global Markets" *Financial Analysts Journal* 54: 70-80.

Frino, A., T. Walter and A. West. 2000. "The Lead-Lag Relationship

Between Equities and Stock Index Futures Markets Around Information Releases" *The Journal of Futures Markets*. 20: 467-487.

Gardner B. and K. Brooks. 1994. "Food Prices and Market Integration in Russia: 1992-93." *American Journal of Agricultural Economics*. 76: 641-646.

Goodwin, B. and T.C. Schroeder. 1991. "Cointegration Tests and Spatial Price Linkages in Regional Cattle Markets." *American Journal of Agricultural Economics* 73: 454-464.

Goodwin, B.K. and M.T. Holt. 1999. "Asymmetric Adjustment and Price Transmission in the U.S. Beef Sector." *Amer. J. Agr. Econ*. (Principal paper) 81: 630-37.

Goodwin, B.K., T. Grennes, Lee Graig. 2002. "Mechanical Refrigeration and the Integration of Perishable Commodity Markets." *Explorations in Economics History*.

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

Haugh, L.D. 1972. "The Identification of Time Series Relationships with Special Reference to Dynamic Regression Models." Ph.D. Dissertation, University of Wisconsin: Madison.

Miller, D.J. and M.L. Hayenga. "Price Cycles and Asymmetric Price Transmission." *American Journal of Agricultural Economics* 83 (2001):551-562.

Mundlak, Y. and Larson D.F. 1992. "On the Transmission of World Agriculture Prices." *World Bank Econ. Rev*. 6: 399-422.

Sung, Myung-Hwan. 1999. "Effects of Exchange Rate Changes on Agricultural Prices under the Financial Crisis in Korea." *Journal of Rural Development* 22: 1-14.

_____. 1996. "Cointegration Tests and the Law of One Price in the Korean Beef Market." *Journal of Rural Development* 19: 53-68.

Sims, C.A. 1972. "Money, Income, and Causality." *American Economic Review* 62: 540-552.