2010

Essays on the Efficiency of Non-Genetically Modified (Non-GM) and Conventional Soybean Features Markets

Kentaka Aruga

University of Rhode Island

ESSAYS ON THE EFFICIENCY OF NON-GENETICALLY MODIFIED (NON-GM) AND CONVENTIONAL SOYBEAN FUTURES MARKETS

BY

KENTAKA ARUGA

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE

REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

ENVIRONMENTAL AND NATURAL RESOURCE ECONOMICS

UNIVERSITY OF RHODE ISLAND

2010

DOCTOR OF PHILOSOPHY DISSERTATION

OF

KENTAKA ARUGA

APPROVED:

Dissertation Committee:

Major Professor ____________________

____

____

____

DEAN OF THE GRADUATE SCHOOL

UNIVERSITY OF RHODE ISLAND

2010

ABSTRACT

This dissertation explores issues related to efficiency, how efficiently markets transmit information, of non-genetically modified (GM) soybean and conventional soybean futures markets at the Tokyo Grain Exchange (TGE).

The first manuscript examines how efficiently non-GM and conventional soybean futures markets react to an announcement to change the contract unit, suppliers, and expiration date on the conventional soybean contract. Box and Tiao's intervention analysis is used for this purpose. The result reveals that the price premium for non-GM soybeans (the price difference between the two soybean contracts) and the volumes of non-GM soybeans increase after the announcement and this effect remained after the announcement. Hence the two soybean futures markets did not respond quickly to the announcement and there was an informational inefficiency after the change occurred.

The second manuscript explores the market linkages between the non-GM and conventional soybean, and the corn futures markets at the TGE in the presence of unknown breaks. Bai-Perron multiple structural change test and Johansen cointegration tests are used for this purpose. The results reveal that cointegration relationships exist between the two soybean futures prices and

between the non-GM soybean and corn futures prices. Yet the breaks found in the soybean futures markets affected these price linkages, and there were periods where the two soybean and corn futures markets were not efficient.

The third manuscript tests if the two soybean futures markets fully reflect available information by testing the market efficiency of the two soybean futures markets. This manuscript also investigates the causality of this long-run relationship to find out if it is the spot price or the futures price that first incorporates new information into the market. Johansen cointegration tests are used for these purposes. The results suggest that both non-GM and conventional soybean futures markets are efficient but the non-GM soybean market is inefficient compared to the conventional soybean market. The test on the causality of the long-run relationship showed that both of the soybean futures markets are led by the spot price for the spot and futures prices to move together in the long-run.

ACKNOWLEDGEMENTS

I would like to thank my advisor James L. Anderson and the faculty at the Department of Environmental and Natural Resource Economics at the University of Rhode Island for supporting me in writing this dissertation. I would also like to thank Christian Vye of the university's Information Technology Services for giving me the opportunity to work as his graduate assistant and providing financial assistance. I am also grateful to the Tokyo Grain Exchange (TGE) for the price data and valuable information about the TGE soybean futures markets. Especially, I appreciate Takahiro Ueyanagi of the TGE for providing the data and explaining the TGE soybean futures markets. I would also like to give special thanks to Frank Asche, and Nobumori Yagi for providing the opportunity to comment on the dissertation.

Finally, I would like to express my gratitude to my family (my parents, Natsuki and Tsutomu Aruga, my grandmother, Toyo Hirasawa, and sister, Mika Toyomura) and fellow graduate students at my department for supporting me throughout the PhD program. I also thank Katy Meigs, a family friend, for editorial assistance.

PREFACE

This dissertation is composed of three manuscripts and a set of supporting appendices. The objective is to address issues related to the efficiency of the non-genetically modified (GM) and conventional soybean futures markets at the Tokyo Grain Exchange (TGE). Efficiency here means information efficiency such that the prices always fully reflect available information. More and more food products are using genetically modified organisms (GMOs) throughout the world, and concern about such products is spreading. However, not much is known about how a segregated market for non-GM food functions as a source of providing effective information to the market participants. This dissertation examines how such a market for non-GM food transmits price information efficiently through the case of the TGE non-GM soybean futures market, the world's first individual futures market for a non-GM commodity.

The first manuscript examines how efficiently the non-GM and conventional soybean futures markets react to new information by testing the effect of an announcement to change the contract unit, suppliers, and expiration date on the conventional soybean futures contract. The result reveals that the price premium for non-GM soybeans (the price difference between the non-GM and conventional soybean futures prices) and the volumes of non-GM soybeans increase after the announcement and this effect remained for at least a month. Hence it is concluded that the two soybean futures markets did not respond quickly to the announcement and there was an informational inefficiency after the change occurred.

The second manuscript focuses on the linkage between the non-GM and conventional soybean futures markets to find out if these markets are cointegrated so that they provide valuable information to each other. The linkages between these two soybean futures markets and the corn futures market are also investigated and effects of unknown breaks on the cointegration, if any, are tested as well. The Johansen cointegration test suggests that a market linkage exists between the non-GM and conventional soybean futures markets and between the non-GM soybean and corn futures markets but that they were not cointegrated during periods with breaks. 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.

The third manuscript tests for market efficiency of the non-GM and conventional soybean futures markets at the TGE to see if the two soybean futures markets fully reflect available information. Both soybean futures markets turned out to be efficient (do provide efficient information) but the non-GM soybean futures market was inefficient compared to the conventional soybean futures market. In this manuscript the causality of the long-run relationships between the spot and futures prices of non-GM and conventional soybeans were also investigated in order to find out whether it is the spot price or the futures price that first incorporates new information to the market. In both soybean futures markets it was the spot price that led the spot and the futures prices to move together in the long-run.

Through these manuscripts the dissertation finds out that the non-GM soybean and conventional soybean futures markets do satisfy the market efficiency condition. However, there were some periods where the prices of the two markets did not respond quickly to known and unknown breaks, and hence, these markets are not perfectly efficient.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Manuscript One: An Intervention Analysis on the Tokyo Grain Exchange Non-Genetically Modified and Conventional Soybean Futures Markets

by

Kentaka Aruga*

is formatted for submission to *Journal of Agribusiness*

* PhD Candidate, Department of Environmental and Natural Resource Economics, The University of Rhode Island, Kingston, RI. 02881. Email: kentaka.aruga@gmail.com

Abstract

This manuscript examines how efficiently the non-genetically modified (non-GM) and conventional soybean futures markets at the Tokyo Grain Exchange (TGE) react to an announcement to change the contract unit, suppliers, and expiration date on the conventional soybean futures contract. Box and Tiao's intervention analysis is used for this purpose. The result reveals that the price premium for non-GM soybeans (the price difference between the non-GM and conventional soybean futures prices) and the volumes of non-GM soybeans increase after the change and this effect remained at least for a month. Hence the two soybean futures markets did not respond quickly to the announcement and there was an informational inefficiency after the change occurred.

1.1 Introduction

Many regions and countries, including the European Union, Australia, New Zealand, and Brazil, now require labeling for genetically modified (GM) food products (Huffman 2003). Japan has followed this trend. McCluskey et al. (2003) revealed that Japanese consumers have a higher preference for non-GM food over GM food. As more consumers became concerned about GM food products in Japan and demanded regulation, the Japanese government issued a law to require labeling for GM food products as of April 2001 (TGE 2003). This law imposed mandatory labeling for most of the GM food products (TGE 2003) so that consumers can identify products containing genetically modified organisms (GMOs).[1] For example, one of the world's largest soy sauce companies, Kikkoman, decided to use only non-GM soybeans for its product (Kikkoman 2006).

To meet the increasing demand on non-GM food products, on May 18, 2000, the Tokyo Grain Exchange (TGE) opened the world's first futures market

---

[1] In 2001 the amended Japanese Agricultural Standard Law took in effect in accordance with the Food Sanitation Law (TGE 2003).

for non-genetically modified (GM) soybeans. Since the opening of the non-GM soybean futures market, it has been known that the price of non-GM soybeans is higher than the price of "conventional soybeans," which contain both non-GM and GM soybeans (Parcell 2001).

Parcell (2001) defines the price difference between the prices of non-GM and conventional soybean futures contracts as the price premium for non-GM soybeans. He argues that this premium should represent the marketing and production costs of segregating non-GM soybeans.[2] It is also known that the price premium for non-GM products exists in the demand side as well. Wachenheim and Wechel (2004) find that consumers are willing to pay a premium for non-GM products using experimental auction and it is arguable that the price premium for the non-GM soybeans at the TGE is also driven from the demand side.

However, in July and August 2002, there were trading days when the conventional soybean price reached a higher price than the non-GM soybeans

---

[2] The segregation costs include various costs of preserving the identity of the non-GM soybeans from the seed level to the distribution level (Bullock, and Dequilbet 2002).

on the last day of trading. The TGE suggests that there was market inefficiency involved in the soybean futures markets during these periods and that this may have driven the price premium to become negative.[3]

To cope with the problem of the price premium becoming negative, which was beyond market expectations, the TGE made a major change in the specification for conventional soybeans on October 29, 2002 (TGE 2002). The TGE was hoping that this change would sharpen the distinction between non-GM and conventional soybean futures contracts and stabilize the markets for the non-GM and conventional soybeans.[4] The details of the specification changes are the following:

- Increase in the minimum contract unit for conventional soybeans from 30 metric tons (mt) to 50 mt starting with October and December 2003 contracts.[5]
- Increase in the number of suppliers of conventional soybeans from six U.S. states to all U.S. states and Brazil.[6]

---

[3] Takahiro Ueyanagi, the TGE planning division officer, interviewed by author, Jan. 8, 2006.

[4] Takahiro Ueyanagi, the TGE planning division officer, interviewed by author, Jan. 8, 2006.

[5] The contract unit for the non-GM soybeans remained 10 mt.

[6] The six U.S. states are Indiana, Ohio, Michigan, Iowa, Illinois, and Wisconsin.

- Change in the last day of trading for conventional soybeans. Before this change, the last day of trading for all conventional and non-GM soybean contracts was two business days before the end of the month. After the change, the last day of trading for conventional soybeans was changed to fifteen business days before the end of the month.

What can be expected from the first change is that the volume of trading for non-GM soybeans would rise. After the change in the contract unit for the conventional soybean futures contract, traders have to trade 50 mt of soybeans to obtain conventional soybeans, so small traders who were trading less than 50 mt of conventional soybeans would have to shift their trade to non-GM soybeans if they wanted to continue their trading at their previous volume.[7] Thus the change may attract traders who want to trade soybeans in smaller amounts to the non-GM soybean futures market. This shift of traders from the conventional soybean futures market to the non-GM soybean futures market may drive the price of non-GM soybean futures contracts to rise after

[7] The contract unit for non-GM soybeans stayed the same (10 mt).

the change.

The second change, the one that widens the suppliers for the conventional soybeans may also increase the comparative price of non-GM soybeans, since the market participants may expect the total amount of available conventional soybeans at the TGE to become larger than the non-GM soybeans after the change is conducted. The suppliers for the non-GM soybeans remain only from the United States while the conventional soybeans will be supplied from countries in the Southern Hemisphere in addition to the United States after the change. Thus the difference in the stock availability between conventional and non-GM soybeans may become more apparent to market participants, and this may affect the soybean prices.

Finally setting the last day of trading for conventional and non-GM soybeans on different dates will help segregate the two soybean futures markets and make it easier for investors to distinguish their portfolios for the two types of soybeans. The change may separate the market participants so that they trade the two soybeans on different days, and this may strengthen the distinction between the two soybean futures markets: one market for soybeans that require labeling under the JAS law and the other for soybean products such as soybean oil and soy sauce that do not require labeling.[8]

The objective of this paper is to examine how efficiently the TGE non-GM and conventional soybean futures markets react to an announcement by testing the influence of the above mentioned specification change on the price premium for non-GM soybeans, and on the trading volumes of non-GM and conventional soybeans. There are still few studies using the TGE non-GM soybean futures price, and there are not any when it comes to how an announcement from the TGE, such as this specification change might affect the market prices. Parcell (2001) explains about this new market for non-GM soybean futures at the TGE and computes the price premium for non-GM soybean contracts. Bullock and Desquilbet (2002) shows the price premium of non-GM soybeans to analyze the costs of non-GM segregation. However both studies only use the TGE soybean prices up until 2001, which is before the specification change occurred.

---

[8] JAS law does not require mandatory labeling for soybean products such as soy sauce or soy oil (MHLW 2001).

In general, there are few studies testing the effects of policy announcements on futures prices. Doukas and Rahman (1986) analyze how monetary policy announcements affect the foreign currency futures market. They find that investors in the foreign exchange market react quickly to new announcements from the Federal Reserve relating to changing monetary policy and the discount rate. Karagozoglu, Martell, and Wang (2003) test how a change in the contract size of S & P 500 futures contracts at the Chicago Mercantile Exchange affects trading volumes after the change is conducted. Their study showed that the specification change of the S & P 500 futures contracts did not change the contract volumes. These previous studies on the effects of announcements on futures markets use the Box and Tiao's (1975) intervention analysis, but these studies are focused on financial futures products. The reaction to the announcement may be different in the commodity futures market. Previous studies using the intervention analysis only tests the reaction for the period before and after the event but this study uses this method to also find out how long the effect from the announcement lasted after the event. This will be done by creating individual dummy variables for each specific period where the impact may have lasted.

It is important to find out how the TGE soybean futures market reacts to an announcement such as this specification change. If the market did not respond quickly to the specification change and the effect of the change remains for a certain period, it would suggest that it took some time for market prices to reflect the new information. If the market is fully efficient, all available information, including public information should immediately be reflected in the price (Fama 1991). Thus if the effect from the announcement stays in the market it means that there is an informational inefficiency in the market.[9] Although the specification change may increase the price of non-GM soybean futures contracts as explained above, this increase should occur only for a short period of time if the market is fully efficient. If the market is efficient the price should adjust quickly to the level before the announcement due to the buying and selling activities of the arbitrageurs.

In the following section I will describe the data used in the study and

---

[9] According to Fama (1991) typical results in event studies using daily data suggest that if the market is efficient prices often adjust within a day after an announcement occurs.

provide more explanation on the changes that was conducted for the conventional soybean futures contracts. In the third section the details of the method used for this research will be explained. The fourth section will show the results of the investigation. In the last section, I will present the conclusions of the study.

1.2 Data

The data used for the analysis are obtained from the TGE via online and personal negotiations with the TGE (TGE 2008). The TGE has its origin in trading rice futures at the Kakigaracho Rice Trading Exchange (TGE 2007). The current TGE opened after World War II in 1952 and soybeans have been traded at this exchange since then (TGE 2007). A separate trading for non-GM soybeans started on May 18, 2000 so the non-GM and conventional soybean futures contracts only extend back that far (TGE 2002).

Since the focus of this research is on how the event that occurred on October 29, 2002 affected the price premium for non-GM soybean futures contracts, the daily price data from January 4, 2002 to September 30, 2003 will be used for the analysis. The price unit is provided in yen per mt.

Table 1.1. Summary of the contract specification at the Tokyo Grain Exchange

	Conventional soybeans		Non-GM soybeans
	Before Oct 29th 2002	After Oct 29th 2002	
Date Trading Began	March 1, 1984		May 18, 2000
Contract Unit	30,000 kg (30 metric tons)	50,000 kg (50 metric tons)	10,000 kg (10 metric tons)
Trading Hours	10:00 a.m., 11:00 a.m., 1:00 p.m. and 2:00 p.m. * 10:00 a.m. and 11:00 a.m. on the last trading day.		9:00 a.m., 10:00 a.m., 2:00 p.m. and 3:00 p.m. * 9:00 a.m. and 10:00 a.m. on the last trading day.
Contract Months	February, April, June, August, October and December within a twelve-month period		
Price Quotation	Yen per 1,000 kilograms		
Last Trading Day	Two business days prior to the delivery day.	Fifteenth calendar day of the delivery month; if that day is not a business day, then the last trading day is moved up to the nearest business day.	Two business days prior to the delivery day.
Delivery Day	One business day prior to the last business day of the delivery month. December 24th for December contract; if not a business day, the delivery day is moved up to the nearest business day.		
Standard Grade	GM or a mixture of GM and Non-GM No. 2 yellow soybeans of Indiana, Ohio, and Michigan origin produced in the U.S.A. (Non screened, stored in silo.)	GM, GM mixed and GM non-segregated No. 2 yellow soybeans produced in the U.S.A. and yellow soybeans produced in the Federative Republic of Brazil and the Republic of Paraguay that satisfy the terms and conditions stipulated in the Exchange Rules (Stored in silo, without screening and sorting processing).	Identity preserved non-genetically modified organism (non-GM) No. 2 yellow soybeans of the growths of Indiana, Ohio and Michigan in the U.S.A. (Stored in silo, without screening and sorting processing).
Delivery Points	Designated warehouses in the Tokyo metropolitan area and the prefectures of Kanagawa, Chiba, Saitama and Ibaraki.		

Source: TGE, 2002

Table 1.1 shows the details of the specification for non-GM and conventional soybeans before and after the specification change took place on October 29, 2002. As mentioned in the introduction, the major differences after October 29, 2002 are that the contract unit for conventional soybeans increased from 30 mt to 50 mt, standard grade changed from six U.S. states to all U.S.

states and Brazil, and the last day of trading became a different day for non-GM and conventional soybeans.

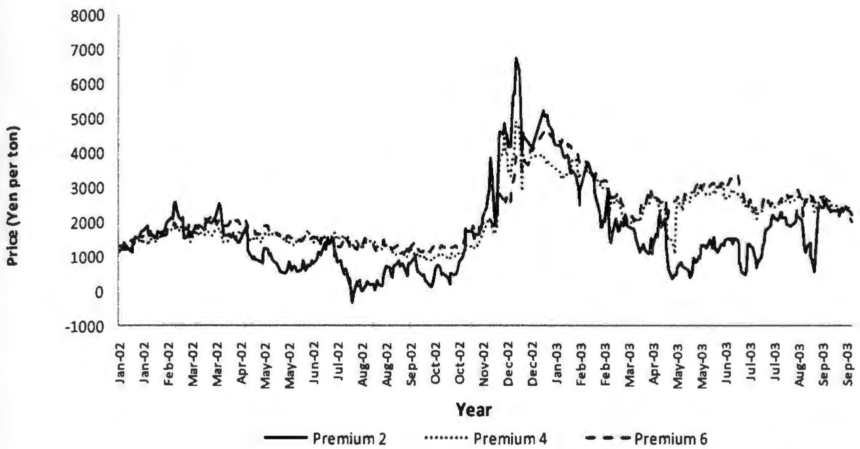
Table 1.2. Descriptions of contract months for non-GM and conventional soybeans

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 1.2 describes the contract months used in the analysis. Due to the lack of liquidity for the nearest futures contract, I used only data on the second- through sixth-nearest contracts. As shown in the table, the second-nearest contracts are either two-month-ahead or three-month-ahead futures contracts, the third-nearest contracts are four-month-ahead or five-month-ahead futures contracts, and so on. The difference between the daily prices of conventional and non-GM soybeans for the second-nearest futures will be the second-nearest price premium, that for the third-, fourth-, fifth-, and sixth- will be the third-, fourth-, fifth-, and sixth-nearest price premiums respectively.

Figure 1.1. Price premiums for non-GM soybeans (price difference between the non-GM and conventional soybean futures contract)



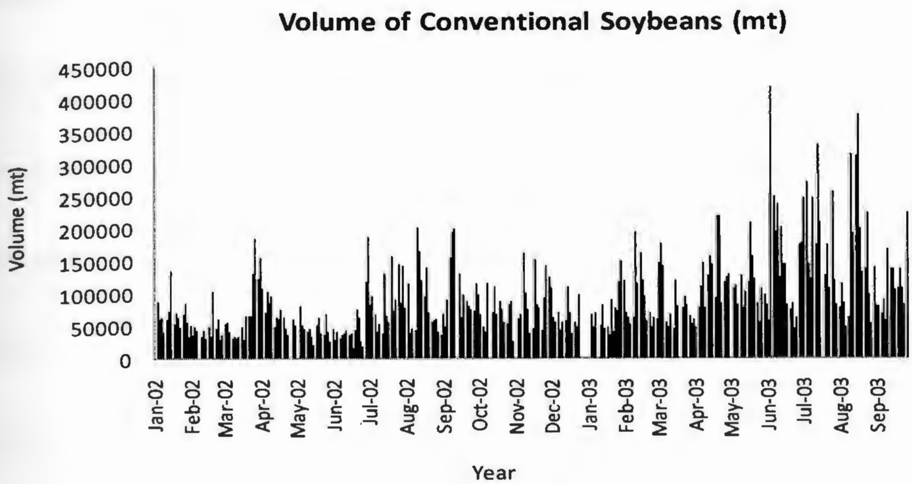
Note: The prices for the non-GM and conventional soybeans are given in yen and are for 1,000 kilograms (1mt) of soybeans. Premium 2, 4 and 6 are the price premiums for second-, fourth- and sixth-nearest futures contracts.

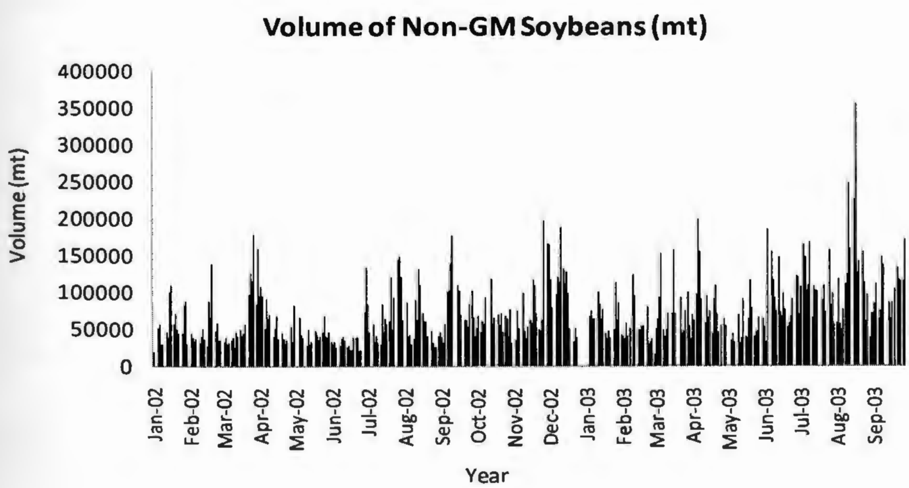
Figure 1.1 shows the changes in the price premiums for non-GM soybeans for the second-, fourth- and sixth-nearest futures contracts.[10] The figure is created using the daily price data of conventional and non-GM soybean futures contracts from January 2002 to September 2003 at the TGE. As

[10] The third- and fifth-nearest contracts had a similar graph.

seen in this figure, the price premium of non-GM soybeans increased after the specification change was conducted at the end of October 2002.

Figure 1.2. Volume of conventional and non-GM soybean futures contracts for the sixth-nearest futures contract





The daily data on the volumes of conventional and non-GM soybean futures contracts are converted to actual volumes traded in mt. The volume data provided by the TGE are the total number of contracts. To get the actual volume of soybeans traded on a certain day, this volume data is multiplied by the contract unit. Since the contract unit for conventional soybeans increased from 30 mt to 50 mt after October 29, 2002, the volume data before the change are multiplied by 30 whereas the data after that date are multiplied by 50. The volume data on non-GM soybeans are multiplied by 10 through the study period. As seen in figure 1.2, it seems that the volume on the non-GM soybean contract increased more than that of the conventional soybean contract after the specification change took place in November 2002.

1.3 Methodology

The Box and Tiao's (1975) intervention analysis is used to test the effects of the specification change on the price premium and the volume traded for the non-GM and the conventional soybean futures contracts. This analysis takes into account of the effect of an announcement on a given response variable using the autoregressive moving average model (Doukas and Rhaman 1986). It also allows the observed autocorrelation in the model residuals to be removed, which improves the statistical testing (Guzhva 2008; Larker, Gorden, and Pinches 1980). As suggested by Larker, Gorden, and Pinches (1980), this method is a more appropriate method for testing effects on financial markets from an announcement compared to the cumulative abnormal returns (CAR) measure, which is often used in event studies when the exact date of the event is unknown (Tsay, Alt, and Gordon 1993).

When using an intervention analysis the impact to be tested must be an event in the strict sense and the time when that event occurred has to be specified a priori (McCleary and Hay 1980). The basic intervention model can be written as

$$Y_t = f(I_t) + N_t \tag{1}$$

where Y_t is the price series, I_t is a dummy variable representing the impact or the event, and N_t denotes the noise component. The noise component is the autoregressive integrated moving average (ARIMA) model. The ARIMA model can be expressed as

$$N_t = \frac{\theta(B)}{\phi(B)} \varepsilon_t \qquad (2)$$

where B is the backshift operator, $\phi(B)$ is the autoregressive operator represented by polynomials of the back shift operator, $\theta(B)$ is the moving average operator represented by polynomials of the back shift operator, and ε_t is the random error (McCleary and Hay 1980).[11] The intervention effect is modeled as

$$f(I_t) = \omega I_t \qquad (3)$$

in which ω is the impact of the interruption on the series.[12] The impact is analyzed using the step function:

$$I = S_t^{t_0} = \begin{cases} 0 \text{ if } t < t_0 \\ 1 \text{ if } t \geq t_0 \end{cases} \qquad (4)$$

where S is the step input, and t_0 is the time period during which the intervention occurs.

Although the specification change was conducted on October 29, 2002, the date November 1, 2002, was chosen for the intervention t_0. This is because the actual trading of conventional soybeans under the new specification began

---

[11] The details are explained in Appendix A.

[12] ω can be also interpreted as the coefficient of I in equation (3).

with the October 2003 and December 2003 contracts (TGE 2002). As shown in table 1.2, trades for the October 2003 and December 2003 contracts start in November 2002 and December 2002, respectively, so the event began to take effect on November 1, 2002.

To avoid biased estimates of autocorrelation functions (ACFs) and partial autocorrelation functions (PACFs), only observations before the intervention is used to estimate the ARIMA model. In Box and Tiao's intervention analysis, it is assumed that the same model identified for the pre-intervention series applies to the post-intervention autocorrelation behavior (Tsay and Hung 1994). Assuming there was no intervention effect before November 1, 2002, an ARIMA model is estimated using the data from January 4, 2002 to October 31, 2003. The Box-Jenkins procedure is used to identify the model (Box and Jenkins 1970). There are three stages in the Box-Jenkins approach: identification stage, estimation stage, and diagnostic stage.

At the identification stage, ACFs and PACFs of the price premium for non-GM soybeans, the volume of non-GM and conventional soybeans are plotted, and the orders of autoregressive and moving average elements are examined by looking at the plots. If the pattern of ACFs shows that the response series are nonstationary, the series will be differenced to remove its trend and make the series stationary. An augmented Dickey-Fuller (ADF) test is conducted to test this (Dickey and Fuller 1979). Then the estimated ACFs and PACFs are compared with various theoretical ACFs and PACFs and the final order of the autoregressive and the moving average elements are determined by the extended sample autocorrelation function (ESACF) (Tsay and Tiao 1984), and the minimum information criteria (MINIC) (Hannan and Rissanen 1982).[13]

At the estimation stage the coefficients of the parameters of the model are estimated. The coefficients are estimated using the maximum likelihood estimation. The log-likelihood function uses the covariance matrix of the vector calculated from equation (1).[14] The stationarity and the significance of the model are tested as well.

At the diagnostic stage the residuals of the model are tested as to whether or not they are white noise. The statistic used for this test is the

---

[13] These are done by using SAS software (SAS 2008).

[14] The details of the process and the functions can be seen in Box and Tiao (1975)

Box-Pierce Q statistic:

$Q = T\sum_{k=1}^{p} r_k^2$ where T is the number of observation and r_k is the autocorrelation of the *k*th variable (Enders 2005).

To find the length of the impact, step functions are created for months from November 2002 until the test statistics show that the coefficient of the step input variable is not significant. For instance, to test if the impact lasted until December 2002 the step function is created as below:

$$I = S_t^{t_0} = \begin{cases} 0, & t < t_0 \\ 1, & t_{Dec\_F} \leq t \leq t_{Dec\_L} \end{cases} \qquad (5)$$

where t_0 is November 1, the day when the event occurred, and t_{Dec_F} and t_{Dec_L} are the first and last trading days of December 2002. Similar step functions are created for the months of January, February, and so on until the coefficient of the step input variables do not show any significance. The data used for the analysis are also changed according to the step functions created for the different months. All analyses include data before the event (from Jan. 4, 2002 to Oct. 31, 2002) but only use the daily data of the month that is tested using the step functions for days after the event. For example for testing whether the impact from the specification change lasted to the months of

December, the data between Jan 4, 2002 and Oct 31, 2002 and the whole daily data of the month of December 2002 is used.

1.4 Results

The results of the ADF test conducted on the data before the specification change for the conventional soybean futures contract (from January 4, 2002 to October 30, 2002) indicate that the series for the price premium for non-GM soybeans should be differenced. After differencing the series, the test results showed that they are all stationary (table 1.3).

Table 1.3. Augmented Dickey-Fuller unit root tests[a]

Variables[b]	Price levels	First differences
Premium 2	-0.98	-12.51**
Premium 3	-0.77	-5.65**
Premium 4	-0.50	-5.73**
Premium 5	-0.41	-5.57**
Premium 6	-0.32	-22.43**

[a]The ADF test result shown is for case with no drift and trend. The lag order for the ADF test is selected by the AIC.

[b]Premium 2 though 6 are the price premiums of second- to sixth-nearest futures contracts.

** Indicates signficance at 1% level

Table 1.4. ARIMA models used for the analysis[a]

Types of contracts[b]	ARIMA model fitted		
	Price premium	Volume of SB	Volume of non-GM
2nd	(0,1,0)	(0,1,1)	(0,1,1)
3rd	(0,1,0)	(0,1,1)	(0,1,1)
4th	(0,1,2)	(0,1,1)	(0,1,1)
5th	(0,1,2)	(1,1,1)	(0,1,1)
6th	(0,1,3)	(1,1,1)	(0,1,1)

[a]SB and non-GM represent the conventional and non-GM soybeans. The parenthisis is the order of the autoregressive, integrated, and moving average components of the ARIMA model.

[b]The 2nd through 6th represent the second-nearest to sixth-nearest futures contracts.

The orders of the ARIMA model used for the analysis are given in table 1.4. For example the ARIMA (1, 1, 1) model is used to estimate the volume of conventional soybeans for the sixth-nearest futures contract, which means that the order of the autoregressive, integrated, and moving average are all one for this model. The autocorrelation test on the series of the price premium before the change occurred revealed that the residuals are white noise.

By applying the step functions into each ARIMA model for the different contract months, the intervention model as explained in equation (1) is estimated for the price premium of each contract month (McCleary and Hay 1980).

Table 1.5. Intervention analysis for the price premium (price difference between the non-GM and conventional soybean futures contracts)[a]

	Input Variables				
Price Premium[b]	Nov	Dec	Jan	Feb	Mar
Premium 2	152.6 (3.11)*	121.1 (1.85)	na	na	na
Premium 3	159.5 (4.29)*	167.4 (2.72)*	123.2 (2.68)*	80.5 (1.83)	na
Premium 4	95.3 (6.11)*	108.8 (2.63)*	122.7 (2.94)*[c]	80.4 (2.09)*[c]	29.3 (1.20)
Premium 5	81.5 (3.91)*	111.6 (4.16)*	115.0 (2.58)*[c]	77.0 (2.01)*[c]	28.5 (0.92)[c]
Premium 6	55.0 (3.08)*	139.0 (4.60)*[c]	134.6 (2.71)*[c]	88.9(2.08)*[c]	36.3 (1.06)[c]

[a]The estimates are the coefficients of the input variables and the values in parentheses are the t-values.
[b]Premium 2 through 6 are the price premiums of second-nearest to sixth- nearest futures contracts.
[c]The coefficient on the moving average was not significant at the 5% level.
*Statistically significant at the 5% level

Table 1.5 shows the estimated coefficients for the input variables (Nov. - Mar.) of different contract months, which represent the effect of the event. For example, the model of the price premium for the second-nearest futures contract with an input variable *Nov* is

$$Y_t^{Pre} - Y_{t-1}^{Pre} = 152.6Nov \quad (6)$$

where Y_t^{Pre} is the price premium at time *t*, and *Nov* is the input variable created to test if there has been any change in the price premium for the month of November 2002 after the specification change was made for the conventional soybeans. The result of this model suggests that after the specification change the price premium for non-GM soybeans increased by an average of about 153 yen during the months of November 2002. As seen in the table, the estimates of the input variable *Nov* for the other contract months are also all significant and positive. This implies that the announcement to change the contract specification for conventional soybeans did have an influence on the price premium and led to a price premium increase in this month.

The results of the input variables *Dec*, *Jan*, *Feb*, and *Mar* for different contract months had different results. For the third-nearest contract, which is either a four-months-ahead or a five-months-ahead futures contract, the impact lasted until January. The input variable *Feb* is not statistically significant at the 5% level, so it indicates that the impact did not continue up until February. On the other hand, for the fourth-, fifth-, and sixth-nearest contracts, the input variables are significant at the 5% level up until the input variable *Feb*, which means that the impact lasted until February. Hence the result of the intervention analysis on the price premium implies that the length of the impact lasted for three to four months after the event occurred.[15]

---

[15] An intervention analysis was also conducted on the percentage change in the price premium and this had a similar result. The price premium increased 4 to 5% in terms of percentage

To find out if this increase in the price premium for non-GM soybeans after the event had any relation to the change in the traded volume of conventional and non-GM soybean futures contracts, an intervention analysis was conducted using the volume data. The results of the ADF test on the volume of conventional and non-GM soybean futures contracts suggest that first-differencing the series improves the estimation, so all the series are first differenced once. Then the orders of the ARIMA model for the time series on the volumes of soybeans are determined using the same method as the previous analysis (table 1.4). The autocorrelation test on the volume series before the change revealed that the residuals are white noise. Here, too, input variables created for each month after the event occurred are applied to each model to test the length of the effect resulting from the event.

---

change, and this effect lasted for four months for the fourth-, fifth-, and sixth-nearest futures contracts.

Table 1.6. Intervention analysis for the volume (mt) of conventional soybeans[a]

	Input variable
Types of contracts	Nov
2nd	-46.3 (-0.14)
3rd	82.6 (0.44)
4th	367.2 (0.58)
5th	1472.5 (1.50)
6th	531.5 (0.36)

[a]The estimates are the coefficients of the input variables and the values in parentheses are the t-values. The 2nd thorugh 6th represent the second- to sixth-nearest futres contracts.

Table 1.6 illustrates the result of the analysis for the volume of the conventional soybean futures contract. None of the estimates for the input variable are significant at the 5% level. This result implies that the specification change for the conventional soybeans did not have an effect on the volumes traded for the conventional soybeans.

Table 1.7. Intervention analysis for the volume (mt) of non-GM soybeans[a]

	Input Variables	
Types of contracts	Nov	Dec
2nd	725.7(1.85)	na
3rd	2294.5(5.76)*	-850.7(-1.39)
4th	4409.1(3.10)*	-1478.2(-0.77)
5th	6956.6(2.25)*	-1468.3(-0.53)
6th	5708.2(1.46)	na

[a]The estimates are the coefficients of the input variables and the values in parentheses are the t-values. The 2nd thorugh 6th represent the second- to sixth-nearest futres contracts.
*Statistically significant at the 5% level

is arguable that this increase in the volumes traded for non-GM soybeans raised the price of non-GM soybean futures contracts and that this contributed to the increase in the price premium for non-GM soybean futures contracts.

1.5 Conclusions

The change in the contract specification for conventional soybeans that took place on October 29, 2002, increased the price premium for non-GM soybean futures contracts traded at the TGE. The intervention analysis on volumes of conventional and non-GM soybeans indicated that the change did not affect the volume of conventional soybeans traded, while it increased the volume of non-GM soybeans traded. This result suggests that the change may have affected some of the market participants to increase their trades on non-GM soybeans and that this contributed for the price of non-GM soybeans to increase compared to the conventional soybeans. The results also indicate that the change had no significant effect on the volume of conventional soybeans traded, so it is reasonable to argue that the effect of the event was mostly absorbed in the non-GM soybean futures market.

The results from the length of the impact on the price premium for non-GM soybeans suggest that the effect on soybean futures prices from the event lasted for three to four months. However, the event only had an impact for a month on the volume of non-GM soybeans. These results revealed that the specification change remained in the market after the announcement. This implies that there was an informational inefficiency in the market since it took at least a month for the price and the volume to adjust to the levels before the change occurred.

In conclusion the announcement from the TGE on the specification change for the conventional soybean futures contract did affect the price premium between the conventional and non-GM soybean futures contracts. It is also found from the study that this effect remained three to four months in the price premium and for a month in the volume of non-GM soybeans. Hence the two soybean futures markets did not respond quickly to the announcement and there was an informational inefficiency after the change occurred.

References

Box, G. E. P., and Jenkins, G. 1970. *Time Series Analysis: Forecasting and Control*. San Francisco: Holden-Day.

Box, G. E. P., and Tiao, G. C. 1975. "Intervention Analysis with Applications to Economic and Environmental Problem." *Journal of the American Statistical Association*, 70(349): 70-79.

Bullock, D. S., and Desquilbet, M. 2002. "The Economics of Non-GM Segregation and Identity Preservation." *Food Policy*, 27(1): 81-89.

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.

Doukas, J., and Rahman, A. 1986. "Foreign Currency Futures and Monetary Policy Announcements: An Intervention Analysis." *The Journal of Futures Markets*, 6(3): 343-373.

Enders, W. 2005. *Applied Econometric Time Series* (Second Edition). New Jersey: John Wiley & Sons.

Fama, E. R. 1991. "Efficient Capital Markets: II." *The Journal of Finance*, 46(5): 1575-1617.

Guzhva, V. S. 2008. “Applying Intervention Analysis to Financial Performance Data: The Case of US Airlines and September 11th.” *The Journal of Financial Economics*, 32(3): 243-259.

Hannan, E. J., and Rissanan, J. 1982. “Recursive Estimation of Mixed Autoregressive Moving Average Order.” *Biometrika*, 69(1): 81-94.

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).

Huffman, W. E. 2003. “Consumers’ Acceptance of (And Resistance to) Genetically Modified Foods in High-Income Countries: Effects of Labels and Information in an Uncertain Environment.” *American Journal of Agricultural Economics*, 85(5): 1112-1118.

Karagozoglu, K. A., Martell, T. F, and Wang, G. H. K. 2003. “The Split of the S&P 500 Futures Contract: Effects on Liquidity and Market Dynamics.” *Review of Quantitative Finance and Accounting*, 21(4):323-348.

Kikkoman. 2006. “‘Shoku no Anzen’ wo Kakuho Suru Hinshitsu-Hoshou-

Katsudou" (*Activities on preserving product quality for securing food safety*). Kikkoman. www.kikkoman.co.jp/csr/houkoku/pdf/2006_07.pdf (accessed December 3, 2008).

Larcker, D. F., Gordon, L. A., and Pinches, G. E. 1980. "Testing for Market Efficiency: A Comparison of the Cumulative Average Residual Methodology and Intervention Analysis." *Journal of Financial and Quantitative Analysis* ,15(2): 267-287.

McCleary, R., and Hay, R. A. 1980. *Applied Time Series Analysis for the Social Sciences*. London: Sage Publications.

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

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

SAS Institute. 2008. *SAS/ETS Examples.* http://support.sas.com/rnd/app/examples/ets/sarma/index.htm (accessed April 15, 2008).

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.204-207). Tokyo Grain Exchange.

Tokyo Grain Exchange. 2007. "Torihiki-jyo Gaiyou" (About the exchange). Tokyo Grain Exchange. http://www.tge.or.jp/japanese/about/about_02.html (accessed December 4, 2007).

Tokyo Grain Exchange. 2008. Conventional and Non-GM Soybeans Price Quotes. Tokyo Grain Exchange. http://www.tge.or.jp (accessed

September 20, 2008).

Tsay, R. S., and Tiao, G. C. 1984. "Consistent Estimates of Autoregressive Parameters and Extended Sample Autocorrelation Function for Stationary and Nonstationary ARMA Models." *Journal of American Statistical Association*, 79(385): 84-96.

Tsay, Y., Alt, F., and Gordon, L. 1993. "The Market Reaction to Announced Deep Cuts in Capital Expenditures." *Managerial and Decision Economics*, 14(1): 1-14.

Tsay, Y., and Hung, K. 1994. "An Intervention Analysis for the Relationship Between Capital Expenditure Decisions and the Market Value of Firms." *Review of Quantitative Finance and Accounting*, 4(2): 199-211.

Wachenheim, C. J., and Wechel, T. V. 2004. "The Influence of Environmental-Impact Information on Consumer Willingness to Pay for Products Labeled as Free of Genetically Modified Ingredients." *Journal of Food Distribution Research*, 35(2): 1-13.

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

by

Kentaka Aruga*

is formatted for submission to *Agricultural and Resource Economics Review*

* PhD Candidate, Department of Environmental and Natural Resource Economics, The University of Rhode Island, Kingston, RI. 02881. Email: kentaka.aruga@gmail.com

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.

2.1 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.

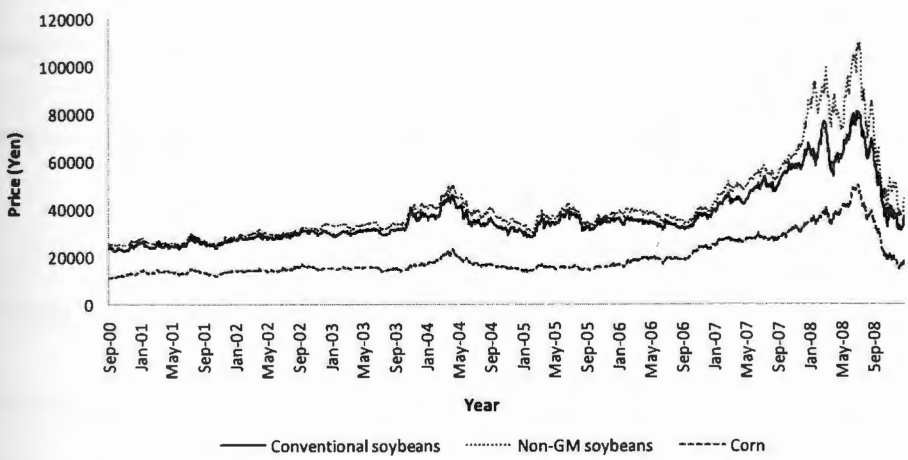
The objective of this paper is to determine whether or not these two soybean futures markets are cointegrated so that they share valuable price information in the presence of breaks in the markets. This will be investigated by testing the cointegration between the non-GM and conventional soybean futures 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 2.1. 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 2.1, 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

[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.

section discusses the results of the analysis. The final section presents conclusions and implications on the cointegration relationship, if found, between the prices of non-GM and conventional soybean, and corn futures contracts.

2.2 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 2.1. 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 2.2. 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 2.1 describes the contract months for non-GM and conventional soybeans and table 2.2 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).

2.3 Methods Used for the Analysis

2.3.1 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, Bremnes, and Wessells 1991; Chen, Firth, and Rui 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:

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

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

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

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, Bremnes, and Wessells 1991). 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

---

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

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

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

2.3.2 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:

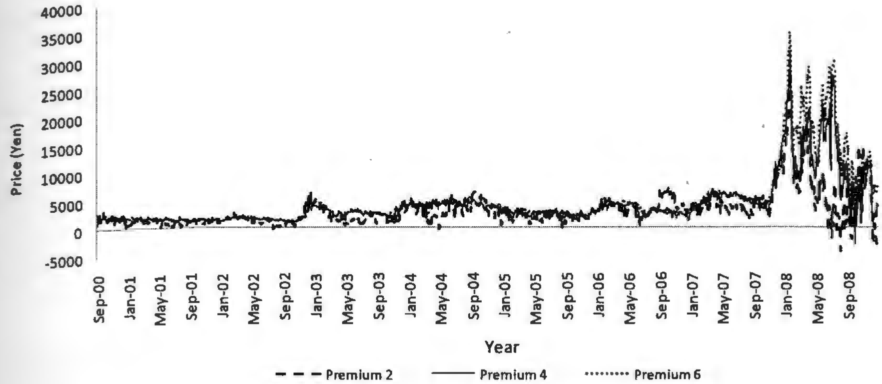
$$y_t = z_t'\delta_j + u_t \quad where\ j = 1, \cdots, m+1 \tag{5}$$

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 2.2. 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 2.2 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,

[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.

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 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.

2.4 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 2.3). Thus the three price series are all integrated of order one, I(1).

Table 2.3. 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 2.4. 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 2.4 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 2.4 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 corn and non-GM soybeans are cointegrated of order one.

Table 2.5. 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

[5] Also, for the fourth-nearest futures contract, the result of the maximum eigenvalue test suggested that there is a cointegration relationship between the corn and non-GM soybean futures prices.

reason for this may be because corn and soybeans are used for different purpose in Japan. As seen in table 2.5, 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 2.6 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.

---

[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 2.6. 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 2.7.

Table 2.7. 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

[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)

seen in figure 2.2, 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 2.7, 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

[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).

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.

Table 2.8. 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	Ho: 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	Ho: 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	Ho: 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	Ho: 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	Ho: 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	Ho: 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	Ho: 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	Ho: 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 2.9. 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	Ho: rank=r	Trace test	Maxtest	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	Ho: rank=r	Trace test	Maxtest	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	Ho: rank=r	Trace test	Maxtest	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	Ho: rank=r	Trace test	Maxtest	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	Ho: rank=r	Trace test	Maxtest	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	Ho: rank=r	Trace test	Maxtest	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 2.8 and 2.9 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 2.1 and 2.2 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 2.10. Summary of the cointegration tests

2nd			
Period	NG vs SB	CO vs NG	CO vs SB
All	Y	Y	Y
1	na	na	na
2	na	na	na
3	na	na	na
4	na	na	na

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

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

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

6th			
Period	NG vs SB	CO vs NG	CO vs SB
All	Y	Y	N
1	Y	N**	N
2	N	N	N
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 2.10 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.

2.5 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-GM 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.

3 Manuscript Three: Are the Tokyo Grain Exchange Non-Genetically Modified and Conventional Soybean Futures Markets Efficient?

by

Kentaka Aruga*

is formatted for submission to *Asian Economic Journal*

* PhD Candidate, Department of Environmental and Natural Resource Economics, The University of Rhode Island, Kingston, RI. 02881. Email: kentaka.aruga@gmail.com

Abstract

This paper tests the market efficiency of the non-genetically modified (non-GM) and conventional soybean futures markets at the Tokyo Grain Exchange to find out if these markets fully reflect available information so that there is no strategy for participants in these markets to make consistent profits from them. The paper also investigates the causality of the long-run relationship between the spot and futures prices of the soybean futures markets to find out whether it is the spot price or the futures price that first incorporates new information to the market. The results suggest that both soybean futures markets are efficient but that the non-GM soybean futures market is relatively inefficient compared to the conventional soybean futures market, and both markets are led by the spot price for the spot and futures prices to move together in the long-run.

3.1 Introduction

The Tokyo Grain Exchange (TGE) is the world's first futures market to create a separate futures market for non-genetically modified (non-GM) soybeans (Parcell 2001). Since May 18, 2000, the soybean futures market at the TGE has been split into two different markets: conventional and non-GM. The main reason for opening this new market for non-GM soybeans was to meet the increasing demand for non-GM soybeans in Japan (TGE 2003). According to McCluskey et al. (2003), Japanese consumers show a high preference for non-GM food over GM food and concerns toward GM products have been spreading.

It is known that the futures market provides an important role in facilitating price discovery of commodities and to hedge price risk (Fortenbery and Zapata 1997). Fontenbery and Zapata (1997) state that the futures market has to be efficient for the price of the market to be able to accurately reflect market participants' supply and demand expectations for a future delivery period. Thus, to find out if the two soybean futures markets are functioning to play the above mentioned roles, this paper will investigate the efficiency of these markets. Market efficiency here means "speculative efficiency" as defined by Bilson

(1981) where prices fully reflect available information so that there is no strategy for participants in the market to make consistent profits from the market. It is important for a market to be efficient since traders engaged in an efficient market can trade at lower transaction costs due to fewer searches for extensive information (Chowdhury 1991). Furthermore, if a market is efficient the futures price becomes a reliable source for forecasting and hence the market provides reliable information for price discovery (Lai and Lai 1991).

There are many studies investigating the market efficiency of the commodity futures market, such as those of wheat, soybeans, rice, nonferrous metals, and so on (Wang and Ke 2005; McKenzie et al. 2002; Chowdhury 1991). The results of these previous studies on market efficiency of commodity futures markets vary, and whether a certain commodity futures market is efficient depends highly on the market itself. Wang and Ke (2005) tested the market efficiency of the Chinese wheat and soybean futures markets and found out that both the soybean and wheat futures markets were not fully efficient. McKenzie et al. (2002) examined the market efficiency of the U.S. rice futures market and concluded that this market is efficient. So far no testing has been conducted on market efficiency for the TGE soybean futures market and the result of this study will be valuable for understanding whether the newly developed non-GM soybean futures market provides effective information for its price discovery process.

This paper also examines whether it is the spot price or the futures price that causes the two prices to move together in the long-run at the TGE soybean futures market. When market efficiency holds in a market, it means that the spot and futures prices are "close together," never drifting far apart (Chowdhury 1991). Most studies on testing market efficiency only examine the existence of the long-run relationship between the spot and futures prices and do not look further to find out the causes of this long-run relationship but this paper will also study how this long-run relationship was achieved. If the test results show that it is the futures price that leads the long-run relationship it will be the futures price that first incorporates new information to the market, and vice versa if the spot price leads the futures price. The result of this test will reveal whether it is the spot price or the futures price that plays an important role in the price discovery process.

Many studies on the price relationship between the spot and futures prices have shown that it is the futures price that leads the spot price, but there are some studies that reveal the opposite case, and so far, there is not any agreement as to which price binds the spot and futures prices to move together in the long-run (Bopp and Lady 1991; Silvapulle and Moosa 1999). The argument for the futures price to lead the spot price is that the futures market has lower transaction cost and is easier for shorting compared to the spot market so the futures price should respond quicker to new information than the spot price (Silvapulle and Moosa 1999). On the other hand the supporters of the spot price leading the futures price believe that if the difference between the spot and futures market diminishes quickly (converges quickly to equilibrium), and if traders cannot perceive this difference and are more aware of the cointegration relationship between the spot and futures prices, the long-run equilibrium tends to be led by the spot price (Quan 1992).

In the following section the details of the data used in the study are explained. In the third section the model and the methods used in this research will be discussed. The fourth section presents the results of the analysis. Finally, in the last section conclusions and implications from the study will be explained.

3.2 Data

The data used in the analysis is obtained from the TGE (TGE 2008). The monthly futures price will be extracted by taking the average price of each month by using the daily price data of the TGE non-GM and conventional soybeans.[1] The terms of the data taken are from June 2000 to October 2008.

Table 3.1. Descriptions of contract months for conventional and non-GM 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.

Note: The source is from Harbest Futures Inc, 2009

[1] The results did not change significantly using the beginning of month, mid-month or end-month futures price as a substitute for the average price to create monthly data. Gulen (1998) also uses average daily price as monthly data to test for market efficiency in the crude oil futures market and this study follows his method.

As seen in table 3.1, there are six contracts per year for both conventional and non-GM soybeans. The data is modified to create types of contract months based on the contract months that are commonly used by traders of conventional and non-GM soybeans at the TGE (Harbest Futures Inc 2009).

Due to the lack of liquidity for the nearest futures contract the monthly futures prices that are used in this study are the prices of the second- through sixth-nearest futures contracts. The prices for the non-GM and conventional soybeans are given in yen and are for 1,000 metric ton (1 mt) of soybeans. The standard grade for the conventional soybeans is GM (genetically modified), GM mixed, and GM non-segregated no. 2 yellow soybeans. That for the non-GM soybeans is identity preserved non-genetically modified (non-GM) no. 2 yellow soybeans.

There is no organized cash market for the non-GM soybeans, and it is common in practice to use the closest contract price as a proxy for the cash price when it is not available (Asche 2002). Thus the second-nearest futures price is used as the spot price in this study.

3.3 Methodology

The market efficiency is tested under the following model:

$$S_t = a + bF_{t-1,t} + \varepsilon_t \quad (1)$$

where S_t is the spot price at time t, $F_{t-1,t}$ is the futures price at time $t-1$ maturing at time t, ε_t is the error term, and a and b are constant coefficients. If $a = 0$ and $b = 1$, the spot price at time t becomes equal to the futures price at some period prior to its contract maturity. When this condition holds, the futures price fully reflects available information and there is no chance for traders to consistently profit through their trades in the market. This is the hypothesis that will be tested to see if the conventional and non-GM soybean futures markets are efficient.

This is examined by using the model used in Lai and Lai (1991) and through the use of Johansen cointegration method (Johansen and Juselius 1990). Many studies have used the Engle and Granger (1987) test for examining market efficiency but Johansen method is more efficient since it can analyze the variables of interest as endogenous in the model and is more useful in a multivariate framework (Asche, Guttormsen, Sebulonsen, and Sissener 2005).

Furthermore, Engle and Granger procedure can give different results for cointegration tests based on which variable will be taken as the dependent variable (Enders 2005, p.385).

For the spot and futures price series to be cointegrated at a certain order, they have to be integrated at the same order.[2] To ensure that this is the case, stationarity tests are conducted on the conventional and non-GM soybean futures prices. To do so, the augmented Dickey-Fuller (ADF) unit root tests are applied in this examination (Dickey and Fuller 1979). If both the spot and futures price series follow the same order, the Johansen cointegration test will be performed. This test examines whether or not there are cointegration relationship between the spot and futures prices at some period prior to contract maturity. First the multivariate cointegration test is conducted on the spot, third-nearest, fourth-nearest, fifth-nearest, and sixth-nearest futures prices. Then if a cointegration relationship is found on these five price series, a bivariate cointegration is tested between the spot and futures prices for different contract

---

[2] Order here means the number of differencing performed for the price series to become stationary.

months (third- to sixth-nearest contracts).

As suggested by Quan (1992), the existence of a long-run relationship between the spot and futures prices needs to hold before doing further tests such as the market efficiency test or the causality test. If the spot and futures prices do not show cointegration relationships, it will mean that both prices are generated independently and it is impossible for one to provide any information for predicting the other (Quan 1992). Thus the market efficiency condition, $a = 0$ and $b = 1$ is tested after the cointegration relationship is found between the spot and futures prices. This condition is tested by putting these restrictions on the cointegrating vector. The causalities of a long-run relationship between the spot and futures prices in the non-GM and conventional soybean futures markets are also tested using the Johansen procedure by imposing restrictions on the so-called speed of adjustment parameters in the Johansen framework (Johansen and Juselius 1990).

3.3.1 The Johansen Cointegration Test

The Johansen cointegration procedure used in this study is based on the following vector error correction model (VECM):

$$\Delta X_t = \Pi X_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + \varepsilon_t \qquad (2)$$

where X_t is the $n \times 1$ vector $(x_{1t}, x_{2t}, \cdots, x_{nt})'$, p is the order of the vector autoregressive process, ε_t is a normally distributed n-dimensional white noise process, $\Pi = -I + \sum_{i=1}^{p} \Pi_i$, and $\Gamma_i = -\sum_{j=i+1}^{p} \Pi_j$.[3] In this research the vector $(x_{1t}, x_{2t}, \cdots, x_{nt})'$ consists of the spot and futures prices of the soybean futures prices at the TGE:

$$(x_{1t}, x_{2t}, \cdots, x_{nt})' = (S_t, F_{t-1}, \cdots, F_{t-4})' \qquad (3)$$

where S_t is the spot price and F_{t-1} to F_{t-4} are the prices of third-nearest to sixth-nearest futures contracts. Whether equation (2) shows a cointegration relationship between the spot and futures prices depends on the rank of the Π matrix.[4] The trace test statistic and the maximum eigenvalue test statistic are used for the cointegration test:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} ln\left(1 - \hat{\lambda}_i\right) \qquad (4)$$

$$\lambda_{Max}(r, r+1) = -T ln\left(1 - \hat{\lambda}_{r+1}\right) \qquad (5)$$

---

[3] n is the number of non-stationary variables used in the model.

[4] This is because other parts of equation (2) will be stationary since difference of the X variables will be integrated of the same order by assumption.

where $\hat{\lambda}_i$ is the estimated values of the unit roots obtained from the estimated Π matrix, T is the number of usable observations, and r is the number of possible cointegrating vectors. The appropriate lag length for the VAR model is determined based on the Akaike information criteria (AIC).

3.3.2 Restriction Testing

The market efficiency condition in equation (1) is tested by imposing restrictions on the cointegrating vector in the Johansen procedure. For restriction testing, Johansen defines the Π matrix as $\Pi = \alpha\beta'$ where β is the matrix of cointegrating vector and α is the speed of adjustment parameters that is outside the cointegrating relationship. The following VECM is used in the study to test these restrictions:

$$\begin{bmatrix}\Delta S_t \\ \Delta F_t\end{bmatrix} = \sum_{i=1}^{k-1} \Gamma_i \begin{bmatrix}\Delta S_{t-i} \\ \Delta F_{t-i}\end{bmatrix} + \alpha\beta' \begin{bmatrix}S_{t-1} \\ F_{t-1}\end{bmatrix} + \begin{bmatrix}\varepsilon_{1t} \\ \varepsilon_{2t}\end{bmatrix} \quad (6)$$

where S is the spot price, and F is the futures price at some period before the contract maturity. A cointegration between the spot and futures prices is a necessary condition for market efficiency. Thus a cointegration between the test variables needs to be verified before performing the restriction test.

If equation (6) is cointegrated it implies that there exists a cointegration vector such that $\alpha\beta'(S_{t-1}, F_{t-1})'$ is stationary. Using this condition the market efficiency condition $a = 0$ and $b = 1$ can be tested under the cointegration framework by testing whether $\beta' X_t^*$ is stationary where $\beta' = (1, -1, 0)$ and $X_t^{*\prime} = (S_t, F_{t-1}, 1)'$. The test statistic used to test this restriction is:

$$L = -T \sum_{i=1}^{r} \ln \frac{1-\hat{\lambda}_i^*}{1-\hat{\lambda}_i} \tag{7}$$

where $\hat{\lambda}_i$ and $\hat{\lambda}_i^*$ denote the ordered characteristic roots of unrestricted and restricted models. This test statistic follows an asymptotic χ^2 distribution with degrees of freedom equal to the number of cointegrating vectors.

The causality of the long-run equilibrium between the spot and futures prices is tested by implementing the restriction on the α matrix and testing whether $\alpha\beta'(S_{t-1}, F_{t-1})'$ is stationary. Defining $\alpha' = (\alpha_1, \alpha_2)$, if $\alpha_1 \neq 0$, the deviation from the long-run equilibrium will be mainly adjusted by the change in the spot price, while if $\alpha_2 \neq 0$ the deviation will be adjusted by the change in the futures price. This would mean that if $\alpha_1 = 0$, there are no changes in the spot price due to change in the long-run relationship between the spot and futures prices and all corrections to reach the long-run equilibrium are done through the changes in the futures price. If $\alpha_2 = 0$, the changes in the equilibrium will be adjusted by the spot price. Thus, if the results of the restriction test suggest $\alpha_1 = 0$, the spot price will lead the futures price and vice versa when $\alpha_2 = 0$. However, if $\alpha_1 \neq 0$ and $\alpha_2 \neq 0$, there will be no price leadership. It cannot be $\alpha_1 = \alpha_2 = 0$ since this would mean that there is no long-run relationship between the spot and futures prices and would contradict the assumption that there is a cointegration relationship.

This test is often known as the weak exogeneity test since, if $\alpha_1 = 0$ or $\alpha_2 = 0$, it will mean that the corresponding variable does not respond to discrepancy from the long-run equilibrium relationship. So in this study when $\alpha_1 = 0$, as seen from equation (6), the spot price becomes weakly exogenous for the futures price and will imply that the spot price leads the futures price while the futures price is weakly exogenous for the spot price if $\alpha_2 = 0$, and in this case the futures price will lead the spot price.

3.4 Results

The result from the ADF unit root tests indicate that in every contract month, conventional and non-GM soybean futures prices all had a unit root (table

3.2). However, all series became stationary after taking the first difference of the series. The table only gives the result of the ADF test in the case with no deterministic trend and drift, but the test had the same result in the case of having a trend and a drift. On the whole, for both conventional and non-GM soybeans, the result indicates that the series of spot and futures prices for different contract months are all integrated of order one.

Table 3.2. Augmented Dickey-Fuller unit root tests

Variables	Price levels	First differences
SSB	-0.89	-4.11*
FSB3	1.26	-3.33*
FSB4	2.25	-3.36*
FSB5	1.42	-7.50*
FSB6	2.57	-2.10*
SNG	-0.19	-6.93*
FNG3	1.00	-7.17*
FNG4	2.08	-6.43*
FNG5	1.80	-4.73*
FNG6	1.86	-2.90*

Note: * denotes significance at 5%. The ADF test result shown is for the case with no drift and trend. The lag order for the ADF test is selected by the AIC. SSB and SNG are the spot prices for the conventional and non-GM soybeans, and FSB and FNG represent the futures prices for the conventional and non-GM soybeans. The numbers after the FSB and FNG are the third- to sixth-nearest futures contracts.

Table 3.3. Multivariate Johansen tests

Conventional soybeans				**Non-GM soybeans**			
Variables	H_0: rank=r	Trace test	Max test	Variables	H_0: rank=r	Trace test	Max test
Spot	r=0	182.01*	67.25*	Spot	r=0	257.75*	95.81*
Third	r<=1	114.77*	59.22*	Third	r<=1	161.94*	81.38*
Fourth	r<=2	55.54*	33.46*	Fourth	r<=2	80.56*	61.25*
Fifth	r<=3	22.08*	19.31*	Fifth	r<=3	19.31**	17.00*
Sixth	r<=4	2.77	2.77	Sixth	r<=4	2.32	2.32

Note: * denotes significance at 5%. **denotes significance at 10%.

Critical values for the cointegration test can be found in Johansen and Juselies (1990).

Spot prices for the conventional and non-GM soybeans are the prices of second-nearest futures contracts as explained in the data section. The lag orders used for both soybeans are two, which are selected by the AIC.

The result of the multivariate Johansen tests indicates that both the conventional and non-GM soybean futures price series have four cointegrating vectors in the system (table 3.3). The number of lags used for these tests are two for both conventional and non-GM soybeans, which were selected by the AIC criteria. For both conventional and non-GM soybean futures prices, the multivariate Johansen test suggests that at least four cointegration relationships exist and these results will strengthen the results of the bivariate cointegration tests when they show a cointegration relationship between the spot and futures prices.

Before conducting a restriction test, cointegration between the spot and futures prices needs to be confirmed. Thus the bivariate cointegration test is performed between the spot and futures prices for each different contract month. Tables 3.4 and 3.5 depict the result of this test. SB and NG stand for the conventional and non-GM soybeans. The lag lengths used for the bivariate cointegration tests are again determined by the AIC criteria and are provided in the table.

Table 3.4. Bivariate Johansen tests for conventional soybeans

	Ho: rank=r	Trace test	Maxtest	Lags	LR statistic under the restrictions (a=0, b=1)	Variables	LR statistic under exogeneity
Spot SB vs Third Nearest SB	r=0	13.50*	13.32*	3	0.52 (0.47)	Spot	0.37 (0.55)
	r<=1	0.18	0.18			Futures	12.50 (0.00)*
Spot SB vs Fourth Nearest SB	r=0	85.85*	85.38*	3	2.64 (0.10)	Spot	0.10 (0.75)
	r<=1	0.47	0.47			Futures	84.01 (0.00)*
Spot SB vs Fifth Nearest SB	r=0	21.30*	21.26*	2	0.02 (0.90)	Spot	0.59 (0.44)
	r<=1	0.03	0.03			Futures	20.19 (0.00)*
Spot SB vs Sixth Nearest SB	r=0	33.31*	33.18*	3	3.05 (0.08)	Spot	0.07 (0.79)
	r<=1	0.13	0.13			Futures	31.35 (0.00)*

Note: * denotes significance at 5%. The values inside the parenthisis are the p-values. SB is the conventional soybean price and LR is the likelihood ratio explained in equaion (7). The spot price (Spot SB) for the conventional soybeans is the price of second-nearest futures contract as explained in the data section.

Table 3.5. Bivariate Johansen tests for non-GM soybeans

	Ho: rank=r	Trace test	Maxtest	Lags	LR statistic under the restrictions (a=0, b=1)	Variables	LR statistic under exogeneity
Spot NG vs Third Nearest NG	r=0	24.83*	24.56*	3	14.04 (0.00)*	Spot	9.40 (0.00)*
	r<=1	0.27	0.27			Futures	15.24 (0.00)*
Spot NG vs Fourth Nearest NG	r=0	95.71*	95.28*	3	27.15 (0.00)*	Spot	0.14 (0.71)
	r<=1	0.44	0.44			Futures	90.98 (0.00)*
Spot NG vs Fifth Nearest NG	r=0	28.74*	28.55*	2	0.62 (0.43)	Spot	2.41 (0.12)
	r<=1	0.19	0.19			Futures	28.36 (0.00)*
Spot NG vs Sixth Nearest NG	r=0	17.41*	16.83*	2	3.00 (0.08)	Spot	1.29 (0.26)
	r<=1	0.58	0.58			Futures	14.87 (0.00)*

Note: * denotes significance at 5%. The values inside the parenthisis are the p-values. NG is the non-GM soybean price and LR is the likelihood ratio explained in equaion (7). The spot price (Spot NG) for the non-GM soybeans is the price of second-nearest futures contract as explained in the data section.

The results show that for both conventional and non-GM soybeans, the spot and futures prices at different contract months are all cointegrated of order one: the null hypothesis of no cointegration relationship, that is, $r = 0$, is all rejected at the 5% significance level as seen in the colums of the trace and maximum eigenvalue tests. Hence we can proceed for testing the market efficiency condition, $a = 0$ and $b = 1$, and the causality between the spot and futures prices by imposing restrictions in the Johansen cointegration procedure.

The results of the restriction tests conducted in the Johansen cointegration framework show that the hypothesis $a = 0$ and $b = 1$ is not rejected for the conventional soybean series for all different contract months, which suggests that the market efficiency condition holds between the spot and futures prices for this market. On the other hand, this condition is met only for the fifth- and sixth-nearest contract months for the non-GM soybean futures market and was rejected for the third- and fourth-nearest contracts. It is known that at the TGE more distant contracts are more active than the nearby contracts, and this could be the reason why the market efficiency condition did not hold for the nearby third- and fourth-nearest futures contracts (Booth and Ciner 1997).[5] Thus the test result for the market efficiency condition can be summarized as the conventional soybean futures market is efficient while the non-GM soybean futures market is somewhat inefficient.

Finally the result of the causality test, which can be seen in the last column of the tables, for both conventional and non-GM soybean futures markets, the null hypothesis of the spot price being weakly exogenous for the futures price is not rejected, except for the case of the third-nearest non-GM soybean futures price. However the opposite case is denied for all tests conducted between the spot and futures prices for different contract months. This suggests that spot price leads the futures price, which implies that the spot price is the one that binds the spot and futures prices to move together in the long-run and that new information is first incorporated into the spot price at the TGE soybean futures markets.

---

[5] Booth and Ciner (1997) explain that the reason why the more distant contracts are more active at the TGE is because of their trading system, which is called '*itayose-hoh*' or single fixed-price auction. In this system the contracts are auctioned in the order of the expiration of the contract. Thus the nearest contracts are auctioned first and then the second-nearest futures contracts are auctioned, and this continues until the furthest contracts are auctioned so that more information is always available for the further contracts (Booth and Ciner 1997).

3.5 Conclusions

The Johansen multivariate and bivariate cointegration tests revealed that the spot and futures prices of the TGE conventional and non-GM soybeans are cointegrated. This result revealed that these prices move together in the long-run. Cointegration is a necessary condition for the market to be efficient so that the prices in the market fully reflect available information and no traders can profit consistently from the market. However this is not a sufficient condition to conclude that a market is efficient.

I therefore tested as to whether the futures price at some period before its maturity will be equal to the spot price in the long-run. This test showed that the sufficient condition for market efficiency does hold for the conventional soybean futures market. On the other hand, it failed for some contract months for the non-GM soybean futures market. This implies that the non-GM soybean futures market is relatively inefficient compared to the conventional soybean futures market. Some investors may be profiting consistently through their trades at the market. The possible reason for this inefficiency may be that there is no organized cash market for the non-GM soybeans, and that the only closest cash market available is the nearest futures contract, which has low liquidity. Furthermore, the non-GM soybean futures market is new compared to the conventional soybean market so that its historical price information may not be as valuable as the conventional soybean market.[6]

Inefficiency can often be caused by misinformation or poor information, order imbalances, market manipulation, and so on. There is no evidence of governmental intervention in the non-GM soybean futures market during the time frame used in this paper, so it is not likely that the inefficiency of the non-GM soybean futures market is related to market manipulation. However misinformation and poor information, and order imbalances can be factors in the inefficiency of the non-GM soybean futures market. Froot, Scharfstein, and Stein (1992) argue that the existence of short-term speculators can lead to informational inefficiency. They suggest when number of short-term speculators increases in the market, allocation of price information can become inefficient and this can lead to market inefficiency. Since the minimum contract unit for the

[6] Conventional soybeans have been traded at the TGE since the 1960s (TGE 2007).

non-GM soybean futures market had been one fifth of the conventional soybean futures market, the non-GM soybean futures market may have attracted more speculators to the market and this may have increased the number of short-term traders in this market.[7]

The result of the causality of the long-run relationship suggested that for both conventional and non-GM soybean futures markets, it is the spot price that leads the spot and futures prices to move together. As mentioned in the introduction when the long-run equilibrium is led by the spot price it is argued in previous studies that this occurs because the market participants believe that the spot and futures price are strongly linked and that they converge quickly to equilibrium (Quan 1992). This could be the case with the two soybean futures markets at the TGE, since both these markets showed a strong cointegration relationship in both the multivariate and bivariate cointegration tests.

[7] Until October, 2008, the minimum contract unit for the non-GM soybeans at the TGE had been 10 mt while that for the conventional soybeans had been 50 mt (TGE 2008).

References

Asche, F., and Guttormsen, A. G. 2002. "Lead Lag Relationships between Futures and Spot Prices". *SNF Working Paper* No.2/02. Institute for Research in Economics and Business Administration, Bergen, Norway.

Asche, F., Guttormsen, A. G., Sebulonsen, T., and Sissener, E. H. 2005. "Competition between Farmed and Wild Salmon: The Japanese Salmon Market." *Agricultural Economics*, 33(3): 333-340.

Bilson, J. F. O. 1981. "The 'Speculative Efficiency' Hypothesis." *The Journal of Business*, 54(3): 435-451.

Booth, G., and Ciner, C. 1997. "International Transmission of Information in Corn Futures Markets." *Journal of Multinational Financial Management*, 7(3): 175-187.

Bopp, A. E., and Lady, G. M. 1991. "A Comparison of Petroleum Futures Versus Spot Prices as Predictors of Prices in the Future." *Energy Economics*, 13(4): 274-282.

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

Coyle, W. 2007. "The Future of Biofuels: A Global Perspective." *Amber Waves,* 5: 24-29.

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.

Enders, W. 2005. *Applied Econometric Time Series* (2nd Ed.). New Jersey: John Wiley & Sons.

Engle, R. F., and Granger C. W. J. 1987. "Co-integration and Error Correction, Representation, Estimation, and Testing." *Econometrica*, 55(2): 251-276.

Fortenbery, T. R., and Zapata, H. O. 1997. "An Evaluation of Price Linkages between Futures and Cash Markets for Cheddar Cheese." *The Journal of Futures Markets*, 17(3): 279-301.

Froot, K. A., Scharfstein, D. S., and Stein, J. C. 1992. "Herd on the Street: Informational Inefficencies in a Market with Short-Term Speculation." *The Journal of Finance*, 47(4): 1461-1484.

Gulen, S. G. 1998. "Efficiency in the Crude Oil Futures Market." *Journal of Energy Fianance and Development*, 3(1): 13-21.

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).

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.

Lai, K. S., and Lai, M. 1991. "A Cointegration Test for Market Efficiency." *The Journal of Futures Markets*, 11(5): 567-575.

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.

McKenzie, A. M., Jiang, B., Djunaidi, H., Hoffman, L. A., and Wailes, E. J. 2002. "Unbiasedness and Market Efficiency Tests of the U.S. Rice Futures Market." *Review of Agricultural Economics*, 24(2): 474-493.

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-GM Soybean Contract." *Journal of Agribusiness*, 19(1): 85-92.

Quan, J. 1992. "Two-Step Testing Procedure for Price Discovery Role of Futures Prices." *The Journal of Futures Markets*, 43(1): 139-149.

Silvapulle, P., and Moosa, I. A. 1999. "The Relationship between Spot and Futures Prices: Evidence from the Crude Oil Market." *The Journal of Futures Markets*, 19(2): 175-193.

Wang, H., and Ke, B. 2005. "Efficiency Tests of Agricultural Commodity Furtures Markets in China." *The Australian Journal of Agricultural and Resource Economics*, 49(2): 125-141.

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. 2007. "Torihiki-jyo Gaiyou" (About the exchange). Tokyo Grain Exchange. http://www.tge.or.jp/japanese/about/about_02.html (accessed December 4, 2007).

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

Appendix A. Explanation on the ARIMA Expression

Say y is the response series, p is the order of the autoregressive part, q is the order of moving average part, and other notation is the same as the ones used in the main text. Then ARIMA$(p, 0, q)$ can be expressed as

$$y_t = (\phi_1 y_{t-1} + \phi_2 y_{t-2} + \cdots + \phi_{p-1} y_{t-p+1} + \phi_p y_{t-p}) +$$

$$(\varepsilon_t - \theta_1 \varepsilon_{t-1} \theta_2 \varepsilon_{t-2} - \cdots - \theta_q \varepsilon_{t-q+1} - \theta_q \varepsilon_{t-q})$$

$$\Leftrightarrow (1 - \phi_1 B - \phi_2 B^2 - \cdots - \phi_{p-1} B^{p-1} - \phi_p B^p) y_t$$

$$= (1 - \theta_1 B - \theta_2 B^2 \cdots - \theta_{q-1} B^{q-1} - \theta_q B^q) \varepsilon_t$$

where B is the backshift operator, $\phi(B)$ is the autoregressive operator represented by polynomials of the back shift operator, $\theta(B)$ is the moving average operator represented by polynomials of the back shift operator, and ε_t is the random error (McCleary and Hay 1980).

Thus

$$y_t = \frac{\theta(B)}{\phi(B)} \varepsilon_t$$

References

McCleary, R., and Hay, R. A. 1980. *Applied Time Series Analysis for the Social Sciences*. London: Sage Publications.

Appendix B. The Computer Software Used for the Analysis

The augmented Dickey-Fuller (ADF) unit root tests (1979) in all manuscripts are conducted using the Eviews software (Quantitative Micro Software 2000). Dickey-Fuller test statistics are computed for three types of regression models:

$$Y_t = \rho Y_{t-1} + e_t \qquad \text{(a)}$$

$$Y_t = \mu + \rho Y_{t-1} + e_t \qquad \text{(b)}$$

$$Y_t = \mu + \beta t + \rho Y_{t-1} + e_t \qquad \text{(c)}$$

where Y_t is the variable of interest, μ is an intercept, ρ and β are coefficients, t is a trend, and e_t is a sequence of independent normal random variables with mean zero and normally independently distributed variance (SAS 2008). The lag order of the ADF test is selected by the Akaike information criterion.

The intervention analysis in the first manuscript is done using SAS program. The Bai-Perron multiple break test in the second manuscript is performed through the use of GAUSS software. The code can be obtained from

Perron's homepage (2009). The cointegration tests for manuscript two and three are done using the Eviews software (Quantitative Micro Software 2000).

References

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.

Perron, P. 2009. "Computation and Hypothesis Testing in Models with Multiple Structural Changes." http://people.bu.edu/perron/code/m-Break.zip (accessed January 15, 2009).

Quantitative Micro Software. 2000. *EViews User's Guide*. Quantitative Micro Software, Irvine, California

SAS Institute. 2009. *SAS/ETS 9.1. User's Guide*. http://support.sas.com/documentation/onlinedoc/91pdf/sasdoc_91/ets_ug_7314.pdf (accessed June 25, 2009).

Bibliography

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.

Asche, F., and Guttermson, A. G. 2002. "Lead Lag Relationships between Futures and Spot Prices". *SNF Working Paper* No.2/02. Institute for Research in Economics and Business Administration, Bergen, Norway.

Asche, F., Guttormsen, A. G., Sebulonsen, T., and Sissener, E. H. 2005. "Competition between Farmed and Wild Salmon: The Japanese Salmon Market." *Agricultural Economics*, 33(3): 333-340.

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.

Bilson, J. F. O. 1981. "The 'Speculative Efficiency' Hypothesis." *The Journal of Business*, 54(3): 435-451.

Booth, G., and Ciner, C. 1997. "International Transmission of Information in Corn Futures Markets." *Journal of Multinational Financial Management*, 7(3): 175-187.

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

Bopp, A. E., and Lady, G. M. 1991. "A Comparison of Petroleum Futures Versus Spot Prices as Predictors of Prices in the Future." *Energy Economics*, 13(4): 274-282.

Box, G. E. P., and Jenkins, G. 1970. *Time series analysis: Forecasting and control.* San Francisco: Holden-Day.

Box, G. E. P., and Tiao, G. C. 1975. "Intervention Analysis with Applications to Economic and Environmental Problem." *Journal of the American Statistical Association*, 70(349): 70-79.

Bullock, D. S., and Desquilbet, M. 2002. "The Economics of Non-GM Segregation and Identity Preservation." *Food Policy*, 27(1): 81-89.

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.

Coyle, W. 2007. "The Future of Biofuels: A Global Perspective." *Amber Waves*, 5: 24-29.

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.

Doukas, J., and Rahman, A. 1986. "Foreign Currency Futures and Monetary Policy Announcements: An Intervention Analysis." *The Journal of Futures Markets*, 6(3): 343-373.

Enders, W. 2005. *Applied Econometric Time Series* (2nd Ed.). New Jersey: John Wiley & Sons.

Engle, R. F., and Granger C. W. J. 1987. "Co-integration and Error Correction, Representation, Estimation, and Testing." *Econometrica*, 55(2): 251-276.

Fama, E. R. 1991. "Efficient Capital Markets: II." *The Journal of Finance*, 46(5): 1575-1617.

Fortenbery, T. R., and Zapata, H. O. 1997. "An Evaluation of Price Linkages between Futures and Cash Markets for Cheddar Cheese." *The Journal of Futures Markets*, 17(3): 279-301.

Froot, K. A., Scharfstein, D. S., and Stein, J. C. 1992. “Herd on the Street: Informational Inefficencies in a Market with Short-Term Speculation.” *The Journal of Finance*, 47(4): 1461-1484.

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.

Gulen, S. G. 1998. “Efficiency in the Crude Oil Futures Market.” *Journal of Energy Fianance and Development*, 3(1): 13-21.

Guzhva, V. S. 2008. “Applying Intervention Analysis to Financial Performance Data: The Case of US Airlines and September 11th.” *The Journal of Financial Economics*, 32(3): 243-259.

Hannan, E. J., and Rissanan, J. 1982. “Recursive Estimation of Mixed Autoregressive Moving Average Order.” *Biometrika*, 69(1): 81-94.

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).

Huffman, W. E. 2003. "Consumers' Acceptance of (And Resistance to) Genetically Modified Foods in High-Income Countries: Effects of Labels and Information in an Uncertain Environment." *American Journal of Agricultural Economics*, 85(5): 1112-1118.

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.

Karagozoglu, K. A., Martell, T. F., and Wang, G. H. K. 2003. "The Split of the S&P 500 Futures Contract: Effects on Liquidity and Market Dynamics." *Review of Quantitative Finance and Accounting*, 21(4):323-348.

Kikkoman. 2006. "'Shoku no Anzen' wo Kakuho Suru Hinshitsu-Hoshou-Katsudou" (*Activities on preserving product quality for securing food safety*). Kikkoman. www.kikkoman.co.jp/csr/houkoku/pdf/2006_07.pdf (accessed December 3, 2008).

Lai, K. S., and Lai, M. 1991. "A Cointegration Test for Market Efficiency." *The Journal of Futures Markets*, 11(5): 567-575.

Larcker, D. F., Gordon, L. A., and Pinches, G. E. 1980. "Testing for Market Efficiency: A Comparison of the Cumulative Average Residual Methodology and Intervention Analysis." *Journal of Financial and Quantitative Analysis*, 15(2): 267-287.

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

McCleary, R., and Hay, R. A. 1980. *Applied Time Series Analysis for the Social Sciences*. London: Sage Publications.

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.

McKenzie, A. M., Jiang, B., Djunaidi, H., Hoffman, L. A., and Wailes, E. J. 2002. "Unbiasedness and Market Efficiency Tests of the U.S. Rice Futures

Market." *Review of Agricultural Economics*, 24(2): 474-493.

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 Tsuite" (*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-GM Soybean Contract." *Journal of Agribusiness*, 19(1): 85-92.

Perron, P. 2009. "Computation and Hypothesis Testing in Models with Multiple Structural Changes." http://people.bu.edu/perron/code/m-Break.zip (accessed January 15, 2009).

Quan, J. 1992. "Two-Step Testing Procedure for Price Discovery Role of Futures Prices." *The Journal of Futures Markets*, 43(1): 139-149.

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

Quantitative Micro Software. 2000. *EViews User's Guide*. Quantitative Micro Software, Irvine, California

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.

SAS Institute. 2008. *SAS/ETS Examples*. http://support.sas.com/rnd/app/examples/ets/sarma/index.htm (accessed April 15, 2008).

SAS Institute. 2009. *SAS/ETS 9.1. User's Guide*. http://support.sas.com/documentation/onlinedoc/91pdf/sasdoc_91/ets_ug_7314.pdf (accessed June 25, 2009).

Silvapulle, P., and Moosa, I. A. 1999. "The Relationship between Spot and

Futures Prices: Evidence from the Crude Oil Market." *The Journal of Futures Markets*, 19(2): 175-193.

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. 2007. "Torihiki-jyo Gaiyou" (About the exchange). Tokyo Grain Exchange. http://www.tge.or.jp/japanese/about/about_02.html (accessed December 4, 2007).

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.

Tsay, R. S., and Tiao, G. C. 1984. "Consistent Estimates of Autoregressive Parameters and Extended Sample Autocorrelation Function for Stationary and Nonstationary ARMA Models." *Journal of American Statistical Association*, 79(385): 84-96.

Tsay, Y., Alt, F., and Gordon, L. 1993. "The Market Reaction to Announced Deep Cuts in Capital Expenditures." *Managerial and Decision Economics*, 14(1): 1-14.

Tsay, Y., and Hung, K. 1994. "An Intervention Analysis for the Relationship Between Capital Expenditure Decisions and the Market Value of Firms." *Review of Quantitative Finance and Accounting*, 4(2): 199-211.

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

Wachenheim, C. J., and Wechel, T. V. 2004. "The Influence of Environmental-Impact Information on Consumer Willingness to Pay for Products Labeled as Free of Genetically Modified Ingredients." *Journal of Food Distribution Research*, 35(2): 1-13.

Wang, H., and Ke, B. 2005. "Efficiency Tests of Agricultural Commodity Furtures Markets in China." *The Australian Journal of Agricultural and Resource Economics*, 49(2): 125-141.

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.