Linkages among the non-genetically modified soybean, conventional soybean, and corn futures markets in the Tokyo Grain Exchange

Aruga, Kentaka

18 April 2011

Paper prepared for the 18th Annual Conference of the EAERE, Rome, 29 June - 2 July 2011

Linkages among the Non-Genetically Modified Soybean, Conventional Soybean, and Corn Futures Markets in the Tokyo Grain Exchange

Kentaka Aruga*

Abstract

The market linkages among the non-genetically modified (non-GM) soybean, conventional soybean, and corn futures markets at the Tokyo Grain Exchange are investigated to find out if the two soybean futures markets and the corn futures market share valuable price information in the presence of unknown breaks. The results reveal that there are market linkages between the non-GM and conventional soybean futures prices and between the non-GM soybean and corn futures prices and that these markets do influence one another. Yet the breaks found in the soybean futures price affected these linkages and there were periods where the two soybean and corn futures markets were not cointegrated. Hence these markets are efficient when the effect from the breaks is not apparent but they become inefficient when the breaks are affecting the three markets.

Keywords: non-genetically modified soybeans; conventional soybeans; corn; cointegration test; structural change

JEL classification: G14, Q13, Q14

* Email: kentaka.aruga@gmail.com

1. Introduction

Genetically modified (GM) food products have been imported to Japan since 1996 (TGE, 2003). However concerns about GM products have grown stronger among consumer and environmental groups worldwide. More people have become aware of issues associated with GM food products in Japan (McCluskey et al., 2003). In April 2001, the Japanese government enacted the amended Japanese Agricultural Standard (JAS) law, which required mandatory labeling for GM food products (TGE, 2003). This law increased the demand for non-GM soybeans in the food industry, and in order to meet with this demand, on May 18, 2000, the Tokyo Grain Exchange (TGE) opened the world's first futures market for non-GM soybeans (TGE, 2003; Parcell, 2001).

After this opening of the non-GM soybean futures market in 2000, the TGE soybean futures market has been split into non-GM and conventional soybean futures markets. Non-GM soybeans are mostly used for food and food products. On the other hand conventional soybeans, which include GM soybeans, are mainly used for processing and extracting soybean oil. Soybean products such as soy sauce and soy oil do not require mandatory labeling (MHLW, 2001), so companies obtaining soybeans for these products can use the conventional soybeans. Thus from the demand side perspective, these different soybeans may belong to different markets and may not be related to each other. However, some traders may be purchasing non-GM soybeans for the same purpose as conventional soybeans since there are no legal barriers on using non-GM soybeans for oil or processing. If many traders were substituting non-GM soybeans for conventional soybeans, the non-GM soybean price would show a substitutive movement with the conventional soybean price, and the two price series would have a cointegration relationship, that is the prices move together and do not take apart within the series tested.

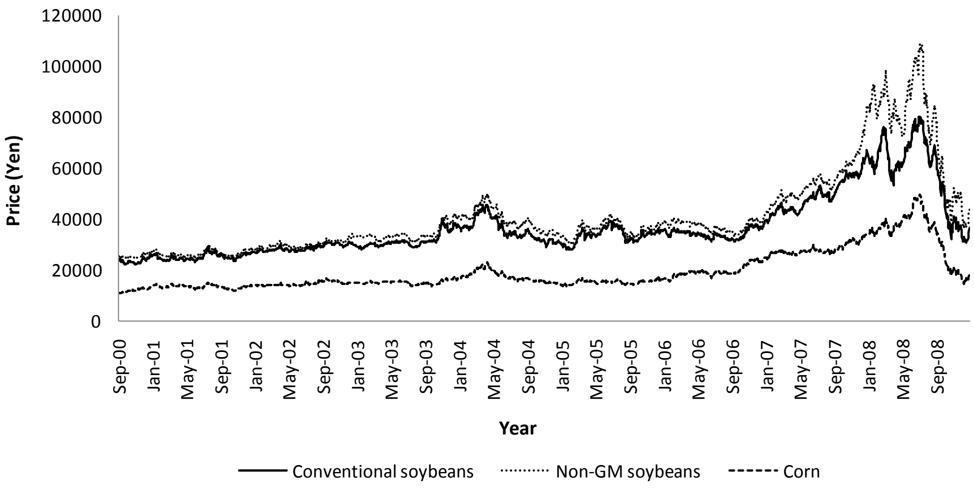
The objective of this paper is to determine whether or not these two soybean futures markets are cointegrated so that they share valuable price information in the presence of breaks in the markets. This will be investigated by testing the cointegration between the non-GM and conventional soybean futures prices. Studying this price linkage is important since markets that are not cointegrated often convey useless price information and can distort the decisions of market participants (Goodwin and Schroeder, 1991). If a cointegration does exist between the two soybean futures markets it would imply that the price discovery process of either one of the soybean futures markets provides valuable information for the other (Malliaris and Urrutia, 1996). It would mean that the non-GM and conventional soybean futures markets are economically linked and price information of these markets could be used for cross-hedging, which would justify the introduction of this new non-GM soybean futures contract.

There are various studies analyzing the price relations of commodity futures markets, but most of these studies focus on testing for market efficiency (Chowdhury, 1991) or finding spatial linkages of futures markets of different regions and locations (Xu and Fung, 2005). However, some studies investigate the price linkages among different commodity futures contracts to find out whether the commodity futures institution is transmitting information efficiently among different contracts. This study also examines the price linkages of different futures contracts within the TGE to pursue this objective. Booth and Ciner (2001) analyze the cointegration among the prices of corn, azuki beans, soybeans, and sugar futures traded at the TGE to find out whether these commodity futures are linked because of common economic fundamentals or because of herd behavior by market participants. They used the cointegration method and found that these four commodity futures that are traded at the TGE are interdependent and that this interdependency is due to common economic fundamentals. Malliaris and Urrutia (1996) examined price discovery on the Chicago Board of Trade (CBOT) for the U.S. grown corn, wheat, oats, soybean, soybean meal, and soybean oil futures prices by using pair-wise cointegration tests and found out that long-run linkages exist among these markets.

Besides the price linkage between the two soybean futures markets, this paper will also test for the linkage between the two soybean and corn futures prices traded at the TGE. Testing these market linkages is meaningful since the two soybeans and corn are mostly imported from the United States so that these commodities can be affected from the U.S. farm policy. It is also important to study these linkages since they can be substitutes. A previous study on testing linkages between the TGE soybean and corn futures markets found that they are cointegrated (Booth and Ciner, 2001) but this study was conducted before the TGE soybean futures market was split into the non-GM and conventional soybean futures markets. It could be that the cointegration result between the soybean and corn futures prices will be different after the non-GM soybean futures market opened at the TGE.

Most of the previous studies on price linkages between certain commodity futures markets do not consider the effects of unknown breaks on the price linkages but this study will consider this and test how such breaks will affect them.

Figure 1. Price of sixth-nearest futures contract for soybeans and corn



Note: The prices are for 1t 1000kg) of soybeans and corn. The price data are obtained from the TGE (TGE 2008a).

The years 2007 and 2008 were dramatic for the U.S. soybean and corn markets. In 2007 the soybean acreage in the United States decreased due to the increase in the corn acreage and this drove up the soybean futures prices in Chicago (OMNICO Corp., 2007). In 2008 with the major world economic crisis (United Nations, 2009), the U.S. economy took a downturn. As seen in Figure 1, there are clear changes in the three markets after 2007.[1] It is reasonable to think that there have been some breaks that affected the soybean and corn futures markets at the TGE and that these breaks may have influenced the price relationships of the two soybean and corn futures markets. This paper will determine whether such breaks existed in the TGE soybean futures markets and identify how these breaks affected the price relationship among the non-GM and conventional soybean, and corn futures contracts.

In the next section the details of the TGE non-GM and conventional soybeans, and corn futures data are described. The third section will explain the methods used for testing the price linkages and the statistical analysis that is applied to determine the breaks in the soybean futures markets. The fourth section discusses the results of the analysis. The final section presents conclusions and implications on the cointegration

[1] The plot of the two soybean and corn futures prices for different contract months (second-nearest through fifth-nearest futures contracts) all showed a dramatic change in 2007 and 2008. The details of the contract months for conventional and non-GM soybean, and corn prices are provided in Tables 1 and 2.

relationship, if found, between the prices of non-GM and conventional soybean, and corn futures contracts.

2. Details of the Data

The daily settled prices of non-GM and conventional soybean, and corn futures contracts at the TGE are used for the analysis (TGE, 2008a). The data on the prices are obtained from the TGE via online and personal negotiations with the TGE (TGE, 2008a). The terms of the data taken are from September 1, 2000, to December 30, 2008. All three markets have six contracts per year and the data is modified to create types of contract months based on the contract months that are commonly used by the traders in the TGE soybean and corn futures markets (Harbest Futures Inc, 2009).

Table 1. Descriptions of contract months for non-GM and conventional soybeans

Month	Nearest Contract	2nd Nearest Contract	3rd Nearest Contract	4th Nearest Contract	5th Nearest Contract	6th Nearest Contract	New futures on the first trading session
Jan.	Feb.	Apr.	Jun.	Aug.	Oct.	Dec.	
Feb.	Feb.	Apr.	Jun.	Aug.	Oct.	Dec.	Feb.
Mar.	Apr.	Jun.	Aug.	Oct.	Dec.	Feb.	
Apr.	Apr.	Jun.	Aug.	Oct.	Dec.	Feb.	Apr.
May.	Jun.	Aug.	Oct.	Dec.	Feb	Apr.	
Jun.	Jun.	Aug.	Oct.	Dec.	Feb	Apr.	Jun.
Jul.	Aug.	Oct.	Dec.	Feb.	Apr.	Jun.	
Aug.	Aug.	Oct.	Dec.	Feb.	Apr.	Jun.	Aug.
Sep.	Oct.	Dec.	Feb.	Apr.	Jun.	Aug.	
Oct.	Oct.	Dec.	Feb.	Apr.	Jun.	Aug.	Oct.
Nov.	Dec.	Feb.	Apr.	Jun.	Aug.	Oct.	
Dec.	Dec.	Feb.	Apr.	Jun.	Aug.	Oct.	Dec.

Source: Harbest Futures Inc, 2009

Table 2. Descriptions of contract months for corn

Month	Nearest Contract	2nd Nearest Contract	3rd Nearest Contract	4th Nearest Contract	5th Nearest Contract	6th Nearest Contract	New futures on the first trading session
Jan.	Mar.	May.	Jul.	Sep.	Nov.	Jan.	
Feb.	Mar.	May.	Jul.	Sep.	Nov.	Jan.	Mar.
Mar.	May.	Jul.	Sep.	Nov.	Jan.	Mar.	
Apr.	May.	Jul.	Sep.	Nov.	Jan.	Mar.	May.
May.	Jul.	Sep.	Nov.	Jan.	Mar.	May.	
Jun.	Jul.	Sep.	Nov.	Jan.	Mar.	May.	Jul.
Jul.	Sep.	Nov.	Jan.	Mar.	May.	Jul.	
Aug.	Sep.	Nov.	Jan.	Mar.	May.	Jul.	Sep.
Sep.	Nov.	Jan.	Mar.	May.	Jul.	Sep.	
Oct.	Nov.	Jan.	Mar.	May.	Jul.	Sep.	Nov.
Nov.	Jan.	Mar.	May.	Jul.	Sept	Nov.	
Dec.	Jan.	Mar.	May.	Jul.	Sept	Nov.	Jan.

Source: Harbest Futures Inc, 2009

Table 1 describes the contract months for non-GM and conventional soybeans and Table 2 is those for the corn futures contracts. The data is modified to create types of contract months based on these contract months. Due to the lack of liquidity for the nearest-contract, data on second-nearest contracts through sixth-nearest contracts are used for the analysis.

The prices for the non-GM and conventional soybeans, and corn are given in yen per tonne of soybeans and corn. The standard grade used for the conventional soybeans is GM, GM mixed, and GM non-segregated No. 2 yellow soybeans. For the non-GM soybeans, identity preserved non-GM No. 2 yellow soybeans is the standard grade. The standard grade for corn is No. 3 yellow corn produced in the United States (less than 15% moisture) (TGE, 2008a).

3. Methods Used for the Analysis

3.1 Cointegration Test

The Johansen cointegration test (Johansen and Juselius, 1990) is used for testing the price linkages of non-GM soybean, conventional, and corn futures prices at the TGE. Some studies have used the Engle and Granger (1987) test for examining the price linkages (Goodwin and Schroeder, 1991) but Johansen method is more efficient since it can analyze the variables of the interests as endogenous in the model and is more useful in a multivariate framework. Enders (2005) suggests that the Engle and Granger procedure can give different test results based on which variable will be taken as the dependent variable. Johansen method has been used for examining linkages among different markets (Asche et al., 1999; Chen et al., 2002) but there are few studies applying this method on the TGE soybean and corn futures markets. Booth and Ciner (2001) is one of those few using this method to test for the price relations between the TGE soybean and corn futures markets.

The time series data of the non-GM soybean, conventional soybean, and corn prices have to be integrated at the same order for the series to be cointegrated. So before performing the cointegration tests, the three price series are tested for their stationarity by the augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979). Then bivariate Johansen cointegration tests (Johansen, and Juselius, 1990) are used for testing the linkages between the prices of non-GM soybean, conventional soybean, and corn futures contracts.

Let Y_t be the $n \times 1$ vector of the non-stationary variables, and k be the order of the vector autoregressive process. Then the vector autoregressive model used for the Johansen cointegration test is denoted as the following:

$$Y_t = \sum_{i=1}^{k} \Pi_i Y_{t-i} + U_t \quad (1)$$

where Y_t is the endogenous variables of interest (prices of soybeans and corn), Π_i is a $n \times n$ matrix of parameters, and U_t denotes a normally distributed n-dimensional white noise process.[2] Converting this model into the error correction model leads to

$$\Delta Y_t = \Pi Y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + U_t \quad (2)$$

where $\Pi = -I + \sum_{i=1}^{k} \Pi_i$, and $\Gamma_i = -\sum_{j=i+1}^{k} \Pi_i$. Since the difference of Y_t variables is integrated of the same order by assumption, whether the variables of interest become cointegrated depends on the rank of the Π matrix. The rank of a matrix is equal to the number of its significantly positive characteristic roots, which is called the eigenvalue.

Using this eigenvalue, the trace and maximum eigenvalue tests are performed to determine the number of cointegrating vectors (Asche et al., 1999). The trace test tests the null hypothesis of at most r positive eigenvalues exist in the Π matrix against the alternative hypothesis that there are more than r positive eigenvalues, where r is the rank of the Π matrix. The test statistic for this test is

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} ln\left(1 - \hat{\lambda}_i\right) \quad (3)$$

where T is the number of observations, and $\hat{\lambda}_i$ is the estimated i th eigenvalue from the Π matrix. The maximum eigenvalue test determines whether there are r or $r+1$ cointegrated vectors in the Π matrix. The null hypothesis of having exactly r positive eigenvalues is tested against the alternative hypothesis of having exactly $r+1$ positive eigenvalues. The test statistic for the maximum eigenvalue test is

$$\lambda_{Max}(r, r+1) = -Tln\left(1 - \hat{\lambda}_{r+1}\right) \quad (4)$$

[2] The model assumes that it does not contain deterministic terms.

3.2 Bai-Perron Multiple Structural Change Test

The Bai-Perron (1998) method is used for determining whether the price series contain unknown breaks. For a long time Chow (1960) test has been the major method for determining structural change in a time series data but this test is not adequate when the breakdate is unknown (Repach and Wohar, 2006). Quand (1960), Andrews (1993), and Andrews and Ploberger (1994) develop a method based on the Chow test for testing structural breaks when the break is unknown but these methods were limited to testing for only one structural break. Furthermore these methods had deficiency in identifying the breakpoints when the series were nonstationary (Hansen, 2000). Bai-Perron test overcomes these problems and is very useful for finding breaks when the potential break date is unknown and the series tend to have more than one break (Repach and Wohar, 2006).

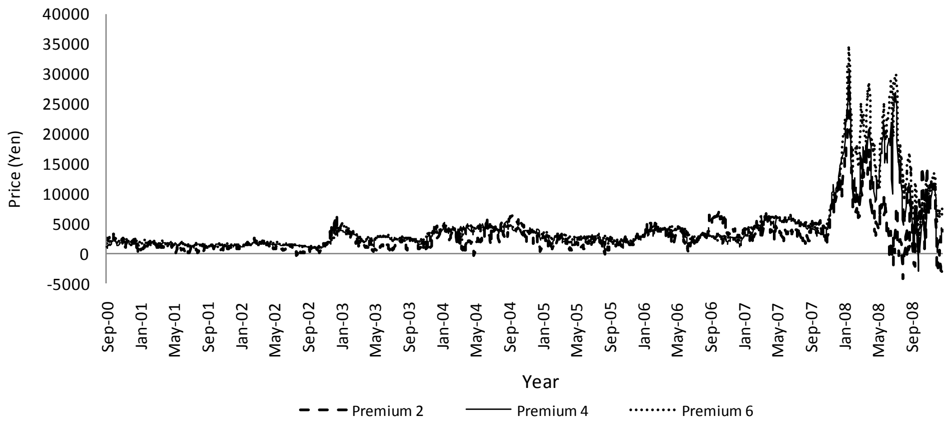
The first stage of Bai-Perron test considers if the price series contain unknown breaks using the "double maximum test." This test uses the maximum F-statistic that is calculated from the global minimum of the sum of squared residuals of the m-partitioned multiple regression models:

$$y_t = z_t'\delta_j + u_t \quad where\ j = 1, \cdots, m+1 \tag{5}$$

where y_t is the dependent variable at time t, z_t is a vector of covariates, δ_j is the corresponding vector of coefficients, m is the number of breaks, and u_t is the disturbance at time t (Bai and Perron, 2006). The unweighted double maximum (UDmax) test statistic is obtained by calculating various F-statistic when the series are divided into one through m breaks. This statistic is compared to the critical values provided by Bai and Perron (2003b). The F-statistic can decrease as m increases, and if this is the case, the marginal p-values will decrease as m increases. Hence Bai-Perron provides the weighted double maximum (WDmax) test to take in account of this change in the F value as the size of m increases by multiplying a weight component to the UDmax test statistic (Bai, and Perron, 1998). When these tests do not reject the null hypothesis of having no structural breaks in the series, there will be no significant evidence of a break in the series.

In the second stage, if there happens to be an unknown break in the first stage, the number of appropriate potential breaks is identified by testing the null of l breaks versus the alternative of $l+1$ breaks. The null hypothesis of l breaks is rejected in favor of the $l+1$ breaks if the overall minimal value of the sum of squared residuals of a model with $l+1$ breaks is sufficiently smaller than that of the l breaks model (Bai and Perron 2003a). Since minimizing the sum of squared residuals is equivalent to maximizing the F-statistic of the model, the test statistic used for this test is called the $\text{supF}(l+1|l)$ test statistic and the critical values are provided by Bai and Perron (1998).

Figure 2. Price premiums for non-GM soybeans (price difference between the non-GM and conventional soybean futures contracts)



Note: Premium 2, 4, 6 are the price premiums for non-GM soybeans of second-, fourth-, and sixth-nearest futures contract respectively.

The price premium, the price difference between the non-GM and conventional soybean contracts, is used to identify the date of the breaks. This is because using the price premium removes factors that would affect the non-GM and conventional soybean futures prices independently.[3] Figure 2 illustrates the change in the price premium of second-, fourth-, and sixth-nearest futures contracts of the whole period (Jan. 2000 to Dec. 2008).[4] As seen in the figure, the price premiums were stable until the end of 2007 and then declined, and then they went up and down in 2008. At most there seem to be three breaks in the series, so the maximum number of breaks (*m*) chosen in the Bai-Perron test is three.

After the breaks are determined by the Bai-Perron test, the price series of

[3] The reason for not using the price difference between the soybean and corn prices is that the data period used in this study starts from the year 2000 where the soybean futures contract at the TGE was separated into the non-GM and convention soybean futures contracts.

[4] As mentioned in the data section, the prices are given in yen and price premiums are calculated with the use of daily settled prices of conventional and non-GM soybean futures contracts.

non-GM and conventional soybeans, and corn are split into periods using the breaks suggested by the test result. Then the bivariate Johansen cointegration test is conducted on each period separated by the breaks identified by the Bai-Perron test. If the cointegration relationships between the three price series changed before and after the break dates, it would mean that the breaks did exist in the series and that they had impacts on the cointegration relationships of the three prices. The Bai-Perron tests are executed on all contract months (second- nearest to sixth- nearest futures contracts), which provide different break dates for each contract month, and the cointegration tests are done on every identified periods determined for each contract month.

4. Results

The results from the ADF unit root tests indicate that in every contract month, conventional and non-GM soybean, and corn futures prices all had a unit root. However all series became stationary after taking the first differences (Table 3). Thus the three price series are all integrated of order one, I(1).

Table 3. Augmented Dickey-Fuller unit root tests for the whole period

Variables	Price levels	First differences
SB2	-0.33	-14.32*
SB3	-0.34	-14.47*
SB4	-0.38	-12.19*
SB5	-0.31	-14.51*
SB6	-0.29	-12.65*
NG2	-0.49	-14.35*
NG3	-0.52	-14.28*
NG4	-0.48	-13.66*
NG5	-0.41	-13.99*
NG6	-0.37	-14.09*
CO2	-0.22	-19.53*
CO3	-0.23	-19.38*
CO4	-0.24	-19.53*
CO5	-0.24	-22.63*
CO6	-0.24	-22.24*

Note: * denotes significance at a 1% level.
The data on the whole period (9/01/00 to 12/30/08) is used for the analysis. The ADF test results are for case with no drift and trend. The lag order for the ADF test is selected by the AIC.
SB, NG, and CO are the futures price of conventional soybeans, non-GM soybeans, and corn.
The numbers after the SB, NG, and CO represents the second- to sixth-nearest futures contracts.

Table 4. Bivariate cointegration tests for the whole period

Variables	H_0: rank=r	Trace test	Max test	Lags
SB2 vs NG2	r=0	47.04*	46.97*	3
	r<=1	0.08	0.08	
CO2 vs NG2	r=0	21.63*	21.56*	4
	r<=1	0.07	0.07	
CO2 vs SB2	r=0	13.66*	13.59*	3
	r<=1	0.06	0.06	
SB3 vs NG3	r=0	64.71*	61.43*	3
	r<=1	3.28	3.28	
CO3 vs NG3	r=0	23.14*	20.30*	4
	r<=1	2.84	2.84	
CO3 vs SB3	r=0	14.86	12.16	4
	r<=1	2.70	2.70	
SB4 vs NG4	r=0	58.20*	54.98*	3
	r<=1	3.22	3.22	
CO4 vs NG4	r=0	19.29	16.71*	4
	r<=1	2.58	2.58	
CO4 vs SB4	r=0	14.58	12.08	4
	r<=1	2.49	2.49	
SB5 vs NG5	r=0	55.62*	52.35*	4
	r<=1	3.27	3.27	
CO5 vs NG5	r=0	20.47*	17.94*	4
	r<=1	2.52	2.52	
CO5 vs SB5	r=0	16.58	14.14	4
	r<=1	2.44	2.44	
SB6 vs NG6	r=0	49.39*	46.30*	4
	r<=1	3.09	3.09	
CO6 vs NG6	r=0	21.54*	19.05*	4
	r<=1	2.49	2.49	
CO6 vs SB6	r=0	17.35	14.93	4
	r<=1	2.42	2.42	

Note: * denotes significance at 5%. SB, NG, and CO are the futures prices of conventional soybeans, non-GM soybeans, and corn. The numbers after the SB, NG, and CO represent the second- to sixth-nearest futures contracts.

Table 4 shows the results of the bivariate cointegration tests for all contract months using the data for the whole period (Sept. 2000 to Dec. 2008). The appropriate lag length for the VAR model is determined based on the Akaike information criteria (AIC). The cointegration equations tested assume no deterministic trends but include intercepts. As seen in Table 4 the null hypothesis of having no cointegration is rejected in the bivariate test between the conventional soybeans and the non-GM soybeans, and between the corn and the non-GM soybeans for the second-, third-, fifth-, and sixth-nearest futures contracts.[5] This suggests that conventional and non-GM soybeans, and

[5] Also, for the fourth-nearest futures contract, the result of the maximum eigenvalue test suggested that

corn and non-GM soybeans are cointegrated of order one.

Table 5. Use of soybeans and corn of total Japanese demand

Soybeans					Corn				
Year	Meal	Process	Food	Others	Year	Meal	Process	Food	Others
2001	1.97	78.75	16.68	2.60	2001	75.10	24.27	0.60	0.03
2002	2.13	79.26	16.03	2.58	2002	76.04	23.28	0.65	0.03
2003	2.33	78.84	16.16	2.67	2003	76.51	22.80	0.66	0.04
2004	2.57	76.25	18.60	2.59	2004	75.81	23.56	0.62	0.02
2005	2.87	75.00	20.03	2.09	2005	75.76	23.59	0.63	0.02
2006	2.95	74.57	20.45	2.03	2006	75.91	23.41	0.66	0.02

Note: The source is obtained from MAFF(2009)

However the results of the third- through sixth-nearest contracts suggest that corn and conventional soybeans are not cointegrated of order one. One reason for this may be because corn and soybeans are used for different purpose in Japan. As seen in Table 5, of the total demand for corn and soybeans in Japan, corn is used for livestock meal and processing but soybeans are mostly used for processing and food.[6] The other possible reason is that more participants of the corn market at the TGE may have been arbitraging between the non-GM soybean contracts rather than between the conventional soybean contracts since between 2003 and 2007, the annual average of the trading volumes for non-GM soybeans were larger than the conventional soybeans, which implies that the non-GM soybean futures market was more active than the conventional soybean futures market during these periods.

Table 6 provides the results of the Bai-Perron test. As mentioned in the previous section, data on the price premium for non-GM soybeans of every contract month are used for the test.

there is a cointegration relationship between the corn and non-GM soybean futures prices.

[6] There is a whole separate market for soybean meal in Japan but soybean meal futures contracts no longer exist at the TGE (TGE, 2008a).

Table 6. Bai-Perron multiple structural change tests

	Premium 2	Premium 3	Premium 4	Premium 5	Premium 6
Test	Statistic	Statistic	Statistic	Statistic	Statistic
UDmax	6.97	20.82*	21.44*	12.79*	19.25*
WDmax	8.56	25.55*	26.30*	14.07*	23.61*
sup-F(2|1)	na[a]	54.12*	43.00*	29.01*	16.55*
sup-F(3|2)	na	45.81*	29.87*	7.46	5.89

Note: * denotes significance at 5%. Premium 2 through premium 6 are the non-GM soybean price premiums for the second- through sixth- nearest futures contract.

[a]Since the double maximum tests suggested that there are no breaks for this series no further analysis is conducted for premium 2.

For the price premium of the second-nearest futures contract, the UDmax and WDmax tests do not reject the null hypothesis of having no breaks in the series, which imply that there are no breaks in this series. On the other hand, the double maximum tests for the price premiums of the third- through sixth-nearest futures contract rejected the null hypothesis and suggested that the series do contain unknown breaks. Since the result of double maximum tests identified the existence of the breaks in the price series of third- through sixth-nearest futures contract we need to look into the results of the $\text{supF}(l+1|l)$ test statistic to identify the optimal number of breaks for these series.

The $\text{supF}(l+1|l)$ test for the price premiums of third- and fourth-nearest futures contracts show that three breaks is the optimal number of breaks for these series. The null hypothesis of having two breaks is rejected in favor of three breaks for these series. On the other hand the null hypothesis is not rejected for premiums 5 and 6, which suggests two breaks is appropriate for the fifth- and sixth-nearest futures contracts. From the results of these tests, the optimal number of breaks for each contract months is determined and each of them is split into periods identified by the breaks, which is shown in Table 7.

Table 7. Periods identified by the Bai-Perron tests

	First		**Second**		**Third**		**Fourth**	
	Start	End	Start	End	Start	End	Start	End
Premium 3	9/1/00	11/26/02	11/27/02	11/19/07	11/20/07	7/30/08	7/31/08	12/30/08
Premium 4	9/1/00	11/26/02	11/27/02	11/20/07	11/21/07	7/30/08	7/31/08	12/30/08
Premium 5	9/1/00	12/10/07	12/11/07	7/30/08	7/31/08	12/30/08	na	na
Premium 6	9/1/00	12/17/07	12/18/07	7/30/08	7/31/08	12/30/08	na	na

Note: Premiums are the price premiums for non-GM soybean futures prices for different contract months and the periods are determined by the results of the Bai-Perron tests.

The breaks identified in November 2002 for the third- and fourth-nearest futures contracts may represent the contract specification change conducted for the conventional soybean futures contract in October 29, 2002.[7] However, as seen in Figure 2, the change in the price premium is small compared to the changes in 2007 and 2008.[8] The break dates of late 2007 suggested by the Bai-Perron test in all price premiums coincide with the period in which soybean stock decreased dramatically due to the increase demand in biofuel energy led by the increasing oil price (OMNICO Corp., 2007).[9] The break identified on July 31, 2008 for all price premiums matches with the months where the crude oil price in the U.S. marked the highest monthly average (IMF 2009). The year 2008 saw a major world economic crisis (United Nations, 2009) so it is likely that this crisis also had an effect on the conventional and non-GM soybean, and corn futures prices.

Using the periods provided in Table 7, Johansen bivariate cointegration tests are done on the price series of conventional and non-GM soybean, and corn futures contracts for each period. First ADF tests are conducted for each price series on all different periods. The results of this test suggest that all series are non-stationary before differencing but are stationary after differencing. Again the AIC is used to identify the most appropriate lag length for the VAR model. Here too the cointegration equations tested assume no deterministic trends but include intercepts.

[7] The contract unit was changed from 30 metric tons (mt) to 50 mt, suppliers were changed from six U.S. states to all U.S. states and Brazil, and the last day of trading changed from two business days to fifteen business days before the end of month for the conventional soybeans (TGE, 2002)

[8] As shown in manuscript one, the impact from the 2002 specification change only lasted for three to four months at most and did not change the price premium permanently.

[9] There was also a shift from soybean acreage to corn acreage in 2007 and this may also affected the soybean stock to decrease for this year (OMNICO Corp., 2007).

Table 8. Bivariate cointegration tests for the third- and fourth-nearest futures contracts on different periods

Third-nearest futures contract

First Period (Sept. 01, 00 to Nov. 26, 02)

Variables	H_0: rank=r	Trace test	Max test	Lags
SB3 vs NG3	r=0	35.23*	32.63*	2
	r<=1	2.60	2.60	
CO3 vs NG3	r=0	12.63	10.00	2
	r<=1	2.63	2.63	
CO3 vs SB3	r=0	15.50	13.09	2
	r<=1	2.41	2.41	

Second Period (Nov. 27, 02 to Nov. 19, 07)

Variables	H_0: rank=r	Trace test	Max test	Lags
SB3 vs NG3	r=0	31.74*	30.28*	4
	r<=1	1.46	1.46	
CO3 vs NG3	r=0	14.32	13.16	2
	r<=1	1.16	1.16	
CO3 vs SB3	r=0	10.42	9.29	3
	r<=1	1.13	1.13	

Third Period (Nov. 20, 07 to Jul. 30, 08)

Variables	H_0: rank=r	Trace test	Max test	Lags
SB3 vs NG3	r=0	16.04	11.78	2
	r<=1	4.27	4.27	
CO3 vs NG3	r=0	10.39	7.48	2
	r<=1	2.91	2.91	
CO3 vs SB3	r=0	14.72	12.47	2
	r<=1	2.25	2.25	

Fourth Period (Jul. 31, 07 to Dec. 30, 08)

Variables	H_0: rank=r	Trace test	Max test	Lags
SB3 vs NG3	r=0	15.07	10.06	2
	r<=1	5.01	5.01	
CO3 vs NG3	r=0	15.03	8.74	2
	r<=1	6.28	6.28	
CO3 vs SB3	r=0	22.64*	15.04	1
	r<=1	7.60	7.60	

Fourth-nearest futures contract

First Period (Sept. 01, 00 to Nov. 26, 02)

Variables	H_0: rank=r	Trace test	Max test	Lags
SB4 vs NG4	r=0	26.25*	23.16*	4
	r<=1	3.08	3.08	
CO4 vs NG4	r=0	13.72	11.40	2
	r<=1	2.32	2.32	
CO4 vs SB4	r=0	16.44	13.55	1
	r<=1	2.90	2.90	

Second Period (Nov. 27, 02 to Nov. 20, 07)

Variables	H_0: rank=r	Trace test	Max test	Lags
SB4 vs NG4	r=0	27.63*	26.15*	4
	r<=1	1.49	1.49	
CO4 vs NG4	r=0	10.88	9.59	2
	r<=1	1.29	1.29	
CO4 vs SB4	r=0	7.40	5.88	4
	r<=1	1.52	1.52	

Third Period (Nov. 21, 07 to Jul. 30, 08)

Variables	H_0: rank=r	Trace test	Max test	Lags
SB4 vs NG4	r=0	15.57	11.24	2
	r<=1	4.34	4.34	
CO4 vs NG4	r=0	14.78	12.34	2
	r<=1	2.43	2.43	
CO4 vs SB4	r=0	9.31	6.12	2
	r<=1	3.19	3.19	

Fourth Period (Jul. 31, 07 to Dec. 30, 08)

Variables	H_0: rank=r	Trace test	Max test	Lags
SB4 vs NG4	r=0	17.30	11.22	1
	r<=1	6.08	6.08	
CO4 vs NG4	r=0	16.07	9.69	1
	r<=1	6.39	6.39	
CO4 vs SB4	r=0	21.34*	13.32	1
	r<=1	8.02	8.02	

Note: * denotes significance at 5%. SB, NG, and CO are the futures prices of conventional soybeans, non-GM soybeans, and corn. The numbers after the SB, NG, and CO represent the second- to sixth-nearest futures contracts.

Table 9. Bivariate cointegration tests for the fifth- and sixth-nearest futures contracts on different periods

Fifth-nearest futures contract

First Period (Sep. 01, 00 to Dec. 10, 07)

Variables	H_0: rank=r	Trace test	Max test	Lags
SB5 vs NG5	r=0	30.99*	28.25*	4
	r<=1	2.74	2.74	
CO5 vs NG5	r=0	15.28	13.06	2
	r<=1	2.23	2.23	
CO5 vs SB5	r=0	12.60	9.56	2
	r<=1	3.04	3.04	

Second Period (Dec. 11, 07 to Jul. 30, 08)

Variables	H_0: rank=r	Trace test	Max test	Lags
SB5 vs NG5	r=0	17.69	13.61	1
	r<=1	4.09	4.09	
CO5 vs NG5	r=0	15.18	12.89	1
	r<=1	2.29	2.29	
CO5 vs SB5	r=0	7.35	4.28	2
	r<=1	3.07	3.07	

Third Period (Jul. 31, 08 to Dec. 30, 08)

Variables	H_0: rank=r	Trace test	Max test	Lags
SB5 vs NG5	r=0	17.51	11.97	1
	r<=1	5.53	5.53	
CO5 vs NG5	r=0	16.76	10.37	1
	r<=1	6.38	6.38	
CO5 vs SB5	r=0	22.22*	13.68	2
	r<=1	8.54	8.54	

Sixth-nearest futures contract

First Period (Sep. 01, 00 to Dec. 17, 07)

Variables	H_0: rank=r	Trace test	Max test	Lags
SB6 vs NG6	r=0	35.52*	30.15*	4
	r<=1	5.37	5.37	
CO6 vs NG6	r=0	19.15	16.90*	2
	r<=1	2.25	2.25	
CO6 vs SB6	r=0	12.34	9.34	4
	r<=1	3.00	3.00	

Second Period (Dec. 18, 07 to Jul. 30, 08)

Variables	H_0: rank=r	Trace test	Max test	Lags
SB6 vs NG6	r=0	15.29	12.72	2
	r<=1	2.58	2.58	
CO6 vs NG6	r=0	12.62	10.38	2
	r<=1	2.24	2.24	
CO6 vs SB6	r=0	7.32	3.88	2
	r<=1	3.44	3.44	

Third Period (Jul. 31, 08 to Dec. 30, 08)

Variables	H_0: rank=r	Trace test	Max test	Lags
SB6 vs NG6	r=0	16.06	10.45	1
	r<=1	5.62	5.62	
CO6 vs NG6	r=0	16.86	10.37	1
	r<=1	6.48	6.48	
CO6 vs SB6	r=0	23.98*	15.02	2
	r<=1	8.96	8.96	

Note: * denotes significance at 5%. SB, NG, and CO are the futures prices of conventional soybeans, non-GM soybeans, and corn. The numbers after the SB, NG, and CO represent the second- to sixth-nearest futures contracts.

Tables 8 and 9 give the results for the third-nearest to sixth-nearest futures contracts. As seen from these tables, in all different contract months, conventional and non-GM soybeans were not cointegrated after the breaks in November 2007, December 2007, and July 31, 2008. Conventional soybeans and corn were mostly not cointegrated during the periods determined by the Bai-Perron test, but the break that occurred in July 31, 2008 changed the price relationship between these two according to the trace test. Thus it is likely that this break, which coincides with the month where U.S. average monthly crude oil reached the highest price of all time (IMF, 2009), affected the cointegration results among the three price series.

It seems that the break that occurred in November, 2002 for the third- and fourth-nearest contracts did not cause a change in the cointegration result between the three prices. As seen in Figures 1 and 2 the price change in late 2002 is relatively small compared to the change in late 2007, and the break in November 2002 did not caused a huge effect on the price relations between the non-GM soybean, conventional soybean, and corn futures prices.

Table 10. Summary of the cointegration tests

2nd				3rd				4th			
Period	NG vs SB	CO vs NG	CO vs SB	Period	NG vs SB	CO vs NG	CO vs SB	Period	NG vs SB	CO vs NG	CO vs SB
All	Y	Y	Y	All	Y	Y	N	All	Y	N**	N
1	na	na	na	1	Y	N	N	1	Y	N	N
2	na	na	na	2	Y	N	N	2	Y	N	N
3	na	na	na	3	N	N	N	3	N	N	N
4	na	na	na	4	N	N	Y*	4	N	N	Y*

5th				6th			
Period	NG vs SB	CO vs NG	CO vs SB	Period	NG vs SB	CO vs NG	CO vs SB
All	Y	Y	N	All	Y	Y	N
1	Y	N	N	1	Y	N**	N
2	N	N	N	2	N	N	N
3	N	N	Y*	3	N	N	Y*

Note: Y denotes that the two prices are cointegrated and N indicates that they are not cointegrated. SB, NG, and CO denote conventional soybean, non-GM soybean, and corn futures contracts. 2nd to 6th represent the second-nearest to sixth-nearest futures contracts.
* Indicates that the trace test did not reject a cointegration relationship between SB and CO, but the maximum eigenvalue test rejected this relationship.
** Indicates that the trace test rejected a cointegration relationship between NG and CO, but the maximum eigenvalue test did not rejected this relationship.

Table 10 gives the summary of the cointegration tests conducted on each period for different contract months. Here, too, it can be seen that the breaks that occurred in late 2007 and July 31, 2008, both had a large impact on the price relations between the non-GM and conventional soybeans, and corn. Thus it can be concluded that these breaks did affect the cointegration relationships of these price series.

5. Conclusions

Testing for the cointegration relationships between the prices of non-GM and conventional soybeans, and corn using the data for the whole period revealed that a cointegration relationship exists between the non-GM and conventional soybean futures prices and for the non-GM soybean and corn futures prices. This result implies that the non-GM and conventional soybean futures market, and the non-GM soybean and corn futures markets are linked and have an influence on one another. Hence these markets can share valuable price information and price information in these markets can affect the decisions of participants in these futures markets. This implies that the price discovery process of the non-GM soybean futures market offers valuable information to the participants in the conventional soybean and corn futures markets and that cross-hedging is possible among these futures markets.

One of the possible reasons that the non-GM soybean market is cointegrated with the conventional soybean and corn futures markets is that the non-GM soybeans can be substitutes for these commodities. Most of the conventional soybeans and some of the corn traded at the TGE are used for producing oil but it is also possible to use the non-GM soybeans for oil. The other reason for these markets to be cointegrated is that the traders may be participating in these futures markets for arbitrage purposes. The cointegration found between the non-GM and corn markets may be related to the activities of arbitragers since the non-GM soybean futures market was more active than the conventional soybean market during 2003 and 2007.

The test results for finding breaks in the price premium for non-GM soybean futures price revealed that there are some breaks in the conventional and non-GM soybean futures markets. According to the Bai-Perron multiple structural change tests, the breaks appeared to occur in late 2007 and in end of July, 2008. This result implies that the two dramatic years of 2007 and 2008 for the soybean markets had influence on the price relationship between the conventional and non-GM soybeans.

These breaks found on the price relationship between the conventional and non-GM soybeans also had an impact on their cointegration price relationship, and that between the two soybean and corn prices. The break found in late 2007 changed the cointegration relationship between the conventional and non-GM soybean futures prices. The two soybean futures prices were cointegrated for the period before this break but they were not cointegrated for the period after this break occurred. The cointegration test conducted for the period after the break that was found in late 2008 also showed an effect on the cointegration relationship between the conventional soybean and corn futures prices. These prices were not cointegrated even for the whole period used in this study but the result of the trace test for the period after this break suggested that these prices are cointegrated. As mentioned in the introduction, 2008 was a dramatic year in terms of world economic crisis and it is reasonable to believe that this break had affected the price relationship of these commodities.

In conclusion a cointegration relationship exists between the non-GM and conventional soybean futures markets, and between the non-GM soybean and corn futures markets. However, the breaks found in these markets affected these relationships. Hence, the price information of these markets can be valuable when the breaks are not affecting the price relationship between the markets but it can become useless when the breaks are affecting the three markets. In this sense, the TGE soybean and corn futures markets are not efficient.

References

Andrews, D. W. K. 1993. "Testing for Parameter Instability and Structural Change with Unknown Change Point." *Econometrica*, 61(4): 821-856.

Andrews, D. W. K., and Ploberger, W. 1994. "Optimal Tests When a Nuisance Parameter Is Present Only under the Alternative." *Econometrica*, 62(6): 1383-1414.

Asche, F., Bremnes, H., and Wessells, C. R. 1999. "Product Aggregation, Market Integration, and Relationships between Prices: An Application to World Salmon Markets." *American Journal of Agricultural Economics*, 81(3): 568-581.

Bai, J., and Perron, P. 1998. "Estimating and Testing Linear Models with Multiple Structural Changes." *Econometrica*, 66(1): 47-78.

Bai, J. 2003a. "Computation and Analysis of Multiple Structural Change Models." *Journal of Applied Econometrics*, 18(1): 1-22.

Bai, J. 2003b. "Critical Value for Multiple Structural Change Tests." *Econometrics Journal*, 6(1): 72-78.

Bai, J. 2006. "Multiple Structural Change Models: A Simulation Analysis." In D. Corbea, S. D., and B. E. Hansen (Eds.), *Econometric Theory and Practice: Frontiers of Analysis and Applied Research* (pp.212-40). Cambridge, U.K.: Cambridge University Press.

Booth, G., and Ciner, C. 2001. "Linkages among Agricultural Commodity Futures Prices: Evidence from Tokyo." *Applied Economics Letters*, 8(5): 311-313.

Chen, G., Firth, M, and Rui, O. M. 2002. "Stock Market Linkages: Evidence from Latin America." Journal *of Banking and Finance,* 26(6): 1113-1141.

Chow, G. C. 1960. "Tests of Equality Between Sets of Coefficients in Two Linear Regressions." *Econometrica*, 28(3): 591-605.

Chowdhury, A. R. 1991. "Futures Market Efficiency: Evidence from Cointegration Tests." *The Journal of Futures Markets*, 11(5): 577-589.

Dickey, D. A., and Fuller, W. A. 1979. "Distribution of the Estimators for Autoregressive Time Series with Unit Root." *Journal of the American Statistical Association*, 74(366): 427-431.

Goodwin, B. K., and Schroeder, T. C. 1991. "Cointegration Tests and Spatial Price Linkages in Regional Cattle Markets." *American Journal of Agricultural Economics*, 73(2): 452-464.

Hansen, B. E. 2000. "Testing for Structural Change in Conditional Models." *Journal of*

Econometrics, 97(1): 93-115.

Harbest Futures Inc. 2009. “Gengetsu no Narabi Ichiran-hyou” (Table of the contract months order). Harbest Futures Inc. http://www.harbest.co.jp (accessed January 6, 2009).

International Monetary Fund (IMF). 2009. “IMF Primary Commodity Prices.” http://www.imf.org/external/np/res/commod/index.asp (accessed January 6, 2009).

Johansen, S., and Juselius, K. 1990. “Maximum Likelihood Estimation and Inference on Cointegration: With Applications to the Demand for Money.” *Oxford Bulletin of Economics and Statistics,* 52(2): 169-210.

Malliaris, A. G., and Urrutia, J. L. 1996. “Linkages Between Agricultural Commodity Futures Contracts.” *The Journal of Futures Markets*, 16(5): 595-609.

McCluskey, J. J., Grimsrud, K. M., Ouchi, H., and Wahl, T. I. 2003. “Consumer response to genetically modified food products in Japan.” *Agricultural and Resource Economics Review*, 32(2): 222-231.

Ministry of Agriculture, Forestry and Fisheries (MAFF). 2009. “Heisei 19 Nendo Shokuryou Jyukyu-hyou” (*2007 Food Demand and Supply Table*). http://www.maff.go.jp/j/zyukyu/fbs/ (accessed January 20, 2009).

Ministry of Health, Labour and Welfare (MHLW). 2001. “Idenshi-Kumikae-Shokuhin ni Kansuru Hyouji ni tuite” (*About the labeling on genetically modified food products*). http://www.mhlw.go.jp/topics/0103/tp0329-2c.html (accessed July 2, 2008).

OMNICO Corp. 2007. “Market Analysis from Supply and Demand.” *Online Catalogue 2007 Vol. 2*. OMNICO Corp. http://www.omnico.co.jp/ (accessed January 20, 2009).

Parcell, J. L. 2001. “An Initial Look at the Tokyo Grain Exchange Non-GMO Soybean Contract.” *Journal of Agribusiness*, 19(1): 85-92.

Quandt, R.E. 1960. “Tests of Hypothesis that a Linear Regression System Obeys Two Separate Regimes.” *Journal of American Statistical Association*, 55: 324-330.

Repach, D. E., and Wohar, M. E. 2006. “Structural Breaks and Predictive Regression Models of Aggregate U.S. Stock Returns.” *Journal of Financial Econometrics*, 4(2): 238-274.

Tokyo Grain Exchange. 2002. *Annual Report 2002*. Tokyo Grain Exchange: 126-129.

Tokyo Grain Exchange. 2003. *Tokyo Kokumotsu Shouhin-tirihiki-jyo Gojyu-nen-shi* (*Fifty Year History of Tokyo Grain Exchange*) (pp.204-07). Tokyo Grain

Exchange.

Tokyo Grain Exchange. 2008a. Conventional and Non-GM Soybeans, and Corn Price Quotes. Tokyo Grain Exchange. http://www.tge.or.jp (accessed January 20, 2009).

Tokyo Grain Exchange. 2008b. "Ippan-daizu no Torihiki-tani-henkou ni tomonau Torihiki-youkou tou no Gaiyou" (*Glossary of the trading after the change in the trading unit for the conventional soybeans*). Tokyo Grain Exchange.

United Nations. 2009. *World Economic Situation and Prospects - Global Outlook 2009.* NewYork: United Nations.

Xu, X. E., and Fung, H.-G. 2005. "Cross-market Linkages between U.S. and Japanese Precious Metals Futures Trading." *Journal of International Financial Markets Institutions and Money*, 15(2): 107-124.