Dynamic Price Relationships in the Grain and Cattle Markets, Pre and Post-Ethanol Mandate.

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Abstract

This paper determines the dynamic interaction between prices of corn, soybean, grain sorghum (milo), wheat, feeder cattle and live (fed) cattle by taking into account the surge in corn consumption stemming from the boost of mandated ethanol production. Corn is a major carbohydrate-feed component of livestock, with grain sorghum and wheat serving as close substitutes. Moreover, soybean is an important protein-feed component. Being non-stationary data, a vector autoregressive (VAR) model (Sims, 1980) that includes an 'error correction' term is applied to the series; likewise known as a vector error correction (VEC) model (Engel and Granger, 1987 and Johansen, 1989). Two separate periods are estimated. The first considers prices prior to recent ethanol mandates. The second includes increased corn consumption from ethanol production, mandated by Energy Policy Acts of 2005 and 2007. Results are consistent with past literature regarding feeder and live cattle prices, among others. More importantly, we find support for the notion of modified feed rations in feedlot operations, given the increased corn prices following the post-ethanol mandated period. The finding is corroborated by two different methods, one via Granger Causality and other via impulse response functions.

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Introduction

This study examines the dynamic interaction between prices of corn, soybean, grain sorghum (milo), wheat, feeder cattle and live (fed) cattle considering the recent surge in corn consumption due to a boost in mandated ethanol production. A vector autoregressive (VAR) model is applied, permitting the forecast of these commodity prices and providing insight into the dynamic relationships among these markets, by specifically considering the recent federal mandated increase in ethanol production that uses corn as main input. The Energy Policy Act of 2005 mandated an increase in the use of renewable fuel energy by doubling the ethanol use by 2012, to 7.5 billion gallons of ethanol. In 2007 Congress passed the Energy Independence and Security Act, which augmented the Renewable Fuels Standard to require that 36 billion gallons of ethanol and other fuels be blended into gasoline, diesel, and jet fuel by 2022. (Ethanol production at the end of 2009 was about 10.7 billion gallons per year and is mandated to reach 13 billion gallons by 2012 and 15 billion gallons by 2015.) This study considers the log of daily data, accounting for the non-stationary property of each series.

The VAR model is applied to determine the effect from the surge in corn demand and its price, on the prices of soybeans and other main feed grains such as sorghum and wheat, as well as on the cattle markets of both feeder and fed cattle. This multivariate model is of a non-structural, reduced form, where all the variables considered are assumed to be jointly endogenous and characterized by autoregressive representations of weakly stationary processes.[1]

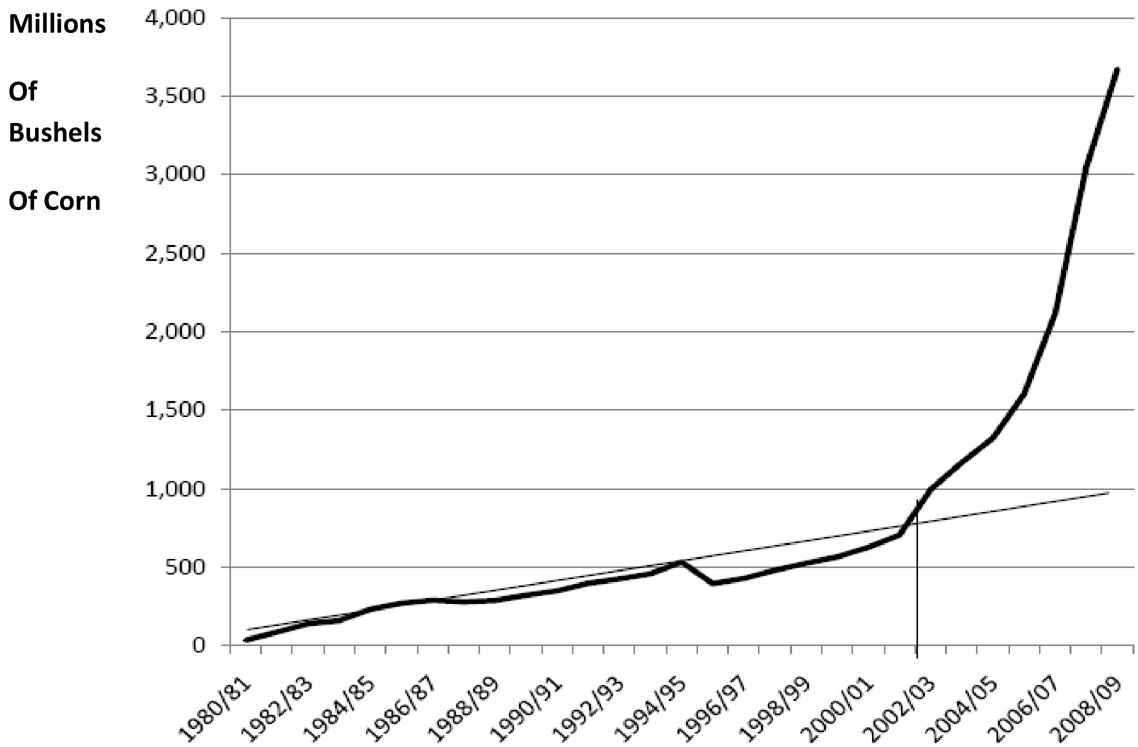
[1] A Stochastic process is weakly stationary if it is (i) Mean Stationary and (ii) Covariance Stationary.
(i) A process is Mean Stationary if $E[x_t] = \mu_t = \mu$ (constant) for all t.
(ii) A Process is Covariance Stationary if $Cov[x_t, x_s] = E[(x_t - u_t)(x_s - u_s)] = \gamma(|s-t|)$ is Only function of the time distance between the two random variables and does not depend on the actual point in time t.

Thus for a VAR of order K, VAR(K), each variable from the Y vector depends on its own lagged values up to K periods, and likewise on the lagged values of the other variables up to K periods.

It is noteworthy to mention that the general form of studying the dynamic interaction between non-stationary series in a VAR setting (i.e., of first order moments) is through a vector error correction (VEC) model, defined below. This VEC model is referred to as an "error correction" VAR model and is similar to the regular VAR model; however, it takes into account co-integration factors between the non-stationary data. These co-integration factors identify a common long-run evolution among the series, materialized as a linear combination of these non-stationary variables. The VEC model is a regular VAR model that includes a lag of log prices as a dependent variable for the error correction term.

The dynamic relationships are estimated using data from daily closing cash prices of corn, soybean, grain sorghum (milo), wheat, feeder cattle and live cattle. Two different periods are considered, the first period is from January 1998 to December 2004 and the second period from January 2004 to April 2009. This latter period includes the surge in corn consumption from ethanol mandated production, as illustrated by Figure 1.

With data from the Foreign Agricultural Service of the USDA, Westhoff (2008) notes that between the marketing years of 2005/2006 and 2007/2008, there was a rise of 35 million tons in U.S. corn consumption attributed to ethanol production alone. This accounted for approximately 43 percent of the increase in total world grain consumption, which if excluded, would have grown around 2 to 2.5 percent (i.e. very similar to world population growth). Prior to 2005, there had been a regular average increase of around 2 percent in total world grain consumption dating back to 2000. Recent hikes in corn consumption beyond this rate of world population growth may be attributable to use for production of ethanol.



Source: Economic Research Service, USDA

Figure 1: Corn consumption from Ethanol production (in millions of bushels).

Tests for Granger causality are performed on the data, but more important, dynamic adjustments of the prices in response to exogenous shocks to grain prices are investigated. These analyses serve to draw inferences with respect to the price relationships and linkages among the markets. The paper proceeds with a brief literature review, followed by the method overview, empirical methods and data, results and discussion.

Literature Review

Initial dynamic studies of agricultural commodities incorporating a VAR model include Bessler and Babula (1987), Featherstone and Baker (1987), Goodwin and Schroeder (1991), Schroeder and Goodwin (1992), Goodwin (1992), and Hsu and Goodwin (1995). Recent studies incorporate the non-stationary properties of multiple series by means of a vector error correction model (VEC). This model incorporates a lagged level variable term called an error correction term, within a VAR setting. This error correction term considers long-run relationships between series, referred to as co-integration among markets. Vector error correction models have been used in studies by Goodwin and Piggott (2001) and Haigh and Bessler (2004). The application of either of these models permits Granger causality tests among the variables. More importantly, these models allow the use of impulse response functions which analyze the effects from shocks to one variable on the other variables being considered.

Method Overview

The vector autoregressive (VAR) model was developed by Sims (1980) and permits an analysis of the dynamic relationships between time series of endogenous or interrelated economic variables in a reduced model setting. Thus simultaneous structural equations describing the economic equilibrium between markets being studied is set aside in favor of a specification where all variables are assumed to be jointly endogenous, and simultaneously estimated. This model reduces spurious a priori restrictions on the dynamic relationships among the variables.

The VAR system for n variables may be defined by:

$$Y_t = \sum_{k=1}^{K} \begin{bmatrix} a_{11}(k) & \cdots & a_{1n}(k) \\ \vdots & \ddots & \vdots \\ a_{n1}(k) & \cdots & a_{nn}(k) \end{bmatrix} Y_{t-k} + E_t \quad (1)$$

where t indicates time (t = 1,……,T); Y_t is a n x 1 vector of economic variables (i.e. prices in this case); K is the lag order of the system; $a_{ij}(k)$ are the parameters to be estimated (with i, j =

1,….n); and E_t is a vector of random errors or innovations. Estimation requires choosing the appropriate lag order, K, of the system.

The preceding model is applicable to stationary data. In the case of two or more series with non-stationary data, a co-integrated VAR model referred to as the vector error correction (VEC) model is applied (Engle and Granger, 1987 and Johansen, 1988). These non-stationary series may be co-integrated (i.e., having a common long-run evolution), thus having a long-run economic relationship. The model then requires a co-integration term that implies the existence of (a) linear combination(s) of these integrated (i.e. non-stationary of order 1 or more) series. In addition, this model takes into account the possibility that the non-stationary elements are not co-integrated by including terms for first differences of the non-stationary series.

The VEC system for n variables (non-stationary series) is defined as follows:

$$\Delta Y_t = \sum_{i=1}^{K-1} \mathrm{A}_i \Delta Y_{t-i} + \Pi Y_{t-1} + E_t \qquad (2)$$

where ΔY_t is a n x 1 vector of the first difference of economic variables (i.e. difference of log prices in this case); $K - 1$ is the lag order of the first difference series and A_i (nxn) are its parameters to be estimated. The lagged level variable (Y_{t-1}) is the error correction term and its parameter to be estimated is Π, which may be of order r (with $0 \leq r \leq K$; for all series integrated of order 1, i.e. I(1)). Lastly, E_t is a vector of random terms or innovations.

Data

Daily cash Prices for corn are from Chicago, for soybeans from Central Illinois, for grain sorghum from U.S. Gulf ports in Louisiana, for wheat from Saint Louis (soft red #2), for feeder cattle from Oklahoma City and for live cattle as the average from Texas and Oklahoma; all obtained through the Commodity Resource Bureau (CRB).

Prices are from January 2nd 1998 through April 22nd, 2009 and are partitioned into two periods. The first period is from 1998 to 2004, prior to the 2005 Energy Act. The second period considers prices beginning in 2004 up until April 2009. Below are figures 2 and 3 with charts of these prices in logarithmic terms.

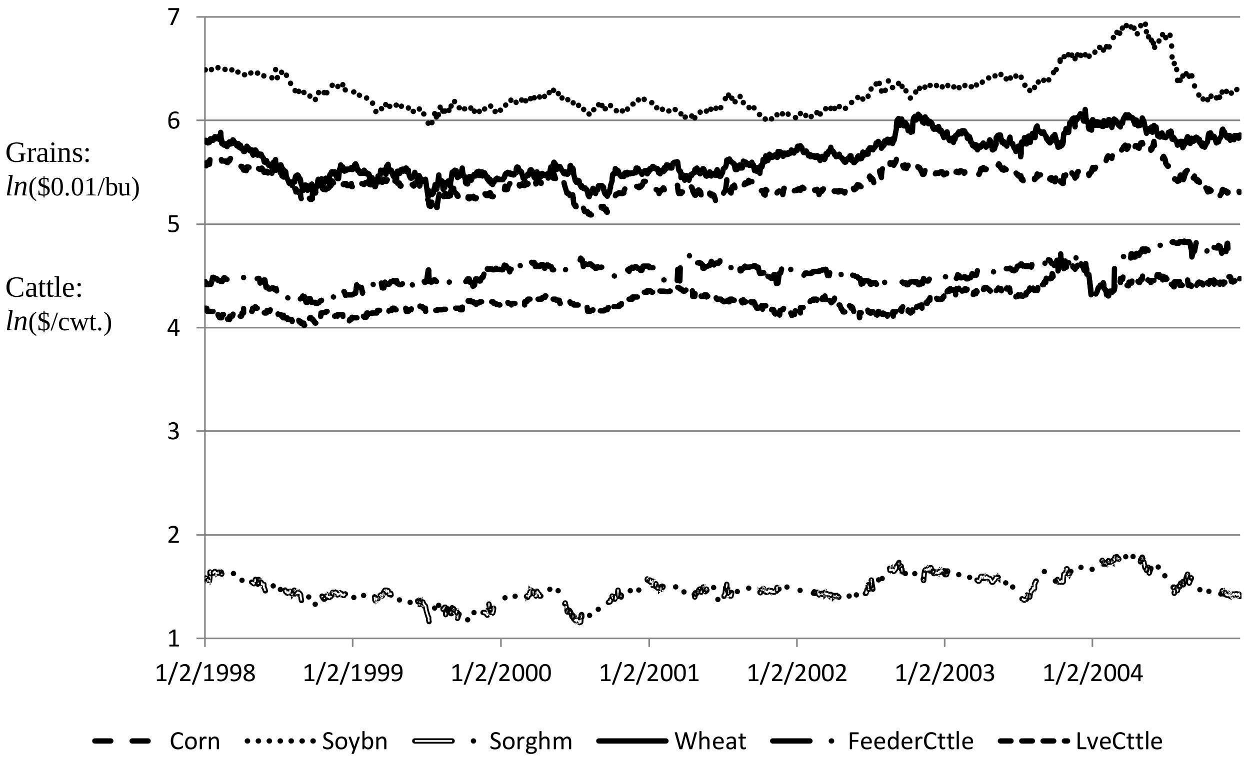


Figure 2: Daily Cash Market Prices in logarithmic terms from Jan. 1998 to Dec 2004.

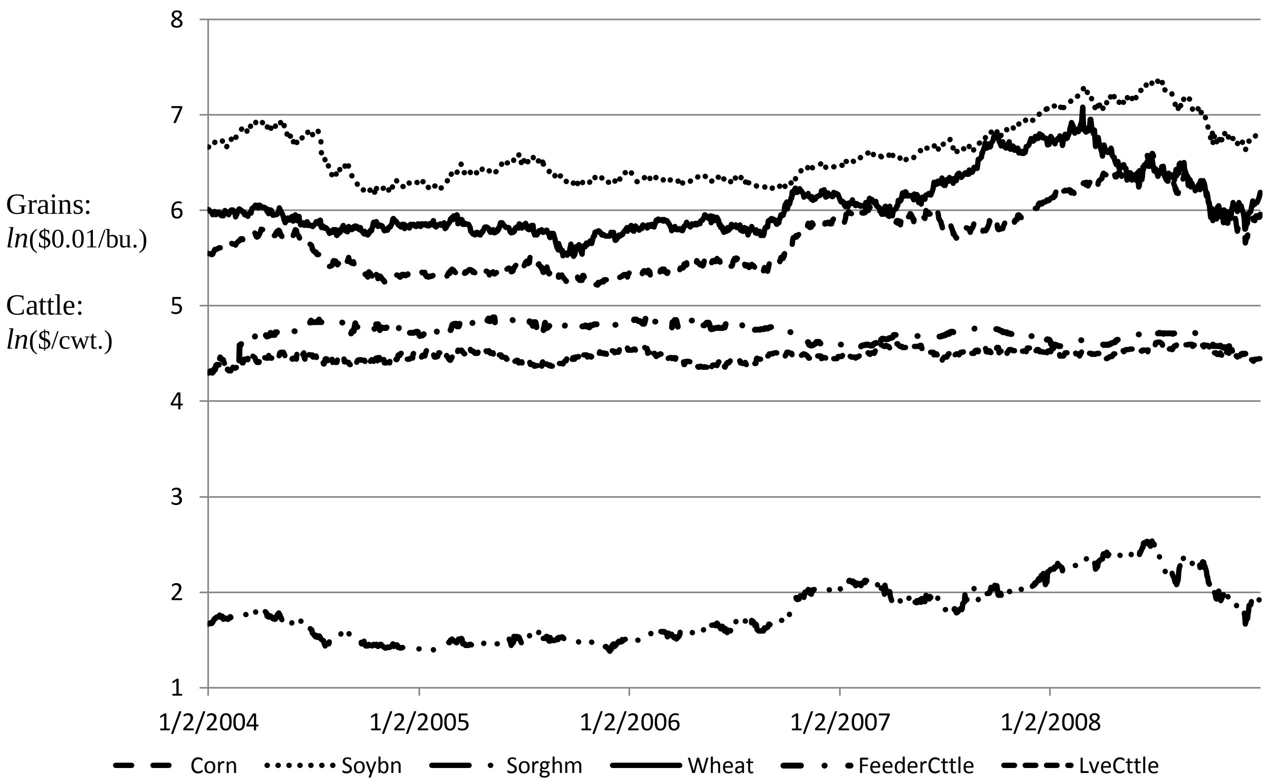


Figure 3: Daily Cash Market Prices in logarithmic terms from January 2004 to April 2009.

Results

Tests of the series being non-stationary for both periods were applied using the Phillips Perron[2] and the KPSS[3] unit root tests. Results for both tests show that the series are non-stationary for the two periods considered, as may be seen in following tables 1 and 2. Therefore the "co-integrated" VAR or VEC model is applied. Estimation of the proper number of lags and coefficients was done by least squares applying Bayes Information Criteria (BIC), [4] and the

[2] Unit Root test from Phillips, P.C.B and P. Perron (1988), where the null hypothesis considers the series being non-stationary.

[3] D. Kwiatkowski, P.C.B. Phillips, P. Schmidt, and Y. Shin (1992) Unit root test that considers the null hypothesis for the series as being stationary. Hence it may reject more often the case of a random walk.

[4] Schwartz (1978), $BIC = -2*\ln \mathit{Likelihood} + k*\ln(n)$, k: # of parameters to be estimated and n: # of observations.

Table 1: Non-Stationary Tests for series, from January 1998 to December 2004.

Dependent Variable **Corn**

	Phillips-Perron Unit Root Test (Ho: Unit Root)					*KPSS Stationary Test (Ho: Stationary series)*				
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	Lags	Eta	Prob10%	Prob5%	Prob1%
Zero Mean	8	-0.06	*0.670*	-0.490	*0.504*					
Single Mean	8	-12.40	*0.076*	-2.551	*0.105*	8	*4.127*	0.347	0.463	0.739
Trend	8	-14.08	*0.219*	-2.750	*0.217*	8	*1.718*	0.119	0.146	0.216

Dependent Variable **Soybean**

	Phillips-Perron Unit Root Test (Ho: Unit Root)					*KPSS Stationary Test (Ho: Stationary series)*				
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	Lags	Eta	Prob10%	Prob5%	Prob1%
Zero Mean	8	-0.04	*0.675*	-0.347	*0.560*					
Single Mean	8	-5.64	*0.378*	-1.752	*0.405*	8	*5.936*	0.347	0.463	0.739
Trend	8	-7.52	*0.623*	-2.141	*0.523*	8	*2.695*	0.119	0.146	0.216

Dependent Variable **Sorghum**

	Phillips-Perron Unit Root Test (Ho: Unit Root)					*KPSS Stationary Test (Ho: Stationary series)*				
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	Lags	Eta	Prob10%	Prob5%	Prob1%
Zero Mean	8	-0.21	*0.637*	-0.479	*0.508*					
Single Mean	8	-12.23	*0.079*	-2.487	*0.120*	8	*7.156*	0.347	0.463	0.739
Trend	8	-16.74	*0.134*	-2.926	*0.155*	8	*1.297*	0.119	0.146	0.216

Dependent Variable **Wheat**

	Phillips-Perron Unit Root Test (Ho: Unit Root)					*KPSS Stationary Test (Ho: Stationary series)*				
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	Lags	Eta	Prob10%	Prob5%	Prob1%
Zero Mean	8	0.00	*0.683*	-0.004	*0.682*					
Single Mean	8	-7.61	*0.239*	-1.924	*0.322*	8	*12.619*	0.347	0.463	0.739
Trend	8	-20.82	*0.059*	-3.635	*0.028*	8	*2.049*	0.119	0.146	0.216

Dependent Variable **Feeder Cattle**

	Phillips-Perron Unit Root Test (Ho: Unit Root)					*KPSS Stationary Test (Ho: Stationary series)*				
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	Lags	Eta	Prob10%	Prob5%	Prob1%
Zero Mean	8	0.05	*0.696*	0.359	*0.789*					
Single Mean	8	-13.19	*0.063*	-2.477	*0.122*	8	*7.984*	0.347	0.463	0.739
Trend	8	-25.14	*0.024*	-3.561	*0.034*	8	*1.031*	0.119	0.146	0.216

Dependent Variable **Live Cattle**

	Phillips-Perron Unit Root Test (Ho: Unit Root)					*KPSS Stationary Test (Ho: Stationary series)*				
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	Lags	Eta	Prob10%	Prob5%	Prob1%
Zero Mean	8	0.06	*0.697*	0.457	*0.813*					
Single Mean	8	-8.43	*0.197*	-1.934	*0.317*	8	*11.641*	0.347	0.463	0.739
Trend	8	-24.42	*0.028*	-3.543	*0.036*	8	*1.027*	0.119	0.146	0.216

Table 2: Non-Stationary Tests for series, from January 2004 to April 2009.

Dependent Variable **Corn**

	Phillips-Perron Unit Root Test (Ho: Unit Root)					*KPSS Stationary Test (Ho: Stationary series)*				
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	Lags	Eta	Prob10%	Prob5%	Prob1%
Zero Mean	7	0.06	*0.698*	0.465	*0.815*					
Single Mean	7	-2.37	*0.735*	-1.061	*0.733*	7	*11.179*	0.347	0.463	0.739
Trend	7	-5.76	*0.764*	-1.743	*0.733*	7	*1.772*	0.119	0.146	0.216

Dependent Variable **Soybean**

	Phillips-Perron Unit Root Test (Ho: Unit Root)					*KPSS Stationary Test (Ho: Stationary series)*				
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	Lags	Eta	Prob10%	Prob5%	Prob1%
Zero Mean	7	0.03	*0.691*	0.291	*0.771*					
Single Mean	7	-2.68	*0.696*	-1.068	*0.730*	7	*7.815*	0.347	0.463	0.739
Trend	7	-5.48	*0.785*	-1.808	*0.702*	7	*2.288*	0.119	0.146	0.216

Dependent Variable **Sorghum**

	Phillips-Perron Unit Root Test (Ho: Unit Root)					*KPSS Stationary Test (Ho: Stationary series)*				
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	Lags	Eta	Prob10%	Prob5%	Prob1%
Zero Mean	7	0.05	*0.695*	0.120	*0.721*					
Single Mean	7	-3.40	*0.609*	-1.309	*0.628*	7	*11.605*	0.347	0.463	0.739
Trend	7	-7.86	*0.596*	-1.967	*0.619*	7	*1.396*	0.119	0.146	0.216

Dependent Variable **Wheat**

	Phillips-Perron Unit Root Test (Ho: Unit Root)					*KPSS Stationary Test (Ho: Stationary series)*				
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	Lags	Eta	Prob10%	Prob5%	Prob1%
Zero Mean	7	0.001	*0.684*	0.006	*0.685*					
Single Mean	7	-4.45	*0.491*	-1.495	*0.537*	7	*8.771*	0.347	0.463	0.739
Trend	7	-7.16	*0.651*	-1.868	*0.672*	7	*1.477*	0.119	0.146	0.216

Dependent Variable **Feeder Cattle**

	Phillips-Perron Unit Root Test (Ho: Unit Root)					*KPSS Stationary Test (Ho: Stationary series)*				
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	Lags	Eta	Prob10%	Prob5%	Prob1%
Zero Mean	7	0.05	*0.696*	0.506	*0.825*					
Single Mean	7	-17.76	*0.210*	-3.743	*0.004*	7	*4.371*	0.347	0.463	0.739
Trend	7	-24.65	*0.270*	-4.844	*0.001*	7	*1.250*	0.119	0.146	0.216

Dependent Variable **Live Cattle**

	Phillips-Perron Unit Root Test (Ho: Unit Root)					*KPSS Stationary Test (Ho: Stationary series)*				
Type	Lags	Rho	Pr < Rho	Tau	Pr < Tau	Lags	Eta	Prob10%	Prob5%	Prob1%
Zero Mean	7	0.03	*0.691*	0.322	*0.779*					
Single Mean	7	-32.41	*0.020*	-4.334	*0.001*	7	*3.528*	0.347	0.463	0.739
Trend	7	-36.49	*0.021*	-4.451	*0.002*	7	*0.458*	0.119	0.146	0.216

Portmanteau Test[5] for cross correlations of residuals, as well as the Univariate AR model test diagnostics[6] for the residuals of each series.

The Johansen[7] co-integration test is conducted for both periods studied. Results for the first period indicate that there is no co-integration factor among the variables (i.e., $r = 0$ for the parameter Π in equation 2). However, results for the second estimated period identify a co-integration factor of order 1 among the series. Results from the co-integration tests are in tables 3 and 4 for each period, respectively. From table 3 the error correction term in the VEC equation is null in the first period, resulting in a VAR of order 3 in ΔY that may be seen from the following table 5. This number of lags (3) in the first estimated period responds to a Portmanteau test that does not reject the null hypothesis of correlations of the residuals distributing randomly or as white noise (table 5).

The VEC or co-integrated VAR model is applied during the second period estimated since it has an error correction term of order 1 (table 4), resulting in a "co-integrated" VAR model of order 5 as indicated in table 6. In this second period, the univariate AR diagnostic test shows no autocorrelation for residuals from 5 lags.

[5] From Hosking (1980), is a test for a group of auto and cross correlations from a model's residuals with the null hypothesis having them distribute as a random walk or white noise.
[6] F test for AR disturbances of Univariate model: Test statistics from the residuals of AR(1), AR(2), AR(3) and AR(4) that test the null hypothesis that residuals are uncorrelated.
[7] Johansen (1991) Co-integration test for many time series. Considers the trace (or the eigenvalues) among the time series and the null hypothesis is that the co-integration vector *r* is equal to any value between one and the number of time series minus one.

Table 3: Cointegration Test for series, from January 1998 to December 2004.

Johansen's Cointegration Rank Test Using Trace

Ho: Rank = r	H1: Rank > r	Eigenvalue	Trace	5% Critical Value
0	0	0.015	*70.604*	82.61
1	1	0.011	*43.798*	59.24
2	2	0.006	*23.598*	39.71
3	3	0.004	*12.523*	24.08
4	4	0.003	*4.800*	12.21
5	5	0	*0.033*	4.14

Table 4: Cointegration Test for series, from January 2004 to April 2009.

Johansen's Cointegration Rank Test Using Trace

Ho: Rank = r	H1: Rank > r	Eigenvalue	Trace	5% Critical Value
0	0	0.023	*87.577*	82.61
1	1	0.016	*56.529*	59.24
2	2	0.015	*35.655*	39.71
3	3	0.006	*15.082*	24.08
4	4	0.005	*6.615*	12.21
5	5	0.001	*0.155*	4.14

Table 5: Portmanteau Test of Residuals, from January 1998 to December 2004.

Test for Cross Correlations of Residuals
(Ho: Residuals from # Lags of Series is a random walk)

Up To Lag	DF	Chi-Square	Pr > ChiSq
4	36	44.74	0.1505
5	72	107.06	0.0046
6	108	145.18	0.0099
7	144	182.55	0.0164
8	180	249.86	0.0004
9	216	277.8	0.0029
10	252	324.76	0.0013

Table 6: Univariate AR Diagnostic Tests, from January 2004 to April 2009.

Test for Univariate Correlations of Residuals after 5 lags
(Ho: Residuals from AR # Lags of univariate Series are uncorrelated)

	AR1		AR2		AR3		AR4	
Variable	F Value	Pr > F	F Value	Pr > F	F Value	Pr > F	F Value	Pr > F
Corn	0.02	0.8797	0.01	0.9867	0.01	0.9989	0.01	0.9999
Soybean	0.01	0.9245	0.01	0.9875	0.02	0.9967	0.02	0.9994
Sorghum	0.00	0.9877	0.00	0.9980	0.00	0.9998	0.02	0.9995
Wheat	0.00	0.9501	0.01	0.9937	0.01	0.9994	0.03	0.9979
Feeder Cattle	0.00	0.9864	0.06	0.9443	0.05	0.9849	0.03	0.9980
Live Cattle	0.02	0.8825	0.02	0.9836	0.07	0.9741	0.09	0.9841

The coefficients for the estimated models for the series from January 1998 to December 2004 are in table 7, and from January 2004 to December 2009 are in tables 8.1 and 8.2. In general, each of the grain and cattle markets has an autoregressive factor of its own with a particular lag, and may include another significant coefficient from its product type with a particular lag (i.e., a specific grain having an autoregressive component from another grain and/or a particular cattle market having an autoregressive component from the other cattle market). Analysis of the impact of these coefficients may be better assessed through Granger Causality tests.

Table 7: Parameter Estimates VAR (3): from January 1998 to December 2004.

VAR Coefficient Estimates (p values in parenthesis)

Lag	Variable	Corn	Soybean	Sorghum	Wheat	Feeder Cattle	Live Cattle
1	Corn	-0.0649*	0.0159	0.0767*	0.0297	0.0103	0.0274
		(0.0499)	(0.5873)	(0.0096)	(0.1635)	(0.6315)	(0.3346)
	Soybean	-0.0235	-0.0155	0.0353	-0.0048	0.0009	0.0187
		(0.4607)	(0.5837)	(0.2165)	(0.8159)	(0.9649)	(0.4936)
	Sorghum	0.2126*	0.0065	-0.2435*	0.0232	-0.0095	0.0128
		(0.0001)	(0.8320)	(0.0001)	(0.3004)	(0.6721)	(0.6662)
	Wheat	0.0408	-0.0560	0.0563	-0.0455+	0.0129	0.0375
		(0.3311)	(0.1330)	(0.1344)	(0.0937)	(0.6350)	(0.2981)
	Feeder Cattle	0.0154	-0.0168	-0.0020	0.0081	-0.1413*	0.0322
		(0.6813)	(0.6129)	(0.9527)	(0.7386)	(0.0001)	(0.3175)
	Live Cattle	0.0425	-0.0516	0.0089	0.0173	0.0418*	-0.0627*
		(0.1318)	(0.0395)	(0.7260)	(0.3418)	(0.0221)	(0.0098)
2	Corn	-0.0772*	0.0297	0.0794*	0.0042	-0.0340	0.0728*
		(0.0221)	(0.3119)	(0.0098)	(0.8445)	(0.1143)	(0.0099)
	Soybean	-0.0532	0.0386	0.0734*	0.0003	-0.0112	0.0660*
		(0.1022)	(0.1724)	(0.0134)	(0.9882)	(0.5894)	(0.0154)
	Sorghum	0.0447	-0.0226	-0.0226	0.0164	-0.0313	0.0652*
		(0.2060)	(0.4622)	(0.4833)	(0.4638)	(0.1663)	(0.0277)
	Wheat	0.0137	-0.0108	0.0469	-0.0036	-0.0202	0.0401
		(0.7487)	(0.7717)	(0.2297)	(0.8959)	(0.4604)	(0.2630)
	Feeder Cattle	-0.0058	0.0385	-0.0137	-0.0101	-0.0236	0.1287*
		(0.8794)	(0.2472)	(0.6952)	(0.6780)	(0.3347)	(0.0001)
	Live Cattle	-0.0313	0.0535*	0.0192	-0.0091	0.0723*	-0.0786*
		(0.2763)	(0.0326)	(0.4643)	(0.6203)	(0.0001)	(0.0011)
3	Corn	-0.0928*	0.0208	0.0304	0.0070	-0.0408+	-0.0151
		(0.0051)	(0.4785)	(0.3032)	(0.7437)	(0.0566)	(0.5956)
	Soybean	-0.034	0.0499+	-0.0346	-0.0069	0.0088	0.0377
		(0.2872)	(0.0788)	(0.2237)	(0.7354)	(0.6684)	(0.1688)
	Sorghum	0.0034	0.0199	-0.0331	-0.0066	0.0106	-0.0421
		(0.9212)	(0.5188)	(0.2845)	(0.7676)	(0.6357)	(0.1574)
	Wheat	-0.0660	0.0552	-0.0016	-0.0506+	-0.0255	-0.0382
		(0.1168)	(0.1392)	(0.9655)	(0.0618)	(0.3472)	(0.2895)
	Feeder Cattle	0.0134	0.0333	0.0242	-0.0317	0.0095	0.0369
		(0.7213)	(0.3176)	(0.4687)	(0.1900)	(0.6956)	(0.2514)
	Live Cattle	0.0154	0.0289	-0.0035	0.0135	0.0478*	0.0047
		(0.5855)	(0.2496)	(0.8894)	(0.4580)	(0.0090)	(0.8448)

* Significant at 5 % level or less

\+ Significant at 10 % level or less

Table 8.1: Parameter Estimates of Π for VEC (5): from January 2004 to April 2009.

Parameters Π Estimates (Standard Errors in parenthesis, yet of Non-Gaussian distribution)

Var. $\Delta_t \backslash y_{t-1}$	Corn	Soybean	Sorghum	Wheat	Feeder Cattle	Live Cattle
Corn	-0.0119	*0.0052*	0.0083	-0.0022	*-0.0080*	*0.0156*
	(0.0075)	(0.0033)	(0.0052)	(0.0014)	(0.0050)	(0.0098)
Soybean	-0.0006	0.0002	0.0004	-0.0001	-0.0004	0.0007
	(0.0072)	(0.0032)	(0.0051)	(0.0014)	(0.0049)	(0.0095)
Sorghum	0.0127	-0.0056	-0.0089	0.0024	0.0085	-0.0167
	(0.0079)	(0.0034)	(0.0055)	(0.0015)	(0.0053)	(0.0103)
Wheat	-0.0144	0.0063	0.0100	-0.0027	-0.0097	0.0188
	(0.0101)	(0.0044)	(0.0071)	(0.0019)	(0.0068)	(0.0132)
Feeder Cattle	-0.0094	0.0041	0.0066	-0.0018	-0.0063	*0.0123*
	(0.0053)	(0.0023)	(0.0037)	(0.0010)	(0.0036)	(0.0069)
Live Cattle	0.0131	-0.0057	-0.0092	0.0025	0.0088	-0.0172
	(0.0046)	(0.0020)	(0.0032)	(0.0009)	(0.0031)	(0.0061)

For the second estimated period there are the long-run estimates in the interaction between the variables given by the error correction term (Π) from previous table 8.1. These long-run estimates are in line with what may be anticipated from the literature, such as the case of corn and soybean having a long run positive (0.0052) relationship due to shared acreage. Similar positive long run relationship is obtained between feeder cattle and live cattle (0.0123) as they are both major components of cattle production profitability. Regarding corn and feeder cattle prices, they have a long run negative relationship (-0.0080) since calf producers tend to sell earlier than usual when corn prices go up, thus driving the calf/feeder prices down (Anderson and Trapp, 2000). It is not clear at this moment the resulting long-run positive relationship between corn and live cattle (0.0156), though may be a spurious finding requiring further study.

Table 8.2: Parameter Estimates A_i *(K-1)* for VEC (5): from January 2004 to April 2009.

(p values in parenthesis)

Lag	Variable	Corn	Soybean	Sorghum	Wheat	Feeder Cattle	Live Cattle
1	Corn	0.0226	-0.0261	0.0518	-0.0068	0.0145	-0.0155
		(0.6017)	(0.4690)	(0.1646)	(0.7758)	(0.7136)	(0.7323)
	Soybean	-0.0142	-0.0160	-0.0047	-0.0176	0.0030	0.0163
		(0.7340)	(0.6448)	(0.8956)	(0.4472)	(0.9379)	(0.7083)
	Sorghum	0.3255	-0.0120	-0.2715	0.0032	-0.0043	0.0002
		(0.0001)	(0.7496)	(0.0001)	(0.8979)	(0.9167)	(0.9969)
	Wheat	-0.0792	-0.1261	0.0263	-0.0143	0.0034	-0.0662
		(0.1752)	(0.0095)	(0.5998)	(0.6580)	(0.9497)	(0.2779)
	Feeder Cattle	0.0278	0.0140	-0.0153	0.0078	-0.0963	0.0614
		(0.3618)	(0.5805)	(0.5586)	(0.6465)	(0.0005)	(0.0541)
	Live Cattle	-0.0325	0.0158	0.0448	0.0091	0.0924	-0.1155
		(0.2235)	(0.4757)	(0.0509)	(0.5390)	(0.0001)	(0.0001)
2	Corn	-0.0212	-0.0498	0.0561	0.0025	-0.0140	0.0177
		(0.6359)	(0.1671)	(0.1453)	(0.9174)	(0.7241)	(0.6981)
	Soybean	-0.0261	0.0052	0.0777	-0.0212	0.0183	0.0823
		(0.5452)	(0.8804)	(0.0367)	(0.3555)	(0.6333)	(0.0615)
	Sorghum	0.1063	-0.0480	-0.0578	0.0026	0.0087	0.0343
		(0.0236)	(0.2043)	(0.1525)	(0.9158)	(0.8338)	(0.4723)
	Wheat	-0.0217	-0.0802	0.2081	-0.0192	-0.0254	0.0251
		(0.7190)	(0.0991)	(0.0001)	(0.5492)	(0.6356)	(0.6834)
	Feeder Cattle	0.0258	0.0071	-0.0377	0.0154	-0.0069	0.0890
		(0.4127)	(0.7810)	(0.1642)	(0.3580)	(0.8039)	(0.0056)
	Live Cattle	-0.0295	0.0369	0.0524	0.0047	0.0527	-0.0614
		(0.2849)	(0.0971)	(0.0274)	(0.7469)	(0.0313)	(0.0292)
3	Corn	-0.0395	0.0514	0.0250	-0.0023	-0.0997	0.0636
		(0.3786)	(0.1544)	(0.5193)	(0.9241)	(0.0119)	(0.1615)
	Soybean	-0.0773	0.0546	0.0374	0.0101	-0.0282	0.0597
		(0.0744)	(0.1168)	(0.3181)	(0.6588)	(0.4600)	(0.1727)
	Sorghum	0.0624	0.0556	-0.1341	0.0341	-0.0732	0.0671
		(0.1845)	(0.1409)	(0.0010)	(0.1702)	(0.0778)	(0.1583)
	Wheat	-0.2051	0.0697	0.0865	-0.0185	-0.0827	-0.0468
		(0.0007)	(0.1521)	(0.0985)	(0.5630)	(0.1214)	(0.4448)
	Feeder Cattle	0.0410	0.0051	-0.0303	0.0064	0.0452	0.0591
		(0.1942)	(0.8394)	(0.2667)	(0.7008)	(0.1050)	(0.0647)
	Live Cattle	-0.0025	0.0416	-0.0104	0.0105	0.0424	0.0192
		(0.9281)	(0.0611)	(0.6628)	(0.4743)	(0.0821)	(0.4926)
4	Corn	-0.0379	0.0548	0.0499	-0.0116	0.0054	-0.0346
		(0.3907)	(0.1291)	(0.1792)	(0.6228)	(0.8921)	(0.4403)
	Soybean	0.0117	0.0758	0.0085	0.0042	0.0013	-0.0284
		(0.7845)	(0.0295)	(0.8132)	(0.8542)	(0.9734)	(0.5119)
	Sorghum	-0.0090	0.0221	0.0153	0.0049	-0.0210	-0.0098
		(0.8466)	(0.5581)	(0.6931)	(0.8435)	(0.6107)	(0.8353)
	Wheat	0.0103	0.0747	-0.0104	-0.0196	-0.0212	-0.0162
		(0.8630)	(0.1249)	(0.8347)	(0.5369)	(0.6893)	(0.7884)
	Feeder Cattle	0.0090	0.0118	-0.0014	0.0055	0.0051	0.0522
		(0.7718)	(0.6424)	(0.9579)	(0.7377)	(0.8555)	(0.0984)
	Live Cattle	-0.0023	0.0091	-0.0151	0.0027	0.0249	0.0291
		(0.9330)	(0.6816)	(0.5083)	(0.8517)	(0.3044)	(0.2914)

Results from Granger Causality tests among the commodities, during each estimated period, are in the following tables 9 and 10.

Table 9: Granger-Causality Test: from January 1998 to December 2004.

Granger-Causality Wald Test: p-values

Lag / ***Lead***	Corn	Soybean	Sorghum	Wheat	Feeder Cattle	Live Cattle
Corn	-	0.3470	<.0001*	0.1321	0.6758	0.1265
Soybean	0.3414	-	0.0517+	0.7564	0.5262	0.0369*
Sorghum	0.0029*	0.0190*	-	0.0973+	0.5878	0.4001
Wheat	0.2487	0.8047	0.0191*	-	0.9269	0.3231
Feeder Cattle	0.1698	0.8499	0.7284	0.6143	-	<.0001*
Live Cattle	0.0698+	0.0525+	0.1037	0.3195	0.0006*	-

* Significant at 5 % level or less
\+ Significant at 10 % level or less

Table 10: Granger-Causality Test: from January 2004 to April 2009.

Granger-Causality Wald Test: p-values

Lag / ***Lead***	Corn	Soybean	Sorghum	Wheat	Feeder Cattle	Live Cattle
Corn	-	0.3694	<.0001*	0.0070*	0.3684	0.1134
Soybean	0.2567	-	0.0127*	0.0095*	0.1124	0.0069*
Sorghum	0.5394	0.4684	-	0.0022*	0.7304	0.0088*
Wheat	0.0582+	0.0146*	0.0040*	-	0.6030	0.1472
Feeder Cattle	0.3253	0.9750	0.3870	0.4738	-	<.0001*
Live Cattle	0.5401	0.1421	0.6448	0.4334	0.0004*	-

* Significant at 5 % level or less
\+ Significant at 10 % level or less

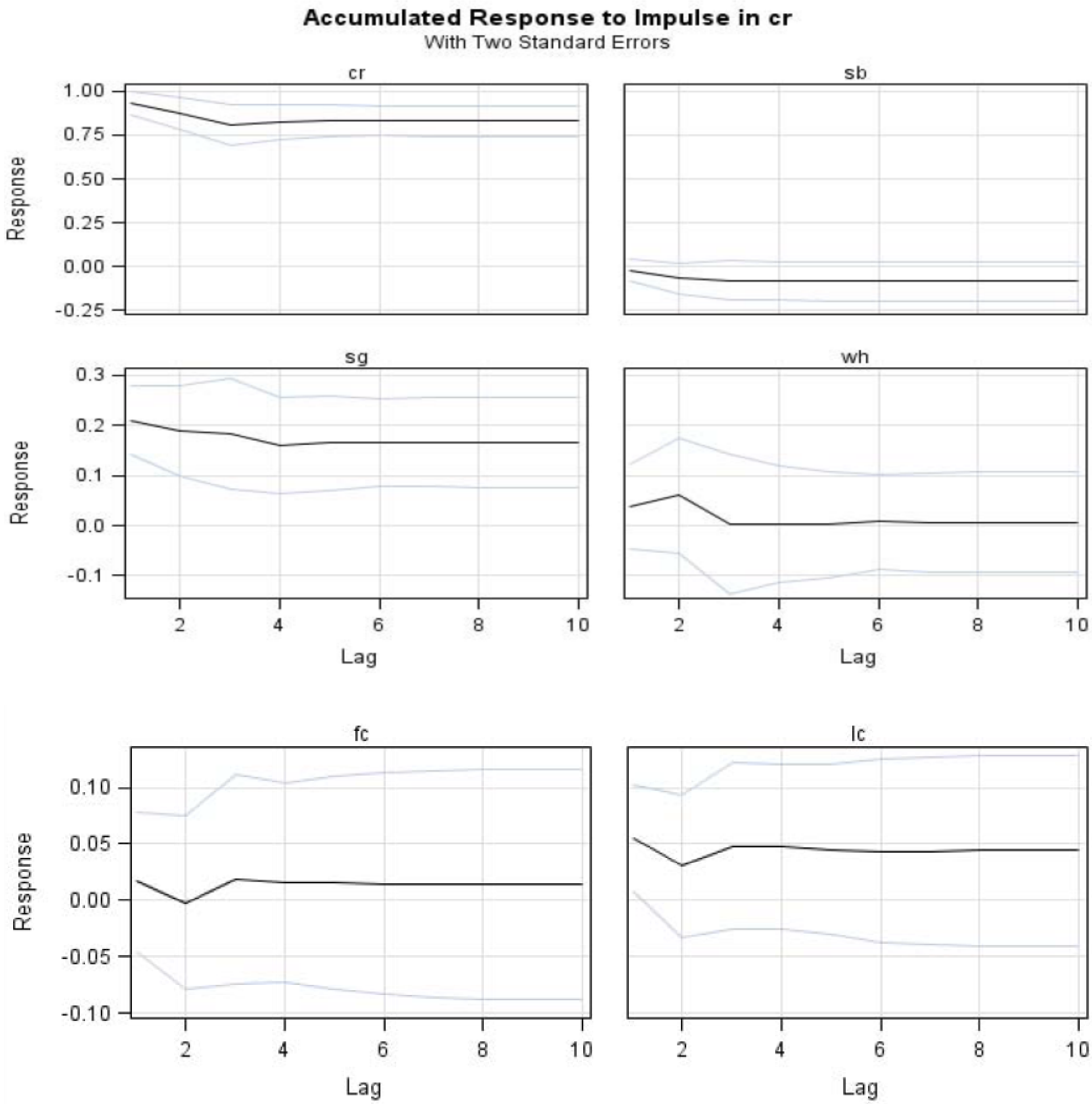
Results for the first period indicate that changes in corn prices Granger cause (or lead) changes in sorghum prices, and conversely changes in sorghum prices also Granger cause changes in corn prices (i.e., there is a bidirectional Granger causality between these two grains). Hence price changes in either of these two grains affect the other one. More importantly, in the second period changes in corn price maintain Granger causality on changes in sorghum prices, but the inverse Granger causality relation does not hold anymore (i.e., changes in sorghum prices do not Granger cause changes in corn prices). Thus for the second period, only corn price changes lead changes in sorghum prices and not vice-versa. This result may be plausibly caused by major corn consumption from ethanol production during this period, bringing about a substitution away from corn to sorghum in livestock feeding components. This latter increase in sorghum consumption produces a subsequent increase in sorghum prices as may be seen toward the end of the period in figure 3.

During the second period, a change in corn prices likewise Granger causes changes in the price of wheat. The same applies for changes in soybean prices, as it has Granger causality on changes of both sorghum and wheat prices. However, none of these Granger Causalities are obtained during the first period. These causality patterns may again possibly respond to modification of livestock feed rations in the second period, although soybean is a protein component and both sorghum and wheat are carbohydrates. In addition, in neither of the two periods considered are changes in corn prices Granger causing changes in soybean prices or vice-versa. Thus there is no Granger Causality in either direction between corn and soybeans.

A bidirectional Granger Causality is determined for cattle markets prices, during both periods estimated. Hence changes in prices of feeder cattle have granger causality in price changes of live cattle and vice-versa. During the second period, price changes in sorghum and soybean Granger cause changes of live cattle prices. However, in the first period only soybean Granger causes changes of live cattle prices.

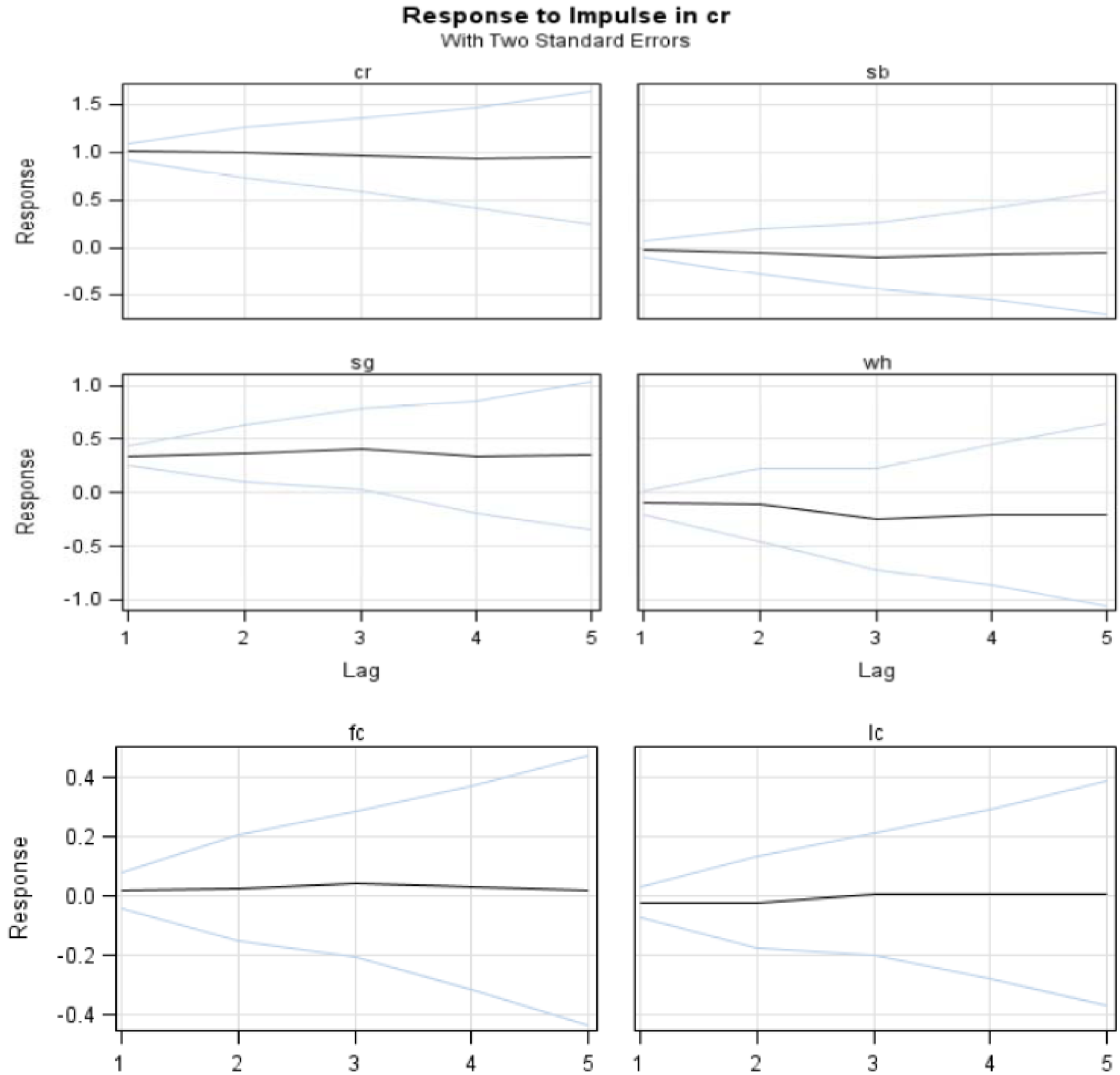
Accumulated impulse responses for the commodities studied were determined for the first period estimated by considering a shock of one unit on a specific commodity, and its corresponding effect on each market over a length of 10 time periods (i.e., days). The result of these accumulated impulse responses includes confidence bands of two standard errors. For the second period estimated through the VEC(5) model, simple impulse responses were computed by considering a one unit shock on a specific variable and its effect on each commodity over a length of five time periods (days). The resulting impulse responses from corn price shocks, for the two periods are in following figures 4.1 and 4.2.

From figure 4.1 it may be noted that after the shock on corn price, only sorghum has an initial increase in its price of 0.2 units, and subsequently lowers to 0.15 units. Yet as seen from figure 4.2 below, in the second period the response from corn price shocks on sorghum prices is much higher beginning at 0.35 units, it subsequently rises to 0.4 units after three days, before returning to about 0.34 units (i.e., the response on sorghum from the shock effect of corn is larger in this period) where it becomes insignificant when taking into account the confidence band.



cr: corn; **sb**: soybeans; **sg**: sorghum; **wh**: wheat; **fc**: feeder cattle; **lc**: live cattle

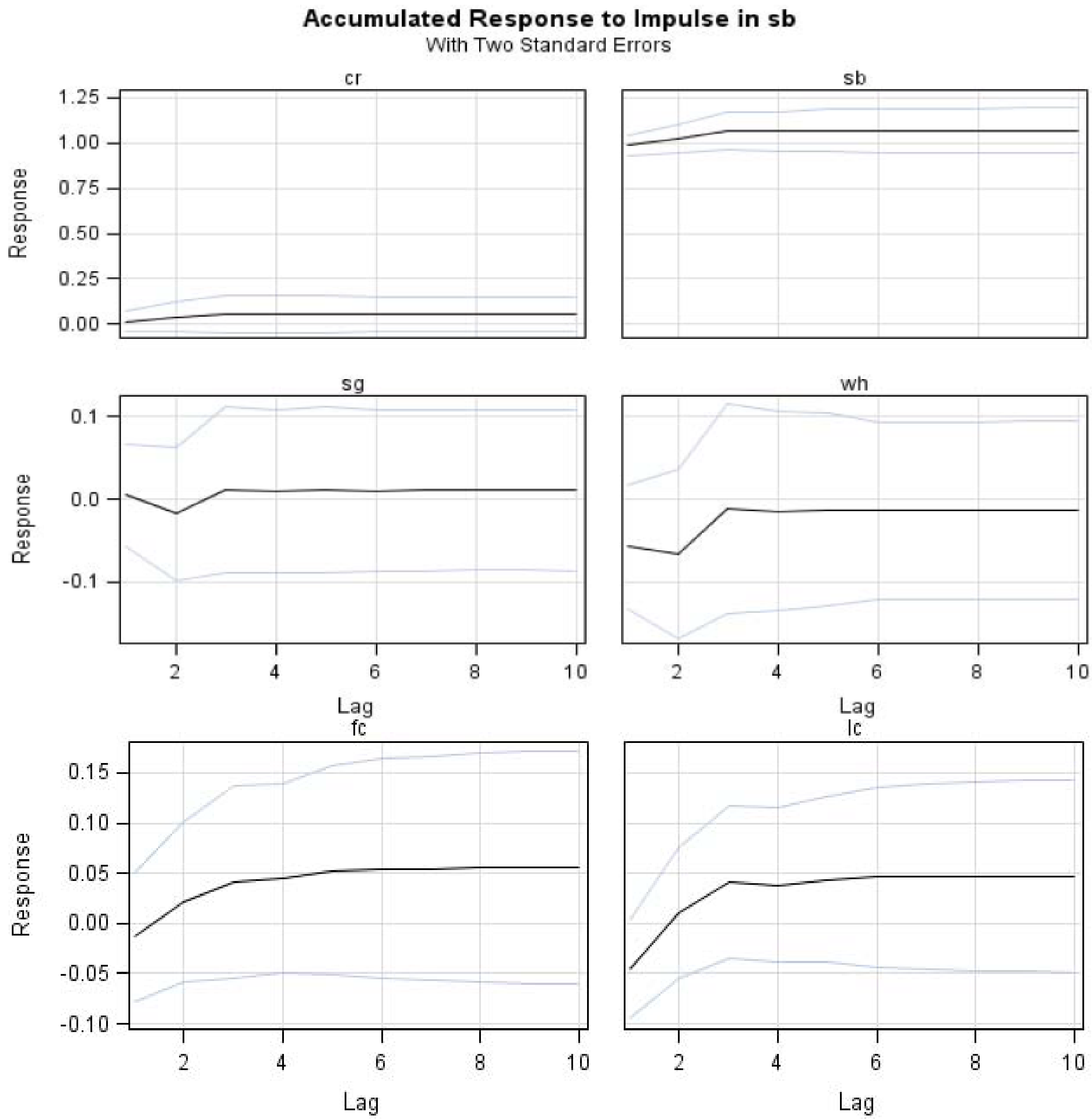
Figure 4.1: Accumulated Price Responses of Selected Markets in days, for a one unit shock in Corn prices, during the period from January 1998 to December 2004.



cr: corn; **sb**: soybeans; **sg**: sorghum; **wh**: wheat; **fc**: feeder cattle; **lc**: live cattle

Figure 4.2: Simple Price Responses of Selected Markets in days, for one unit shock in Corn price, during the period from January 2004 to April 2009.

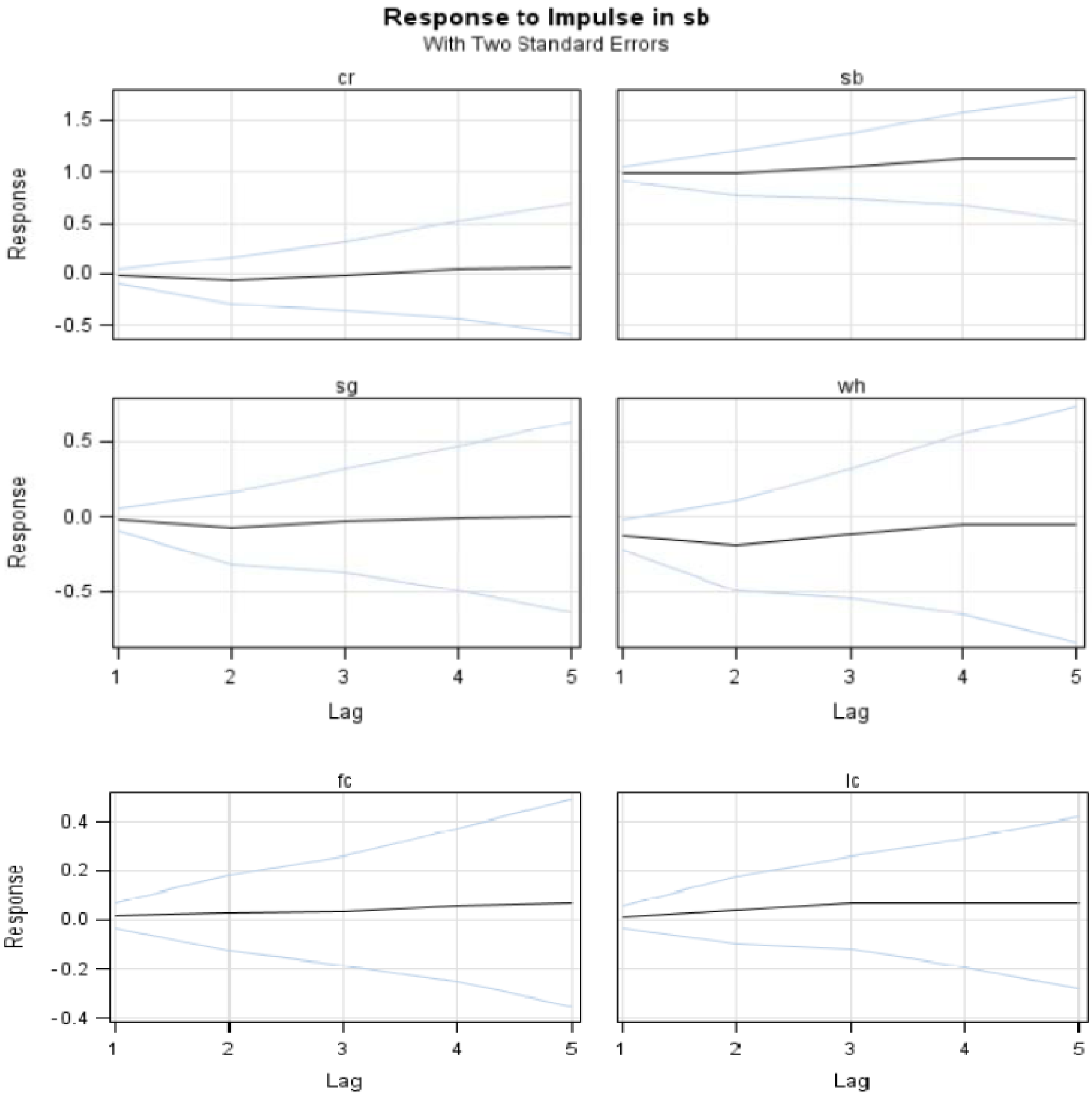
The impulse responses determined from shocks of one unit of soybean prices on each market are in the following figures 5.1 and 5.2, considering the first and second estimated period, respectively.



cr: corn; **sb**: soybeans; **sg**: sorghum; **wh**: wheat; **fc**: feeder cattle; **lc**: live cattle

Figure 5.1: Accumulated Price Responses of Selected Markets in days, for a one unit shock in Soybean prices, for the period from January 1998 to December 2004.

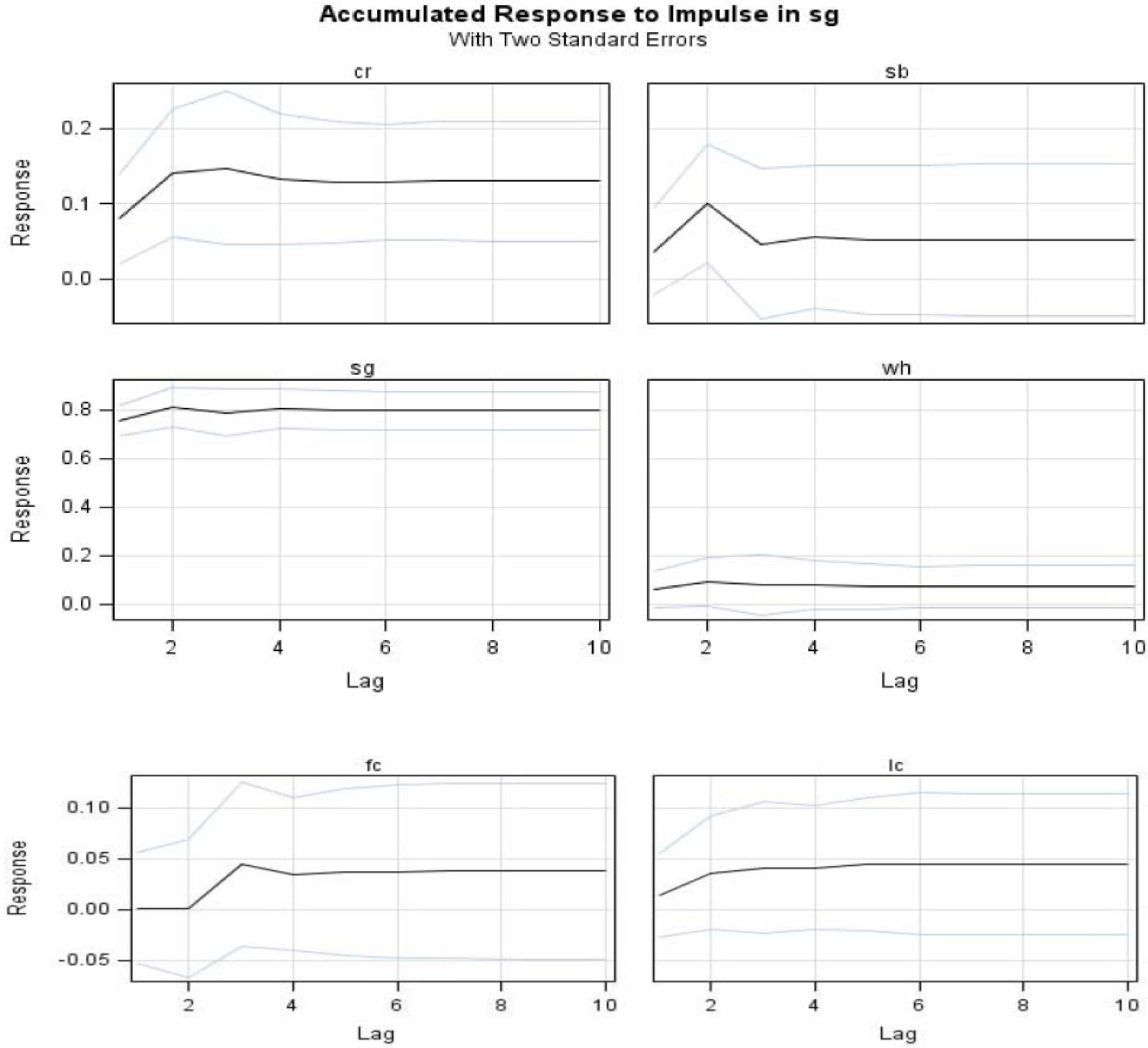
For the first period from figure 5.1 above, only soybean has an accumulated price response which is expected, yet no other market has a significant response. However, for the second period in figure 5.2 below, wheat prices have a decrease to 0.21 units on the first day before this drop becomes insignificant.



cr: corn; **sb**: soybeans; **sg**: sorghum; **wh**: wheat; **fc**: feeder cattle; **lc**: live cattle

Figure 5.2: Simple Price Responses of Selected Markets in days, for a one unit shock in Soybean prices, for the period from January 2004 to April 2009.

The impulse responses from shocks of one unit of grain sorghum prices on each market are in the following figures 6.1 and 6.2, for both estimated periods.

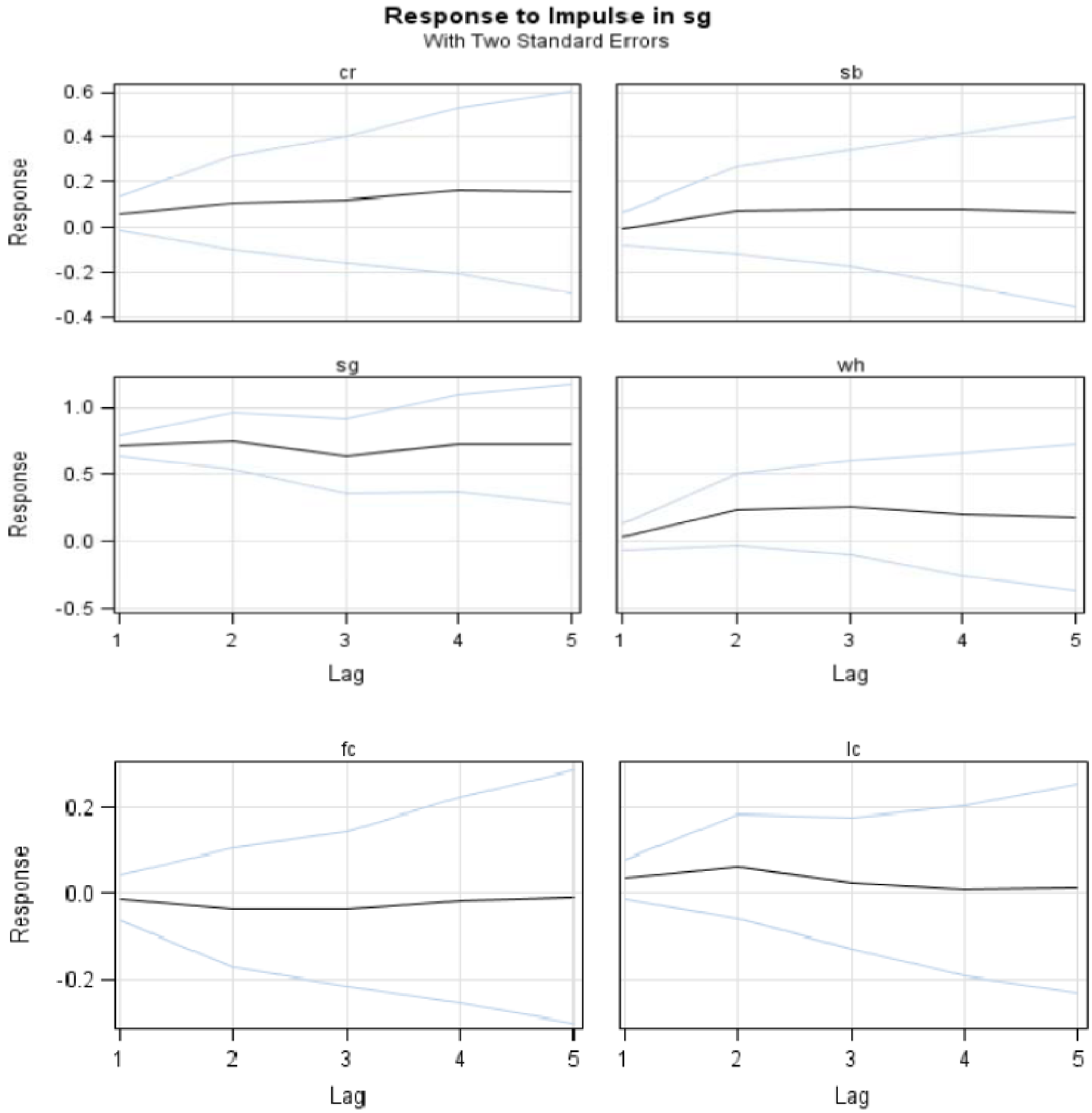


cr: corn; **sb**: soybeans; **sg**: sorghum; **wh**: wheat; **fc**: feeder cattle; **lc**: live cattle

Figure 6.1: Accumulated Price Responses of Selected Markets in days, for a one unit shock in Sorghum prices, for the period from January 1998 to December 2004.

During the first period above, corn prices experience an accumulated response that increases to about 0.15 units at the third day, before decreasing to a steady accumulated response of 0.13

units at the fourth day. Likewise, soybean prices experience an increased accumulated response of 0.1 units in the second day before decreasing to a non-significant value afterwards.

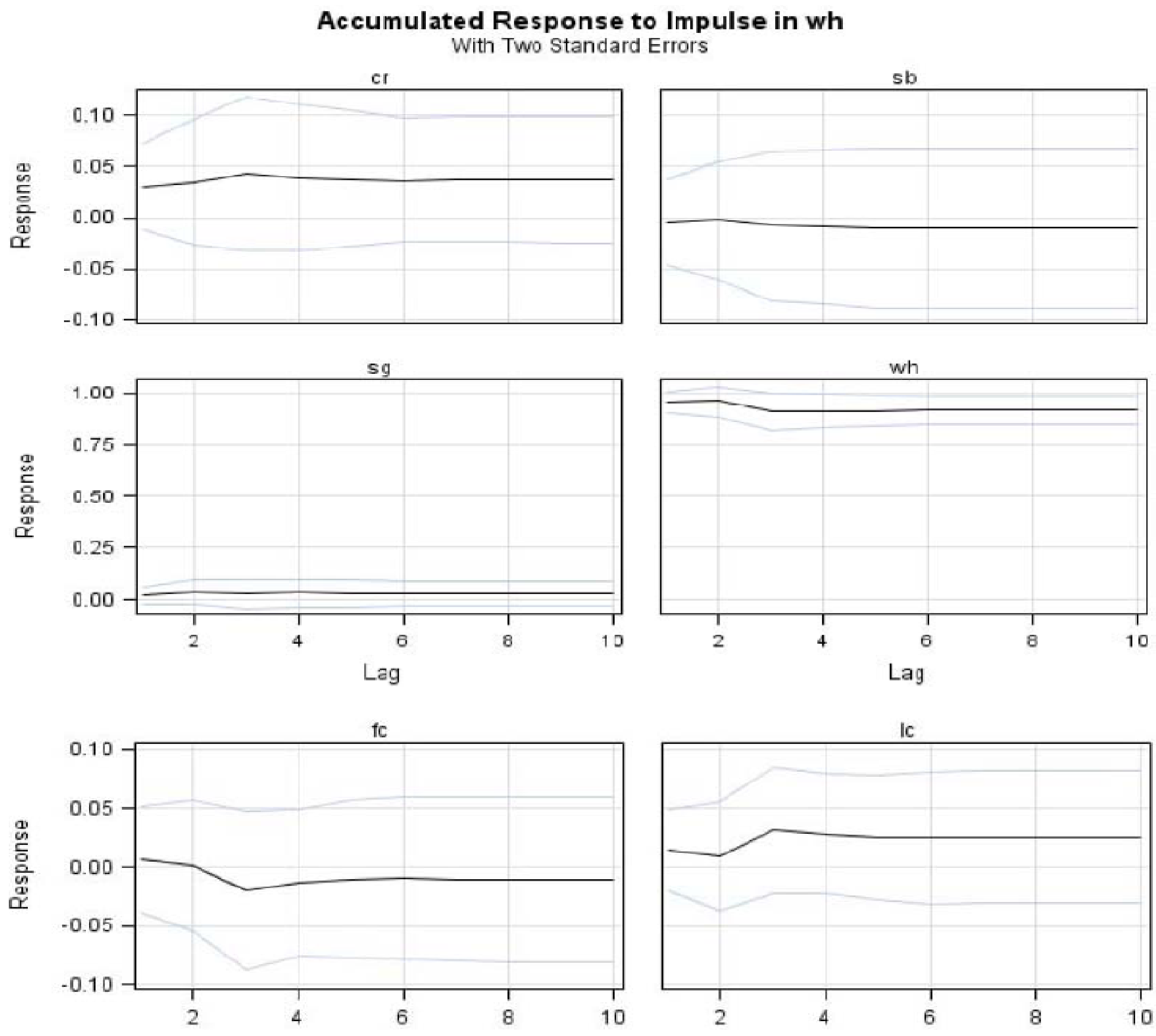


cr: corn; **sb**: soybeans; **sg**: sorghum; **wh**: wheat; **fc**: feeder cattle; **lc**: live cattle

Figure 6.2: Simple Price Responses of Selected Markets in days, for a one unit shock in Sorghum prices, for the period from January 2004 to April 2009.

For the second period above however, corn prices do not have a significant response from a shock to sorghum prices. Soybean prices are likewise not significantly affected by a shock to sorghum prices.

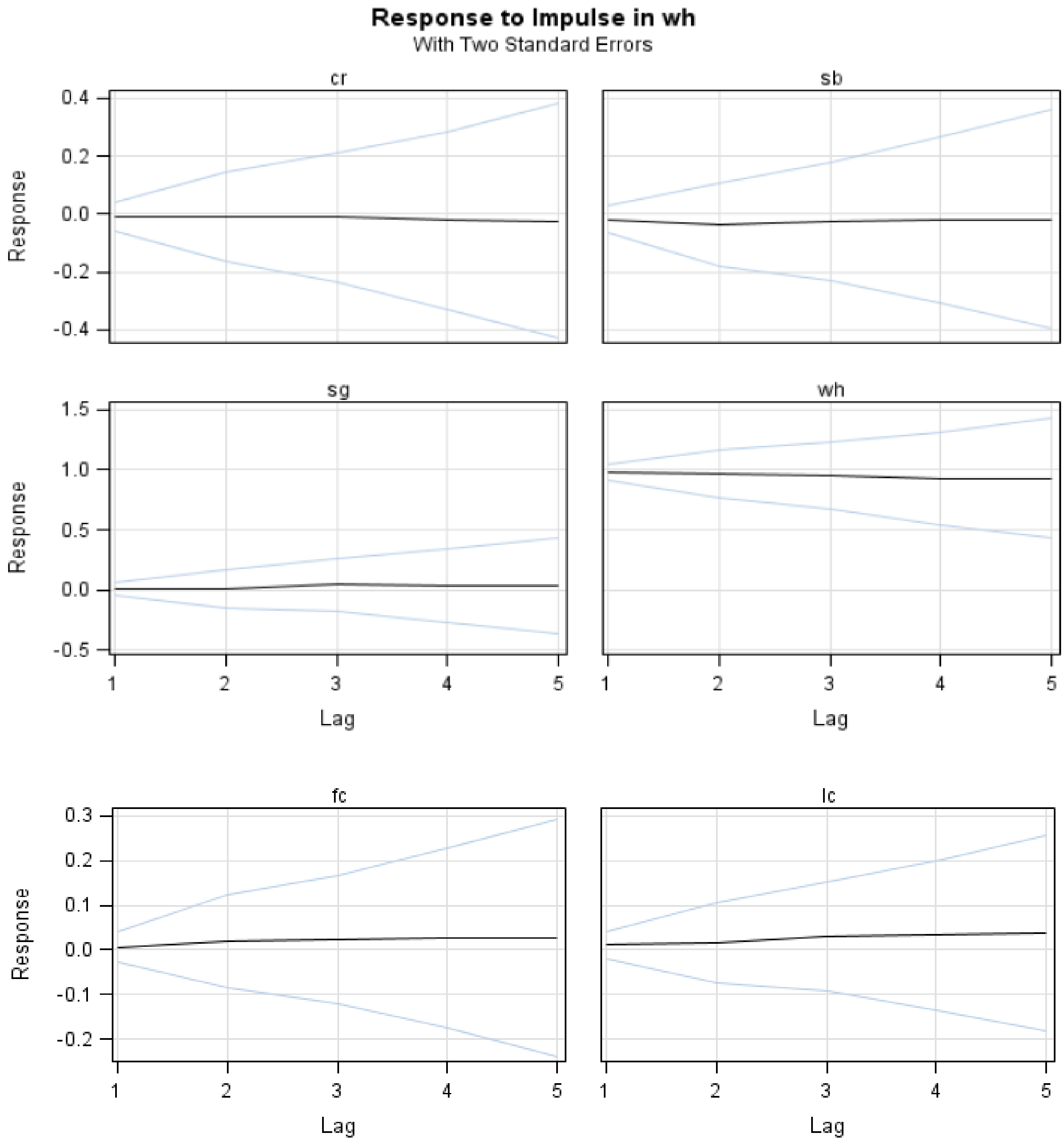
Next, the impulse responses obtained from shocks of one unit of wheat prices on each market, are in the following figures 7.1 and 7.2, considering both estimated periods.



cr: corn; **sb**: soybeans; **sg**: sorghum; **wh**: wheat; **fc**: feeder cattle; **lc**: live cattle

Figure 7.1: Accumulated Price Responses of Selected Markets in days, for a one unit shock in Wheat prices, for the period from January 1998 to December 2004.

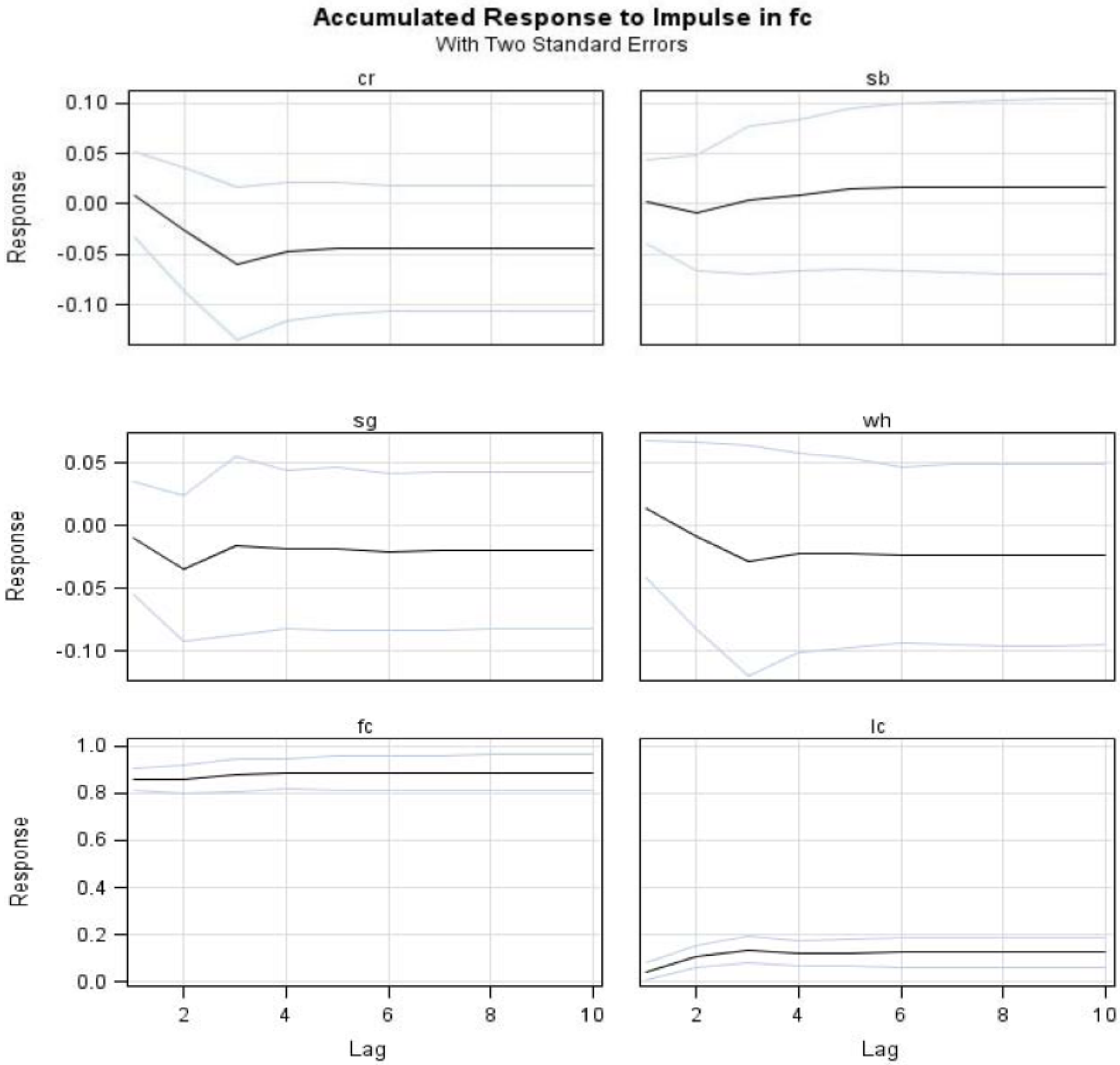
Shocks to wheat prices do not produce a significant response on any other market, for both periods considered.



cr: corn; **sb**: soybeans; **sg**: sorghum; **wh**: wheat; **fc**: feeder cattle; **lc**: live cattle

Figure 7.2: Simple Price Responses of Selected Markets in days, for one unit shock in Wheat prices, for the period from January 2004 to April 2009.

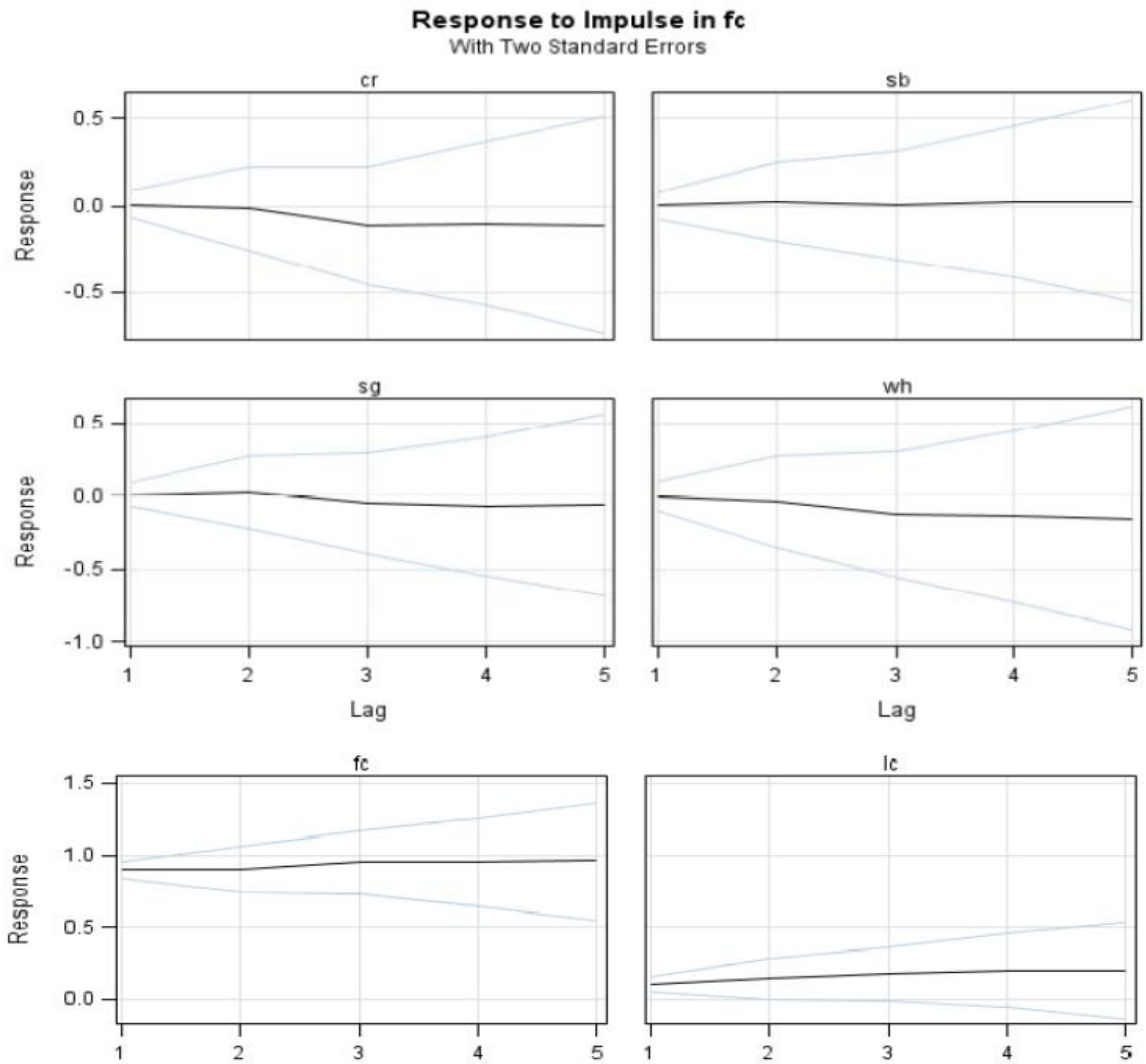
In following figures 8.1 and 8.2, the impulse responses on each market are determined from shocks of one unit in feeder cattle prices, for both estimated periods.



cr: corn; **sb**: soybeans; **sg**: sorghum; **wh**: wheat; **fc**: feeder cattle; **lc**: live cattle

Figure 8.1: Accumulated Price Responses of Selected Markets in days, for a one unit shock in Feeder Cattle prices, for period from January 1998 to December 2004.

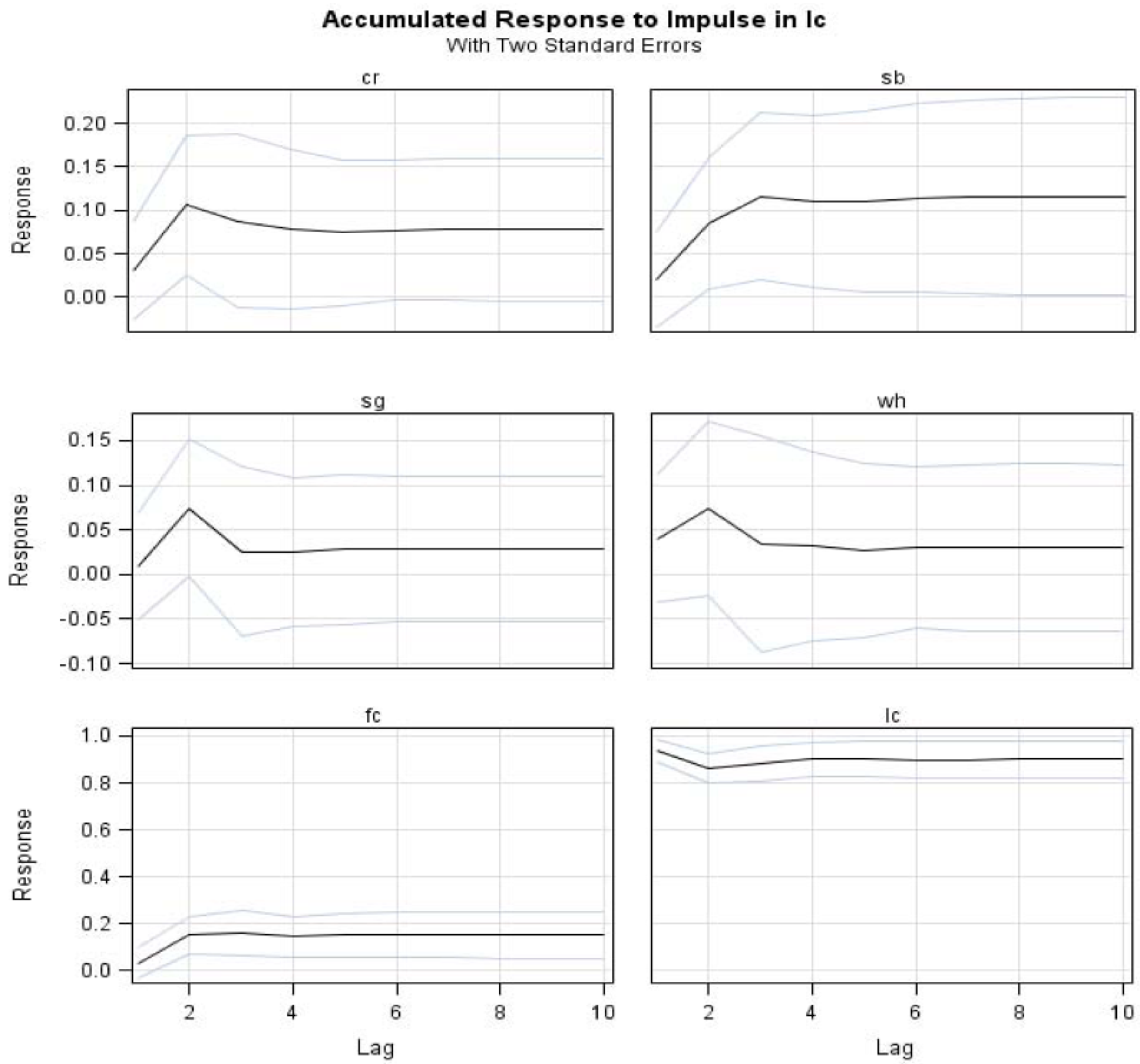
During the first period, an increasing accumulated price response of 0.13 units for live cattle is obtained at the third day, and then maintained through the rest of the days. This price response for live cattle is similar during the second estimated period, rising from 0.13 to 0.16 on the second day and then becoming insignificant, as seen below in figure 8.2



cr: corn; **sb**: soybeans; **sg**: sorghum; **wh**: wheat; **fc**: feeder cattle; **lc**: live cattle

Figure 8.2: Simple Price Responses of Selected Markets in days, for one unit shock in Feeder Cattle prices, for period from January 2004 to April 2009.

In the following figures 9.1 and 9.2, the impulse responses from shocks of one unit of live cattle prices on each market are determined for each estimated period.

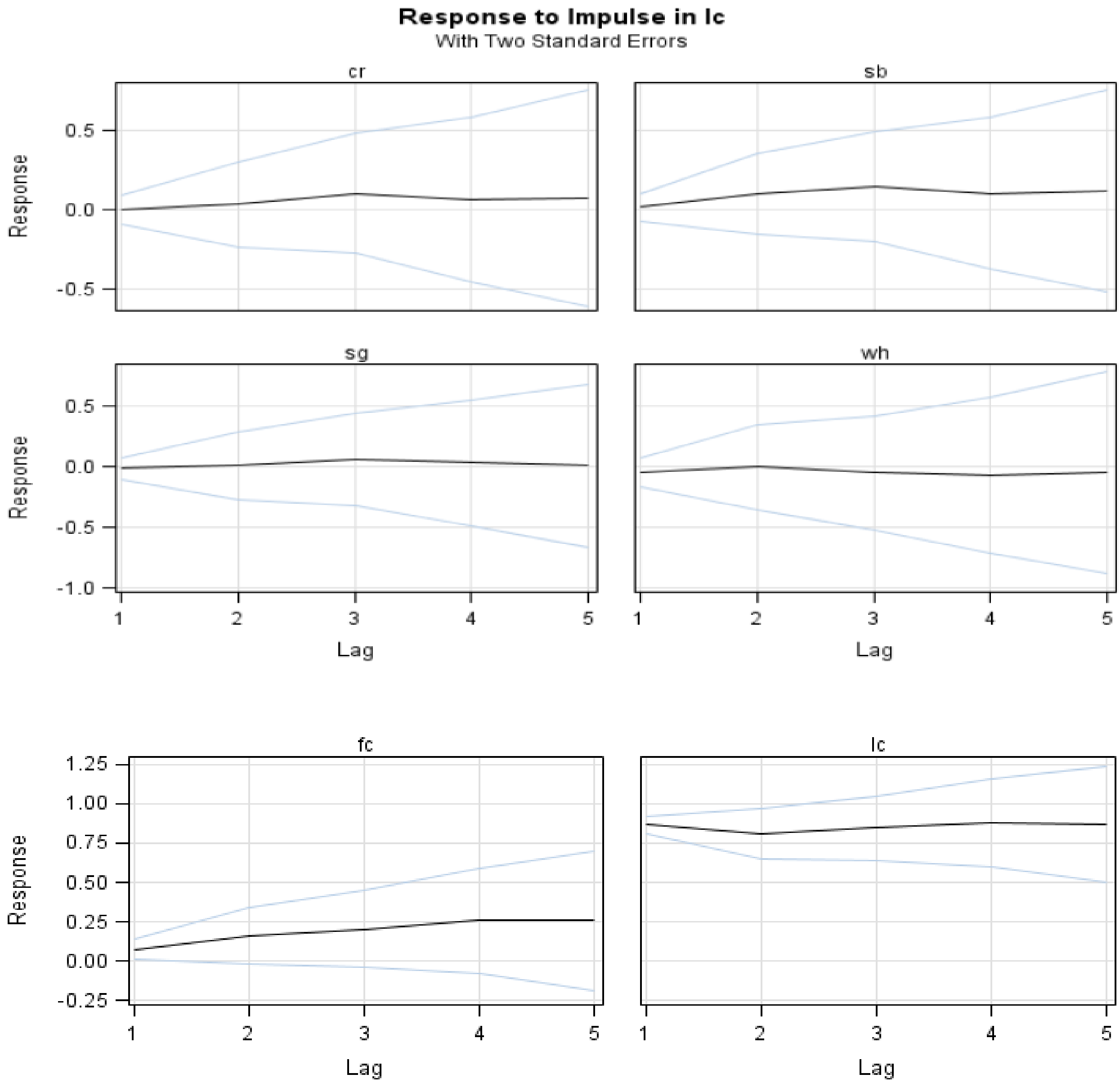


cr: corn; **sb**: soybeans; **sg**: sorghum; **wh**: wheat; **fc**: feeder cattle; **lc**: live cattle

Figure 9.1: Accumulated Price Responses of Selected Markets in days, for one unit shock in Live Cattle prices, for period from January 1998 to December 2004.

As seen from the first period above, corn prices have an accumulated price response of 0.10 units in the second day and then it decreases to insignificant value from the third day onwards.

Also soybeans have an accumulated price response of 0.12 units in the third day, before becoming steady in subsequent days; yet this value is almost insignificant after the seventh day. Feeder cattle prices reach a response of 0.16 units at the second day, maintained thereafter.



cr: corn; **sb**: soybeans; **sg**: sorghum; **wh**: wheat; **fc**: feeder cattle; **lc**: live cattle

Figure 9.2: Price Responses of Selected Markets in days, for one unit shock in Live Cattle prices, for period from January 2004 to April 2009.

However during the second period from figure 4.8.2 above, only feeder cattle prices experience a significant price response at 0.11 during the first day, but then becomes insignificant for the rest of the days considered.

Discussion

Relevant differences regarding the dynamic relationships between the commodities were determined after comparing results from the first and second estimated periods. In the first period, corn and sorghum price changes have bi-directional Granger Causality. However, in the second period only changes in corn price Granger Cause price changes in sorghum. This may reflect substitution away from corn to sorghum used in livestock feeding rations[8] during the second period where corn had higher prices, since both grains are carbohydrate nutrients in the feed diet. The increase in sorghum consumption during the second period estimated, instead of corn, may lead to a rise in the price of sorghum. This may be corroborated through the impulse response functions, where a shock to the corn price during the second period almost doubles the response effect on sorghum when compared to the effect obtained from the first period, as can be seen from figures 4.2 and 4.1, respectively.

Another result refers to the first period where corn has no Granger Causality with wheat or vice-versa. This lack of relationship is corroborated by a null response from wheat due to a shock from corn prices or likewise from a null response of corn due to a shock from wheat prices. However, for the second estimated period changes in corn price and changes in wheat price are

[8] "Higher corn prices provide an incentive to substitute other feed sources, most likely grain sorghum, for animal feed."pg. 3. *Factsheet, Livestock Marketing Information Center* - (Oklahoma) State Extension Services in Cooperation with USDA, EFC-02, Feb. 2007.
"During 2008/09, sorghum has been used as a lower priced substitute to corn." pg. 3. *Feed Outlook,FDS-09d* ERS – USDA, March 13, 2009.

determined to have bi-directional Granger Causality. Nonetheless, for this second period there is no response from shocks on price changes of one commodity on the other. It is not clear if this latter is a spurious result since wheat is also a substitute feed for corn, and thus it would be anticipated to have a response from shocks to corn prices during this period. The bi-directional Granger Causality found between them corroborates their direct relationship, since it translates into price changes of one commodity being affected by the price changes of the other commodity and vice-versa.

Regarding the cattle markets, there is a bi-directional Granger Causality for both estimated periods. This bi-direct relationship is corroborated through the impulse response functions obtained from shocks on either the feeder cattle or live cattle markets. These results are anticipated according to the literature, since both feeder and cattle prices are main risk components in the cattle feeding industry. Thus a shock in feeder cattle prices leads to an increase in live cattle prices (for either period considered), in order to maintain cattle production profitability. Conversely, a shock in live cattle prices likewise leads to an increase in feeder cattle prices.

An unusual result determined for the first period is that a shock in live cattle prices produces a positive response function on both corn and soybean prices. This is corroborated by live cattle prices having Granger Causality on corn and soybean prices. However, these results are not determined during the second period, either by Granger Causality results or impulse response functions. A plausible explanation for live cattle prices leading corn and soybean prices during the first period is that under regular conditions, an increase in live or fed cattle prices may potentially induce corn growers to likewise increase their prices since more than 50% of corn is used for feed rations, and soybean is a relevant protein ration. These mildly rising prices may be seen from figure 2, where both corn and soybean follow a rise in the prices of live cattle, especially towards the second half of the first estimated time period.

Two unexpected results regard the anticipated relationship between corn and feeder cattle prices, and corn and soybean prices. In the first case, corn price changes have no Granger Causality on feeder cattle price changes, especially for the second estimated period. This Granger Causality may have been expected according to the literature with reference to cattle production profitability (i.e., rising corn prices, especially in the second period, should lead to lower feeder cattle prices). This lack of a relationship is corroborated by the null response obtained on feeder cattle markets from a shock to corn prices as can be seen from Figure 3.2. However, there is a negative long run relationship determined between these two commodities, and it is identified by the negative error correction term during the second estimated period. Thus the anticipated inverse relationship is duly captured in the long-run.

The other unexpected result is that for both estimated periods, price changes in corn have no Granger Causality effect on price changes of soybean, nor vice-versa. These results are likewise obtained from the null impulse response functions due to shocks on either market. This may be observed in figures 3.1 and 3.2 from shocks to corn prices, and from figures 4.1 and 4.2 from shocks to soybean prices. These unusual results are obtained despite the known positive relationship between corn and soybeans as they share planting acreage.

However, for the second estimated period a long-run positive relationship has been identified between corn and soybean prices through the error correction term from the co-integrated VAR model. This positive value confirms their long-run direct relationship, especially for the second period where much acreage was taken from soybean for corn production.

Conclusions

A multivariate non-structural model was applied to gauge the interrelationship between grain and cattle daily cash market prices, and to specifically contrast the results determined from two different estimated periods, a pre-ethanol mandated period and a post-ethanol mandated period. The objective of the paper sought to determine the influence that a surge in the demand of corn consumption, with its increased price, may have on related markets considering non-stationary, first order moment prices. These six interrelated markets to corn – sorghum being a direct substitute for carbohydrate feed ration of cattle production, soybean being a direct substitute for planted acreage, wheat being a less direct carbohydrate substitute in feed rations for livestock, as well as feeder cattle and live cattle being major components of price risk for cattle production along with corn; are each impacted by corn's change in demand and price in a unique form. The effect of the changes in corn prices on these markets is analyzed within a co-integrated VAR model framework.

The main results are consistent with the literature such that steadily rising corn prices, due to mandated ethanol production, lead to rising sorghum prices. This may be in response to livestock producers modifying the feeding rations from corn to sorghum as anticipated by the literature, since both are carbohydrates. Also feeder cattle and live cattle price changes have bi-directional Granger Causality for both periods estimated. This is in line with cattle production profitability, as both these prices are the main sources of risk for cattle production.

Results determined for the second period regarding corn and soybean reveal that each has Granger Causality on grain sorghum. This is in contrast to results obtained from the first period which determined bi-directional Granger Causality between corn and grain sorghum. Likewise for the first period, bi-directional Granger Causality was determined between soybean and grain sorghum. A plausible explanation for corn having Granger Causality on sorghum during the second period may be due to livestock feed rations being modified by substituting grains, especially corn for sorghum, as a consequence of the substantial increase in corn prices. In addition, impulse response functions in the second period corroborate this previous finding, since a shock of corn prices results in a significant increase in grain sorghum prices.

A result which may not have been anticipated was that price changes in corn, specifically in the second period estimated, also led (Granger Causality) price changes in wheat, and vice-versa, the price changes in wheat likewise led price changes in corn. This bi-directional Granger Causality may respond to wheat additionally being used as carbohydrate in the feed ration. Null responses on wheat prices from shocks to corn prices were obtained; however a long-run positive relationship between corn and wheat was determined with the error correction term.

Two unexpected results are that corn price changes had no Granger Causality on feeder cattle prices during the second period estimated (i.e. during rising corn prices) as was anticipated by the literature for increasing corn prices in order to maintain cattle production profitability. It is also unexpected that corn and soybeans had no Granger Causality among them (not even bi-directional) for either period estimated, despite their acreage relationship. However, for both these cases there was an error correction term which accounted for the long-run relationship between these commodities and with the proper sign. That is, there was an inverse long-run relationship established between corn and feeder cattle given by a negative value for the error correction term, and there was a positive long-run relationship determined between corn and soybeans identified by a positive value for the error correction term. These error correction terms corroborate the literature regarding the anticipated relationship between these commodities.

Further venues of study may include identifying at what corn price feedlot operators are actually switching away from corn to sorghum, as well as the effect of potential further feed substitutions towards alfalfa or others.

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