Semi-Parametric, Generalized Additive Vector Autoregressive Models of Spatial Price Dynamics

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Abstract

An extensive empirical literature addressing the behavior of prices over time and across spatially distinct markets has grown substantially over time. A fundamental axiom of economics—the Law of One Price"—underlies the arbitrage behavior thought to characterize such relationships. This literature has progressed from a simple consideration of correlation coefficents and linear regression models to classes of models that address particular time series properties of price data and consider nonlinear price linkages. In recent years, this literature has focused on models capable of accommodating structural change and regime switching behavior. This regime switching behavior has been addressed through the application of nonlinear time series models such smooth and discrete threshold autoregressive models. The regime switching behavior arises because of unobservable transactions costs which may result in discrete trade/no trade regimes or smooth, continuous transitions among different states of the market. As the empirical literature has evolved, it has applied increasingly flexible models of regime switching. For example, Goodwin, Holt, and Prestemon (2012) applied smooth transition autoregressive models to consider regional linkages in markets for oriented strand board lumber products. Enders and Holt (2012) examined commodity price relationships using a series of overlapping smooth transition functions to capture structural changes and mean shifting behavior. This literature has also involved an evolution in the methods for statistically testing structural change and regime switching behaviors. Chow tests with known break points have evolved into tests of discrete and gradual mean shifting with unknown break points and variable speeds of adjustment among regimes. These tests address the widely recognized problems associated with nonstandard test statistics and parameters that may be unidentified under null hypotheses. In this paper, we propose a new class of semi-parametric models that accommodate mean shifting behavior in a vector autoregressive modeling framework. We view this approach as a natural next step in the evolution of nonlinear time series models of spatial and regional price behavior. To this end, we consider recent advances in semiparametric modeling that have developed methods for additive models that consist of a mixture of parametric and nonparametric components. Our vector autoregressive models adopt the "Generalized Additive Models" (GAM) estimation procedures Hastie and Tibshirani (1986) and Linton (2000). In particular, we use the backfitting and integration algorithms developed for GAM model estimation to incorporate a non-parametric mean shift in the linkages describing individual pairs and larger groups of market prices. Our empirical specification involves simple and

vector error correction models that relate price differences to lagged values of prices and price differentials. Our application is to daily data collected from a number of important corn and soybean markets at spatially distinct markets in North Carolina. These data have been previously utilized to evaluate regional price linkages and spatial market integration (see, for example, Goodwin and Piggott (2001)). We use generalized impulse response functions to evaluate the dynamics of regional price adjustments to localized shocks in individual markets. Implications for regional price adjustments and, in particular, adjustments during recent periods of high volatility, are discussed in the paper. Finally, we offer suggestions for further extensions of the semi-parametric analysis of regime switching behavior.

1 Literature Review

The question dealing with the validity of Law of One Price has been extensively investigated in the literature since it has important implications both for the economists and traders; as its implication being that no persistent opportunities for spatial arbitrage exist and may help the policymakers to decide on the trade policies to be imposed. The general conclusion underlying this concept is that prices for homogenous products at different geographical locations should not differ more than transport and transaction costs such as insurance, contract fees etc. However one obvious reason why the prices of homogenous products may not be the same is the aforementioned transaction and transport costs and other impediments to trade such as tariffs and quotas and as a result of this nonzero costs deviations from the LOP should contain significant nonlinearities. Most recently, following these theoretical arguments several studies have employed nonlinear models to investigate the validity of LOP. Among these are Micheal et al(1994),Obstfeld and A.M. Taylor(1997), A.M. Taylor(2001),O'Connel and Wei(2002).In these studies the nonlinear nature of the adjustment process is generally investigated in terms of a threshold autoregressive(TAR) model of some sort and are cumulating evidence in favor of the threshold-type nonlinearity in deviations from the LOP. Among the studies that uses variants of discrete cointegration models of the sort introduced by Balke and Fomby(1997) are Goodwin and Piggott(2001), Lo and Zivot(2001),Sephton(2003),Park et al(2007) that have found support for the validity of LOP and threshold effects and mentioned that the path of adjustment to equilibrium depends on the size of the shock introduced into the system. However since there exists some reasons to think that the patterns of price adjustment in the markets are smooth rather than discrete even though the economic behavior underlying the adjustments is of a discrete nature (i.e. arbitrage is either profitable or not)(Goodwin et al. 2011) the literature progressed through the usage of smooth transition models instead of discrete models of transition and among the studies taking this approach are Goodwin, Holt, and Prestemon (2012) and Enders and Holt (2012).

In this paper the price dynamics will be investigated by using a class of semiparametric modeling framework that have developed methods for additive models that consist of a mixture of parametric and nonparametric components.

Econometric Method and Data

GAM Type Models

Nonparametric regression allows us to relax the assumption of linearity which might be proper for many economic variables and helps us to explore the data visually, uncovering structure in the data that might otherwise be missed when the data is evaluated in a parametric form. However, it is a known fact that many forms of nonparametric regression do not work well when the number of independent variables in the model is large and we need a large data set to avoid the problem of 'curse of dimensionality' which is defined as the problem of rapidly increasing variance for increasing dimensionality.One other pitfull of using nonparametric regression is the interpretation of results and the realtionship to be explored between dependent and independent variables is hard to grasp.

To get rid of these problems,Stone (1985) proposed additive models that manages an additive approximation to the multivariate regression function.By doing so,the curse of dimensionality problem is overcomed because each individual additive terms is estimated using a univariate smoother separately but the approximation is obtained locally not universally.Also the interpretation problem is avoided as the estimates of the individual terms explain how the dependent variable changes with the independent variables.

The extensions of the additive model that are valid for wide range of distribution families such as exponential family has been proposed by Hastie and Tibshirani (1986) by the use of Generalized Additive Models(GAM) that enable the mean of the dependent variable to depend on an additive predictor through a nonlinear link function. Following Hastie and Tibshirani(1986) the basic GAM modeling framework which is used to investigate the price relationships may be stated as follows:

Let Y be a response random variable and $X_1, X_2, \cdots, X_p$ be a set of predictor variables.

A regression procedure can be viewed as a method for estimating the expected value of Y given the values of $X_1, X_2, \cdots, X_p$.The standard linear regression model assumes a linear form for the conditional expectation:

$$E(Y|X_1, X_2, \cdots, X_p) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p$$

The additive model generalizes the linear model by modeling the conditional expectation as:

$$E(Y|X_1, X_2, \cdots, X_p) = \beta_0 + \beta_1 s_1(X_1) + \beta_2 s_2(X_2) + \cdots + \beta_p s_p(X_p)$$

where $Esi(X)$, i = 1, 2,$\cdots, p$ are smooth functions.

These functions are not given a parametric form but instead are estimated in a nonparametric fashion by using Back-Fitting and Local-Scoring Algorithms.
In our analysis we use a smoother for the time trend as a tool for summarizing the trend of a response measurement Y as a function of one or more predictor measurements $X_1, X_2, \cdots, X_p$ in a nonparametric fashion and aim to see the mean shifting behavior of prices in Corn and soybean markets for three distinct regions in a vector autoregressive modeling framework.Our response variables for the basis of the analysis are the logarithmic prices and the returns for each market in question whereas the independent variables are taken to be lagged values of prices and returns.

2 Data

Our application is to daily corn and soybean prices observed at three North Carolina terminal markets. Prices were obtained at Candor, Cofield and Roaring River for the corn markets whereas the prices for the soybean market were obtained at Fayetville, Raleigh and Elizabeth City.
The data spans the period 31 January 1988 and 31 August 2012.On holidays where all prices were missing in each of the markets mentioned the observations were omitted from the sample and a smooth continuity of the prices was assumed. The logarithmic transformations of the prices and the returns are taken as the basis for the empirical analysis.

3 Empirical Application

This section provides the empirical results for spatial price dynamics in accordance with the theory of semi-parametric Generalized Autoregressive models for three North Carolina terminal markets taking into account the structural changes that may be observed over time. The major markets investigated are Candor, Cofield and Roaring River for the corn and Fayetville, Raleigh and Elizabeth City for the soybean. The correlation between soybean prices in Raleigh and soybean prices in Fayetville seems to be high with a positive Pearson coefficient of magnitude 0.99 and the same type of relationship is observed between the prices in Elizabeth City and Raleigh and Fayetville with high corelation coefficients of 0.94 both(Table 2).The price development in the three markets has an almost stable appearance between the period 1990 and 1995 and a slight decrease in prices in these markets may be observed after 1998 and then the soybeans prices tend to increase over time after 2007(Figure 1). Unlike Figure 1 we can observe tendency of mostly stable prices in the corn markets with some price increases after years 1995 and 2007(Figure 2).The Pearson correlation coefficients indicate that there is a strong and positive relationship between corn prices in Candor,Cofield and corn prices in Roaring River with coefficients of magnitude over 0.99 in each market pairs(Table 1).

So overall we may indicate that the figures and the correlation coefficients show a clear relationship between the prices in each market. However we can obtain limited information about a casual relationship between variables using the figures and correlation coefficients because of possible different statistical time series properties. Therefore the analysis of aforementioned price relationships is continued by estimating the semiparametric Generalized Additive Vector Autoregressive regression models. As specified GAM models are nonlinear in parameters so nonlinear estimation methods are called for and the optimal lag lengths for each of the specified models are chosen by applying the AIC criterion.According to this criterion the optimal lag length for corn markets is chosen as 6 whereas the optimal lag lenth is determined as 12 for the soybean markets.

The results of the GAM models for the logarithm of the prices and the returns will be given and interpreted separately.According to the Tables 3-5 we can clearly see that for the logarithmic prices in Candor,Cofield and Roaring River corn markets the smoothed time trend is significant at the 0.05 significance level and this fact is also supported by the Chi-Square significance test with values of 22.1390,20.935, 14.7353 and their corresponding p values smaller than 0.0001,0.0001 and 0.0021 respectively.By the examination of the Figures 3-5 we see that the smoothing components of the logarithmic prices in these three markets shows how the trend is moving nonparametrically and conclude that there is a mean that is moving in a way that we can capture all these movements nonparametrically by smoothing components which also shows correspondence with the movement of the corn prices in logarithmic terms given in Figure 2.

When the same analysis is done with the returns in these three markets we see that our expectations about the volatility of nonlinear trends around zero seems to be satisfied.The existence of trend in returns is not expected and we see that this is confirmed by the examination of the nonlinear time trend coefficients in Tables 6-8 with unsignificant coefficients and corresponding Chi-Square significance test statistics values of 0.5410,0.6386 and 0.6020 for Candor,Cofield and Roaring River markets respectively and this fact is supported by the careful examination of Figures 6-8 showing the smoothing components of the returns.

Tables 9-11 shows the significance of the smoothed time trends for the logarithmic prices in the Fayetville,Raleigh and Elizabeth City soybean markets at the 0.05 significance level with corresponding p values smaller than 0.0001 for Fayetville and Raleigh and a p value of 0.0014 for the Elizabeth City.The same conclusion may be obtained through the examination of the Chi-Square significance test statistics with values 0.0049 and 0.0020 for Fayetville and Elizabeth City markets and with value of 0.0060 which is significant at the 0.001 level for the Raleigh market.The movements in the mean of the logarithmic prices in these three soybean markets may be captured by the smoothing components in a nonparametric fashion and this fact is also exhibited with the correspondence of the Figures 9-11 showing the smoothing components and Figure 1 exposing the movement of soybean prices in these three soybean markets.

The insignificant time trend coefficients for the returns in the prices indicated in Tables 12-14 with p vaues of 0.1671,0.1578 and 0.1291 for Fayetville, Raleigh and Elizabeth City respectively confirms our expectations about the nonexistince of trend in the returns in these three soybean markets and the same fact is again supported with the Chi-Square values of 0.5604,0.5517 and 0.5431.According to Figures 12-14 the nonlinear trend just oscillate around zero.

The overall conclusions reported in regression results is also supported by the information that may be obtained from the given Figures in the Appendix part and indicates that smoothed nonlinear time trend is an important feature of these markets and has a significant role in explaining spatial and regional price behavior. Mean shifting behavior in a vector autoregressive modeling framework that are accommodated by semi-parametric models is generally supported by the estimated models and the figures of the smoothing components plots used in the Appendix also supports this conclusion. This paper made an initial attempt to examine the price dynamics in soybeans and corn markets in three distinct markets using semi-parametric VGAM regression approaches taking into account the nonlinearity of the time trend component. However the out-of-sample forecasting from the aforementioned models can be obtained and the forecasting performance of these models can be compared and also by using the impulse response functions the dynamics of these model may be investigated further as a suggestion for future research in this area.

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4 APPENDIX

Table 1: Correlation Coefficients of Corn Markets

	Candor	Cofield	Roaring River
Candor	1.00000	0.99579	0.99716
Cofield	0.99579	1.00000	0.99373
Roaring River	0.99716	0.99373	1.00000

Table 2: Correlation Coefficients of Soybean Markets

	Fayetville	Raleigh	Elizabeth City
Fayetville	1.00000	0.99992	0.94343
Raleigh	0.99992	1.00000	0.94356
Elizabeth City	0.94343	0.94356	1.00000

Table 3: GAM Results of Logarithmic Prices for Candor Corn Market

	Parameter Estimate	Standard Error	t Value	Probability
Intercept	0.06	0.01887	3.18	0.0016
$c1_1$	0.25119	0.18756	1.34	0.1816
$c1_2$	0.43876	0.20481	2.14	0.0331
$c1_3$	0.02852	0.2026	0.14	0.8881
$c1_4$	-0.09633	0.20201	-0.48	0.6339
$c1_5$	0.34807	0.2004	1.74	0.0836
$c1_6$	-0.05127	0.18118	-0.28	0.7774
$c2_1$	-0.03963	0.14475	-0.27	0.7844
$c2_2$	-0.21465	0.16927	-1.27	0.2059
$c2_3$	-0.19384	0.16955	-1.14	0.254
$c2_4$	0.01857	0.16625	0.11	0.9112
$c2_5$	-0.16828	0.1661	-1.01	0.3119
$c2_6$	0.09866	0.14452	0.68	0.4954
$c3_1$	0.74409	0.1627	4.57	¡.0001
$c3_2$	-0.13681	0.17313	-0.79	0.4301
$c3_3$	0.17697	0.17309	1.02	0.3075
$c3_4$	0.01871	0.17271	0.11	0.9138
$c3_5$	-0.37123	0.17412	-2.13	0.0339
$c3_6$	0.05722	0.16334	0.35	0.7264
Linear(t)	0.00018393	0.0000801	2.3	0.0224

Table 4: GAM Results of Logarithmic Prices for Cofield Corn Market

	Parameter Estimate	Standard Error	t Value	Probability
Intercept	0.0372	0.01996	1.86	0.0634
$c1_1$	-0.1835	0.19836	-0.93	0.3558
$c1_2$	0.39438	0.2166	1.82	0.0698
$c1_3$	0.05102	0.21426	0.24	0.812
$c1_4$	-0.21351	0.21364	-1	0.3185
$c1_5$	0.48696	0.21194	2.3	0.0224
$c1_6$	0.00149	0.19161	0.01	0.9938
$c2_1$	0.56346	0.15308	3.68	0.0003
$c2_2$	-0.29424	0.17902	-1.64	0.1014
$c2_3$	-0.21491	0.17931	-1.2	0.2318
$c2_4$	0.10898	0.17583	0.62	0.5359
$c2_5$	-0.22458	0.17566	-1.28	0.2022
$c2_6$	0.03225	0.15284	0.21	0.8331
$c3_1$	0.64908	0.17206	3.77	0.0002
$c3_2$	-0.00105	0.1831	-0.01	0.9954
$c3_3$	0.06987	0.18305	0.38	0.703
$c3_4$	0.08088	0.18265	0.44	0.6582
$c3_5$	-0.52392	0.18414	-2.85	0.0048
$c3_6$	0.12504	0.17275	0.72	0.4698
Linear(t)	0.00017435	0.00008471	2.06	0.0405

Table 5: GAM Results of Logarithmic Prices for Roaring River Corn Market

	Parameter Estimate	Standard Error	t Value	Probability
Intercept	0.05746	0.01866	3.08	0.0023
$c1_1$	-0.15137	0.18553	-0.82	0.4153
$c1_2$	0.41027	0.20258	2.03	0.0438
$c1_3$	-0.05054	0.20039	-0.25	0.8011
$c1_4$	-0.20907	0.19982	-1.05	0.2964
$c1_5$	0.46753	0.19822	2.36	0.0191
$c1_6$	-0.0298	0.17921	-0.17	0.868
$c2_1$	0.15821	0.14317	1.11	0.2701
$c2_2$	-0.32152	0.16743	-1.92	0.0559
$c2_3$	-0.10551	0.16771	-0.63	0.5298
$c2_4$	0.07844	0.16445	0.48	0.6337
$c2_5$	-0.30172	0.16429	-1.84	0.0674
$c2_6$	0.08449	0.14295	0.59	0.555
$c3_1$	0.9516	0.16093	5.91	¡.0001
$c3_2$	-0.04277	0.17125	-0.25	0.803
$c3_3$	0.13964	0.17121	0.82	0.4154
$c3_4$	0.14395	0.17083	0.84	0.4002
$c3_5$	-0.39031	0.17222	-2.27	0.0242
$c3_6$	0.06567	0.16157	0.41	0.6847
Linear(t)	0.00030516	0.00007923	3.85	0.0001

Table 6: GAM Results of Returns for Candor Corn Market

	Parameter Estimate	Standard Error	t Value	Probability
Intercept	-0.00563	0.00865	-0.65	0.5161
$r1_1$	-0.70264	0.18884	-3.72	0.0002
$r1_2$	-0.22932	0.20224	-1.13	0.2579
$r1_3$	-0.28805	0.20868	-1.38	0.1686
$r1_4$	-0.37806	0.20492	-1.84	0.0662
$r1_5$	-0.06805	0.19695	-0.35	0.73
$r1_6$	-0.20992	0.17663	-1.19	0.2357
$r2_1$	0.08031	0.14226	0.56	0.5729
$r2_2$	-0.11261	0.15027	-0.75	0.4543
$r2_3$	-0.20456	0.15481	-1.32	0.1875
$r2_4$	-0.13495	0.15223	-0.89	0.3762
$r2_5$	-0.2264	0.14925	-1.52	0.1305
$r2_6$	-0.0909	0.14217	-0.64	0.5231
$r3_1$	0.68821	0.16326	4.22	¡.0001
$r3_2$	0.44599	0.1942	2.3	0.0224
$r3_3$	0.58986	0.20328	2.9	0.004
$r3_4$	0.53794	0.20375	2.64	0.0088
$r3_5$	0.11324	0.19087	0.59	0.5535
$r3_6$	0.29351	0.16461	1.78	0.0757
Linear(t)	0.0000598	0.00005027	1.19	0.2353

Table 7: GAM Results of Returns for Cofield Corn Market

	Parameter Estimate	Standard Error	t Value	Probability
Intercept	-0.00464	0.00931	-0.5	0.6188
$r1_1$	-0.28086	0.20318	-1.38	0.168
$r1_2$	0.07127	0.21759	0.33	0.7435
$r1_3$	-0.02013	0.22452	-0.09	0.9286
$r1_4$	-0.30307	0.22048	-1.37	0.1704
$r1_5$	0.07496	0.2119	0.35	0.7238
$r1_6$	-0.11446	0.19004	-0.6	0.5475
$r2_1$	-0.17605	0.15306	-1.15	0.2511
$r2_2$	-0.40296	0.16168	-2.49	0.0133
$r2_3$	-0.46007	0.16657	-2.76	0.0061
$r2_4$	-0.22144	0.16379	-1.35	0.1775
$r2_5$	-0.32309	0.16058	-2.01	0.0452
$r2_6$	-0.21324	0.15296	-1.39	0.1645
$r3_1$	0.61622	0.17565	3.51	0.0005
$r3_2$	0.5275	0.20894	2.52	0.0122
$r3_3$	0.54381	0.21871	2.49	0.0135
$r3_4$	0.55638	0.21922	2.54	0.0117
$r3_5$	-0.00744	0.20536	-0.04	0.9711
$r3_6$	0.29687	0.1771	1.68	0.0949
Linear(t)	0.00005096	0.00005409	0.94	0.3469

Table 8: GAM Results of Returns for Roaring River Corn Market

	Parameter Estimate	Standard Error	t Value	Probability
Intercept	-0.00693	0.00859	-0.81	0.4205
$r1_1$	-0.25092	0.18742	-1.34	0.1818
$r1_2$	0.12553	0.20071	0.63	0.5322
$r1_3$	-0.04671	0.2071	-0.23	0.8217
$r1_4$	-0.31518	0.20337	-1.55	0.1224
$r1_5$	0.08332	0.19546	0.43	0.6702
$r1_6$	-0.0883	0.1753	-0.5	0.6149
$r2_1$	0.29063	0.14119	2.06	0.0405
$r2_2$	-0.02209	0.14914	-0.15	0.8824
$r2_3$	-0.04576	0.15364	-0.3	0.7661
$r2_4$	0.0701	0.15108	0.46	0.643
$r2_5$	-0.19588	0.14812	-1.32	0.1872
$r2_6$	-0.07853	0.1411	-0.56	0.5783
$r3_1$	0.01223	0.16203	0.08	0.9399
$r3_2$	-0.042	0.19273	-0.22	0.8276
$r3_3$	0.12018	0.20175	0.6	0.5519
$r3_4$	0.28289	0.20222	1.4	0.163
$r3_5$	-0.08776	0.18943	-0.46	0.6435
$r3_6$	0.15795	0.16336	0.97	0.3345
Linear(t)	0.00007063	0.00004989	1.42	0.1581

Table 9: GAM Results of Logarithmic Prices for Fayetville Soybean Market

	Parameter Estimate	Standard Error	t Value	Probability
Intercept	0.22091	0.03462	6.38	¡.0001
c11	-0.87421	0.85636	-1.02	0.3083
c12	0.05584	0.85376	0.07	0.9479
c13	-0.05135	0.85413	-0.06	0.9521
c14	-0.14739	0.84607	-0.17	0.8619
c15	-0.12666	0.85258	-0.15	0.882
c16	-0.47529	0.85407	-0.56	0.5784
c17	-0.17597	0.85191	-0.21	0.8365
c18	-0.55087	0.83951	-0.66	0.5123
c19	1.12167	0.82141	1.37	0.1733
c110	0.53007	0.82499	0.64	0.5211
c111	0.11693	0.82064	0.14	0.8868
c112	0.71875	0.81612	0.88	0.3794
c21	1.18987	0.854	1.39	0.1648
c22	0.23378	0.85788	0.27	0.7855
c23	0.12959	0.85857	0.15	0.8801
c24	-0.01309	0.85041	-0.02	0.9877
c25	0.00737	0.85897	0.01	0.9932
c26	0.66519	0.86672	0.77	0.4435
c27	-0.05872	0.86361	-0.07	0.9458
c28	0.67279	0.84941	0.79	0.4291
c29	-1.2726	0.83124	-1.53	0.1271
c210	-0.38008	0.83547	-0.45	0.6496
c211	0.11527	0.83002	0.14	0.8897
c212	-1.05486	0.82089	-1.29	0.2
c31	0.60043	0.11981	5.01	¡.0001
c32	-0.181	0.13585	-1.33	0.184
c33	-0.31119	0.1357	-2.29	0.0227
c34	0.36856	0.13588	2.71	0.0072
c35	0.02515	0.13602	0.18	0.8535
c36	-0.18762	0.12776	-1.47	0.1433
c37	0.11663	0.12842	0.91	0.3647
c38	-0.0271	0.12154	-0.22	0.8237
c39	0.02197	0.11694	0.19	0.8512
c310	-0.06514	0.11534	-0.56	0.5727
c311	-0.0447	0.11247	-0.4	0.6914
c312	0.17748	0.08547	2.08	0.0389
Linear(t)	0.00038395	0.0000899	4.27	¡.0001

Table 10: GAM Results of Logarithmic Prices for Raleigh Soybean Market

	Parameter Estimate	Standard Error	t Value	Probability
Intercept	0.22091	0.03462	6.38	¡.0001
c11	-0.87421	0.85636	-1.02	0.3083
c12	0.05584	0.85376	0.07	0.9479
c13	-0.05135	0.85413	-0.06	0.9521
c14	-0.14739	0.84607	-0.17	0.8619
c15	-0.12666	0.85258	-0.15	0.882
c16	-0.47529	0.85407	-0.56	0.5784
c17	-0.17597	0.85191	-0.21	0.8365
c18	-0.55087	0.83951	-0.66	0.5123
c19	1.12167	0.82141	1.37	0.1733
c110	0.53007	0.82499	0.64	0.5211
c111	0.11693	0.82064	0.14	0.8868
c112	0.71875	0.81612	0.88	0.3794
c21	1.18987	0.854	1.39	0.1648
c22	0.23378	0.85788	0.27	0.7855
c23	0.12959	0.85857	0.15	0.8801
c24	-0.01309	0.85041	-0.02	0.9877
c25	0.00737	0.85897	0.01	0.9932
c26	0.66519	0.86672	0.77	0.4435
c27	-0.05872	0.86361	-0.07	0.9458
c28	0.67279	0.84941	0.79	0.4291
c29	-1.2726	0.83124	-1.53	0.1271
c210	-0.38008	0.83547	-0.45	0.6496
c211	0.11527	0.83002	0.14	0.8897
c212	-1.05486	0.82089	-1.29	0.2
c31	0.60043	0.11981	5.01	¡.0001
c32	-0.181	0.13585	-1.33	0.184
c33	-0.31119	0.1357	-2.29	0.0227
c34	0.36856	0.13588	2.71	0.0072
c35	0.02515	0.13602	0.18	0.8535
c36	-0.18762	0.12776	-1.47	0.1433
c37	0.11663	0.12842	0.91	0.3647
c38	-0.0271	0.12154	-0.22	0.8237
c39	0.02197	0.11694	0.19	0.8512
c310	-0.06514	0.11534	-0.56	0.5727
c311	-0.0447	0.11247	-0.4	0.6914
c312	0.17748	0.08547	2.08	0.0389
Linear(t)	0.00038395	0.0000899	4.27	¡.0001

Table 11: GAM Results of Logarithmic Prices for Elizabeth City Soybean Market

	Parameter Estimate	Standard Error	t Value	Probability
Intercept	0.17175	0.03856	4.45	¡.0001
c11	-0.6112	0.95372	-0.64	0.5222
c12	-0.13211	0.95084	-0.14	0.8896
c13	-0.21006	0.95124	-0.22	0.8254
c14	0.22829	0.94227	0.24	0.8088
c15	0.38559	0.94952	0.41	0.685
c16	-0.06118	0.95118	-0.06	0.9488
c17	0.05662	0.94878	0.06	0.9525
c18	-0.41587	0.93497	-0.44	0.6569
c19	1.38663	0.9148	1.52	0.1309
c110	0.49761	0.91879	0.54	0.5886
c111	-0.20339	0.91395	-0.22	0.8241
c112	0.62995	0.90892	0.69	0.4889
c21	0.57101	0.9511	0.6	0.5488
c22	0.46151	0.95542	0.48	0.6295
c23	0.30163	0.95618	0.32	0.7527
c24	-0.37125	0.9471	-0.39	0.6954
c25	-0.49105	0.95663	-0.51	0.6082
c26	0.24997	0.96526	0.26	0.7959
c27	-0.31518	0.9618	-0.33	0.7434
c28	0.56246	0.94599	0.59	0.5527
c29	-1.58952	0.92576	-1.72	0.0873
c210	-0.21307	0.93047	-0.23	0.8191
c211	0.48933	0.92439	0.53	0.597
c212	-0.88979	0.91423	-0.97	0.3314
c31	1.01201	0.13344	7.58	¡.0001
c32	-0.19053	0.15129	-1.26	0.2091
c33	-0.41497	0.15113	-2.75	0.0065
c34	0.37512	0.15133	2.48	0.0139
c35	-0.02408	0.15149	-0.16	0.8738
c36	-0.13978	0.14229	-0.98	0.3269
c37	0.10634	0.14302	0.74	0.4579
c38	-0.0407	0.13536	-0.3	0.7639
c39	0.07653	0.13024	0.59	0.5574
c310	-0.09021	0.12846	-0.7	0.4832
c311	-0.08236	0.12526	-0.66	0.5115
c312	-0.0287	0.09519	-0.3	0.7633
Linear(t)	0.00032414	0.00010012	3.24	0.0014

Table 12: GAM Results of Returns for Fayetville Soybean Market

	Parameter Estimate	Standard Error	t Value	Probability
Intercept	-0.00771	0.00954 -	0.81	0.42
r11	-1.85697	0.89163	-2.08	0.0383
r12	-1.64485	1.22014	-1.35	0.1789
r13	-1.67114	1.40527	-1.19	0.2355
r14	-1.99249	1.5039	-1.32	0.1865
r15	-2.08777	1.51607	-1.38	0.1698
r16	-2.27165	1.53674	-1.48	0.1406
r17	-2.05366	1.53071	-1.34	0.181
r18	-2.47037	1.49713	-1.65	0.1002
r19	-0.88109	1.47158	-0.6	0.5499
r110	-0.3277	1.35145	-0.24	0.8086
r111	-0.15566	1.16327	-0.13	0.8937
r112	0.55313	0.84629	0.65	0.514
r21	1.37642	0.88813	1.55	0.1225
r22	1.53039	1.21625	1.26	0.2095
r23	1.64877	1.40371	1.17	0.2413
r24	1.81429	1.51006	1.2	0.2307
r25	1.8559	1.52121	1.22	0.2236
r26	2.29584	1.54442	1.49	0.1384
r27	1.82337	1.53602	1.19	0.2364
r28	2.3765	1.50012	1.58	0.1145
r29	0.66894	1.47685	0.45	0.651
r210	0.26696	1.35587	0.2	0.8441
r211	0.37616	1.16595	0.32	0.7473
r212	-0.7721	0.85019	-0.91	0.3647
r31	0.47849	0.10762	4.45	¡.0001
r32	0.20695	0.11068	1.87	0.0627
r33	-0.13586	0.11093	-1.22	0.2219
r34	0.25831	0.11103	2.33	0.0208
r35	0.20565	0.10434	1.97	0.0499
r36	-0.04695	0.10198	-0.46	0.6456
r37	0.07713	0.09739	0.79	0.4291
r38	0.07088	0.09051	0.78	0.4343
r39	0.06144	0.08953	0.69	0.4932
r310	-0.00827	0.08334	-0.1	0.9211
r311	-0.07734	0.08068	-0.96	0.3387
r312	0.16679	0.08095	2.06	0.0404
Linear(t)	0.00007609	0.0000549	1.39	0.1671

Table 13: GAM Results of Returns for Raleigh Soybean Market

	Parameter Estimate	Standard Error	t Value	Probability
Intercept	-0.00798	0.00949	-0.84	0.4015
r11	-0.85052	0.88657	-0.96	0.3383
r12	-0.76321	1.21323	-0.63	0.5299
r13	-0.89592	1.3973	-0.64	0.522
r14	-1.41007	1.49538	-0.94	0.3466
r15	-1.37778	1.50748	-0.91	0.3616
r16	-1.57323	1.52803	-1.03	0.3042
r17	-1.39884	1.52203	-0.92	0.359
r18	-1.94281	1.48864	-1.31	0.1931
r19	-0.46039	1.46324	-0.31	0.7533
r110	0.0316	1.34379	0.02	0.9813
r111	0.19602	1.15667	0.17	0.8656
r112	0.68893	0.84149	0.82	0.4138
r21	0.3669	0.8831	0.42	0.6782
r22	0.64641	1.20935	0.53	0.5935
r23	0.85591	1.39575	0.61	0.5403
r24	1.23632	1.5015	0.82	0.4111
r25	1.14652	1.51259	0.76	0.4492
r26	1.60845	1.53567	1.05	0.296
r27	1.17941	1.52732	0.77	0.4407
r28	1.85241	1.49161	1.24	0.2155
r29	0.24643	1.46848	0.17	0.8669
r210	-0.10042	1.34818	-0.07	0.9407
r211	0.0347	1.15934	0.03	0.9761
r212	-0.91275	0.84537	-1.08	0.2814
r31	0.48071	0.10701	4.49	¡.0001
r32	0.21536	0.11006	1.96	0.0515
r33	-0.11565	0.1103	-1.05	0.2954
r34	0.25685	0.1104	2.33	0.0208
r35	0.20493	0.10375	1.98	0.0494
r36	-0.05431	0.1014	-0.54	0.5927
r37	0.06648	0.09684	0.69	0.4931
r38	0.06919	0.09	0.77	0.4428
r39	0.06544	0.08903	0.74	0.463
r310	-0.00055677	0.08287	-0.01	0.9946
r311	-0.08557	0.08022	-1.07	0.2872
r312	0.17104	0.08049	2.12	0.0346
Linear(t)	0.00007735	0.00005459	1.42	0.1578

Table 14: GAM Results of Returns for Elizabeth City Soybean Market

	Parameter Estimate	Standard Error	t Value	Probability
Intercept	-0.01062	0.01076	-0.99	0.3246
r11	-0.65658	1.00504	-0.65	0.5142
r12	-0.82653	1.37534	-0.6	0.5484
r13	-0.97183	1.58402	-0.61	0.5401
r14	-0.78432	1.6952	-0.46	0.644
r15	-0.65374	1.70891	-0.38	0.7024
r16	-0.962	1.73222	-0.56	0.5792
r17	-1.10508	1.72541	-0.64	0.5225
r18	-1.80952	1.68756	-1.07	0.2847
r19	-0.37898	1.65877	-0.23	0.8195
r110	-0.05974	1.52335	-0.04	0.9688
r111	-0.32832	1.31123	-0.25	0.8025
r112	0.2939	0.95393	0.31	0.7583
r21	0.4012	1.0011	0.4	0.689
r22	0.86581	1.37095	0.63	0.5283
r23	1.07028	1.58226	0.68	0.4994
r24	0.68874	1.70214	0.4	0.6861
r25	0.45548	1.71471	0.27	0.7907
r26	1.00013	1.74087	0.57	0.5662
r27	0.87541	1.7314	0.51	0.6136
r28	1.70251	1.69093	1.01	0.315
r29	0.0802	1.6647	0.05	0.9616
r210	0.03761	1.52833	0.02	0.9804
r211	0.58755	1.31426	0.45	0.6552
r212	-0.39936	0.95834	-0.42	0.6773
r31	0.26785	0.1213	2.21	0.0282
r32	0.08929	0.12476	0.72	0.4749
r33	-0.31675	0.12504	-2.53	0.0119
r34	0.15026	0.12515	1.2	0.2311
r35	0.13149	0.11761	1.12	0.2647
r36	-0.02658	0.11495	-0.23	0.8173
r37	0.06053	0.10978	0.55	0.5819
r38	0.06516	0.10202	0.64	0.5237
r39	0.12783	0.10092	1.27	0.2065
r310	0.05249	0.09394	0.56	0.5768
r311	-0.05602	0.09094	-0.62	0.5384
r312	-0.03168	0.09125	-0.35	0.7288
Linear(t)	0.00009423	0.00006189	1.52	0.1291

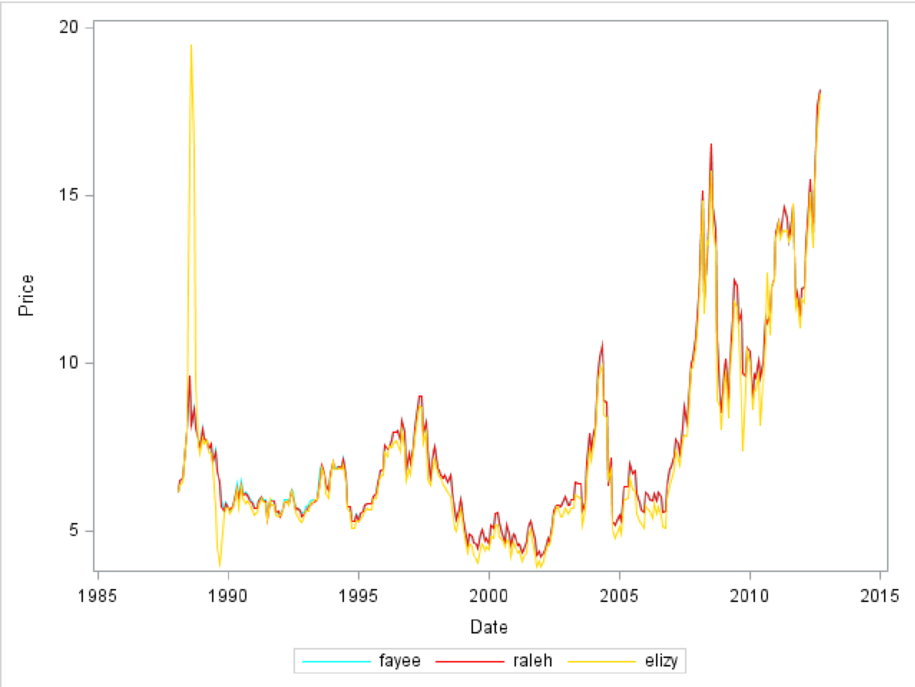

Figure 1: Soybean Markets

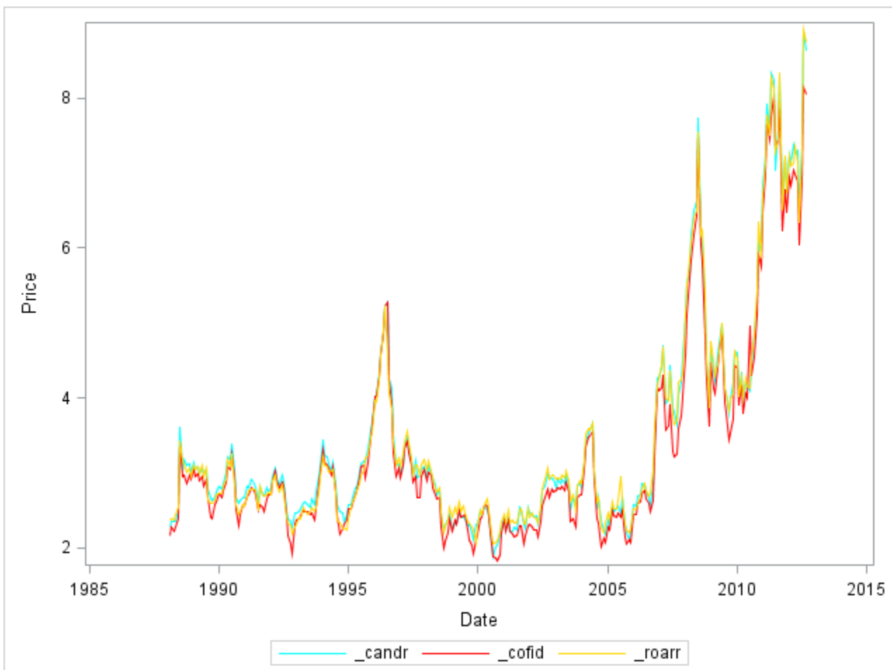

Figure 2: Corn Markets

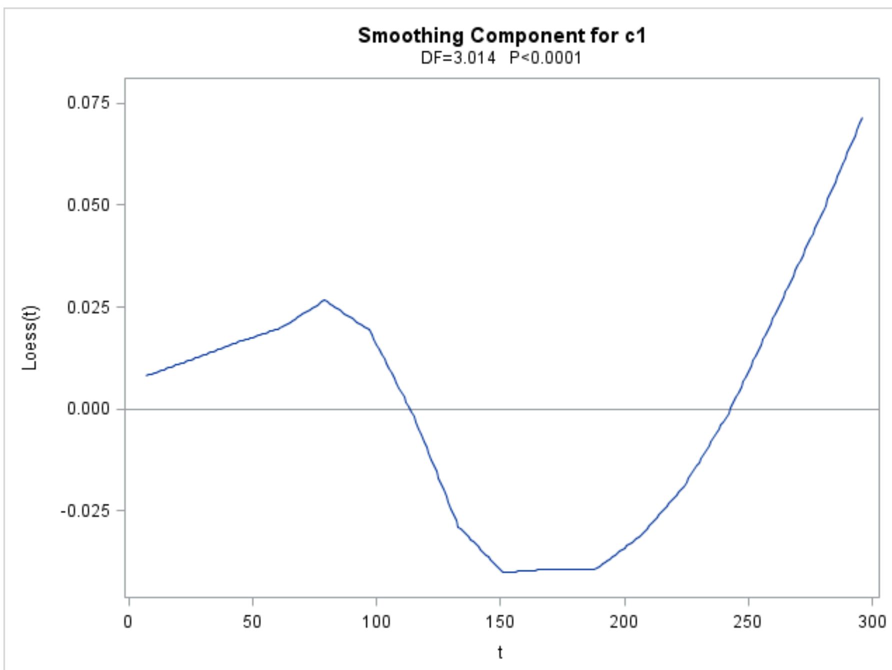

Figure 3: Smoothing Component for Logarithmic Prices in Candor Corn Market

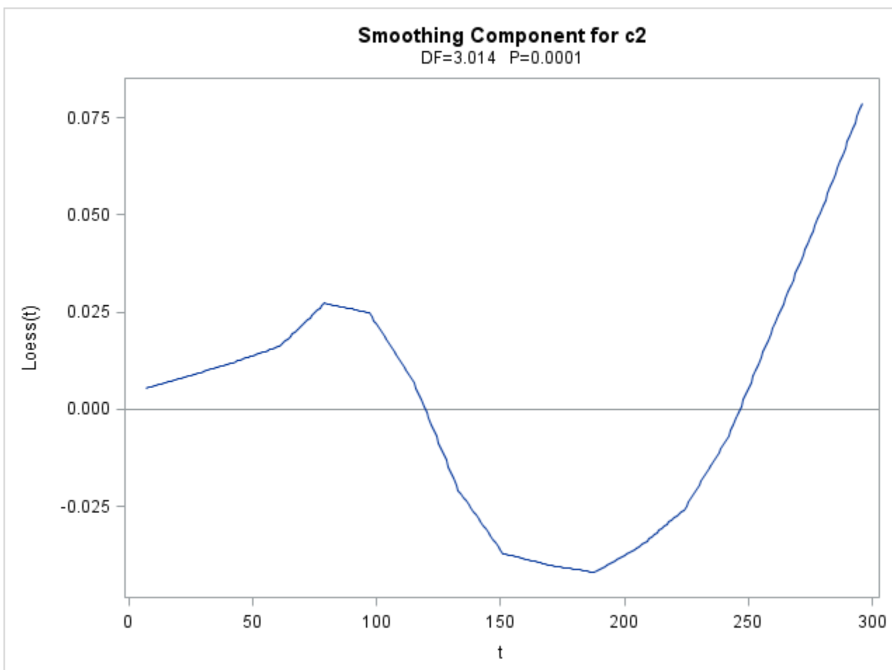

Figure 4: Smoothing Component for Logarithmic Prices in Cofield Corn Market

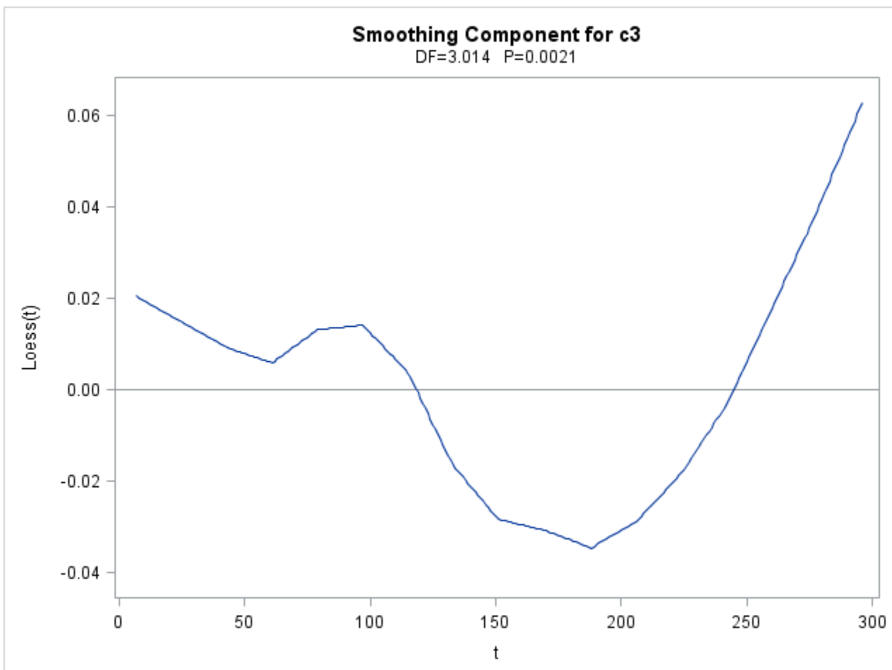

Figure 5: Smoothing Component for Logarithmic Prices in Roaring River Corn Market

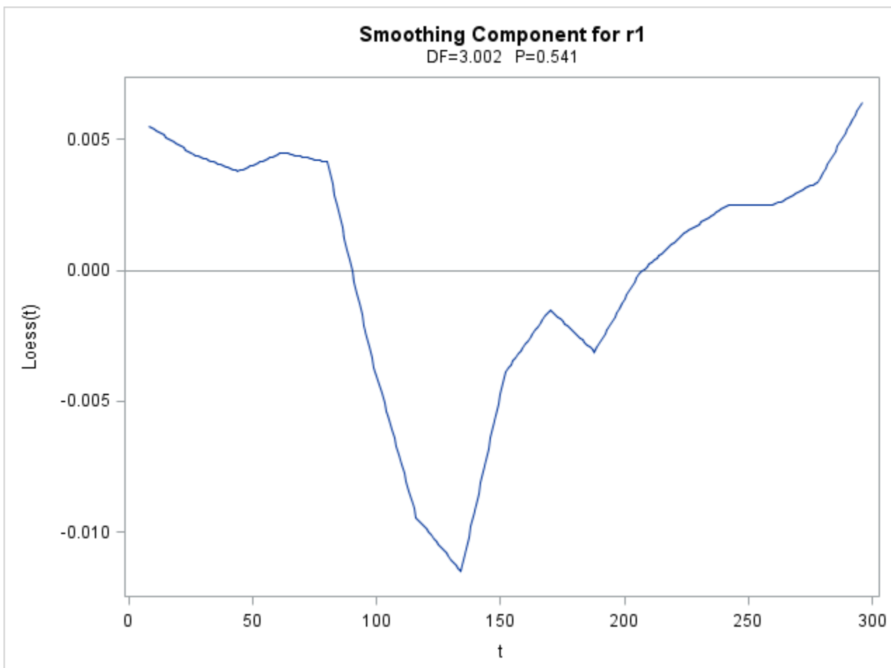

Figure 6: Smoothing Component for Returns in Candor Corn Market

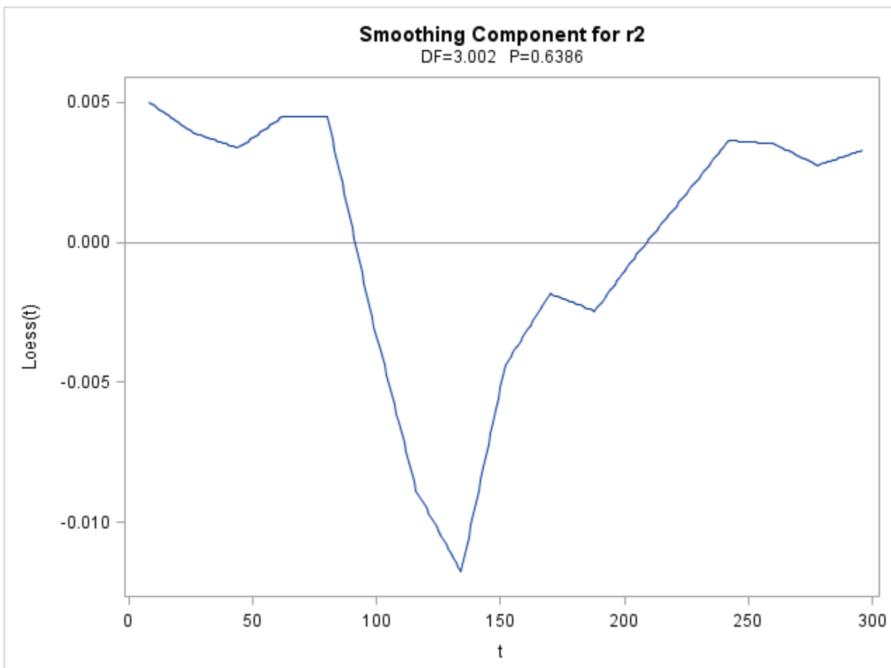

Figure 7: Smoothing Component for Returns in Cofield Corn Market

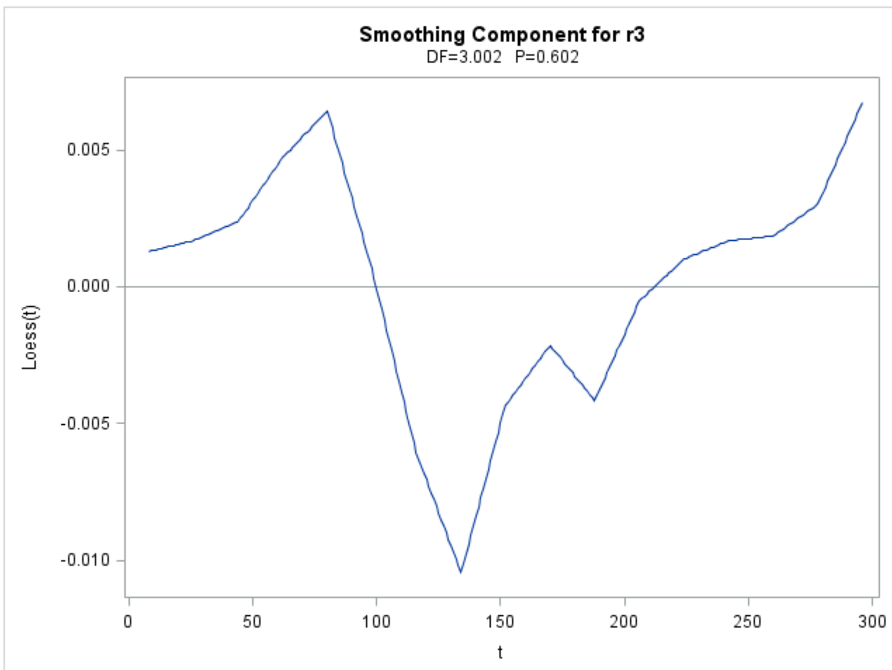

Figure 8: Smoothing Component for Returns in Roaring River Corn Market

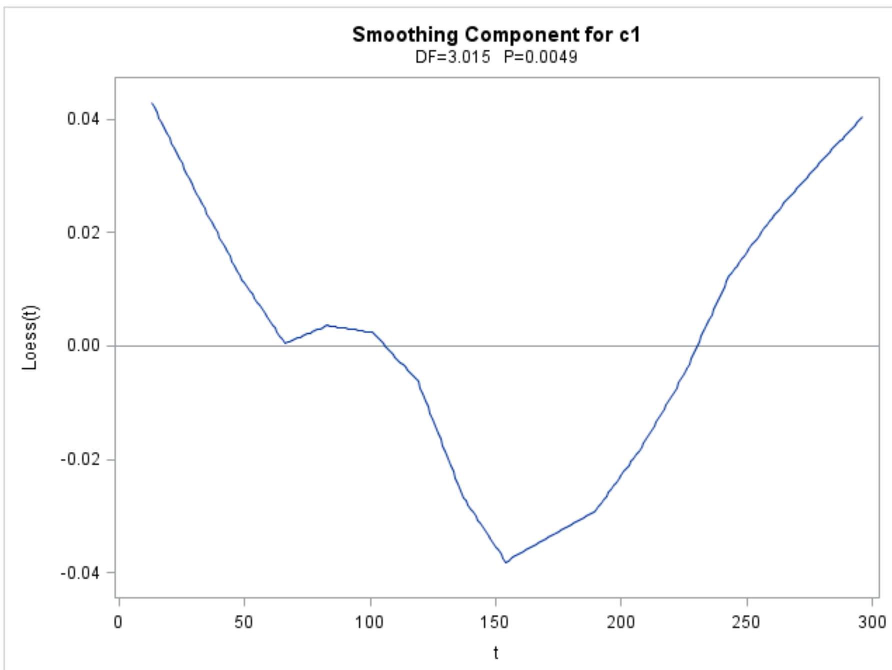

Figure 9: Smoothing Component for Logarithmic Prices in Fayetville Soybean Market

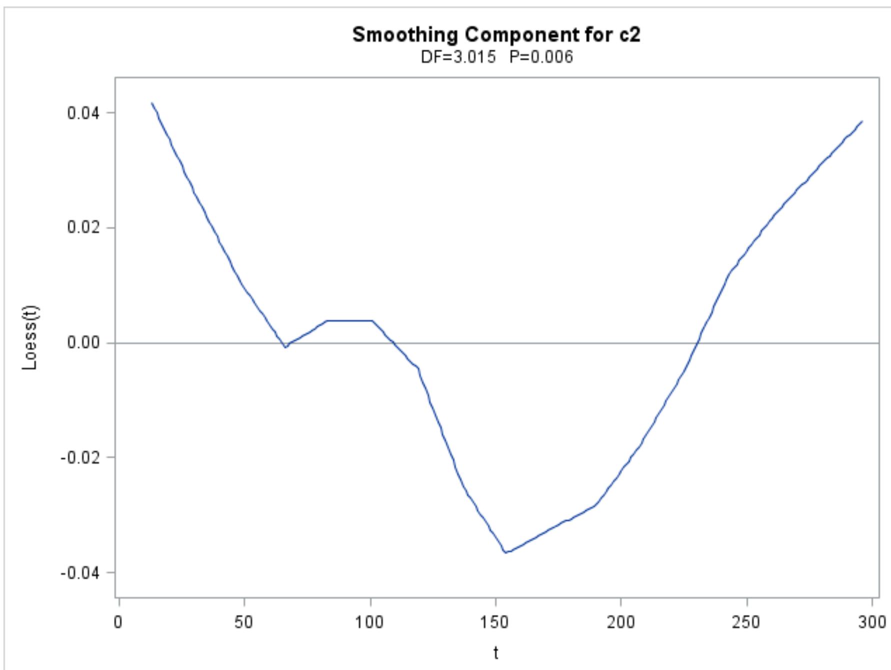

Figure 10: Smoothing Component for Logarithmic Prices in Raleigh Soybean Market

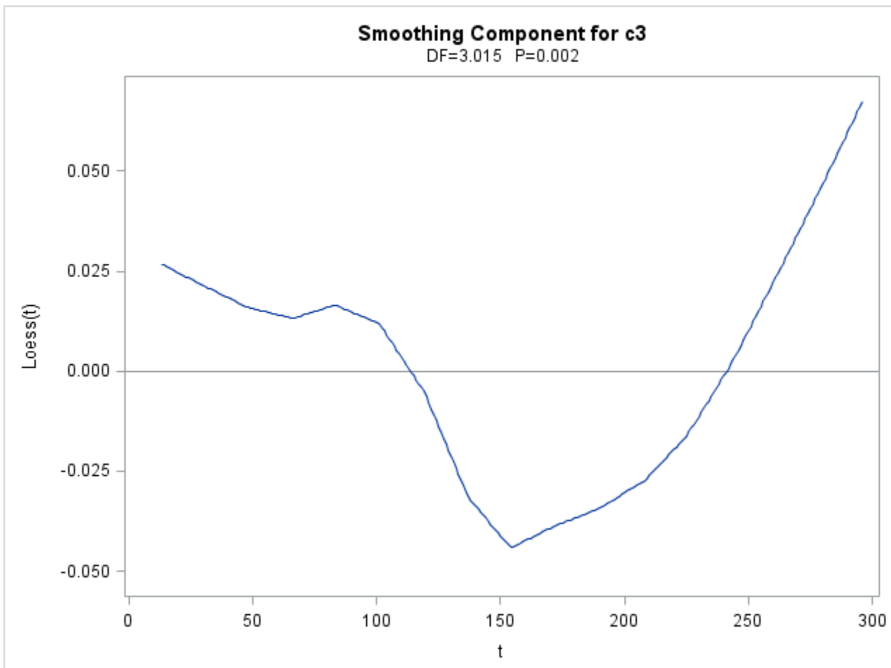

Figure 11: Smoothing Component for Logarithmic Prices in Elizabeth City Soybean Market

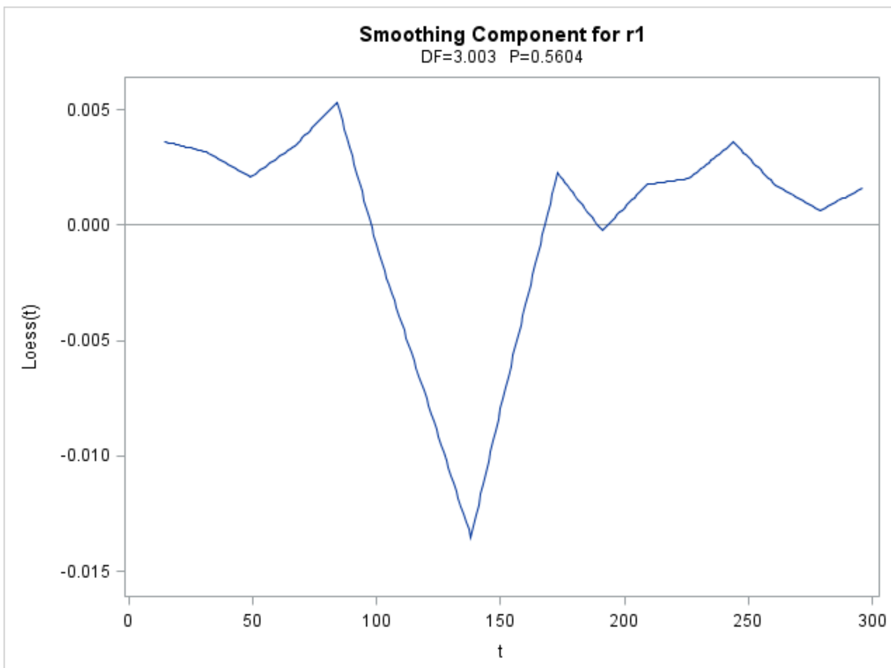

Figure 12: Smoothing Component for Returns in Fayetville Soybean Market

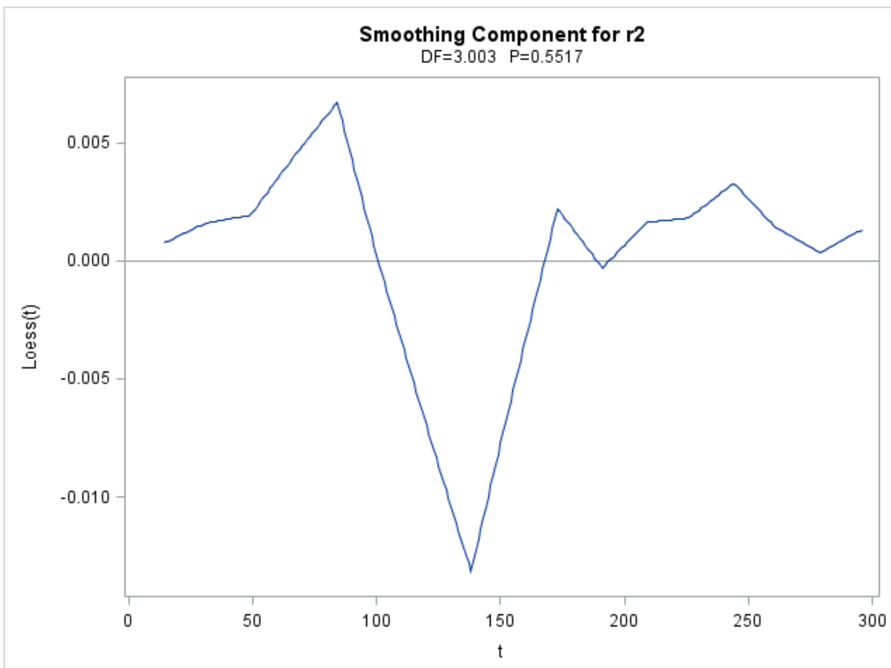

Figure 13: Smoothing Component for Returns in Raleigh Soybean Market

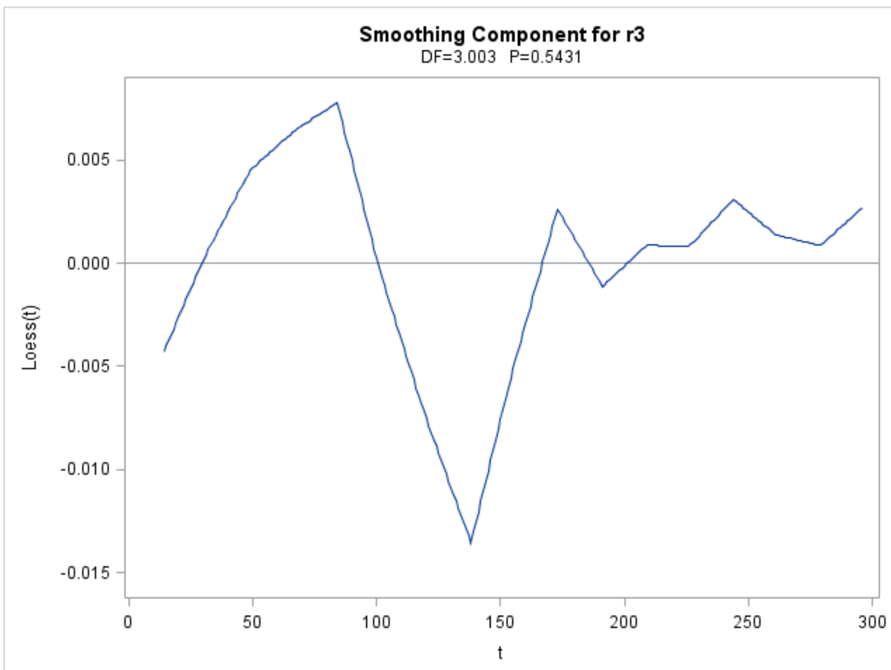

Figure 14: Smoothing Component for Returns in Elizabeth City Soybean Market