An Intervention Analysis on the Tokyo Grain Exchange Non- Genetically Modified and Conventional Soybean Futures Market

Aruga, Kentaka

University of Rhode Island

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Kentaka Aruga *

Abstract

This paper examines how efficiently the price premium for non-genetically modified (non-GM) soybeans 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. Intervention analysis is used for this purpose. The results reveal that the price premium for non-GM soybeans increases after the change and this effect remains at least for a month. Hence, prices of the two soybean futures markets did not respond quickly to the announcement and there was an informational inefficiency after the announcement occurred.

Key Words: price premium, non-genetically modified soybeans, conventional soybeans, intervention analysis, Tokyo Grain Exchange
JEL Classifications: C1, O13

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* Corresponding author. Tel.: +81 46 826 9572; fax: +81 46 855 3809.
E-mail addreses: kentka.aruga@gmail.com (K. Aruga)

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 are becoming concerned about GM food products in Japan, in April 2001, the Japanese government issued the Japanese Agricultural Standard (JAS law) to require labeling for GM food products (TGE, 2003).[1]

On May 18, 2000, to meet consumer demand, the Tokyo Grain Exchange (TGE) opened the world's first futures market for non-genetically modified (GM) soybeans. Since the opening of the non-GM soybean futures market, it is known that the price of non-GM soybeans is relatively 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 the price premium should represent the marketing and production costs of segregating non-GM soybeans.[2] The price premium can exist in the demand side as well. For example, Wachenheim and Wechel (2004) find that consumers are willing to pay a premium for non-GM products using experimental auction.

However, in July and August 2002, there were trading days when the conventional soybean price became higher than the non-GM soybeans on the last day of trading. On October 29, 2002, to cope with the problem of the price premium to become negative, the TGE made a major change in the specification for conventional soybeans (TGE, 2002). The TGE was hoping that the specification change would sharpen the distinction between non-GM and conventional soybean futures contracts and stabilize the markets for non-GM and conventional soybeans. 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.[3]

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

[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).

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

- Increase in the number of suppliers for conventional soybeans from six U.S. states to all U.S. states and Brazil.[4]
- 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.

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 specification change on the price premium for non-GM soybeans. 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 the market will be considered as not efficient. This is because if the market is fully efficient, it is believed that all available information, including public information should immediately be reflected in the price (Fama, 1991).[5] Hence, this paper tests the efficiency of the TGE non-GM and conventional soybean futures markets by investigating their responses to the announcement which occurred in October 2002.

In general, there are few studies testing the effects of policy announcements on futures prices (Bjursell et al., 2010). 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

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

[5] 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.

period where the impact may have lasted.

In the following section I will describe the data used in the study and provide more explanation on the changes that was conducted for the conventional soybean futures contracts. In the third section the details of the method will be explained. The fourth section will show the results of the study. In the last section, the conclusions will be presented.

2. The Data

The price data are obtained from the TGE via online and personal negotiations with the TGE. 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). The daily price data from January 4, 2002 to September 30, 2003 are used in the study and the price unit is provided in yen per mt.

Table 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

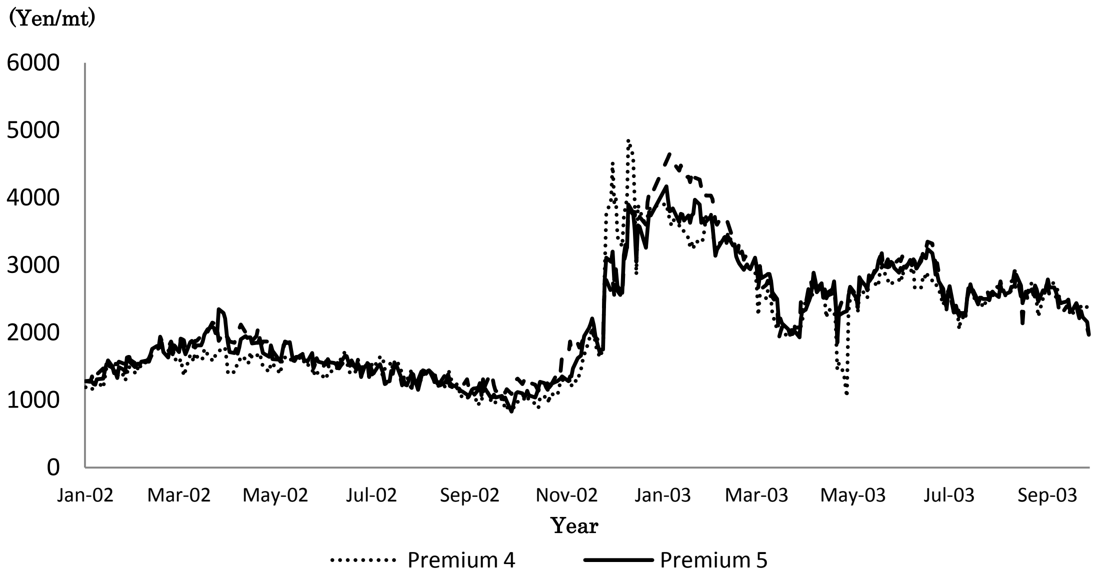
Table 1 shows the details of the specification for non-GM and conventional soybeans before and after the specification change took place on October 29, 2002. The major differences after October 29, 2002 are that the contract unit for conventional soybeans increased from 30 mt to 50 mt, standard grade changed from six U.S. states to all U.S. states and Brazil, and the last day of trading became different between the non-GM and conventional soybeans.

Table 2. Descriptions of contract months for non-GM and conventional soybeans

Month	Nearby Contract	2nd Nearby Contract	3rd Nearby Contract	4th Nearby Contract	5th Nearby Contract	6th Nearby 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.

Table 2 describes the types of contracts traded at the TGE. Due to the lack of liquidity for nearby contracts, I used only data on the fourth- through sixth-nearby contracts.[6] The difference between the daily prices of conventional and non-GM soybeans for the fourth-nearby futures will be the fourth-nearby price premium, that for the fifth-, and sixth- will be the fifth-, and sixth-nearby price premiums.

[6] It is known that at the TGE the further contracts are more active than the nearby contracts. 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 nearby contracts are auctioned first and then the second-nearby 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).



Note: The prices for the non-GMO and conventional soybeans are given in yen and are for 1,000 kilograms (1mt) of soybeans. Premium 4, 5 and 6 are the price premiums for fourth-, fifth- and sixth-nearby futures contracts.

Figure 1. Price premiums for non-GM soybeans (price difference between the non-GM and conventional soybean futures contract)

Figure 1 shows the changes in the price premiums for non-GM soybeans for the fourth-, fifth-, and sixth-nearby futures contracts. As seen in this figure, the price premium for non-GM soybeans increased after the specification change was conducted at the end of October 2002.

3. Methodology

An intervention analysis is used to test the effects of the specification change on the price premium for non-GM soybeans. 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).[7]

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[7] The recently developed distributional event response model (DERM) is another option for testing

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

(1) $$Y_t = f(I_t) + N_t$$

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

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

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). The intervention effect is modeled as

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

in which ω is the impact of the interruption on the series. The impact is analyzed using the dummy variable I_t:

(4) $$I_t = \begin{cases} 0 \text{ if } t < t_0 \\ 1 \text{ if } t \geq t_0 \end{cases}$$

where 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 with the October 2003 and December 2003 contracts (TGE, 2002). As shown in table 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 the 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

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the effect of an event but this model is more useful when the length of the event is known (Rucker et al., 2005). The purpose of this study is to identify the width of the event, and hence, I used the traditional Box and Tiao model in the study.

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 for different contract months 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).

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).[8] 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 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, dummy variables are created for months from November 2002 until the test statistics show that the coefficient of the dummy variable is not significant.[9] For instance, to test if the impact lasted until December 2002, the dummy variable I_t is created as below:

$$I_t = \begin{cases} 0, & t < t_0 \\ 1, & t_{Dec\_F} \le t \le t_{Dec\_L} \end{cases} \qquad (5)$$

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 dummy variables are created for the months of January, February, and so on until the coefficient of the dummy variables do not show any significance. The data used for the analysis are also changed according to the dummy variables

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

[9] Preliminary tests suggested that the coefficient of dummy variables created for months before October 29th was not significant so periods before the specification is not included in the test.

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 dummy variable 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.

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 (see Table 3).

Table 3. Augmented Dickey-Fuller unit root tests

Variables	Price levels	First differences
Premium 4	-0.50	-5.73**
Premium 5	-0.41	-5.57**
Premium 6	-0.32	-22.43**

Note: 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. Premium 4 though 6 are the price premiums of fourth- to sixth-nearby futures contracts. ** Indicates signficance at 1% level.

Table 4. ARIMA models used for the analysis

	ARIMA model fitted
Types of contracts	Price premium
4th	(0,1,2)
5th	(0,1,2)
6th	(0,1,3)

Note: SB and non-GM represent the conventional and non-GM soybeans. The parenthesis is the order of the autoregressive, integrated, and moving average components of the ARIMA model. The 4th through 6th represent the fourth- to sixth-nearby futures contracts.

The orders of the ARIMA model used for the analysis are given in table 4. The autocorrelation test on the series of the price premium before the change occurred revealed that the residuals are white noise.

By applying dummy variables 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 5. Intervention analysis for the price premium (price difference between the non-GM and conventional soybean futures contracts)

	Input Variables				
Price Premium	Nov	Dec	Jan	Feb	Mar
Premium 4	95.3 (6.11)*	108.8 (2.63)*	122.7 (2.94)*	80.4 (2.09)*	29.3 (1.20)
Premium 5	81.5 (3.91)*	111.6 (4.16)*	115.0 (2.58)*	77.0 (2.01)*	28.5 (0.92)
Premium 6	55.0 (3.08)*	139.0 (4.60)*	134.6 (2.71)*	88.9(2.08)*	36.3 (1.06)

Note: The estimates are the coefficients of the input variables and the values in parentheses are the t-values. Premium 4 through 6 are the price premiums of fourth- to sixth- nearby futures contracts. *Statistically significant at the 5% level.

Table 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 fourth-nearby futures contract with an input variable *Nov* is

(6) $$\mathrm{Y}_{\mathrm{t}}^{\mathrm{Pre}} - \mathrm{Y}_{\mathrm{t-1}}^{\mathrm{Pre}} = 95.3Nov$$

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 95 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 led to the price premium increase for this month.

The results of the input variables *Dec*, *Jan*, *Feb*, and *Mar* in Table 5 suggests that for all contract months, the input variables are significant at the 5% level up until the input variable *Feb*, which means that the impact lasted until February. This implies that the length of the impact from the intervention on the price premium lasted for four months after the event occurred.[10]

[10] An intervention analysis was also conducted on the percentage change in the price premium and this had a similar

5. Conclusions

This paper examined how efficiently the TGE non-GM and conventional soybean futures markets react to an announcement by testing the influence of the specification change that occurred on October 29, 2002 on the price premium for non-GM soybeans. The result revealed that the price premium for non-GM soybean futures contracts increased after the specification change took place at the TGE.

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 four months. Hence, the impact from the specification change remained in the market after the announcement, which implies that there was an informational inefficiency in the market.

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 did not disappear immediately for the price premium for 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.

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result. The price premium increased 4 to 5% in terms of percentage change, and this effect lasted for four months for the fourth-, fifth-, and sixth-nearby futures contracts.

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