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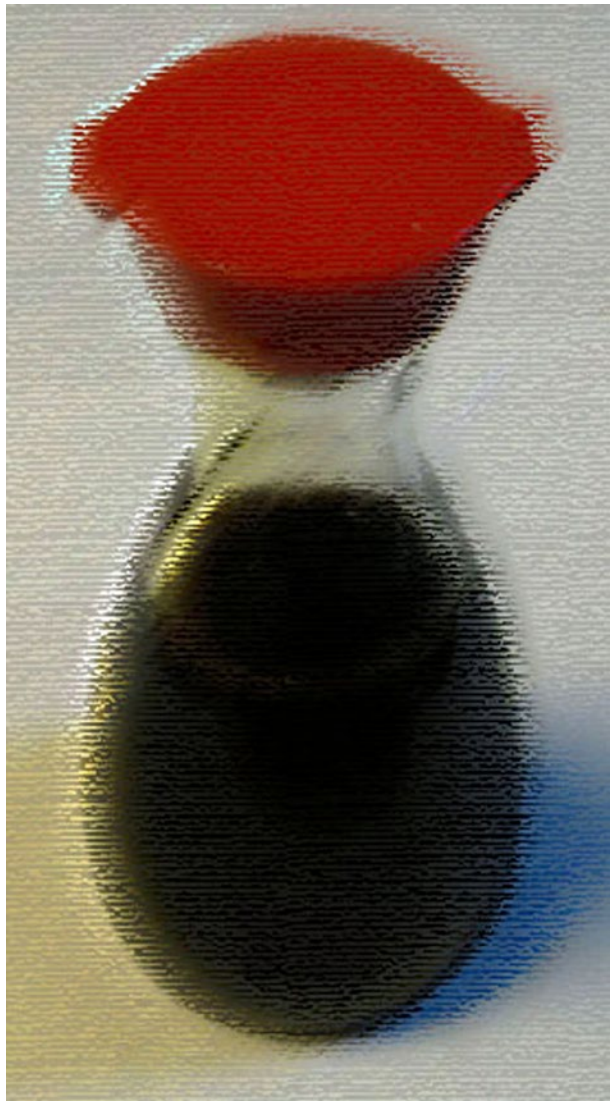

RESEARCH ARTICLE

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RESEARCH ARTICLE

An intervention analysis on the Tokyo Grain Exchange non-genetically modified and conventional soybean futures markets

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Abstract: This paper examines how efficiently the price premium for non-genetically modified (non-GM) soybeans at the Tokyo Grain Exchange (TGE) reacts to an announcement to change the contract unit, suppliers, and expiration date on the conventional soybean futures contract. An 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 did not disappear immediately. This implies that the two soybean futures markets did not respond quickly to the announcement and there was an informational inefficiency after the announcement. The TGE non-GM soybean futures market is one of the first segregated markets for a non-GM commodity. An intervention of clearing houses on such newly opened markets can often lead to market inefficiency so a further study is necessary in order to understand what causes such inefficiency and to find out how clearing houses can minimize the effects of intervention.

Keywords: price premium, non-genetically modified soybeans, intervention analysis

JEL classifications: C1, O13

AUTHOR BIOGRAPHY

Kentaka Aruga is an assistant professor at Ishikawa Prefectural University, Japan. He received his PhD from the Department of Environmental and Natural Resource Economics at the University of Rhode Island. His dissertation was about testing market efficiency of the Tokyo Grain Exchange (TGE) non-genetically modified (non-GM) soybean futures market. This paper is one of the works that is extended from the dissertation. He is currently conducting research on various commodity markets such as corn, soybeans, seafood, gold, silver, copper, energy, and so on.

PUBLIC INTEREST STATEMENT

This paper is one of the few studies that tests how a newly opened market reacts to announcements of a clearing house. It is known from the Nobel laureate Eugene Fama's "efficient market hypothesis" that if a market is efficient prices react immediately to new announcements. Based on this theory, this paper tests the efficiency of the Tokyo Grain Exchange (TGE) non-genetically modified (non-GM) soybean futures market. This market is the world's first segregated market for a non-GM commodity. Inefficient markets have trouble attracting market participants. The results of this study suggested that the TGE non-GM soybean market became inefficient after the announcement. Hence, it can be implied that clearing houses need to be cautious when intervening a newly opened market through announcements. I believe this paper will provide useful information for market participants when similar markets for a non-GM commodity open at other parts of the world.

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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, Grimsrud, Ouchi, and Wahl (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 (Tokyo Grain Exchange [TGE], 2003).[1]

On 18 May 2000, to meet consumer demand, the TGE opened the world's first futures market for non-genetically modified (non-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 29 October 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]
- Increase in the number of suppliers for conventional soybeans from six US states to all US 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 delivery day. After the change, the last day of trading for conventional soybeans was changed to fifteenth calendar day of the delivery 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 does not respond quickly to the specification change, the market will be considered as inefficient. 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, Frino, Tse, & Wang, 2010). Doukas and Rahman (1986) analyzed how monetary policy announcements affect the foreign currency futures market. They found 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) tested

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 used 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 test the reaction for the period before and after the event but this study use this method to also find out how long the effect from the announcement lasts after the event. This will be done by creating individual dummy variables for each specific 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 18 May 2000 so the non-GM and conventional soybean futures contracts only extend back that far (TGE, 2002). The daily price data from 4 January 2002 to 30 September 2003 are used in the study and the price unit is provided in yen per mt.

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

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.

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 premiums 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 & Rahman, 1986). It also allows the observed autocorrelation in the model residuals to be removed, which improves the statistical testing (Guzhva, 2008; Larcker, Gorden, & Pinches, 1980). As suggested by Larcker et al. (1980), this method is a more appropriate method for testing effects on financial markets from an announcement compared to the cumulative abnormal returns measure, which is often used in event studies when the exact date of the event is unknown (Tsay, Alt, & Gordon, 1993).[7]

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 & Hay, 1980). The basic intervention model can be written as

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

Table 1. Summary of the Contract Specification at the TGE

	Conventional soybeans		Non-GM soybeans
	Before October 29th 2002	After October 29th 2002	
Date trading began	1 March 1984		18 May 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 am, 11:00 am, 1:00 pm and 2:00 pm * 10:00 am and 11:00 am on the last trading day		9:00 am, 10:00 am, 2:00 pm and 3:00 pm * 9:00 am and 10:00 am on the last trading day
Contract months	February, April, June, August, October and December within a 12-month period		
Price quotation	Yen per 1,000 kg		Yen per 1,000 kg
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 USA (Non-screened, stored in silo)	GM, GM mixed and GM non-segregated No. 2 yellow soybeans produced in the USA 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 USA (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).

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

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

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 & Hay, 1980). The intervention effect is modeled as

$$f(I_t) = \omega I_t \tag{3}$$

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

$$I_t = \begin{cases} 0 & \text{if} \quad t < t_0 \\ 1 & \text{if} \quad t \geq t_0 \end{cases} \tag{4}$$

where t_0 is the time period during which the intervention occurs.

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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.

Source: Aruga (2011).

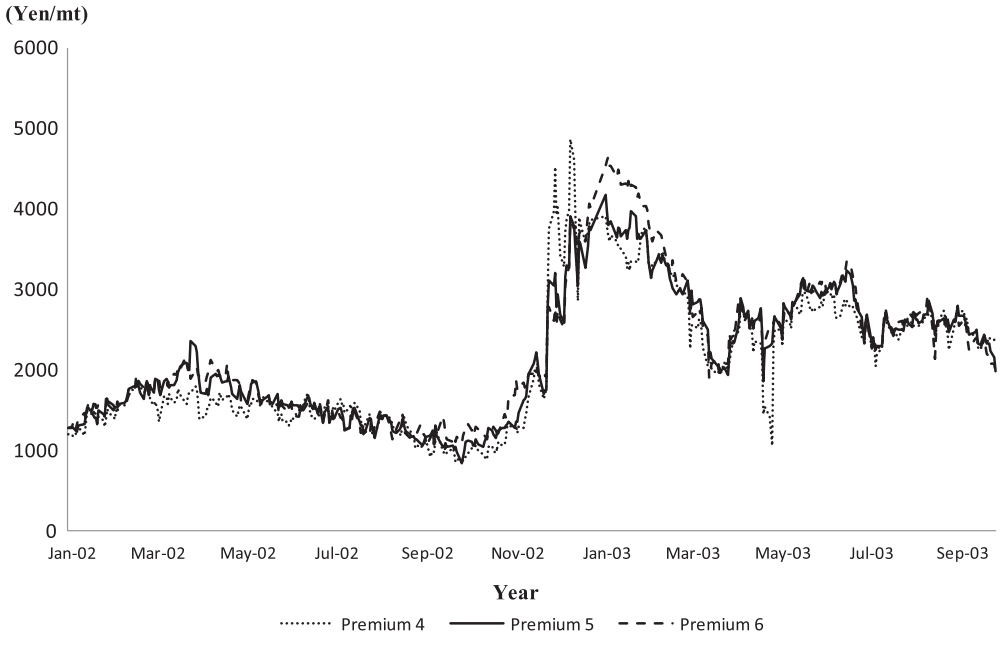

Figure 1. Price premiums for non-GM soybeans (price difference between the non-GM and conventional soybean futures contracts).

Notes: Premium 4, 5, and 6 are the price premiums for fourth-, fifth-, and sixth-nearby futures contracts.

Although the specification change was conducted on 29 October 2002, the date 1 November 2002 was chosen for the intervention t_0 because the actual trading of conventional soybeans under the new specification began to take effect on the furthest contract from this date.

To avoid biased estimates of autocorrelation functions (ACFs) and partial autocorrelation functions (PACFs), only observations before the intervention are 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 & Hung, 1994). Assuming there was no intervention effect before 1 November 2002, an ARIMA model is estimated using the data from 4 January 2002 to 31 October 2002.

The Box–Jenkins procedure is used to identify the model (Box & Jenkins, 1970). At the identification stage in the Box–Jenkins approach, an augmented Dickey–Fuller (ADF) test is conducted to see if the series need to be differenced in order to make them stationary. Then the estimated ACFs and PACFs are compared with various theoretical ACFs and PACFs and the final orders of the autoregressive and the moving average elements are determined by the extended sample autocorrelation function (Tsay & Tiao, 1984), and the minimum information criteria (Hannan & Rissanen, 1982). The identified ARIMA model is analyzed by the maximum likelihood estimation and whether the residual of the model is white noise, is diagnosed by the Box–Pierce Q statistic.

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.[8] For instance, to test if the impact lasted until December 2002, the dummy variable I_t is created as below:

$$I_t = \begin{cases} 0, & t < t_0 \\ 1, & t_{\text{Dec\_}F} \le t \le t_{\text{Dec\_}L} \end{cases} \tag{5}$$

where t_0 is 1 November, the day when the event occurred, and $t_{\text{Dec\_}F}$ and $t_{\text{Dec\_}L}$ 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 coefficients of the dummy variables do not show any significance. The data used for the analysis are also changed according to the dummy variables created for the different months. All analyses include data before the event (from 4 January 2002 to 31 October 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 4 January 2002 and 31 October 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 4 January 2002 to 31 October 2002) indicate that the series for the price premium for non-GM soybeans should be differenced. After the series are differenced, the test results showed that they are all stationary (see Table 3).

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 reveals that the residuals are white noise.

Table 3. ADF Unit Root Tests

Variables	Price levels	First differences
Premium 4	−.50	−5.73**
Premium 5	−.41	−5.57**
Premium 6	−.32	−22.43**

Notes: 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. Premiums 4–6 are the price premiums of fourth- to sixth-nearby futures contracts.

**Significance at 1% level.

Table 4. ARIMA Models Used for the Analysis

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

Notes: The parenthesis is the order of the autoregressive, integrated, and moving average components of the ARIMA model. The 4th to 6th represent the fourth- to sixth-nearby futures contracts.

Table 5. Intervention Analysis for the Price Premium (Price Difference between the Non-GM and Conventional Soybean Futures Contracts)

Price premium	Input variables				
	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)

Notes: The estimates are the coefficients of the input variables and the values in parentheses are the *t*-values. Premiums 4 to 6 are the price premiums of fourth- to sixth-nearby futures contracts.

*Statistically significant at the 5% level.

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 & Hay, 1980).

Table 5 shows the estimated coefficients for the input variables (November to March) 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

$$Y_t^{\text{Pre}} - Y_{t-1}^{\text{Pre}} = 95.3\,\text{Nov} \tag{6}$$

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 95 yen during the month of November 2002. As seen in the table, the estimates of the input variable Nov for the other contract months are also 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.

It is believable that following reasons are relevant to the increase in the price premium after the specification change was implemented. First, it is likely that the change in the minimum contract unit for the conventional soybeans affected the volume of trades on conventional and non-GM soybeans and this shift in trade volume is attributed to the increased price premium. Because market participants who wanted to trade soybeans for less than 50 mt will no longer be able to trade conventional soybeans after the change, these traders will move from the conventional to non-GM soybean market. To identify if there was such a shift in trades, I performed the similar intervention analysis using the volumes of conventional and non-GM soybean futures markets. As seen in Table 6, the results on whether the contract volumes changed after November 2002 reveal that only the volumes for the

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Table 6. Intervention Analysis for the Volumes of Conventional and Non-GM Soybeans

Types of contracts	Input variables		
	Nov. conventional soybeans	Nov. non-GM soybeans	Dec. non-GM soybeans
4th Nearby contract	367.2 (.58)	4409.1(3.10)*	−1478.2(−.77)
5th Nearby contract	1472.5 (1.50)	6956.6(2.25)*	−1468.3(−.53)
6th Nearby contract	531.5 (.36)	5708.2(1.46)	na

Notes: The estimates are the coefficients of the input variables and the values in parentheses are the *t*-values.
*Statistically significant at the 5% level.

non-GM soybean contracts are significant. This suggests that only the volumes of non-GM soybean contracts increased after the specification change. This is likely to imply that the market participants started to buy more non-GM soybeans compared to conventional soybeans after the change and this shift contributed to the increase in the price premium for non-GM soybeans.

The second probable reason for the increased price premium is that the change in the last trading day for the conventional soybean contracts strengthened the distinction between the conventional and non-GM soybean markets and this change made some of the traders that were involved in both soybean futures markets to participate in only one market. If this change in the last trading day shifted traders that were participating in the two soybean markets to the non-GM soybeans, it is likely that trading volumes in the non-GM soybeans to increase and this will raise the non-GM soybean price.

The results of the input variables Dec, Jan, Feb, and Mar in Table 5 suggest 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 indicates that the length of the impact from the intervention on the price premium lasted for four months after the event occurred.[9] Because the specification change started between the October and December 2003 contracts, the new specification only took effect on the furthest contract when it was implemented in November 2002. It took another four months until this new specification was introduced on the fourth-nearby futures contract. Hence, the reason why the impact from the intervention lasted for a while might be because the new specification was implemented in a gradual way. However, if the market was fully efficient, the effect of the specification change should immediately be reflected in the price series and such effect should not even last for a month. In this sense, the TGE soybean futures market did not respond efficiently when the specification change took place.

5. Conclusions

This paper examined how efficiently the TGE non-GM and conventional soybean futures markets react to an announcement by testing the influence on the price premium for non-GM soybeans of the specification change that occurred on 29 October 2002. 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.

The TGE non-GM soybean futures market is one of the first segregated markets for a non-GM commodity so I believe the result of this study will provide useful information when more clearing houses like the TGE start to deal with a non-GM commodity. As the case of this study, an intervention of clearing houses can often cause market inefficiency in commodity markets so a further study is necessary to understand what causes such inefficiency and to find out how clearing houses can minimize the effects of intervention.

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Notes

1. In 2001, the amended JAS 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 & Desquilbet, 2002).
3. The contract unit for the non-GM soybeans remained 10 mt.
4. The six US 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.
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 & Ciner, 1997).
7. The recently developed distributional event response model is another option for testing the effect of an event but this model is more useful when the length of the event is known (Rucker, Thurman, & Yoder, 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.
8. Preliminary tests suggested that the coefficient of dummy variables created for months before 29 October was not significant so periods before the specification is not included in the test.
9. An intervention analysis was also conducted on the percentage change in the price premium and this had a similar result. The price premium increased 4–5% 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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