An Intervention Analysis on the Relationship between Futures Prices of Non-GM and GM Soybeans in China

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Abstract

In 2004, the Dalian Commodity Exchange (DCE) introduced a separate futures contract for No. 2 soybeans, which includes GM soybeans. With this change, the No. 1 soybean futures contract defaulted to a non-GM contract. We define the difference between the prices of non-GM and GM soybeans as the price premium for non-GM soybeans. An intervention analysis is used to test the effects of the events on the price premium. We investigate three events—two contract specification changes in 2005 and 2010 and one grain law implementation in 2012—focusing on both the direction and size of their impacts. In conclusion the contract specification changes did affect the price premium. It is also found the law issue has permanently increased the price premium. Studying the market response linkages between the two soybean futures markets is helpful for understanding whether the newly opened GM soybean futures market transmits price information effectively.

Keywords: China soybeans, GMO, non-GMO, Intervention analysis, Impulse response function.

1. Introduction

In 2002, China adopted a mandatory labeling policy of genetically modified (GM) food products. This law imposed mandatory labeling for all GM food products so that consumers can identify products containing genetically modified organisms (GMOs). China also started a new trading system in 2002 in an effort to separate the trading of imported GM soybeans from domestically produced non-GM soybeans. The strategy of separating trading was intended by Chinese regulators to protect domestic on-GMO production, provide non-GM soybean growers a higher selling price, and facilitate marketing. Also in 2002, Li et al. (2003) conducted a survey in Beijing that revealed that the willingness to pay (WTP) for GM rice and GM soybean oil was positively affected by respondents' perceptions of their characteristics. These results imply that, unlike Europe and Japan, there is a potential market for GM foods in China. However, recently non-GM soybeans are widely perceived to be healthier than GM, such that GM soybeans may not be perfect substitutes for non-GM soybeans in either consumption or processing demand.

A natural progression for the price discovery process for a regulated differentiated market is the development of a futures market contract. Thus, establishing quality specifications with an identity-preserved market, such as the Dalian Commodity Exchange (DCE) GM soybean contract, is important. The lack of a well-defined and liquid cash non-GMO soybean market does not appear to hamper the development of the non-GMO futures contract. On December 22, 2004, the DCE launched a new kind of more inclusive futures contract to incorporate both GM and non-GM soybeans, that is, the SB#2 soybean contract, which made SB#1 a non-GM soybean contract by default. SB#2 aims to connect China's and international soybean futures markets and enhance the perceived impacts of China's demands on international soybean markets. This contract can be considered as the first public futures contract for an identity-preserved (IP) crop in China. It also brought new challenges to China's soybean futures markets research. Since the introduction of biotech commodities in 1996, farmers have rapidly adopted this new technology for production, primarily for soybeans, cotton, and corn (Nelson, 2001). In 2013, GM field area rose to a global total of 174 million hectares. (GMO Compass). In terms of valuation and price changes, GM soybeans have a positive impact on producer returns (output), because there is a decrease in production costs, easier management and higher yields. China has become the sixth largest producer of GM commodities, following the United States, Brazil, Argentina, India and Canada (GMO Compass, 2014).

Commercialized GMO in China include Bt cotton, delayed-ripening tomatoes, cucumber mosaic virus (CMV) resistant sweet peppers, and color-altered petunias. However, as of this writing, no major GM grain or oilseed crop, such as soybeans, corn, rice, or wheat, has been approved for commercialization in China. This makes China the largest producing country of non-genetically modified soybeans. Soybeans are primarily used as inputs for Chinese food products. Non-GM soybeans are mostly used for food and food products. On the other hand, imported GM soybeans are mainly used for vegetable oil, feed, and industrial purposes. However, some traders may be purchasing non-GM soybeans for the same purpose as GM soybeans, since there are no legal barriers on using non-GM soybeans for oil or processing. Parcell (2001) defines the difference between the prices of non-GM and GM soybean futures contracts as the price premium for non-GM soybeans. The objective of this paper is to examine how efficiently this price premium for non-GM soybean futures reacts to three events, including two contract specification changes and one legal issue by identifying the magnitude and duration of their impacts.

Intervention analysis is used for this purpose. Studying the market linkage between the two soybean futures markets is helpful for understanding whether the newly opened GM soybean futures market transmits price information effectively and efficiently. There have been some breaks that may have influenced the price relationships of the two soybean futures markets on DCE. This discussion includes three events: (i) The DCE implemented amendments to the GM soybean contract specification to make that contract more nearly conform with the international soybean trade standards in 2005; (ii) The DCE made another contract specification change on both non-GM and GM contracts to sharpen the distinction between non-GM and GM soybean futures contracts and stabilize the markets for non-GM and GM soybeans in 2010; and (iii) The Government of China issued the Grain Law and an explanatory notice for the regulation of GM products on February 21, 2012. We use an intervention analysis first suggested by Box and Tiao (1965, 1975) and further developed by Larcker et al. (1980), Enders et al. (1992) and others. Intervention analysis has advantages over the standard event study method first introduced by Ball and Brown (1968) and Fama et al. (1969), since it allows the observed autocorrelation in the model residuals to be removed, thus providing improved estimates for reliable statistical testing. Also, intervention analysis provides an impulse response function to study the transitional effects following an event.

2. Literature Review

Intervention methodology was developed by financial economists to assess the performance of securities markets. 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. Similarly, Thomakos et al. (2008) analyzed the effects of macroeconomic announcements on returns volatilities, covariance's and correlations between Eurodollar futures and U.S. Treasury bond futures and showed that all three react to the information content of announcements. Little research has been undertaken to assess the market functionality of identity-preserved crops, such as the GM soybean futures markets.

Parcell (2001) describes this new market for non-GM soybean futures at the Tokyo Grain Exchange (TGE) and computes the price premium for non-GM soybean contracts. Aruga (2011) examines how efficiently the price premium for non-GM soybeans at the TGEreact to an announcement to change the contract unit, suppliers, and expiration date on the conventional soybean futures contract. To date, however, there is little published on the workings of GM soybean futures markets in China. Wang and Ke (2005) studied the efficiency of the soybean futures market and concluded that there is a long-term equilibrium relationship between the futures price (non-GMO) and cash price for soybeans and the soybean futures market is weakly short-term efficient. Zheng et al. (2012) tested the price discovery of the Chinese soybean futures market and indicated that the Chinese non-GM soybean futures market is efficient, but they did not analyze the GM soybean futures. Our study would be the first to analyze the relationship between the non-GM and GM soybean futures markets in China. The result of this study will help understand whether the newly developed GM soybean futures market provides valuable information for its price discovery process.

3. Data

The data are obtained from the DataStream 5.1 provided by Thomson Reuters. The price unit is provided in Chinese Yen per metric tone. Due to the lack of liquidity of first nearby contracts, we construct time series of daily settlement prices of the third nearby contracts. When the futures price moves into the maturity month, we roll over the futures price to the next maturity month. Only observations that have both non-GM and GM prices on a given day are used in the analysis.

A separate trading for GM soybean contracts started on December 22, 2004, and since we use the third nearby contracts, the GM soybean futures contracts extend back from January 1, 2005. Table 1 shows the details of the contract specifications for non-GM and GM soybeans.

Futures Premium

Parcell (2001) defines the price difference between the prices of non-GM and GM soybean futures contracts as the price premium for non-GM soybeans. We use the same definition in this study. We take the difference between daily settlement prices of the third nearby non-GM and GM soybean futures contracts as the price premium. We first test if there is structural change in the premium series. To examine this, the Bai-Perron multiple structural change test (Bai and Perron, 1998) and Chow test are applied. Both test results show that two breaks are the statistically adequate number of breaks for this series, which are October 23, 2006, and September 13, 2011. The premium series thus are split into three periods identified by the above two breaks. As seen in the Figure 1, the price premium for non-GM soybeans was positive from beginning of the dataset until 2010. Between late 2010 to mid 2012, the price for GM soybeans was surprisingly higher than that for the non-GM soybeans. Reasons for this might be: (i) During that period, the concept of GM was not well known by Chinese consumers, and due to the higher oil extraction rate of GM soybeans (GMO Compass), the processor would pay a premium for the GM soybeans; (ii) The world soybean price, which included large percentage of GM soybeans, increased dramatically after the food crisis in 2006 and 2007. (USDA) At the same time, the production of non-GM soybeans in China could not meet domestic demand. Thus the imported amount of soybeans did not decrease even though the price was higher than their domestic non-GM soybeans. Starting 2013, the premium for non-GM soybeans becomes positive and remained level until the end of our data period. This could be the result of the widespread world controversy of the safety issue of GMOs. Descriptive statistics of the settlement price of non-GM and GM soybeans, as well as the premiums, are summarized in Table 2. There are 2,365 observations in the sample. The average daily premium is -51.5 CNY per metric ton with a standard deviation of 256.7 Chinese Yuan. The average premium is positive in period 1 and in period 3, but negative in period 2.This significant change of values in premiums reflects the change of consumers' attitudes.

Event Descriptions

There have been some disruptions that affected the soybean futures markets at the DCE and that these breaks may have influenced the price relationships of the two soybean futures markets. This discussion includes following events. First, the DCE implemented amendments to the GM soybean contract specification in 2005. This change was intended to make China's GM soybean markets more closely conform with the international soybean trade standards, giving priority to imported soybeans. Several grade specifications changed here. For example, the new contract specification changes the oil extraction rate up to 21%. The new specification starts from contracts traded in January 2006, which started on October 10, 2005.Secondly, in 2010, The DCE made another contract specification change on both the non-GM and the GM contracts. The DCE was expecting that the specification change would sharpen the distinction between non-GM and GM soybean futures contracts and stabilize the markets for non-GM and GM soybeans.

The details of the specification changes include the revised quality standard and new mandatory requirement regarding new registrations of standard warrants for soybeans according to the new national labeling standards. The packaging materials, or accompanying documents, should indicate the product name, category, grade, place of origin, harvest year and month. The contract using the new specification starts from the contracts traded in March2010. Thirdly, on February21th, 2012, the Government of China issued the Grain Law and an explanatory notice for the regulation of GM foods. It was the first time that GM food control laws had been made at the national level in China. The law states that: "The scientific research, experiment, production, marketing and export and import of genetically modified grain seeds should comply with relevant state regulation. No institution or individual should apply genetically modified technology to major grain crops without permission." The law applies to grains, edible vegetable oil and oilseeds. This implies that the production, trade and consumption of unauthorized genetically modified grain and oilseeds will be banned in China.

4. Methodology

An intervention analysis is used to test the effects of the events on the price premium for non-GM soybeans in each sub-period. We utilize the following econometric ARMA model:

$$\text{Preemium}_t = \alpha + \gamma(t) + \sum_{i=1}^{\infty} \beta_i \,\text{Premium}_{t-j} + \sum_{j=0}^{\infty} \varphi_j \varepsilon_{t-j} + \omega EVENT_t \quad (1)$$

where Premium_t is the Premium in period t ; α is a constant; $\gamma(t)$ is a time trend; ε_{t-j} is a normal *i.i.d.* disturbance; $EVENT_t$ is an event dummy variable; and β_i, φ_j and ω are the coefficients to be estimated.

We consider five intervention functions in this study. As presented in Figure 2, in all five models, $EVENT_t$ takes the value of 0 before event day, and 1 on the event day. The value of $EVENT_t$ beyond event day depends on the chosen intervention function. In model 1 the intervention function represents a pure jump, where the event dummy remains equal to unity until the end of the sub-sample period. The pure jump intervention function arguably models the effect of the event as a constant permanent change to the premium within the period. Model 2 is an impulse function that best characterizes a purely temporary intervention for one month after the event. Model 3 through model 5 are prolonged impulse functions that assume that the intervention will remain to be unity for one month and begin to decay and reaching zero after 80 days, 105 days and 240 days for models 3, 4, and 5, respectively.

Equation 1 can be expressed as:

$$B(L)\text{Premium}_t = \alpha + \gamma(t) + \Gamma(L)\varepsilon_t + \omega EVENT_t \quad (2)$$

where $B(L)$ and $\Gamma(L)$ are polynomials in the lag operator L. The coefficients of $B(L)$ are the autoregressive (AR) components, and the coefficients of $\Gamma(L)$ are the moving average (MA) components of the autoregressive moving average (ARMA) model. The coefficient ω is of special interest to the analysis, as it provides the information about the impact of the event on the performance of the difference between price of non-GM and GM soybeans.

An augmented Dickey–Fuller test was performed on premium series to ensure that these three sub-series did not contain a unit root. Sequential t-tests beginning with lag 12were utilized to determine the appropriate number of lags for the unit root test (Ng and Perron 1995). The three events within each period are assumed to be exogenous structural breaks for the premium series. The unit root hypothesis was rejected at the less than 1% level for the first two periods; however, it was not rejected for the third period. The absence of a unit root means that the effect of the first two events will eventually die out, but not for the third period case. We thus add the trend in the ARMA model for the third period. The estimation procedure was conducted using the standard Box–Jenkins method. In choosing among alternative plausible ARMA models, the lowest Akaike Information Criterion method was utilized. Diagnostic checking was performed by plotting the residuals and the correlogram of residuals squared to insure that they are characterized by a white noise process. Also, the autoregressive heteroskedasticity (ARCH) Lagrange multiplier test was performed and it resulted in on-significant statistics, which implies the absence of the ARCH effect.

5. Results

The best fitting model for these three periods is an ARMA (2, 1) model. It can be written as:

$$\text{Premium}_t = \alpha + \gamma(t) + \sum_{i=1}^{2} \beta_i \,\text{Premium}_{t-i} + \sum_{j=0}^{1} \varphi_j \varepsilon_{t-j} + \omega EVENT \quad (3)$$

The empirical results of the effects of these three events on the premium for non-GM soybeans for all five models are reported in Table 3. It presents maximum likelihood estimates of the intervention analysis of daily premium for non-GM soybeans in the Dalian futures market using ARMA (2, 1) models. To account for the global financial crisis, we create a variable, CRISIS, which equals unity between September 15, 2008 and June 30, 2009 in period 2 (Gilbert, 2010). The statistically significant coefficients of the event dummies represent the initial, or impact, effects of the events. In the first period, the coefficients indicate the initial increase of 15.6 to 29.6 CNY per metric ton per day for model 1 through 5. To provide the economic sense of the increase in the premium performance, we compare this number with the average premium per day before the event date: it represents a 35.6% to 67.5% increase in premium. In the second period, the initial effect is a decrease of 33.6 to 58.3 CNY per metric ton per day, which represents a decrease of 38.1% to 66.2% in the premium.

As for the third period, the event has an initial effect of an increase of 16.9% to 30.7% in the premium. As one can see, the results are heavily influenced by the choice of the intervention function. This illustrates the importance of the intervention function chosen for the analysis. The long-run effect estimation requires judgment in model selection. Quite likely, prolonged impulse models, such as models 3, 4, 5, with the decaying function would be appropriate in the case of the first two events, as the exogenous effects would dissipate over time and the premium would begin to move back to their original patterns. However, this requires arbitrarily setting the event dummy to zero at some point of time after the attack while the event could still be a significant factor in the premium. Some traders in the soybean futures market may still consider the contract specification change and the law issue effect of the GM products when they perform in the soybean futures market. Hence, the event dummy that stays equal to unity through the end of the sample period is a reasonable modeling assumption. Based on this judgment, we utilize model 1 to estimate the long-run effect of the three events and the impulse response functions. The long-run effect of the events can be assessed by calculating the change in the long-run mean of the premium series in model 1. The long-run effect (LRE) of intervention is given by the following equation:

$$LRE = \frac{\omega}{(1-\beta_1-\beta_2)} \quad (4)$$

where β_1 and β_2 are AR term coefficients of ARMA(2,1) model presented in equation 3.

After substituting the coefficients in Eq. 3.4, we find that LRE equals to 23.1, negative 54.5 and 52.8 CNY, respectively, in each period using model 1. The LRE yields much larger economic significance than the initial effect in the first period. The magnitude of the impact is much smaller than the cumulative change of the premium allegedly caused by the event. However, the LRE of the last two periods is very similar in magnitude to their initial effect, suggesting that almost all of the premium change can be attributed to the event in the last two periods.

Impulse Response Function

One of the advantages of the intervention analysis is that the model can provide researchers with additional information, such as the transitional effects of an event. As implied by the unit root test, the effect of the event of the first two periods will eventually die out and the daily decrease will dampen and eventually disappear, but not for the third period. The reduction rate of daily losses that are attributable to the event can be provided by the impulse response function.

Using a lag operator we rewrite Eq. 3 as:

$$(1-\beta_1 L-\beta_2 L^2)\,\mathrm{Pr}emium_t = \omega EVENT_t + \sum_{j=0}^{2}\varphi_j \varepsilon_{t-j} \quad (5)$$

and

$$\mathrm{Pr}emium_t = \frac{1}{(1-\beta_1 L-\beta_2 L^2)}(\omega EVENT_t + \sum_{j=0}^{2}\varphi_j \varepsilon_{t-j}) \quad (6)$$

Next, we substitute

$$\frac{1}{(1-\beta_1 L-\beta_2 L^2)} \text{ with } \frac{1}{(1-\lambda_1 L)(1-\lambda_2 L)}$$

where λ_1 and λ_2 are characteristic roots of the polynomial $B(L)=0$. With the characteristic roots, the ARMA (2, 1) model can be inverted to obtain the impulse response function.

$$\mathrm{Pr}emium_t = \omega \sum_{i=0}^{\infty}\lambda_1^i \sum_{i=0}^{\infty}\lambda_2^i EVENT_{t-1} + \sum_{i=0}^{\infty}\lambda_1^i \sum_{i=0}^{\infty}\lambda_2^i \sum_{j=0}^{2}\varphi_j \varepsilon_{t-j} \quad (7)$$

Equation 8 is an impulse response function. By differentiating Eq. 3.7 and updating by i periods, one can trace the response of the premium's performance to the event:

$$\frac{d\,\mathrm{Pr}emium_{t+i}}{dEVENT_t} = \omega(1+\lambda_1+\lambda_1^2+\cdots+\lambda_1^i)(1+\lambda_2+\lambda_2^2+\cdots+\lambda_2^i) \quad (8)$$

Since in the limit, $i\to\infty$, the LRE of the intervention:

$$LRE = \frac{\omega}{(1-\lambda_1)(1-\lambda_2)} = \frac{\omega}{(1-\beta_1-\beta_2)} \quad (9)$$

Equation 9 can be utilized to calculate the effect of the event in a predetermined period of time after the occurrence. For instance, if an event happens in period t, one can expect the decrease in daily premium in period t+3 by:

$$\frac{d\,\mathrm{Pr}emium_{t+3}}{dEVENT_t} = \omega(1+\lambda_1+\lambda_1^2+\lambda_1^3)(1+\lambda_2+\lambda_2^2+\lambda_2^3) \quad (10)$$

Where ω reflects the direct impact of the premium performance and the following terms reflect the effect of the event multiplied by the effect of $\mathrm{Pr}emium_{t+2}$, $\mathrm{Pr}emium_{t+1}$ and $\mathrm{Pr}\,emium_t$, respectively.

Figure 3 shows the impulse response of the premium's performance to the three events utilizing the estimates of model 1, where the vertical bars represent the trajectory of the IRF and the lines are the smoothed trend using moving averages method. For model 1, the characteristic roots of the polynomial $B(L)=0$, λ_1 and λ_2 are estimated to be 0.5583 and negative 0.9583, 0.278 and negative 0.975, 0.8743 and negative 1.6783, respectively, for three periods. The area above the curve represents the cumulative effect on the premium. Since the absolute values of both λ_1 and λ_2 are less than unity in the first two periods, the relative impact on the premium performance is decreasing with time and reaches zero after 330 days and 210 days, respectively . However, the relative impact of the issue of law keeps a level of 10 CNY per metric ton, since the absolute value of λ_2 is more than unity.

6. Conclusions

As the largest soybean importer, China’s high demand means that many foreign growers cannot ignore price signals from China when making important production and marketing decisions. This paper examined how efficiently the DCE non-GM and GM soybean futures markets react to two contract specification changes and one law issue by testing the influence on the price premium for non-GM soybeans. We implement intervention analysis to ten years of daily prices on soybean futures contracts to analyze the pattern of the market responses to three major events (the contract specification changes in 2005 and 2010, and the grain law issue in 2012), of which effects are considered to persist for a long period of time rather than a one-day jump. The consequences of these events on the price premium were captured by an ARMA model. Results show that premium response to each of these three events is statistically significant, and the durations are different for each event. The range for change of premium is negative 60 to positive 70 percentage points, with the impact of the contract specification change in 2010 being the largest. The results revealed that the price premium for non-GM soybean futures contracts changed substantially after events. Among the three events, the impact of grain law issue on premium is permanent in our sample period.

In conclusion, the contract specification change from the DCE for the soybean futures contract did affect the price premium between the GM and non-GM soybean futures contracts. Therefore, these two cases of changes can be considered as successful. Hence, there was an informational efficiency in the market. It is also found from the study that the effect of the legal issue did not disappear for the price premium for non-GM soybeans. It permanently raised the price premium for non-GM soybean. The dispute of GM foods involves consumers, farmers, biotechnology companies, governmental regulators. However, this did not deter the development of the GM futures market in China. The fact that the non-GM and GM soybeans futures markets are efficient can provide government planners more evidence and confidence to help the start of the futures trading for other commodities. For international soybean growers, traders and processors, an efficient DCE GM soybean futures market will generate stronger interest in participating in Chinese futures trading asa mechanism to hedge international transactions and against variations in their local markets, which may arise from the growing Chinese demand which lead growing imported GM soybeans.

Table 1. Summary of the contract specification at the DCE

	SB #1 (Non-GM)	SB #2 (GM)
Date Trading Began	1998	Dec 22th, 2004
Contract Unit	10 metric tons	
Trading Hours	9:00-11:30 a.m, 1:30-3:00 pm. Beijing Time, Monday-Friday	
Contract Month	Jan, Mar, May, July, Sep, Nov	
Price Quotation	CNY/MT	
Last Trading Day	10th trading day of the delivery month	
Last Delivery Day	3rd day after the last trading day of the delivery month	
Standard Grade	No. 3 Yellow; GM soybeans are not permitted to be delivered	Imported GM soybeans
Delivery Points	The warehouses appointed by the DCE	

Source: DCE2014

Table 2. Summary Statistics

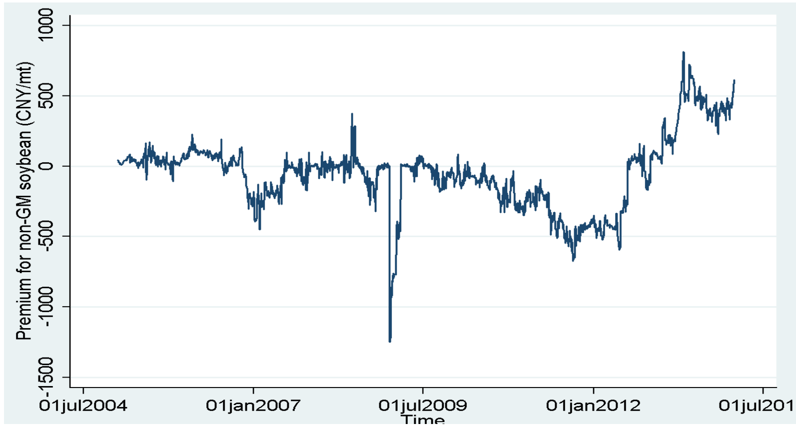
	N	Mean	Standard deviation	Minimum	Maximum
Period 1					
Non_GM Soybean Price	471	2750.852	179.9875	2499	3275
GM Soybean Price	471	2700.448	180.2317	2465	3162
Premium	471	52.478	45.58	-107	228
Period 2					
Non_GM Soybean Price	1277	3924.073	572.3639	2626	5466
GM Soybean Price	1277	4060.454	587.3064	2520	5473
Premium	1277	-136.3814	182.8043	-1247	374
Period 3					
Non_GM Soybean Price	617	4567.948	210.6559	4106	4991
GM Soybean Price	617	4522.908	323.1852	3904	5145
Premium	617	45.041	386.5613	-666	812
Whole Period					
Non_GM Soybean Price	2365	3855.183	758.2016	2499	5466
GM Soybean Price	2365	3910.84	788.075	2465	5473
Premium	2365	-51.506	256.6782	-1247	812

Source: Data stream 5.1

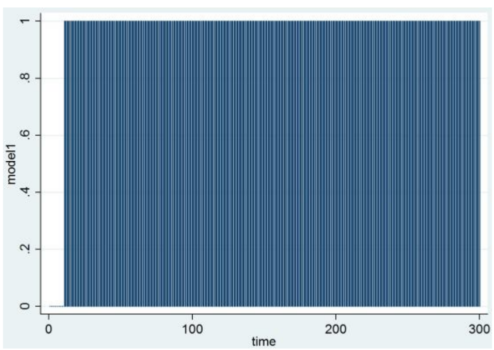
Table 3. The impact of the events on Premium of non-GM soybean in china

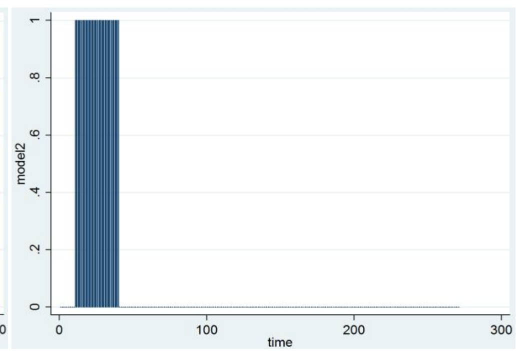
Period 1					
	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	44.352a	54.505a	56.292a	56.978a	56.811a
	(9.897)	(7.014)	(6.826)	(6.868)	(7.268)
Premiumt-1	-0.108a	-0.108a	-0.120a	-0.119a	-0.113a
	(0.027)	(0.030)	(0.028)	(0.028)	(0.028)
Premiumt-2	0.433a	0.229a	0.226a	0.227a	0.231a
	(0.018)	(0.020)	(0.019)	(0.019)	(0.020)
εt-1	0.914a	0.908a	0.919a	0.919a	0.917a
	(0.031)	(0.033)	(0.029)	(0.029)	(0.030)
EVENT	15.593a	24.218a	22.932b	20.594a	29.574a
	(3.226)	(1.847)	(18.882)	(19.149)	(2.527)
Adj. R-sq.	0.781	0.783	0.784	0.784	0.783
Initial effect	35.61%	55.30%	52.37%	47.03%	67.54%
LRE	23.105	27.551	25.654	23.072	33.542
LRE(%)	52.76%	62.92%	58.58%	52.57%	76.60%
Period 2					
	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	-103.510b	-146.572a	-145.930 a	-145.259b	-144.929b
	(54.639)	(62.351)	(62.590)	(62.884)	(62.992)
Crisis	6.789a	16.904 a	16.849 a	16.797 a	16.773 a
	(1.135)	(3.007)	(2.950)	(2.891)	(2.893)
Premiumt-1	-0.403 a	-0.450 a	-0.449 a	-0.450 a	-0.450 a
	(0.062)	(0.057)	(0.057)	(0.057)	(0.057)
Premiumt-2	0.417 a	0.460 a	0.459 a	0.460 a	0.459 a
	(0.059)	(0.055)	(0.055)	(0.054)	(0.054)
εt-1	-1.676 a	-0.638 a	-0.637 a	-0.638 a	-0.638 a
	(0.163)	(0.052)	(0.052)	(0.052)	(0.052)
EVENT	-53.786c	-58.299 a	-33.567 a	-48.239 a	-44.172 a
	(7.249)	(1.212)	(6.459)	(4.527)	(4.808)
Adj. R-sq.	0.806	0.806	0.806	0.806	0.806
Initial effect	-61.07%	-66.19%	-38.11%	-54.77%	50.15%
LRE	-54.5329	-58.8762	-33.8957	-48.7111	-44.6042
LRE(%)	-61.92%	-66.85%	-38.49%	-55.31%	-50.64%
Period 3					
	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	-593.800 a	-580.232 a	-580.929 a	-581.427 a	-582.757 a
	(138.682)	(128.705)	(130.763)	(131.095)	(133.908)
t	1.908 a	1.993 a	1.994 a	1.995 a	1.997 a
	(0.421)	(0.319)	(0.323)	(0.324)	(0.328)
Premiumt-1	0.752 a	0.756 a	0.760 a	0.760 a	0.759 a
	(0.187)	(0.180)	(0.177)	(0.183)	(0.176)
Premiumt-2	-0.756 a	-0.761 a	-0.764 a	-0.765 a	-0.763 a
	(0.182)	(0.175)	(0.172)	(0.178)	(0.171)
εt-1	-0.834 a	-0.839 a	-0.842 a	-0.841 a	-0.841 a
	(0.166)	(0.159)	(0.156)	(0.162)	(0.155)
EVENT	53.017 a	29.182 a	45.150 a	39.272 a	51.798 a
	(7.350)	(5.564)	(3.979)	(3.707)	(6.065)
Adj. R-sq.	0.789	0.789	0.789	0.789	0.789
Initial effect	30.65%	16.87%	26.10%	22.71%	29.95%
LRE	52.780	29.049	44.948	39.092	51.566
LRE(%)	30.51%	16.79%	25.99%	22.60%	29.81%

Note: a Statistical significance at the 1% level
b Statistical significance at the 5% level
c Statistical significance at the 10% level

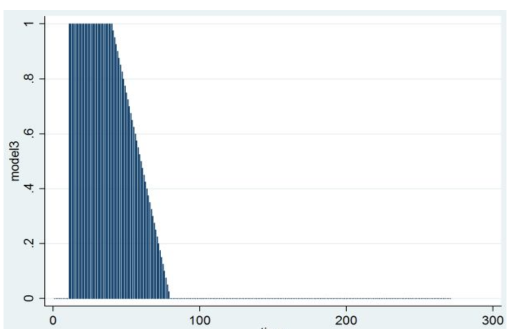


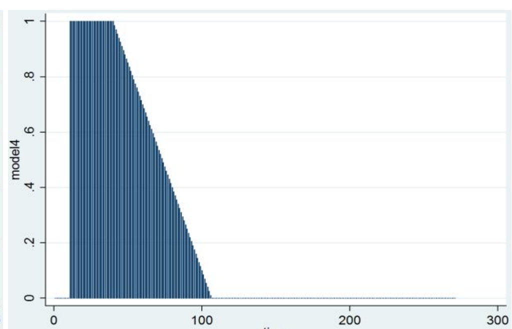
Note: The prices for the non-GM and GM soybeans are given in Chinese yen and are 1 mt of soybeans.
Figure 1. Price premium for non-GM soybeans (price difference between the non-GM and GM soybean future contract)



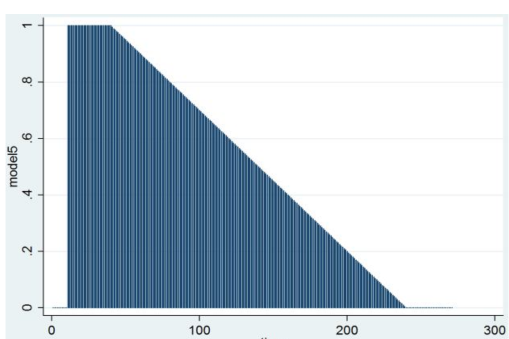


Panel A: Model 1 Panel B: Model 2



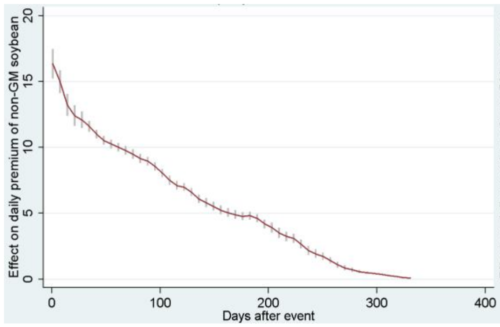


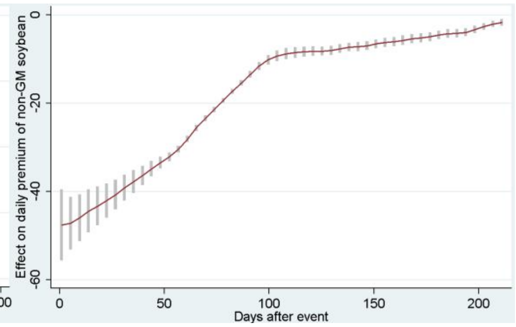
PanelC: Model 3 Panel D: Model 4



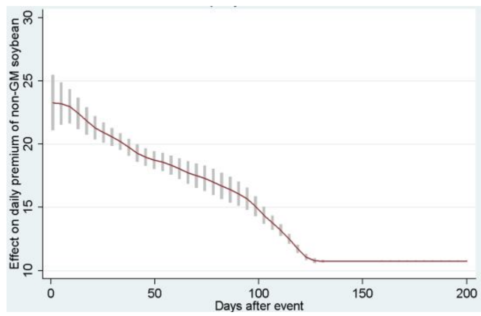
Panel D: Model 5

Figure 2. Intervention models. Panel A through E illustrate intervention functions utilized in the analysis.





Panel A Panel B



Panel C

Figure 3. Impulse response function of the premium for non-GM soybean price after event in 2005 (Panel A), 2010 (Panel B) and 2012 (Panel C)

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