THE EMERGENCE OF GM FOOD PRODUCTS IN CHINA: THREE ESSAYS ON ECONOMIC IMPACTS

by

NANYING WANG

(Under the Direction of Jack E. Houston)

ABSTRACT

This dissertation explores issues related to economic impacts of Genetically Modified (GM) foods on both demand side and futures market side. The primary objectives involve measuring the college students' willingness to pay toward GM food products in both the U.S. and China, testing the market response linkages between the GM and non-GM soybean prices in China's futures markets and examining the dynamic correlation between them.

The first section examines the willingness to pay for multiple nutrition-enhanced GM grain breakfast products. Our study provides results using mixed-logit model to analyze choice experiment survey data. The results reveal that college students from the U.S. and China are both willing to pay a premium for products with attributes of non-GM, less pesticide/herbicide use and food quality certification from U.S. However, the attributes of additional nutritional benefits, the U.S. brand, origin of raw material from the U.S. are significant only for the U.S. students, the attribute of food quality certification from China is only valued differently by Chinese students.

The second section examines how efficiently the Dalian Commodity Exchange's non-GM and GM soybean futures markets react to three events including two contract specification changes from the exchange and one law issue by testing the influence of the above changes on the price premium (the price difference between non-GM and GM soybeans). We first use Bai-Perron test to find the structure change point of the premium series. Next we test the intervention effect of events in each sub-periods. The results show that the specification changes of contract do have effects on the price premium. Also, the law issue has a huge positive permanent effect on the price premium.

The third section explores the co-movement between these two soybeans markets. We analyze the volatility by incorporating changes in important economic variables into the DCC-GARCH model. This research provides statistical evidence that the futures prices of soybeans in China are being influenced by the increasing consumption of soybeans, the import quantity of soybean, the trading volume in futures market and weather. We also find spillover effect from non-GM to GM in soybean markets.

INDEX WORDS: Genetically Modified Organism, Willingness to pay, China, Commodity Futures Market, Soybeans.

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CHAPTER 1

INTRODUCTION AND LITERATURE REVIEW

1.1 Background and Literature Review

Genetically Modified (GM) staple foods have had wide exposure in the global news media, but as products with enhanced functional attributes appear, consumers will face choices between GM products that bring tangible benefits (but carry unknown risks) and traditional nutritional supplements. Micronutrient deficiencies challenge health organizations and governments throughout the world, and transgenic plants offer effective ways to increase the vitamin and mineral content of staple food crops.

Many regions and countries, including the European Union, Australia, New Zealand, and Brazil, now require labeling for GM food products (Huffman, 2003). China has followed this trend. In 2002, China adopted a mandatory labeling policy of non-GM food products. Li et al. (2002) conducted a survey in Beijing, China, that revealed that the willingness to pay (WTP) for GM rice and GM soybean oil was positively affected by respondents. These results imply that, unlike Europe and Japan, there is a potential market for GM foods in China. GM food producers and exporters can use this information to design effective marketing strategies. China is a world leader in promoting agricultural biotechnology research through public investment, but it has been careful in allowing field experiments without permitting commercialization. Further, evidence of Chinese consumers' attitudes toward GM foods from the existing literature is mixed and sometimes confusing.

U.S. farmers have planted millions of acres of genetically modified varieties of corn, cotton, and soybeans, and the U.S. is by far the largest user of GM crops. By 2013, roughly 91% of the planted area of soybeans, 88% of cotton and 85% of corn were genetically modified varieties (USDA). Since much of the corn and soybeans harvested each year are processed into products like corn oil and lecithin, it is not surprising that an estimated 80% of processed food sold in the United States contains ingredients derived from GM crops (Center for food safety, 2014). Also, export markets remain a critical source of revenue for U.S. farmers. Given the importance of GM crops to the Chinese and the U.S. economies, consumers from these two countries are in a unique situation regarding their perception of GM foods.

With high protein content and a high concentration of amino acids, soybeans and soybean products have become an indispensable part of the food and feed chains in the world. The world market for soybeans has typically been characterized by high concentration on both supply and demand sides. The U.S., Brazil and Argentina are the major producers and exporters. According to the UN-COMTRADE (2011), total exports by these countries accounted for almost 90% of all soybeans traded over the past eleven years. On the demand side, data from the UN-COMTRADE (2011) show that China and E.U. currently account for approximately 60% and 15%, respectively, of all soybean imports in the world.

However, China only emerged as a major soybean importer during the last decade. Until 2002, China was the second largest importer in the soybean market, but since then it has started to import increasing quantities of soybeans. Between 2002 and 2010, soybean imports by China grew at an average rate of 23% per year. This expansion implies that China currently buys most of the soybeans exported by Brazil, U.S. and Argentina. In 2010, China was the destination of 64% of Brazilian soybean exports, 56% of U.S. soybean exports, and 82% of Argentine soybean exports (UN-COMTRADE, 2011). Most of the imported soybeans are GM soybeans.

GM food products have been imported to China since 1997 (DCE, 2003). China is now the world's fourth-largest non-GM soybean producer and is also the biggest soybean importer (Zhao et al., 2010). On December 22, 2004, to meet consumer and commercial processors' demand, the Dalian Commodity Exchange (DCE) opened a separate trading market for No. 2 soybeans (SB#2). The SB#2 includes GM soybeans, which makes SB#1 a non-GM contract.

Non-GM soybeans are mostly used for food. On the other hand, GM soybeans are mainly used for processing and extracting soybean oil. 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 and also GM 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 GM soybeans, the non-GM soybean price would show a substitutive movement with the GM soybean price.

1.2 Objectives

Although GM food impacts have been intensively studied in recent decades, a comprehensive study of its impacts on college student consumers and the Chinese futures market are still rare. By conducting an analysis of survey results and of the Chinese soybean futures market, this dissertation attempts to provide more information about the economic impacts of GM food products to current literature. The overall objective of this dissertation is to evaluate college students' attitudes toward a GM breakfast product, test the efficiency of Chinese soybean futures market and identify the co-movement between non-GM and GM soybean prices in Chinese futures market. The specific research objectives include:

1. Measure willingness to pay (WTP) for multi-nutrition enhanced GM staple breakfast products within the U.S. and Chinese college student groups.
2. Examine how efficiently the DCE's non-GM and GM futures markets react to two contract change announcements and one commodity law issue by testing the price premium for non-GM soybeans following the events.
3. Identify which factors affect the monthly non-GM and GM soybeans futures price volatility of China.
4. Examine the dynamic correlation across non-GM and GM soybean futures prices traded on the Dalian Commodity Exchange.

1.3 Outline of Dissertation

In the following chapters, the differences in consumer preferences and valuations for novel genetic modified breakfast grain products are presented and analyzed in Chapter 2. The perception of consumers from a developing country, such as China, is discussed and compared to attitudes in developed countries, such as the U.S. We conduct a survey project using a choice experiment survey instrument to measure behavioral intentions with a focus on consumers' willingness to pay. We then estimate a mixed-logit model in which the decision on buying a GM food is a function of the attributes, including non-GM, less pesticide use, safety certification, country of origin, and others.

In Chapter 3, an intervention analysis is used to test the effects of three regulatory events on the price premium for non-GM soybeans. We use an ARMA model to estimate the premium in the time series and then specify five different models for responses to the three events.

In Chapter 4, we analyze the volatility by incorporating changes in important economic variables into the Dynamic Conditional Correlation-Generalized Autoregressive Conditional Heteroskedastic (DCC-GARCH) model. Spillover effects between the two soybean markets are also tested.

In Chapter 5, a summary of the dissertation research is presented. Conclusions, implications, and limitations of the studies are discussed.

CHAPTER 2

CONSUMER ATTITUDES TOWARD THE USE OF GENE TECHNOLOGY IN FUNCTIONAL BREAKFAST GRAIN PRODUCTS: COMPARISON BETWEEN COLLEGE STUDENTS FROM THE U.S. AND CHINA[1]

[1]Wang, N, J. Houston, G. Colson and Z. Liu. 2015. To be submitted to *Journal of International Business and Economics.*

Abstract

Second-generation Genetically Modified (GM) crops are associated with consumer-oriented benefits such as improvement of nutritional quality. Given such an evolving market environment, this paper presents differences in consumer preferences and valuations for a novel genetic modified breakfast grain products. The perception of consumers from a developing country such as China is discussed compared to attitudes in developed countries such as U.S. Our survey results reveal that there are notable differences in the attitude and perception of college students across these two countries. Purchase intent for GM foods was low, unless a benefit was promised, some modifications are viewed more positively than others. Overall, it appears that GM foods may be acceptable in the U.S. and Chinese market. This finding has potential implications for establishing various GM marketing strategies and information campaigns.

Keywords: Genetic Modification, College Students, Staple Food Products,

Willingness to Pay

2.1. Introduction

Genetically Modification (GM) of plants represents a revolutionary technological change in agriculture. Unlike traditional forms of plant and animal breeding, recombinant DNA techniques enable researchers to directly manipulate the genetic composition of target organisms. The first generation of genetically modified crop varieties, currently most widespread in the maize and soybean sectors, sought to increase farmer profitability by improving agronomic traits. The second generation of GM crops is focusing on breeding for attributes desired by consumers (e.g., better nutritional content, improved storability). This achievement opens the way for the development of nutritionally complete cereals to benefit nutrition-deficient populations. These attributes can be used in processed foods, such as soda, juices, bread, processed meats and cereal. Over time, as the adoption of such lower-cost technologies spreads, this outward shift in the supply curve would be expected to lower the consumer price of nutrient value in food.

However, the debate over genetic modification remains intense. Supporters believe the breeding of new plants by recombinant DNA technology removes the economic burden and potential environmental problems (Brookes & Barfoot, 2005; Weiss et al., 2006). Advocates see GM food as key to ensuring food security in developing countries, promising to solve the problem of world hunger. The controversy over GM foods has manifested in labeling regulations and trade disputes between importing and exporting countries of GM food products. In 2014, there are 64 countries that required labeling of all genetically modified foods. The European Union, Australia, New Zealand, China, and India require GMO labeling, they believe mandatory labeling and traceability are needed to allow for informed choice, preclude potential misleading of consumers and facilitate the withdrawal of products if adverse effects on health or the environment occur. However, many other countries, such as the United States and Canada, make no distinction between marketed GMO and non-GMO foods.

The other issue concerns trade. Some countries, particularly in Europe, maintain tighter restrictions on genetically modified seeds than the U.S. China has approved some types of genetically modified crops, but its approval process often takes longer than in the U.S. These differences in planting of GM crops and regulatory systems are already causing international trade dispute. Starting in 1997, the U.S. largely stopped shipping bulk commodity corn to the EU because such shipments commingled corn including genetically modified varieties not approved by the EU. In 2002, Zambia refused emergency food aid from developed countries, fearing that the included GM food was unsafe. In 2010, flax exports from Canada to Europe were rejected when traces of an experimental genetically modified flax were found in shipments. China quarantine authorities refused to accept 545,000 tonnes of the U.S. corn in November and December 2013 because shipments contained a GM variety that has been awaiting China's approval for more than two years.

A factor that is at least as important in determining the extent of continued expansion of transgenic crop plantings and the development and adoption of new GM varieties is consumer attitudes. Understanding consumers’ attitudes toward GM foods is important not only to the decision makers, GM food producers and exporters can also use this information to design effective marketing strategies.

GM staple products

Within different types of GM food, GM staple foods have had wide exposure in global news media. Due to the important role of staple foods, they have not been approved to be commercialized in the world. In developing countries, the main sources of vitamins and minerals for low-income rural and urban populations are staple foods. However, the major staple food crops, in particular cereal grains, are poor sources of key mineral nutrients, such as folic acid, iron, lysine, selenium, vitamin A, zinc and which are essential for normal growth and metabolism (Welch and Graham, 2004). Even in the West, lifestyle choices and lack of education can lead to an improper diet and, hence, deficiencies in some vitamins and iron (Franz and Bantle, et al, 2002). Micronutrient deficiencies challenge health organizations and governments throughout the world, and transgenic plants offer effective ways to increase the vitamin and mineral content of staple crops. As products with enhanced functional attributes appear, consumers may face choices between GM products that bring tangible benefits (but carrying unknown risks) and traditional nutritional supplements.

GM development in China

China is the world's most populous nation and has been one of the world leaders in promoting agricultural biotechnology research through public investment (Huang, Rozelle, Pray, & Wang, 2002). However, China has been careful in allowing field experiments without permitting commercialization. In China, only cotton and antiviral papaya have been approved for commercialization. However, China has been importing GM raw materials, including soybeans, corn, cotton, canola seed and sugar beets (USDA). In China, it is no secret that soybean oil, corn (maize), and cotton on the market are most genetically modified. Many people in China are starting to be concerned about GM ingredients in food. Evidence of Chinese consumers' attitudes toward GM foods from the existing literature is mixed and sometimes confusing. There is concern about the extent to which consumers will accept genetically modified (GM) staple foods if they are commercialized in China. The uncertainty about Chinese consumers' attitudes toward GM foods contributes to uncertainty for policy makers on how China should proceed with its future biotechnology policies in general and GM foods in particular. In addition, China's final decision on whether it should commercialize GM crops will greatly influence what the rest of Asia does about GM food.

GM development in the U.S.

The U.S. is by far the largest user of GM crops. By 2013, roughly 91% of the planted area of soybeans, 88% of cotton and 85% of corn were genetically modified varieties (USDA). Since much of the corn and soybeans harvested each year are processed into products like corn oil and lecithin, it is not surprising that an estimated 80% of processed food sold in the United States contains ingredients derived from GM crops (Center for food safety, 2014). The U.S. farmers in general have embraced GMOs, but at the same time are still frustrated with the uncertainty of marketing GM crops. Export markets remain a critical source of revenue for U.S. farmers. Labeling regulations for GM in the U.S. is a controversial topic as well. There have been numerous efforts to pass labeling laws in the U.S., especially at the state level. As of September 2013, legislation for GMO labeling was pending in at least 20 U.S. states.

Given the importance of GM staple crops to the Chinese and U.S. economies, consumers from these two countries are in a unique situation regarding their perception of GM foods. Different cultural and experiential backgrounds in the U.S. and China may address the risks and benefits of this new technologies in disparate ways in the international exchange of GM foods. College students are chosen here as our target group, since, although their shopping habits are still developing, they represent a critical portion of the 'next generation' of consumers, as well as future business leaders, and thus they will play an important role in the future acceptance and use of GM products. Country-of-origin labeling is an increasingly politicized credence attribute in the globalizing food system. Mixed with different regulation of GM products, it is not clear if this emphasis on origin in country would result in different consumer preferences for breakfast cereal products.

The major objective of this study is to assess consumers' willingness to pay for various attributes of multi-nutrition enhanced GM staple products within college students' consumer groups in the U.S. and China. We also test the effect of geographical origin of ingredients and brand on willingness to pay and then compare the attitudes difference between college students within these two countries.

In order to understand the factors affecting consumers' acceptance of functional GM foods and to estimate the willingness to pay (WTP) for functional GM products, we conduct a survey project. Survey participants were sent an email with a linked webpage to complete a self-administered questionnaire concerning their health habits and perceptions of GMOs. A choice experiment survey instrument (Lusk, Roosen, and Fox 2003) was designed to measure behavioral intentions with a focus on consumers' willingness to pay a premium for breakfast grain products made of non-GM ingredients and willingness to accept a discount for products made of GM ingredients although they are nutritional enhanced. Specifically, the WTP for GM breakfast products - cereal and/or toast (U.S.), bun and/or porridge (China) - the four major breakfast products in these two countries are considered. Altogether, 400 consumers were interviewed, from which 130 were complete from the U.S. and 122 from China. All surveys were completed during November 2013 to December 2013. Attempts were made to include students with different majors in various colleges. The questionnaire, initially written in English, was translated into Chinese (Mandarin). We then estimate a mixed-logit model (Hensher, Rose, and Green 2005, Revelt and Train 1998) in which the decision on buying a GM food is a function of the attributes including non-GM, less pesticide, safety certification, country of origin, etc.

Results reveal differences in the attitudes and perceptions of GM foods between college students in these two countries. Both of them are willing to pay a premium for the attributes, such as non-genetically modified, additional nutrition, food quality certification from U.S. and less pesticide or herbicide use. However, American students are also willing to pay a premium for the U.S. brand and the products in which raw material is from the U.S. Chinese college students are more willing to pay a premium for the product with Chinese food quality certification. Taking the non-GM attribute as an example, American college students are willing to pay $0.98 premium and Chinese students would likely to pay ￥1.30 premium for the breakfast product.

2.2. Literature Review

A large number of studies have shown that consumers' concerns about GM foods are rising and acceptance of GM foods varies among countries (Hoban, 1998; Lusk, Roosen, and Fox, 2003; Lusk et al., 2005; Costa-Font et al., 2008; Ding et al., 2012). Consumers in general are likely to be willing to pay a premium for non-GM foods, but this does not guarantee everyone is resistant to GM foods, nor that GM foods are always inferior to their non-GM counterparts. Particularly, in the United States, the introduction of GM foods has not elicited strong public concern or widespread opposition. Hossain et al. (2003) reported that less than 60% of Americans supported the use of genetic technology when it did not bring any tangible benefit to consumers, whereas, when specific benefits were provided (more nutritious, for instance), 75-80% of the same population approved its use.

There are also studies on the Chinese consumers' attitude. However, the evidence from the existing literature is mixed and sometimes confusing. On one extreme, a study in Guangzhou, Shanghai, and Beijing by Greenpeace (2004) claimed that GM foods were generally not accepted by Chinese consumers. On the other extreme, Huang (2005) found that about two thirds of consumers not only accepted GM foods but also believed that they would personally benefit from consuming GM foods. For the second generation of GM products, Steur (2012) concluded from a survey conducted in Shanxi province that the perceived benefits seem to be high enough to compensate for potential negative reactions to GM food.

2.3. Survey and Choice Experiment Design

In fall 2013, a survey was conducted in the U.S. and China to elicit college students' opinions and valuation for nutritionally enhanced GM breakfast products. College students from the University of Georgia (U.S.) and Southwest University (China) were invited to participate in the project and answer questions from an online survey. These two universities are public universities in the southern part within each country. Respondents were randomly selected campus wide. To achieve this, we sent out emails with instruction and link of the survey to the email lists in different classes randomly selected in these two universities. Each questionnaire lasting approximately 15 minutes.

The survey collected responses concerning consumers' purchasing behavior. Respondents were first asked about their opinion of GM food. Then we gave the respondents a brief introduction of knowledge of GM nutrition-enhanced products. Next we presented the main part of the survey: a discrete-choice experiment (12 questions for each student). Finally, respondents were asked about their socioeconomic characteristics, including age, education and income, etc.

2.3.1. Sample Characteristics

A total of 252 individuals completed the full survey process and provided complete responses. Table 1 and Table 2 present summary statistics of socio-demographic information and attitudes toward GM food for (a) the Entire Sample, (b) the respondents from Southwest University (China), and (c) the respondents from the University of Georgia (U.S.).

In terms of the socio-demographics of the sample, more female respondents (60%) answered than males (40%). Respondents' average age is 23 years (varying from 18 to 36 years old); persons younger than 18 were not selected for the interviews. The students are from most different majors. For the U.S. college students, about half of them are Christian, and for the Chinese students, about 85% of them do not have a stated religion. As for their health habits, on average more than half of them do exercise once or twice a week, and approximately half of them have the habits of taking vitamin supplement. The average annual income of the U.S. respondents' parents was approximately 50,000 to 75,000 U.S. dollars, while for the Chinese students, it was between 40,000 to 50,000 RMB (approximately 6,000 to 8000 U.S. Dollars).

As for their attitude, 94.8% of them have heard of GM food, and only 1.5% have not. About 15% of the respondents agreed with the statements that GM food have substantial benefits, only 23% are concerned with their negative effects. Almost half of respondents are not sure if they are beneficial or harmful. To ascertain the respondents' idea about the effects of GM food on the environment, we simply asked whether they believe GM foods could bring good or bad effects to environment. Almost 60% of the respondents agree that GM foods can have both effects. Also, almost half of the students believe that GM technology benefits producers more than consumers.

For their attitudes towards if GM food should be labeled, results showed that the attitudes of students from these two countries are quite different. Only 33% of the U.S. students are proponents, while 60% are not sure. However, 95% of the Chinese students think that GM food should be labeled. This result is consistent with the current regulation of each country.

The students' opinions of the effects of GM technology on environment are quite similar. Around 60% of them believe that they can both have good effect and bad effect. To analyze how risky it is consuming GM foods, responses were given scores between 0 and 10 (0 for no risk and 10 for significant risk), so average scores could be calculated to estimate in general how risky it is in college students' minds. U.S. students gave an average score of 4.64, which is lower than the 5.52 of the Chinese students. However, the scores largely show that the students do not perceive GM food as "dangerous", but at the same time they still are concerned they may not be totally safe.

Similarly, we asked how necessary it is to produce GM food, where 0 means unnecessary and 10 mean necessary. The U.S. students gave a slightly higher score of 4.72, and Chinese students gave an average score of 4.24. Since wheat products have not been commercialized in U.S., we also asked the U.S. students a question about their opinion about it. It is surprising to find that half of the respondents support production. There seems to exist a positive outlook for the commercialization of wheat in the U.S. Due to the large importing amount of GM products in China, we also collect the opinion on importing GM products for the Chinese students. About 85% respondents from China think the importing behavior have some effect on them, but only 11% of them believe the effect is huge.

2.3.2. Consumer Preferences for Attributes toward GM breakfast products

In the later part of the survey, we implemented a choice experiment in order to assess college students' attitudes toward the different attributes of GM breakfast food products. We used cereal and toast as target products for the U.S students, while used porridge and buns for Chinese students, which are most common breakfasts for college students in these two countries. The respondents could choose one of the products and answer the following questions with different attributes based on the product they have chosen.

The core section of the survey consisted of a discrete-choice experiment, following standard procedures (Louviere et al., 2000; Street and Burgess, 2007). Choice experiment has been widely used as a tool for making probabilistic determinations about human decision making in which the survey respondents were asked to choose from sets of alternative product descriptions and asked to select the one they would purchase. In the choice experiment, participants were given instructions to consider themselves in a situation in which they were in the markets and needed to make a shopping choice. One of the advantages of a choice experiment, in contrast to traditional yes/no polling type questions, is that it yields quantitative measures of the tradeoff between attributes of interest.

Specifically, in each of the 12 scenarios, each student was asked to select between two different breakfast products and the 'Prefer to Choose' option. In each scenario, they were asked to make a choice between two different breakfast products. Each product included seven different key attributes. These included different prices, whether they are GM, and if they are more nutritious, etc. Each of these seven attributes was varied according to their respective two different levels summarized in Table 3. The choice scenarios were generated using NGENE 1.1.1 software, pretested, and revised to create an efficient experimental design (an example choice scenario is presented in Figure 1). As previously stated, the scenarios were individually presented.

2.3.3. Mixed Logit model

To analyze the consumers' choice, one recognized framework is a mixed logit model (MXL) with random and correlated coefficients. This approach has become increasingly standard in choice experiment research for estimating consumers' willingness to pay for certain attributes. It was proposed by Revelt and Train (1998), and it reveals the unobserved heterogeneity in consumer choices through a more general specification of the unknown utilities defined on the entire sample of consumers. The model is a good approximation to the economic principle of utility maximization (Train, 2009). This method relaxes the assumption that all respondents have the same preferences for some breakfast product attributes by allowing for random taste variation among individuals. Thus, it supports consideration of a correlated distribution of taste parameters.

In this study, the model can be expressed and estimated as follows. Survey respondents $i (i = 1, \cdots, N; N = 252)$ are faced with 12 choice scenarios $(t = 1, \cdots, T; T = 12)$ among different breakfast products. At each scenario, the student consumer was presented with a set of alternatives. Each choice set consists of three elements: two breakfast products and the 'Prefer to Choose' option. In total, there are 25 alternatives, indexed by $j (j = 1, \cdots, J; J = 25)$, including 24 breakfast products and the one 'Prefer to Choose' option. The Train model assumes that an individual i obtains a certain level of utility (U_{ijt}) from choosing product j in choice scenario t. Random utility theory postulates that consumers have latent preferences or utilities that comprise the sum of observable components (explainable) and random components (not explainable). Assuming the utility is linear in parameters, the individual i' utility function from alternative j in choice scenario t is defined by a deterministic component $x_{ijt}\beta$ and a stochastic component $\varepsilon_{i\,jt}$:

$$U_{i\,jt} = x_{ijt}\beta + \varepsilon_{ijt} \tag{2.1}$$

Where x_{ijt} is a vector representing the attributes of alternative j in choice scenario t and β is a vector of unknown parameters. The elements of vector x_{ijt} are described in Table 4. The error term is assumed to be independent and identically distributed over individuals, alternatives, and choice scenarios.

Using equation (2.1), we estimate six models, which include estimation using total data of U.S. and China, as well as their subsamples which group by students who chose different products as their experimental product.

The probability of individual i choosing alternative j in choice scenario t is expressed as:

$$P_{ijt} = \Pr ob(U_{ijt} > U_{ikt} \forall j \neq k)$$

$$= \Pr ob(x_{ijt}\beta + \varepsilon_{ijt} > x_{ikt}\beta + \varepsilon_{ikt} \forall j \neq k) \tag{2.2}$$

The probability is attained from utility maximization of the formula of the conditional logit model:

$$P_{ijt} = \frac{\exp(x_{ijt}\beta)}{\sum_{k=1}^{J} \exp(x_{ikt}\beta)} \tag{2.3}$$

Letting $y_i = y_{i1}, \cdots, y_{iT}$ denote individual consumer $i's$ sequence of choices, conditional on $\beta = \{\beta_{0,i}, \cdots, \beta_{N,i}\}$. Given the independent error structure, the probability of $i's$ sequence of choices is equal to

$$L(y_i|\beta) = \prod_{t=1}^{T} \frac{\exp(x_{ijt}\beta)}{\sum_{k=1}^{J} \exp(x_{ikt}\beta)} \tag{2.4}$$

which corresponds to a product of logits. The unconditional probability of individual *i's* sequence of choices is the integral of the expression $L(y_i|\beta)$ over β.

Note that preference heterogeneity can be incorporated in this model by assuming that the vector of unknown parameters is random instead of fixed. Specifically, coefficients in vector β are defined as random variables following density function f:

$$\beta \sim h(\theta + \upsilon, \Omega) \tag{2.5}$$

Where h is a probability distribution function, θ is the mean vector value of the distribution, v is an *i.i.d* error term vector, and Ω is a parameter covariance matrix. Given this specification, the choice probability can be written as:

$$P_{ijt} = \int \frac{\exp(x_{ijt}\beta)}{\sum_{k=1}^{J} \exp(x_{ikt}\beta)} h(\beta) d\beta \quad (2.6)$$

The unconditional probability of individual *i's* sequence of choices is the integral of the expression $L(y_i|\beta)$ over β, which is expressed as:

$$L(y_i|\beta) = \int L(y_i|\beta) f(\beta) d\beta \quad (2.7)$$

Where $f(\beta)$ is the multivariate distribution of the parameters. Summing the logarithm of the unconditional probabilities gives the log-likelihood function,

$$\sum_i \ln L(y_i|\beta) . \quad (2.8)$$

The normal distribution, having support on both the negative and positive range, implies that some consumers like and some consumers dislike the considered attributes. Following Louviere, Hensher and Swait (2000), with a fixed price coefficient, the willingness to pay is equal to the ratio of the attribute's coefficient to the price coefficient. For example, $-\beta_{Non-GM} / \beta_{\mathrm{Price}}$ is the additional WTP for one breakfast product with non-GM ingredients compared with an otherwise equivalent product with GM ingredients. In addition, with a fixed price coefficient, the distribution of WTP corresponds to the scaled distribution of the attribute's coefficient. The mean and variance of WTP estimated under MXL models were calculated using the simulation approach with 200 iterations. The WTP measures follow similar interpretation of the partworth utilities but they offer dollar values or RMB values for various attributes.

Such a model displayed in equation (6) does not have a closed form and as a result cannot be estimated by a conventional maximum likelihood method. Train (2009) described a simulated maximum likelihood approach that approximates the likelihood function. In this study, we estimate our mixed logit model with random and correlated coefficients using statistical package STATA 13, which estimate the mixed logit model using simulated maximum likelihood. The explanatory variables included the factors representing the attributes obtained from the discrete choice experiment.

2.4. Results

Because consumers in these two countries may differ in culture, experiences and other unmeasured features, it is possible that these consumer groups differ in their food product preferences. Table 5 displays the results of the MXL models for each of the two sample categories: the U.S. respondents and the Chinese respondents.

In each of the two models reported in Table 5, the signs of the coefficient estimates fall in line with expectations and the majority of the attributes are statistically significant at the 1% level. The price coefficient is negative and statistically different from zero, which is consistent with expectations that college students prefer, holding all other factors constant, breakfast products with lower price. With regard to the non-GM attribute, in each of the two models the coefficient is found to be positive and statistically different from zero. This implies that students in both countries prefer non-GM products and are willing to pay a premium for this attribute. This corresponds with the perception that people worry there might be some uncertainty in GM food products. Additionally, the variance coefficient for non-GM is found to be significant and sizeable, indicating that consumers are heterogeneous in their preferences for non-GM products.

For the enhanced nutrition benefit, only the coefficient of the U.S. students group is significant and positive. The Chinese student respondents apparently do not think that paying more for additional nutrition is necessary. Similarly, U.S. brand and raw ingredients from U.S. are only significant in the U.S. group. The origin of brand and raw ingredients from U.S. were not preferred by the Chinese students.

For the products with food quality certification approved by a Chinese agency, respondents from the U.S. do not particularly value it. Only Chinese respondents prefer this attribute. However, the foods quality certification approved by a U.S. agency are valued by students from both countries. This shows that, in general, consumers have trust in the institutions, and thus they may perceive more clear benefits in GM foods with certain certification. Moreover, the coefficient for 30% less pesticide or herbicide use is positive and significant. This shows that students from both countries prefer less pesticide usage. In both models, the "prefer to choose" alternative in each choice situation had a negative part-worth utility. The "prefer to choose" alternative plays the role of a ‘status quo’ option, which is characterized by the absence of all attributes used to generate the product profiles. In other words, this negative significant coefficient of "prefer to choose" refer to that the students prefer to choose from the two existing option in each choice situation.

While the signs of the coefficient estimates correspond with expectations, for how much the students are willingness to pay for the premium, we computed their willingness to pay. We computed WTP for students groups choosing different products as their target product within each country first. The results are displayed in Table 6 (U.S.) and Table 7

(China). The two models within each country exhibit high consistency in terms of significance and signs of coefficients. Also, the results of the t test of WTP for each attribute indicate that no significant differences of the WTP value were observed for each attribute when selecting cereal and bread ($p > 0.1$). Our results suggested that there was no difference in response between consumers choosing different breakfast product within each country, and thus we pool the two groups and estimate a single model within each country.

Table 8 provides estimates of the consumers' willingness to pay (WTP) of the students from both countries for breakfast product with different attributes calculated using the coefficient estimates from the mixed logit models.

Note that we use the U.S. Dollar and Chinese Yuan as monetary units in U.S. and China, respectively. To interpret the importance of WTP for breakfast products with different benefits, the premium should be compared with the "currently" available market prices for these products in U.S. and China, as we selected in the choice model (Hensher & Greene, 2003). The "currently" market prices are $2.8 for U.S. plain cereal and toast and 1.0 RMB for Chinese plain porridge and bun. The WTP values reflect consumers' preference of certain attributes provided in all 12 scenarios; i.e., attributes about the non-GM content, more nutrition benefits and so on.

A key focus of this experiment was to evaluate the WTP for the non-GM attribute. With all else equal, U.S. college consumers are willing to pay 98.2 U.S. Cents more for one pack of cereal or one loaf of toast with non-GM content. For the Chinese students, our experimental results suggest that consumers are willing to pay modestly higher prices for breakfast identified as non-GM. The estimated WTP for this attribute was about 1.1 RMB (about 2 U.S. cents) per bun or porridge. Similarly, U.S. college students are willing to pay a premium for U.S. certification and for 30 percent less pesticide or herbicide use of 1.13 USD and 60 cents, respectively. The other attributes for which Chinese college consumers would pay a premium are U.S. and China certification, with premiums of 1 RMB and 1.5 RMB, respectively. It is, perhaps, surprising that they would pay higher for the China agency certification. This may be attributed to the fact that it is difficult for them to validate the U.S. certification agency.

Because these attributes were independently displayed in the experiment, and there were no significant interaction effects for these attributes, these WTP values are additive. Thus, we can calculate what consumers are willing to pay for certain mixed additive attributes. For example, with attributes GM and more nutrition, U.S. students would pay a discount of 57 Cents USD. In this study, the benefit perceptions of applying gene technology to produce food products are seen as outweighing risk perceptions of that application.

2.5. Conclusions and Policy Discussion

Public perceptions and attitudes to the introduction of emerging technologies have long been recognized as important factors in determining the likelihood of consumer support and prospective success in product development. Now there is concern about the extent to which consumers will accept genetically modified (GM) staple foods if they are commercialized in the U.S. and China. In this article, we described choice-modeling experiments to determine willingness to pay of college student consumers from the U.S. and China regarding breakfast foods with GM and other attributes related with consumer benefits when the consumers are placed in an online purchasing situation. This is the first study that uses online survey results of college students within U.S. and China. Our analysis of data predicts that food products made of genetically modified ingredients have a place in supermarkets in these two counties.

The results suggest that consumers from different countries have different concerns and interests towards GM food products. The U.S. students group value almost every attribute with a premium, except for the food with quality certification in China. They are prepared to pay a premium of about one dollar for the non-GM attributes compared with GM products. The Chinese students are more concerned with GM food and pesticide or herbicide use. Their willingness to buy non-GM is quite high, which is about one Dollar in U.S. and one RMB in China. Our results also support the notion that Chinese consumers are willing to support the staple GM food if they have the quality certification from the regulatory institutions.

Based on the findings of this study and given that our sample is college students, we conclude that the commercialization of GM foods is not likely to receive great resistance from the consumers in China and U.S., though the people would pay a premium for the non-GM attribute. Our results did not verify the findings of other studies that Chinese consumers are willing to pay a very high premium for GM foods (Wang, 2003; Zhang, 2002). In fact, foods emphasizing their selling point by labeling as non-GM foods are indeed more expensive than GM foods in these two countries. These survey results suggest the governments and the GM food marketers have an opportunity to make extra efforts for the public to understand the benefits or usefulness from applying gene technology to produce food products, thus increasing the public's acceptance of GM foods. The food industry could highlight the benefits, such as labelling non-GM, a decrease in the amount of pesticides applied to crops or increased nutritional values, brought by the added GM ingredients.

The results obtained contribute to the knowledge of the food market, particularly of genetically modified foods, when identifying consumers' preferences. Based on these findings, food producers and marketers can develop specific marketing mixes according to the needs of the consumers to increase profit. For example, the GM technology primarily focused on insect and disease resistance should be continued: it will assist U.S. and China improve its food safety and will meet consumers’ demand for less pesticide residuals in food.

Providing such a framework is also important for policy development, decision making, and risk communication about GM. Because trust in the regulatory institutions of certification of the quality of food exerts a strong effect on the benefit perceptions, governments should take the responsibility of monitoring the proper functioning of the safety mechanism in producing GM foods so as to gain trust from the consuming public. Moreover, governments should increase transparency in formulating fair laws and communicate more frequently and effectively with consumers. Adequate regulations, constant monitoring, and intensive research are essential to avoiding possible harmful effects from GM food technology.

Table 2.1. GMO Consumer Sample Characteristics, Demographic, 2013

		U.S.(n=130)		China (n=122)		Total(n=252)	
Variable	**Variable Definition**	**Count**	**% of sample**	**Count**	**% of sample**	**Count**	**% of sample**
Age	Years of Age	25.28	5.85	21.74	1.89	23.57	4.74
Gender	1 if Male	58	44.62	41	33.61	99	39.29
	2 if Female	72	55.38	81	66.39	153	60.71
Major	1 if Visual and Performing Arts-related	2	1.54	16	13.11	18	7.14
	2 if Science and Math	36	27.69	12	9.84	48	19.05
	3 if Business	34	26.15	78	63.93	112	44.44
	4 if Engineering & Technology	8	6.15	11	9.02	19	7.54
	5 if Language, Literature & Social Science	50	38.46	5	4.10	55	21.83
Grad	1 if Undergraduate students	51	39.23	79	64.75	130	51.59
	2 if Graduate students	79	60.77	43	35.25	122	48.41
Religion	1 if Christianity	60	46.15	2	1.64	62	24.60
	2 if Buddhism	2	1.54	11	9.02	13	5.16
	3 if Hinduism	2	1.54	0	0.00	2	0.79
	4 if Islam	0	0.00	3	2.46	3	1.19
	5 if Judaism	3	2.31	0	0.00	3	1.19
	6 if no religion	57	43.85	103	84.43	160	63.49
	7 if other	6	4.62	3	2.46	9	3.57
Income	1 if parents' income is $0-$25,000	19	14.62	34	27.87	53	21.03
	2 if $25,001-$50,000	26	20.00	32	26.23	58	23.02
	3 if $50,001-$75,000	17	13.08	14	11.48	31	12.30
	4 if $75,001-$100,000	21	16.15	10	8.20	31	12.30
	5 if $100,001-$125,000	17	13.08	16	13.11	33	13.10
	6 if $125,001-$150,000	9	6.92	4	3.28	13	5.16
	7 if $150,001-$175,000	4	3.08	2	1.64	6	2.38
	8 if $175,001-$200,000	5	3.85	3	2.46	8	3.17
	9 if $200,000+	12	9.23	7	5.74	19	7.54
Exercise	1 if never	9	6.92	13	10.66	22	8.73
	2 if 1-2 times a week	51	39.23	87	71.31	138	54.76
	3 if 3-5 times a week	51	39.23	16	13.11	67	26.59
	4 if almost every day	19	14.62	6	4.92	25	9.92
Vitamin	1 if never	60	46.15	76	62.30	136	53.97
	2 if 0-2 times a week	23	17.69	37	30.33	60	23.81
	3 if 3-5 times a week	17	13.08	4	3.28	21	8.33
	4 if almost every day	30	23.08	5	4.10	35	13.89

Table 2.2. GMO Survey Sample Characteristics, Attitude, 2013

Variable	Variable Definition	U.S.(n=130) Count	U.S.(n=130) % of sample	China (n=122) Count	China (n=122) % of sample	Total(n=252) Count	Total(n=252) % of sample
Heard	**1 if yes**	122	93.85%	117	95.90%	239	94.84%
	2 if not sure	6	4.62%	3	2.46%	9	3.57%
	3 if no	2	1.54%	2	1.64%	4	1.59%
Attitude	**1 if GM foods are beneficial**	23	17.69%	15	12.30%	38	15.08%
	2 if GM foods are harmful	39	30.00%	19	15.57%	58	23.02%
	3 if GM foods are neither	27	20.77%	10	8.20%	37	14.68%
	4 if do not know	41	31.54%	78	63.93%	119	47.22%
Benefit	**1 if producers benefit more**	74	56.92%	75	61.48%	149	59.13%
	2 if consumers benefit more	6	4.62%	3	2.46%	9	3.57%
	3 if both benefit	42	32.31%	42	34.43%	84	33.33%
	4 if neither benefit	8	6.15%	2	1.64%	10	3.97%
Label	**1 if not necessary manda-tory**	11	8.46%	2	1.64%	13	5.16%
	2 if should mandatory	43	33.08%	116	95.08%	159	63.10%
	3 if not sure	76	58.46%	4	3.28%	80	31.75%
Environment	**1 if bad effects**	45	34.62%	14	11.48%	59	23.41%
	2 if good effects	11	8.46%	20	16.39%	31	12.30%
	3 if neither	9	6.92%	5	4.10%	14	5.56%
	4 if both	65	50%	83	68.03%	148	58.73%
Necessary	**0 if unnecessary** **10 if very necessary**	4.72		4.24		4.97	
Risk	**0 if no risk** **10 if huge risk**	4.64		5.52		5.06	
Wheat	**1 if support commercialization**	72	55.38%				
	2 if not support	58	44.62%				
Import effect	**1 if no effect**			4	3.28%		
	2 if some effect			104	85.25%		
	3 if huge effect			14	11.48%		

Table 2.3. GM grain breakfast attributes and levels in the choice experiment

GM grain breakfast good attributes	Attribute levels
Price	$4 (￥1.5)
	$2.8(￥1.0)
Genetic Modification	Non-GM
	GM
Additional Nutritional Benefits	Yes
	No
Brand	A U.S. brand name company
	A Chinese brand name company
Raw material Origin	US
	China
Food Quality Certification	US
	China
	None
Pesticide/Herbicide Use	30% less than current level
	current level

Table 2.4. Variables used in the analysis

Variable	Variable definition
GM	1 if Non-GM
Nutri	1 if contain more nutrition
Brand	1 if it is a U.S. brand
Raw	1 if raw material from U.S.
CertUS	1 if certified in U.S.
CertChina	1 if certified in China
Herbi	1 if 30% less Persitcide/Herbicide use
Prefer	1 if Prefer to 'Choose'

Table 2.5. Breakfast Product Attribute Preferences: Mixed logit Estimates

Variable	U.S (n=130)		China (n=122)	
	Mean Coef.	St.dev. Coef.	Mean Coef.	St.dev. Coef.
Price	-1.188***		-0.652***	
	(0.129)		(0.243)	
Non-GM	0.965***	1.549***	1.025***	1.529***
	(0.204)	(0.163)	(0.174)	(0.147)
Nutrition	0.452**	0.589***	0.190	0.819***
	(0.154)	(0.181)	(0.141)	(0.131)
U.S. Brand	0.577***	0.512***	-0.179	0.008
	(0.158)	(0.165)	(0.139)	(0.149)
U.S. Raw material	0.738***	0.661***	-0.026	0.119
	(0.150)	(0.149)	(0.124)	(0.122)
China Certification	-0.171	0.501**	0.825***	0.689**
	(0.265)	(0.226)	(0.279)	(0.346)
U.S. Certification	1.208***	1.702***	0.827***	0.740***
	(0.247)	(0.236)	(0.193)	(0.148)
30% Less Pesticide	0.755***	0.685***	0.580***	0.847***
	(0.152)	(0.125)	(0.134)	(0.102)
Prefer to Choose	-4.950***	3.050***	-2.868***	2.909***
	(0.838)	(0.249)	(0.738)	(0.264)
Log-Likelihood	-960.276		-1035.736	
Log-Likelihood Ratio	799.21		594.53	
Observations	4680		4392	

Note: Standard Deviations in parenthesis. * , ** , and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 2.6. GM Product Preferences: Mixed logit Estimates of the U.S. Students

Variable	US Cereal (n=94)			U.S Bread (n=36)			WTP
	Mean Coef.	St.dev. Coef.	WTP	Mean Coef.	St.dev. Coef.	WTP	Diff p-value
Price	-1.035***			-1.671***			
	(0.143)			(0.285)			
Non-Genetic	0.835***	1.527***	$1.957***	1.095***	1.559***	$1.354**	0.215
Modification	(0.227)	(0.180)	(0.260)	(0.072)	(0.293)	(0.631)	
Additional	0.351**	0.826***	$0.491**	0.776**	0.186***	$0.424**	0.515
Nutritional Benefits	(0.187)	(0.178)	(0.195)	(0.341)	(0.017)	(0.171)	
U.S. Brand	0.522***	0.484***	$0.544***	0.854**	0.514**	$0.581***	0.308
	(0.183)	(0.144)	(0.182)	(0.351)	(0.283)	(0.191)	
Raw material	0.920***	0.177***	$0.749***	0.691**	0.722**	$0.814***	0.175
Origin from U.S.	(0.168)	(0.073)	(0.275)	(0.327)	(0.314)	(0.125)	
Food Quality Certi-	1.262***	1.197***	$1.209***	1.196***	3.975***	$1.715***	0.494
fication from U.S.	(0.296)	(0.577)	(0.232)	(0.625)	(0.757)	(0.116)	
Food Quality Certi-	0.069	1.678**	$0.266	1.730	2.414***	$0.335**	0.283
fication from China	(0.362)	(0.267)	(0.371)	(0.612)	(0.440)	(0.156)	
30% less Pesticide	0.574***	0.743***	$0.875**	1.403***	0.538**	$0.589***	0.590
/Herbicide Use	(0.171)	(0.12)	(0.132)	(0.341)	(0.275)	(0.133)	
Prefer to Choose	-4.252***	4.268***	$-4.107***	-5.842***	3.257***	$-5.303***	0.3623
	(0.945)	(0.523)	(1.267)	(0.572)	(0.784)	(0.331)	
Log-Likelihood	-715.73			-232.139			
Log-Likelihood Ratio	597.73			206.19			
Observations	3384			1296			

Note: Bootstrapped Standard Errors in parenthesis. * , ** , and *** denote significance at the 10%, 5%, and 1% levels, respectively. WTP Diff. presents the p-value for a t-test comparing the WTP between the students who chose Cereal and Bread, respectively.

Table 2.7. GM Product Preferences: Mixed logit Estimates of Chinese Students

Variable	China Cereal (n=91) Mean Coef.	St.dev. Coef.	WTP	China Bread (n=31) Mean Coef.	St.dev. Coef.	WTP	WTP Diff p-value
Price	-0.616***			-0.692***			
	(0.283)			(0.105)			
Non-Genetic	0.849***	1.632***	￥1.179*	1.735***	1.470***	￥1.131*	0.715
Modification	(0.192)	(0.196)	(0.427)	(0.253)	(0.261)	(0.637)	
Additional	0.212	0.766***	￥0.344	0.297	0.855**	￥0.392	0.747
Nutritional Benefits	(0.166)	(0.142)	(0.727)	(0.275)	(0.231)	(0.667)	
U.S. Brand	-0.194	0.288	￥-0.014	-0.151	0.065	￥-0.054	0.712
	(0.165)	(0.146)	(0.597)	(0.270)	(0.181)	(0.088)	
Raw material	-0.007	0.239	￥0.211	0.098	0.270	￥0.266	0.646
Origin from U.S.	(0.145)	(0.174)	(0.556)	(0.241)	(0.200)	(0.626)	
Food Quality Certi-	0.946***	0.709***	￥1.037*	0.535***	0.827***	￥1.204*	0.190
fication from U.S.	(0.228)	(0.165)	(0.386)	(0.062)	(0.190)	(0.675)	
Food Quality Certi-	0.882***	0.720***	￥1.433*	0.833	0.667	￥1.497*	0.676
fication from China	(0.140)	(0.297)	(0.525)	(0.552)	(0.621)	(0.763)	
30% less Pesticide	0.681***	0.862***	￥1.069**	0.512***	0.824***	￥1.005**	0.581
/Herbicide Use	(0.162)	(0.137)	(0.264)	(0.155)	(0.191)	(0.232)	
None	-3.050***	3.375***	￥-7.530	-2.581***	2.288***	￥-7.070	0.875
	(0.910)	(0.527)	(12.098)	(0.331)	(0.646)	(18.596)	
Log-Likelihood	-754.688			-274.182			
Log-Likelihood Ratio	475.80			125.64			
Observations	3276			1116			

Note: Bootstrapped Standard Errors in parenthesis. * , ** , and *** denote significance at the 10%, 5%, and 1% levels, respectively. WTP Diff. presents the p-value for a t-test comparing the WTP between the students who chose Cereal and Bread, respectively.

Table 2.8. Willingness to Pay for GM Enhanced breakfast product

Variable	U.S. Total (n=130)	China Total (n=122)
Non-GM	$0.982***	￥1.147*
	(0.385)	(0.644)
Nutrition	$0.414	￥0.356
	(0.261)	(0.297)
U.S. Brand	$0.573***	￥-0.023
	(0.285)	(0.147)
U.S. Raw material	$0.728**	￥0.224
	(0.310)	(0.185)
U.S. Certification	$1.133**	￥1.048*
	(0.518)	(0.564)
China Certification	$0.301	￥1.467*
	(0.463)	(0.789)
30% Less Pesticide	$0.584**	￥1.045**
	(0.295)	(0.513)
Prefer to Choose	$-4.419***	￥-7.150
	(0.987)	(15.245)

Note: Bootstrapped Standard Errors in parenthesis. * , ** , and *** denote significance at the 10%, 5%, and 1% levels, respectively.

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Scenario 1: **Based on the bundle of characteristics shown: Which of the following two cereals would you purchase?**

Product A

Product B

Characteristics	***Product A***	***Product B***
Price	*$4*	*$2.8*
Genetic Modification	*GM*	*Non-GM*
Additional Nutritional Benefits improved with Vitamin, Protein and Essential Mineral	*Yes*	*No*
Brand	*A Chinese Brand Name Company*	*A U.S. Brand Name Company*
Country Where Raw Ingredients Originate from	*China*	*U.S.*
Food Quality Certification Approved by Country Agency	*U.S.*	*None*
Pesticide/Herbicide use	*Grown using current Pesticide/Herbicide practices*	*30% less use of current Pesticide/Herbicide practices*

I would purchase

- Product A
- Product B
- Neither of the two options above

Figure 2.1. Example of Choice Set (English Version)

CHAPTER 3

AN INTERVENTION ANALYSIS ON THE RELATIONSHIP BETWEEN FUTURES PRICES OF NON-GM AND GM CONTRACT SOYBEANS IN CHINA[2]

[2] Wang, N. and J. E. Houston. 2015. To be submitted to *Journal of Business and Economic Policy.*

Abstract

China adopted a mandatory labeling policy of Genetically Modified (GM) food products in 2002. The strategy of separating trading was intended by Chinese regulators to protect domestic non-GMO production, provide non-GM soybean growers a higher selling price, and facilitate marketing. On December 22, 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.

Parcell (2001) defines the difference between the prices of non-GM and GM soybean futures contract 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 for non-GM soybeans in each sub-period. We investigate the impacts of 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 change from the DCE for the soybean futures contract did affect the price premium between the GM and non-GM soybean futures contracts. Hence, there appeared to be informational efficiency in the market. It is also found the law issue has permanently increased the price premium for non-GM soybeans. 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

3.1. 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 non-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 react 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. This is the first study to identify the market linkage between the IP (GM) futures market and the non-IP (non-GM) soybean market of the same commodity in China. Hence, the results of this study are expected to provide a valuable resource to participants in the GM soybean futures market and will be helpful when new markets for other GM products are developed in China.

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.

3.2. Literature Review

Intervention methodology was developed by financial economists to assess the performance of securities markets. Numerous studies have used daily data to examine the impact of particular types of events on futures prices. 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. Christiansen and Ranaldo (2007) analyzed the impact of macroeconomic announcements on realized variance and correlation of bond and stock returns and showed that macroeconomic announcements have a significant impact on realized stock-bond correlation. Similarly, Thomakos *et al*. (2008) analyzed the effects of macroeconomic announcements on returns volatilities, covariances 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. Bullock and Parcell (2002) provide an overview of the development of the Tokyo Grain Exchange non-GM soybean contract as an identity preserved futures contract. Aruga (2011) examines how efficiently the price premium for non-GM soybeans at the TGE react to an announcement to change the contract unit, suppliers, and expiration date on the conventional soybean futures contract. The results reveal that prices of the two soybean futures markets did not respond quickly to the announcement and there was an informational inefficiency after the announcement occurred.

To date, however, there is little published on the workings of GM soybean futures markets in China, and even less published literature on the statistical characteristics of prices. Wang (2003) studied the efficiency of the Chinese wheat and soybeans futures markets and assessed the conditions in agricultural commodity futures and cash 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. Zhao *et al*. (2010) assessed the impacts of the global financial crisis in 2008 on soybean markets. They split the sample into two sub-periods, defining September 15th, 2008, as the break point. Their results show that, after September 2008, the magnitude of the VECM coefficients have considerably changed, including the error correction terms, whose estimated parameters increased compared to the prior period. He and Wang (2011) provided empirical evidence of Chinese soybean futures markets behavior, their result showing that GM soybeans only take a small percentage in the whole market share, and it is completely distinct from the non-GM soybean market. 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.

3.3. Data

The data are obtained from the Datastream 5.1 provided by Thomson Reuters. The price unit is provided in Chinese Yen per metric tonne. 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 were 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 become 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 March 2010.

Thirdly, on February 21th, 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.

3.4. 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:

$$\mathrm{Pr}\,eemium_t = \alpha + \gamma(t) + \sum_{i=1}^{\infty} \beta_i \,\mathrm{Pr}\,emium_{t-j} + \sum_{j=0}^{\infty} \varphi_j \varepsilon_{t-j} + \omega EVENT_t \qquad (3.1)$$

where $\mathrm{Pr}\,emium_t$ is the $\mathrm{Pr}\,emium$ 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:

$$B(L)\,Premium_t = \alpha + \gamma(t) + \Gamma(L)\varepsilon_t + \omega EVENT_t \tag{3.2}$$

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 12 were utilized to determine the appropriate number of lags for the unit root test (Campbell and Perron 1991; 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 non-significant statistics, which implies the absence of the ARCH effect.

3.5. Results

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

$$\text{Pr}\,emium_t = \alpha + \gamma(t) + \sum_{i=1}^{2} \beta_i \,\text{Pr}\,emium_{t-i} + \sum_{j=0}^{1} \varphi_j \varepsilon_{t-j} + \omega EVENT \qquad (3.3)$$

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:

$$LRE = \frac{\omega}{(1-\beta_1-\beta_2)} \tag{3.4}$$

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:

$$(1-\beta_1 L-\beta_2 L^2)\,\mathrm{Pr}emium_t = \omega EVENT_t + \sum_{j=0}^{2}\varphi_j \varepsilon_{t-j} \tag{3.5}$$

and

$$\mathrm{Pr}emium_t = \frac{1}{(1-\beta_1 L-\beta_2 L^2)}(\omega EVENT_t + \sum_{j=0}^{2}\varphi_j \varepsilon_{t-j}) \tag{3.6}$$

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.

$$\Pr emium_t = \omega \sum_{i=0}^{\infty} \lambda_1^i \sum_{i=0}^{\infty} \lambda_2^i EVENT_{t-1} + \sum_{i=0}^{\infty} \lambda_1^i \sum_{i=0}^{\infty} \lambda_2^i \sum_{j=0}^{2} \varphi_j \varepsilon_{t-j} \tag{3.7}$$

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:

$$\frac{d \Pr emium_{t+i}}{dEVENT_t} = \omega(1+\lambda_1+\lambda_1^2+\cdots+\lambda_1^i)(1+\lambda_2+\lambda_2^2+\cdots+\lambda_2^i) \tag{3.8}$$

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

$$LRE = \frac{\omega}{(1-\lambda_1)(1-\lambda_2)} = \frac{\omega}{(1-\beta_1-\beta_2)} \tag{3.9}$$

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:

$$\frac{d \Pr emium_{t+3}}{dEVENT_t} = \omega(1+\lambda_1+\lambda_1^2+\lambda_1^3)(1+\lambda_2+\lambda_2^2+\lambda_2^3) \tag{3.10}$$

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 $\Pr emium_{t+2}$, $\Pr emium_{t+1}$ and $\Pr emium_t$, 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.

3.6. 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 a stronger interest in participating in Chinese futures trading as a 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 3.1. 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 3.2. 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: Datastream 5.1

Table 3.3. 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	44.352[a]	54.505[a]	56.292[a]	56.978[a]	56.811[a]
	(9.897)	(7.014)	(6.826)	(6.868)	(7.268)
Premiumt-1	-0.108[a]	-0.108[a]	-0.120[a]	-0.119[a]	-0.113[a]
	(0.027)	(0.030)	(0.028)	(0.028)	(0.028)
Premiumt-2	0.433[a]	0.229[a]	0.226[a]	0.227[a]	0.231[a]
	(0.018)	(0.020)	(0.019)	(0.019)	(0.020)
εt-1	0.914[a]	0.908[a]	0.919[a]	0.919[a]	0.917[a]
	(0.031)	(0.033)	(0.029)	(0.029)	(0.030)
EVENT	15.593[a]	24.218[a]	22.932[b]	20.594[a]	29.574[a]
	(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

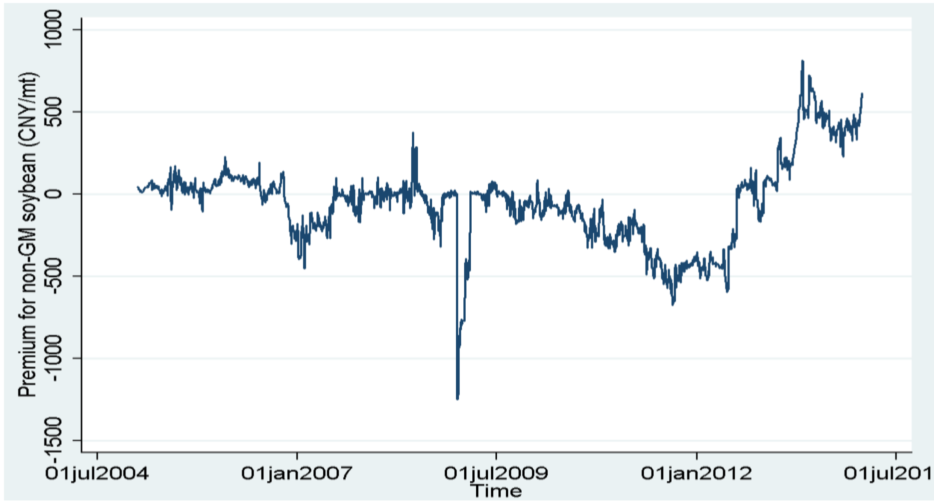
	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	-103.510[b]	-146.572[a]	-145.930[a]	-145.259[b]	-144.929[b]
	(54.639)	(62.351)	(62.590)	(62.884)	(62.992)
Crisis	6.789[a]	16.904[a]	16.849[a]	16.797[a]	16.773[a]
	(1.135)	(3.007)	(2.950)	(2.891)	(2.893)
Premiumt-1	-0.403[a]	-0.450[a]	-0.449[a]	-0.450[a]	-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	-53.786[c]	-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)

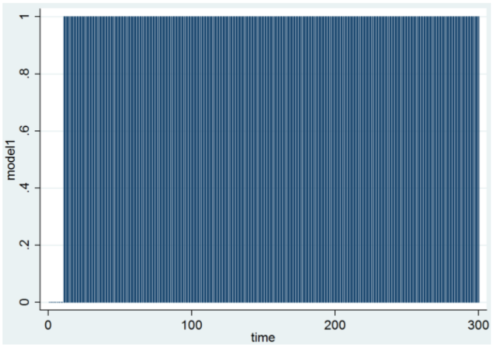
Premiumt-1	0.752 [a]	0.756 [a]	0.760 [a]	0.760 [a]	0.759 [a]
	(0.187)	(0.180)	(0.177)	(0.183)	(0.176)
Premiumt-2	-0.756 [a]	-0.761 [a]	-0.764 [a]	-0.765 [a]	-0.763 [a]
	(0.182)	(0.175)	(0.172)	(0.178)	(0.171)
εt-1	-0.834 [a]	-0.839 [a]	-0.842 [a]	-0.841 [a]	-0.841 [a]
	(0.166)	(0.159)	(0.156)	(0.162)	(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

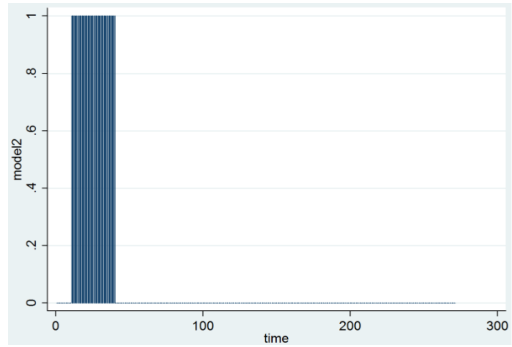


Note: The prices for the non-GM and GM soybeans are given in Chinese yen and are 1 mt of soybeans.

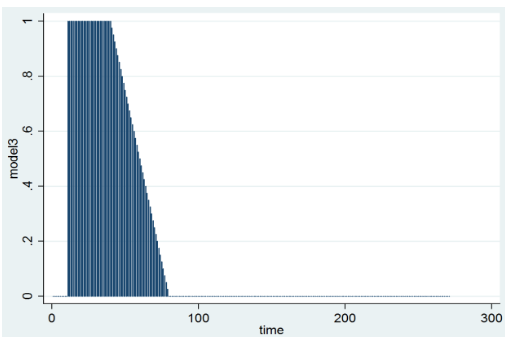
Figure 3.1. Price premium for non-GM soybeans (price difference between the non-GM and GM soybean future contract)



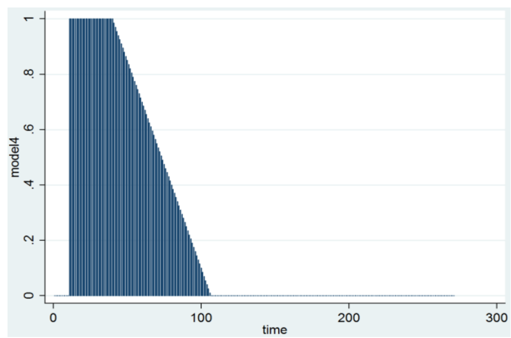
Panel A: Model 1



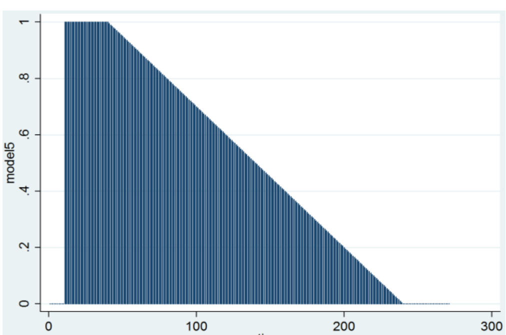
Panel B: Model 2



Panel C: Model 3

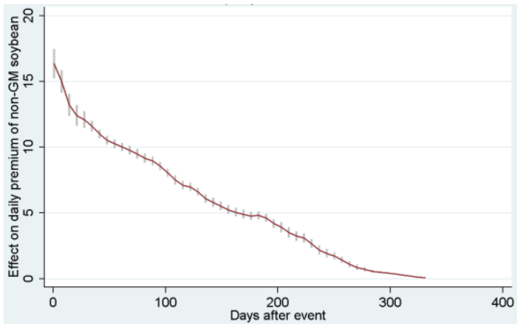


Panel D: Model 4

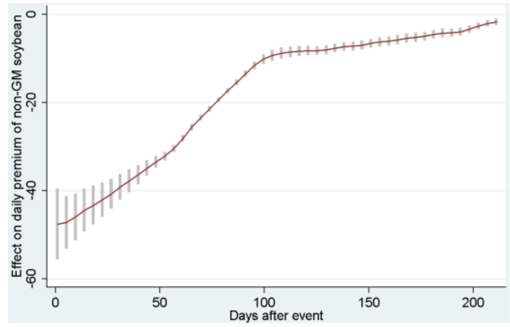


Panel D: Model 5

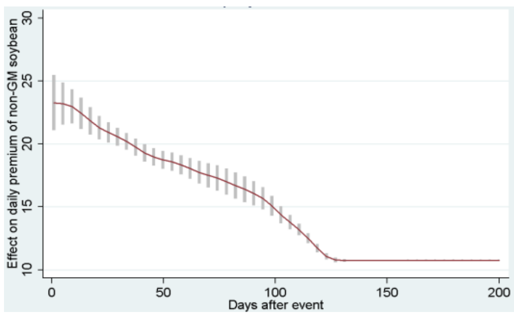
Figure 3.2. Intervention models. Panel A through E illustrate intervention functions utilized in the analysis.



Panel A



Panel B



Panel C

Figure 3.3. Impulse response function of the premium for non-GM soybean price after event in 2005 (Panel A), 2010 (Panel B) and 2012 (Panel C)

CHAPTER 4

THE COMOVEMENT BETWEEN NON-GM AND GM SOYBEAN PRICES IN CHINA: EVIDENCE FROM DALIAN FUTURES MARKET[3]

[3] Wang, N. and J. E. Houston. 2015. To be submitted to *International Journal of Business, Humanities and Technology*.

Abstract

The price variability of agricultural commodities reached record levels in 2008, and again more recently in 2010, raising concerns about this increased price volatility would be temporal or structural. The Chinese soybean futures market is the second largest in the world, after the CME group, in terms of trading volume. There are two soybean futures contracts in China: non-GM and GM. With the emergence of the GM soybean contract in 2004, the components of non-GM futures price volatility might have changed.

This study examines the volatility determinants as well as seasonality of non-GM and GM soybean futures prices traded in Dalian Commodity Exchange from 2005 to 2014. Also, we test the co-movement between these two soybeans markets. We analyze the volatility by incorporating changes in important economic variables into the Dynamic Conditional Correlation-Generalized Autoregressive Conditional Heteroskedastic (DCC-GARCH) model. This research provides statistical evidence that the futures prices of soybeans in China are being influenced by the increasing consumption of soybeans, the import quantity of soybean, the trading volume in futures market and weather. We also find spillover effect from non-GM to GM in soybean markets. A better understanding of the volatility determinants provides important additional information for various market participants, including commodity traders, hedgers, arbitrageurs, exchanges and regulatory agencies.

Keywords: China, DCC-GARCH Model, time-varying correlation, macroeconomic

4.1. Introduction

China is the world's largest producer and importer of non-GMO soybeans (Futures Industry Association, 2008). In China's domestic market, soybeans are a very significant agricultural commodity used as a major staple for human consumption, for conversion into human-consumable oil, and as an important animal feed ingredient. The price variability of agricultural commodities reached record levels in 2008, and again more recently in 2010 (Schneph, 2008), raising concerns about this increased price volatility would be temporal or structural. The Chinese soybean futures market is the second largest in the world, after the CME group, in terms of trading volume. There are two soybean futures contracts in China: non-GM and GM. Due to its dominant market share of trading volume, the non-GM contract is the representative of China's soybean markets (He and Wang, 2011). However, the introduction of the new GM contracts in 2004 presents a number of new opportunities for hedging/managing/speculating price risk, but also presents new challenges because of the difficulty of measuring expected volatility.

Volatility is a directionless measure of the extent of the variability of a price, it is a numerical measure of the risk faced by individual investors and financial institutions. The biggest drawback of volatility is the associated uncertainty of marketing production, investment in technology, innovation etc. Increasing risk would lead to inefficient resource allocation for producers, merchandisers, and speculators, it also has the potential to limit access to food in developing countries that depend on imports and have lower incomes (OECD 2011). Therefore, it's significant to study the universal volatility law of agricultural futures market. To measure expected volatility, it is very important to understand the relationship between these two soybean, their price determinants, and the underlying factors behind their price fluctuation. GM soybean is a close substitute of non-GM soybean, and therefore fluctuations in the price of GM soybean should result in corresponding fluctuations in non-GM soybean, vice versa. However, there is no literature before price volatilities of non-GM soybean and GM soybean are correlated or not. Consequently, it is important to analyze these two markets simultaneously to determine the factors behind their price volatility.

This research examines the influence of nine relevant factors on monthly soybeans futures prices. Price determinants include demand and supply factors. Macroeconomic factors affecting commodity prices have been studied in the literature. We use the industrial production index of China as a proxy of China's economic growth. Economic growth results in increased demand for goods, and therefore may generates an increase in demand for soybean. Weather plays an important role in the demand side of soybean markets. To capture the impact of weather, dummies for planting, growing, storage periods are used. On the supply side, storage levels are among the determinants of soybean prices. We use the ratio of stock and usage of soybean in China to account for this effect. Also, the production quantity of non-GM soybean in China is considered.

The estimation period covers a volatile period – the Global Financial Crisis – and it enables to assess the effect of changing economic conditions on the volatility of soybean. We made a specification with a dummy for this event. We also consider the speculative and hedging influences in China's futures market, represented by trading volume. Other variables found to affect soybean prices are included here, including crude oil price; the weighted exchange rate between China and three other major import partners, which are

U.S., Brazil and Argentina; and finally, the total import quantity of China from U.S., Brazil and Argentina is considered due to its large amount each year.

The purpose of this study is two-fold. First, we investigate the dynamic correlation across non-GM and GM soybean futures, with a focus on the persistency correlation across these two soybean futures prices traded on the Dalian Commodity Exchange. Further, Factors like percentage changes of industrial production index, trading volume, etc. are used to test whether they affect soybean price volatility. Our results can assist market participants better understanding which direction volatility in soybean go when levels of these factors change.

DCC-GARCH model is used to estimate volatility spillover effects and dynamic conditional correlation. Our study answers the following research questions: Does volatility in non-GM soybean prices have a spillover effect on the volatilities of GM soybean or vice versa? Which economic and natural factors most explain volatility in soybean markets? This study differentiates from previous studies in that it is the first to analyze the persistency of relation between non-GM and GM soybean futures prices in China.

This study can provide some knowledge of the conditions in Chinese agricultural commodity futures markets. Awareness of the origins and drivers of markets interaction help investors, consumers and regulators. It also contributes to securities pricing, portfolio optimization, developing hedging and regulatory strategies, etc. It is also in the interests of international market participants from countries like Canada, the USA, Australia and the European Union, who are the major grain exporters to China. In addition, the finding of this paper has relevant policy implications in asset allocation and risk management in designing agricultural commodity portfolios for investment decisions.

The study finds that the two soybean futures have high persistency. In addition, the study finds that the time-varying conditional correlation between non-GM and GM soybean futures is influenced by trading volume, ratio of stock and use, Chinese production and import level and the financial crisis. It also shows high volatility in the growing season.

4.2. Literature Review

In the last decade, many researchers offer contributions to finance agricultural research by explaining the volatility process. Kenyon at al. (1987) show that corn, soybeans, and wheat futures price volatility is affected by seasons, lagged volatility, and loan rates. Sørensen (2002) considers seasonal price patterns for corn, soybeans, and wheat futures, and concludes that the seasonal components for all three commodities peak about two to three months before the beginning of harvest. For the literature on how fundamentals affect volatility, it has been established that volatility is time-varying (Koekebakker and Lien 2004), highly persistent (Jin and Frechette 2004), and that, at least for grains and oilseeds, it is affected by supply and demand inflexibilities (Hennessy and Wahl 1996). Karali and Thurman (2010) investigate the determinants of daily price volatility in U.S. corn, soybeans, wheat, and oats futures markets and identify two significant factors Samuelson effect and the strong seasonality. Chen et al. (2010) found that exchange rates are very useful in forecasting future commodity prices but not vice versa. They also found positive relationship between exchange rate and international commodity prices.

More recent studies consider a time period when China had already developed its futures market and become the largest soybean importer. The results by Liu (2002) suggest that the large-volume trading is an important source of futures volatility in the Chinese soybean futures market. Chan *et al* studied China's soybean, wheat and other futures markets, and found that negative returns appear to have a greater impact on volatility than positive returns do, while volume has a positive effect on volatility (Chan et al., 2004). Hernandez (2012) found that the variability of oil spot prices, soybean imports to China, and the number of index funds are able to explain monthly soybeans future price volatility, from September 2006 to August 2011.

Many researchers apply the ARCH-family volatility model in financial market, particularly in commodity market, such as Oglend and Sikveland (2008), Huang et al. (2009). Co-movement of commodity prices received substantial attention in economic literature. For example, applying a Dynamic Conditional Correlation-Generalized Autoregressive Conditional Heteroskedastic (DCC-GARCH) analysis on a daily return series for the period 1997 to 2010, Dajcman et al. (2012) examines the co-movement dynamics between the developed European stock markets of the United Kingdom, Germany, France and Austria. The author's find that the co-movements between stock market returns are time varying and scale dependent and financial crisis in the observed period did not uniformly increase co-movement between stock market returns across all scales. However, little effort has been dedicated to the study of the joint movements among the prices of non-GM and GM soybean.

4.3. Model

The goal of GARCH models is to provide a measure of volatility. One of the earliest volatility models, autoregressive conditional heteroscedastic (ARCH), was proposed by Engle (1982), which captured the time-varying conditional variances of time series based on past information. This model was then enhanced by Bollerslev (1986) who proposed a generalized ARCH (GARCH) which took into account both past error terms and conditional variances into its variance equation simultaneously to avoid the problem that the number of parameters to be estimated becomes too large as the number of lagging periods to be considered increases in the ARCH model. It has been shown that commodity futures prices also exhibit time-varying and can be effectively studied using GARCH models (Myers and Hanson, 1993; Goodwin and Schnepf, 2000).

Bollerslev (1990) further extended the GARCH model in a multivariate sense to propose a Constant Conditional Correlation Multivariate GARCH (CCC-GARCH) model where the conditional correlation amongst different variables were assumed to be constant, this may be inconsistent with reality (Longin and Solnik, 1995, 2001). Therefore, Engle (2002) finally proposed a DCC-GARCH model where the conditional correlations amongst variables were allowed to be dynamic by including a time dependent component in the conditional correlation matrix.

The main merit of DCC-GARCH model in relation to other time varying estimation methods is that it accounts for changes in both the mean and variance of the time series. Another advantage of DCC-GARCH model is that DCC-GARCH model estimates correlation coefficients of the standardized residuals and so accounts for heteroscedasticity directly (Chiang et al., 2007). Also, DCC-GARCH has the ability to adopt a student-t distribution of variances, which is more appropriate in capturing the fat-tailed nature of the distribution of index returns (Pesaran and Pesaran, 2009). This choice allows to estimate time-varying correlations of returns with heavy tails.

The DCC-GARCH approach has been widely used in recent papers investigating notably the linkages between bond prices (Antonakakis, 2012), stock prices (Cai, Chou and

Li, 2009 or Bali and Engle, 2010), stock and bond prices (Yang, Zhou and Wang, 2009) with an extension to commodity futures (Silvennoinen and Thorp, 2013) or to commodity prices (Creti, Joets and Mignon, 2013). We adopt the bivariate DCC-GARCH model in our study and modify it to include exogenous variables that might have an impact on the conditional volatility.

We measure the monthly return from holding a futures contract on month t as

$$rt = 100 \times \left(\ln F_t - \ln F_{t-1} \right) \tag{4.1}$$

where F_t is monthly settlement price of the futures contract on the last day of month t.

Assume that soybean market returns from the two series are bivariate normally distributed with zero mean and conditional variance-covariance matrix H_t, our bivariate DCC-GARCH model can be presented as follows:

$$\begin{cases} r_t = \mu_t + \varepsilon_t \middle| I_{t-1} \rightarrow N(0, H_t) \\ H_t \equiv D_t R_t D_t + G'GX_t \end{cases} \tag{4.2}$$

Meanwhile, the returns on the soybeans is fat tailed or leptokurtic where a normal distribution assumption is not appropriate. Our remedy for this is to use a Student-t distribution setting. That is, the conditional distribution $u_t | \Omega_{t-1} \rightarrow f_{Student\text{-}t}(u_t; v)$, where v is the degree of freedom parameter.

In these formulas, r_t is the (2×1) vector of the returns on soybean prices; ε_t is a (2×1) vector of zero mean return innovations conditional on the information available at time t-1; $\mu_{i,t} = \delta_{i0} + \delta_{i1} r_{i,t-1}$ for market i; G is the (2×2) lower triangular coefficient matrix on the exogenous variable X_t; D_t is a (2×2) diagonal matrix with elements on its main diagonal being the conditional standard deviations of the returns on each market in the sample and R_t is the (2×2) conditional correlation matrix. D_t and R_t are defined as follows:

$$D_t = diag(h_{11t}^{1/2} \cdots h_{22t}^{1/2}) \tag{4.3}$$

where h_{iit} is chosen to be a univariate GARCH (1,1) process;

$$R_t = (diagQ_t)^{-1/2} Q_t (diagQ_t)^{-1/2} \tag{4.4}$$

where $Q_t = (1-\alpha-\beta)\overline{Q} + \alpha u_{t-1}u'_{t-1} + \beta Q_{t-1}$ refers to a (2×2) symmetric positive definite matrix with $u_{it} = \varepsilon_{it} / \sqrt{h_{iit}}$, $\overline{Q}$ is the (2×2) unconditional variance matrix of u_t, and α and β are non-negative scalar parameters satisfying $\alpha + \beta \prec 1$.

The DCC model is constructed to permit a two-stage estimation of H_t. During the first step, a univariate GARCH model is fitted for each of the assets and the estimates of h_{iit} are obtained. In the second step, the asset returns are transformed by their estimated deviations and used to calculate the parameters of the conditional correlation. The log-likelihood function for the DCC model can be written as follows:

$$L = -\frac{1}{2}\sum_t (k\log(2\pi) + \log|H_t| + r_t' H_t^{-1} r_t) \tag{4.5}$$

The conditional correlation coefficient ρ_{ij} between two markets i and j is then expressed by the following equation:

$$\rho = \frac{(1-\alpha-\beta)\overline{q_{ij}} + \alpha u_{i,t-1}u_{j,t-1} + \beta q_{ij,t-1}}{\left((1-\alpha-\beta)\overline{q_{ii}} + \alpha u_{i,t-1}^2 + \beta q_{ii,t-1}\right)^{1/2}\left((1-\alpha-\beta)\overline{q_{jj}} + \alpha u_{j,t-1}^2 + \beta q_{jj,t-1}\right)^{1/2}}$$

(4.6)

In this formulation, q_{ij} refers to the element located in the i th row and j th column of the symmetric positive definite matrix Q_t.

We also analyzed the data using GARCH-BEKK model. The results are consistent with the GARCH-DCC model here. The results of GARCH-BEKK model are showed in Appendix B.

4.4. Data

We study non-GM and GM futures contracts that are traded on the Dalian Commodity Exchange (DCE). Both futures contracts have expiry dates in January, March, May, July, September and November. They are traded until the 10th trading day of the delivery month. Standard contract size is 10 metric tons and price is quoted as CNY per metric ton. We construct price daily time series for both soybeans by rolling over the third nearby contracts. When the futures price moves into the maturity month, we use the futures price for the next maturity month. We then use the price of the last day of the month as the proxy for the monthly soybean price. Futures price data are obtained from Datastream 5.1 provided by Thomson Reuters. Our sample covers the period from January 2005 to January 2014.

Commodity price volatility has been attributed to a number of factors, including demand and supply factors. Also, factors such as the integration of energy markets, macroeconomic conditions, and financial speculation all have been identified as key drivers of commodity price volatility (Masters and White 2008; Mitchell 2008; Irwin et al. 2008, 2009, 2010; Tangermann 2011). The following factors are considered as potentially overriding the factors leading to volatility of soybean prices in China's market. All these variables are recorded monthly and not seasonal adjusted.

For the macroeconomic factors, industrial production index is used to represent the Chinese macro-economic environment. Further, changes in exchange rates may reallocate purchasing power and price incentives across countries without changing the overall food supply–demand balance. Here we use the weighted average of the foreign exchange value of the CNY, which is based on the value of CNY compared to the currencies of major China trading partners of soybeans, which are U.S. (Dollar), Brazil(Brazil) and Argentian (Peso). Here we include percentage changes in "Industrial production index" and "weighted average of the foreign exchange value of the CNY" in the DCC GARCH model. The data utilized is obtained from DATASTRAM, FRED and the Central Bank of Argentina.

Inventory can reduce volatility so long as stocks are accumulated in periods of excess supply and released in times of excess demand. Because the important role inventories play in stabilizing demand and supply shocks, we include inventory data in our volatility analysis. We use the percentage change of stocks-to-use ratio computed with the series of "Ending Stocks" and "Total Use" of soybean of China published in World Agricultural Supply and Demand Estimates (WASDE) reports released monthly by the World Agricultural Outlook Board of USDA. Also, since China's soybean crop has been unable to keep pace with the rapid growth of domestic consumption, imports have grown rapidly to make up for the lack of domestic supply. The increasing deficit has been replaced by imports from Argentina, Brazil, and the U.S. These countries export approximately 90 percent of the world's soybeans. More importantly, China will consume 60 percent of all exported soybeans by

2011(USDA). We use the percentage change of the summation from these three countries as the proxy from China's soybean imports. In recent years, there has been special interest regarding the relationship between energy markets and agricultural commodity prices. The integration between energy and agricultural markets is accounted for via oil spot prices. We use the percentage change of crude oil price stated in Dollars per Barrel from U.S. Energy Information Administration.

We also consider the speculative and hedging influences in China's futures market, represented by trading volume. Trading volume can be used as a proxy for information flows. Trading volume is likely to be associated with speculation, since day traders or speculators trade in and out in short periods of time, and seldom hold a position for too long. Fung and Patterson (2001) find that volume increases volatility. We use the percentage change of the total volume as the exogenous variables.

Dummy variables are used to account for the seasonal effects. We use three dummies to represent planting, growing and harvesting season. Inventory season is used as base categories and thus its impact is shown in the intercept. In general, volatility increases in the spring, peaks in the summer, and declines toward the end of a year. Yang and Brorsen (1993), Chatrath *et al*. (2002) and Adrangi and Chatrath (2003) all conform seasonality effect in futures market. The world financial crisis became prevalent on September 15, 2008 when the major investment bank Lehman Brothers announced that it will be filing for bankruptcy. This caused many ripple effects in the financial markets, causing a credit constraint for firms and consumers. This may have effect on the volatility of the commodity markets as well. For this event, our variable CRISIS takes the value of one on the dates between September 15, 2008 and June 30, 2009 and zero for the rest.

Figure 1 shows the monthly returns to the non-GM and GM soybeans, for which the correlation coefficient is 0.81. As expected, there is a positive correlation between the returns of soybean markets. The values of the unconditional correlations are somewhat high. Clearly the series show a great deal of variation. The non-GM soybean shows greater variation than GM. One may see that during the second half of year 2008, the returns exhibits high volatility, reflecting a financial crisis, after that, the correction can be seen in both markets. Table 1 presents descriptive statistics of the monthly returns and macro and economic variables employed in the empirical analysis. Table 2 shows the unit root test results for futures price series. As can be seen in the table, both the levels and the logs of futures prices in all markets contain a unit root, that is, these series are non-stationary. However, we can reject the existence of a unit root for the return series, computed as the differences of log futures prices.

4.5. Empirical Results

In estimating our DCC-GARCH model for the two soybean futures, we first experiment the model with one lag, two lags, and three lags returns in the mean equation. Conditional variance equations include ARCH, GARCH parameters as well as exogenous variables discussed earlier that might have impact on volatility. To determine the appropriate length of lags, we computed the Akaike information criterion (AIC) for each model. For both soybean contracts, the one-lag model has the smallest AIC, and hence it was selected and reported here as the appropriate model. Table 3 presents the coefficient estimates and their p-values from the DCC-GARCH model. The statistical significance in this table is not indicated by asterisks, but rather by the p-value that are in parentheses under the estimates.

Non-GM Soybean

The mean equation results show a constant return of -0.008, but it is not significant. The first lagged returns is significant with a positive coefficient. The constant conditional variance is 2.006. The ARCH parameter of 0.313 implies that positive disturbances (shocks, news) to non-GM soybean increase conditional variance by that amount. The GARCH parameter for non-GM soybean is 0.224, showing that non-GM soybean volatility in the past period has some effect on volatility in the current period and is persistent.

Conditional variance results show that the World financial Crisis resulted in an increase in non-GM soybean price volatility. This event increases the conditional variance by 1.85 percent. For the macro variables, percent changes in FX and IPI both have insignificant effects on the conditional variance of non-GM soybean returns. A reason that the weighted FX does not influence monthly soybeans futures price volatility is that the currency CNY move relatively at the same pace of the three other currencies. This IPI does have a significant effect could be the result that non-GM soybean is a daily commodity in China and the demand for soybean is not effected much by the macro-economic environment. Additionally, lagged shocks in GM market does not show significant effect on non-GM market.

For the speculation behavior, both percent change in non-GM and GM soybean total trading volume have significant effects on the conditional variance of non-GM soybean returns. For a one-percent increase in total trading volume of non-GM soybean, the conditional variance increase by 1.09 percent, while for a one-percent increase in GM soybean volume, the variance increases by 0.1 percent. The positive effect of volume (a proxy for speculative activity) is consistent with results in the literature. For the demand/supply side variables, both the percent change of stock/use ratio in China and the import quantity of China have significant effect on the variance as we expected. A one-percent change in the soybean stock/use ratio increases the variance by 4.75 percent while for a one-percent change in import quantity, the conditional variance of non-GM soybean decreases by 3.28 percent. Interestingly, the percent change of production of China is not statistically significant. This may due to the significant increase of soybean imports by China since the fourth quarter of 2006 has far exceeded the increase of the domestic production of China. The changes in percent change of crude oil price is not significant, either. This result agree with those obtained by Du et al. (2009), who concluded that there is no statistical evidence that the oil prices affect the variability of soybeans prices, but disagree with those obtained by Mitchell (2008) and Saghaian (2010). For the seasonality factors, only the dummy for growing time is found to be significant, showing higher volatility compared to other time. Thus we can tell that weather plays an important role in the non-GM soybean volatility in China.

GM Soybean

GM soybean futures have a constant return of -0.12 which is not significant. The coefficient on the first lagged return is positive. The constant conditional variance is 2.2. The ARCH parameter is 0.21 and statistically significant. The GARCH parameter is 0.21, showing a small level of persistence. Similar to non-GM soybean, the financial crisis in 2008 is found to have significant impact on the conditional variance of GM soybean futures. Due to this crisis, the GM soybean variance increased by 2.92 percent, which bigger than the increase of non-GM soybean variance. This is probably because that China produces only 20% of its soybean consumption and most soybean imports are Genetic Modified. The crisis has caused severe influences in the international commodity market, the international trade of soybean thus been affected. Among macro variables, neither FX or IPI is significant, which is the same as the results for non-GM soybean. For the speculation behavior, both the trading volume of non-GM and GM soybean have a significant positive effect on variances of GM soybean.

Different from non-GM soybean, the factor of production of China shows significant effects on variances of GM soybean. A one-percent increase in production decreases the conditional variances by 20.2 percent, while a one-percent increase in stock/use ratio and import quantity in China increase the variances by 5 percent and decrease by 2.3 percent respectively. There is a huge effect of the production quantity on the volatility of GM soybean, which we can conclude the price of the imported product largely depend on the production power of the domestic product. Interestingly, the crude oil price is not statistically significant. Same as non-GM soybean, for the seasonal effect, only the growing season has significant negative effect on conditional variance. Additionally, the lagged shock of non-GM market is found to increase the conditional variance of GM soybean by 0.13, showing spillover effects from non-GM to GM soybean market.

Comovenment

Finally we turn to the DCC components. The effect of time-varying correlation is captured by the coefficient DCC(1) and DCC(2), which are the parameters governing the DDC-GARCH process. DCC(1) is the sensitivity of correlations due to shocks, it reveals the speed at which the correlations matrix changes; while DCC (2) shows the persistence in the dynamic correlation, with 1 being constant correlations.

The DCC parameters in our model are significant at the 1% level, revealing that the correlation has a dynamic component. Wald test rejects the null hypothesis that DCC(1)=DCC(2)= 0 at all levels (χ^2 = 1102.45) and p-value = 0.000. The DCC(1) is has an estimated value of 0.2, means the correlation is sensitive due to shocks, but not very big. DCC(2) is estimated to be 0.77. This means that there is a relatively high level of persistence over time in the correlation between these two soybeans, which is consistent with what we see in the graph. In summary, the dynamic volatilities in the returns in non-GM soybean and GM soybean markets are generally interdependent over time, sometimes very strongly.

Estimated dynamic conditional correlations within soybean markets plotted in Figure 2. The average time-varying correlations are quite similar to the unconditional correlations reported earlier which is 0.8. The expected high to positive relationship between non-GM and GM soybeans is evident. The stable near 0.9 correlation between non-GM and GM soybeans breaks down sharply in early 2008, however, still positive and remaining so for the remaining two years. After the crisis, the correlation starts to rise in 2010 and keep the 0.9 level again till 2012. Then the correlation begins to drop again in 2013. Figure 2 confirms the time-varying properties of correlations.

4.6. Conclusions

The DCE non-GMO soybean contract is the first market price series with sufficient information to appropriately model a price integration linkage for an IP market in China. Because of the large amount of GMO soybeans imported, market participants start to pay more attention to the GMO futures markets. This paper analyzes the dynamic conditional correlations in the returns on these two soybean prices using multivariate DCC-GARCH model. The dynamic correlations enable a determination of whether the non-GM and GM returns are substitutes or complements, which can be used as trading strategies. Further, we analyze the impact of major economic variables on the volatility in these markets. This research provides statistical evidence that the futures prices of soybeans in China are being influenced by the increasing consumption of soybeans, the import quantity of soybean, the trading volume in futures market and weather condition during the growing season of soybean. Soybeans price volatility has important implications for producers, traders, and consumers. For both soybean contracts, we find some volatility persistence—as measured by the response to lagged absolute change—the effects are not large. We find statistically significant persistence in the form of an ARCH effect. The ARCH coefficients are relatively small in size, which indicates that conditional volatility does not change very rapidly. The GACH are not very large, either, indicating weak gradual fluctuations over time. Spillover effect was found from non-GM market to GM market.

The results of this study reveal that there is insufficient evidence to show that soybeans imports to China influenced monthly soybeans futures price volatility. For the speculation behavior, both the trading volume of non-GM and GM soybean have a significant positive effect on variances of the soybeans volatility. Among the macroeconomic variables considered, neither the IPI or FX affects the volatility of the two soybeans. We found the positive effect the percentage change of stock/use ratio on volatility in both soybean markets. Volatility in soybean markets is also found to change in response to the financial crisis event. The financial crisis increased both the two soybean price returns. The impact of negative shocks on GM soybean variance is larger than the impact of negative shocks in the non-GM soybean variance. China's soybean market is found to exhibit some seasonality with higher volatility in the growing season, which is from July through August. (INTA, 2011)

Knowledge of the co-movements of soybean returns and volatilities is important in constructing optimal hedging and trading strategies, asset allocation and risk management. The price movements of soybeans influence the activity of traders in three ways. First, the price volatility will influence the level of capital or credit that will be required of dealers to buy and store crops; second, the price level will affect the amount of capital or credits needed to maintain margin accounts for hedging activities, and finally, the price volatility will increase the risk of non-performance on producer contracts. Also, the pattern of price movements has an impact on managerial decisions of soybeans producers. First, increasing volatility will affect the level of profit and the value of the land used for production. Second, large variation of prices affects the level of revenue protection, and hence the cost of revenue insurance.

For practical purposes, our study will be helpful for understanding the value of other newly developed markets where the product traded is a close substitute for an existing market. In addition to adequate monetary policy, regulations are very much necessary to be created and/or enforced in order to prevent another financial calamity, as soybean volatilities were highly affected by the 2008 U.S. financial crisis.

Table 4.1. Summary Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum
Non_GM Soybean Return	0.571	5.008	-16.965	12.684
GM Soybean Return	0.464	6.028	-18.02	24.484
%ΔNon_GM Soybean Volume	0.186	0.828	-0.891	3.465
%ΔGM Soybean Volume	0.534	3.267	-0.898	32.417
%ΔNon_GM Soybean Open Interest	0.014	0.227	-0.415	1.452
%ΔGM Soybean Open Interest	0.217	1.26	-0.95	11.46
%ΔChina Soybean Production	-0.003	0.023	-0.077	0.119
%ΔChina Soybean Import	0.05	0.29	-0.549	1.321
%ΔChina use/stock	-0.0004	0.106	-0.359	0.63
%ΔChina IPI	-0.001	0.022	-0.11	0.07
%ΔU.S. Soybean Production	0.001	0.036	-0.139	0.201
%ΔU.S. Soybean Stock	0.007	0.205	-0.476	1.13
%ΔFX	0.0086	0.191	-0.52	0.884

Notes. Sample period is 01/01/2005-12/01/2013 and total number of observations is 108. Returns are calculated as $r_t = 100 \times (\ln F_t - \ln F_{t-1})$, where F_t is monthly settlement price of the futures contract on month *t*.

Table 4.2. Augmented Dickey-Fuller Unit Root Test

Variable	τ	p-value
Futures Prices		
F_nonGM	-1.49	0.541
F_GM	-1.9	0.334
Log of Futures Prices		
Ln F_nonGM	-1.51	0.5271
Ln F_GM	-1.91	0.3265
Futures Returns		
R_nonGM	-6.12	<0.0001
R_GM	-7.69	<0.0001

Notes. The τ statistics and their p-values are presented for single-mean Augmented Dickey-Fuller unit root test with one lag. GM and nonGM refer to GM soybean and non-GM soybean respectively. Futures returns are calculated as $r_t = 100 \times (\ln F_t - \ln F_{t-1})$.

Table 4.3. DCC model results for non-GM and GM soybean futures

Mean Eq.	Non_GM	GM
Constatnt	-0.008	-0.120
	(0.983)	(0.722)
R_{t-1}	0.037	0.032
	(0.000)	(0.001)
Variance Eq.	**Var(Non_GM)**	**Var(GM)**
Constant	2.006	2.199
	(0.001)	(0.000)
ARCH(1)	0.313	0.213
	(0.002)	(0.045)
GARCH(1)	0.224	0.213
	(0.013)	(0.072)
Lag_Gmreturn	0.002	
	(0.969)	
Lag_NonGMreturn		0.132
		(0.000)
Crisis	1.852	2.952
	(0.005)	(0.000)
FX	0.533	-3.168
	(0.768)	(0.160)
IPI	-7.670	-8.150
	(0.359)	(0.344)
Non_GMVol	1.092	1.051
	(0.000)	(0.000)
GMVol	0.097	0.076
	(0.070)	(0.040)
Stock/use	4.749	5.281
	(0.001)	(0.042)
Production	-9.883	-20.223
	(0.148)	(0.001)
Import	-3.284	-2.300
	(0.005)	(0.002)
Oil	3.034	-0.105
	(0.174)	(0.967)
Planting	-1.154	-0.638
	(0.767)	(0.231)
Growing	-1.550	-1.181
	(0.029)	(0.007)
Harvesting	0.026	0.309
	(0.968)	(0.568)
DCC(1)	0.202	

	(0.073)	
DCC(2)	0.770	
	(0.000)	
LLF	-491.142	
LR	184.768	
	(0.000)	
Lyung-Box Q	44.612	54.346
	(0.097)	(0.045)

Note. The estimated coefficients on each term in the equation and their p-values are presented. LLf refers to loglikelihood function value. Likelihood ratio (LR) test statistics and its p-value for the null hypothesis of no exogenous variables in variance equations are given. Lyung-Box Q statistics and their p-value for the test of independence of the model residuals are presented.

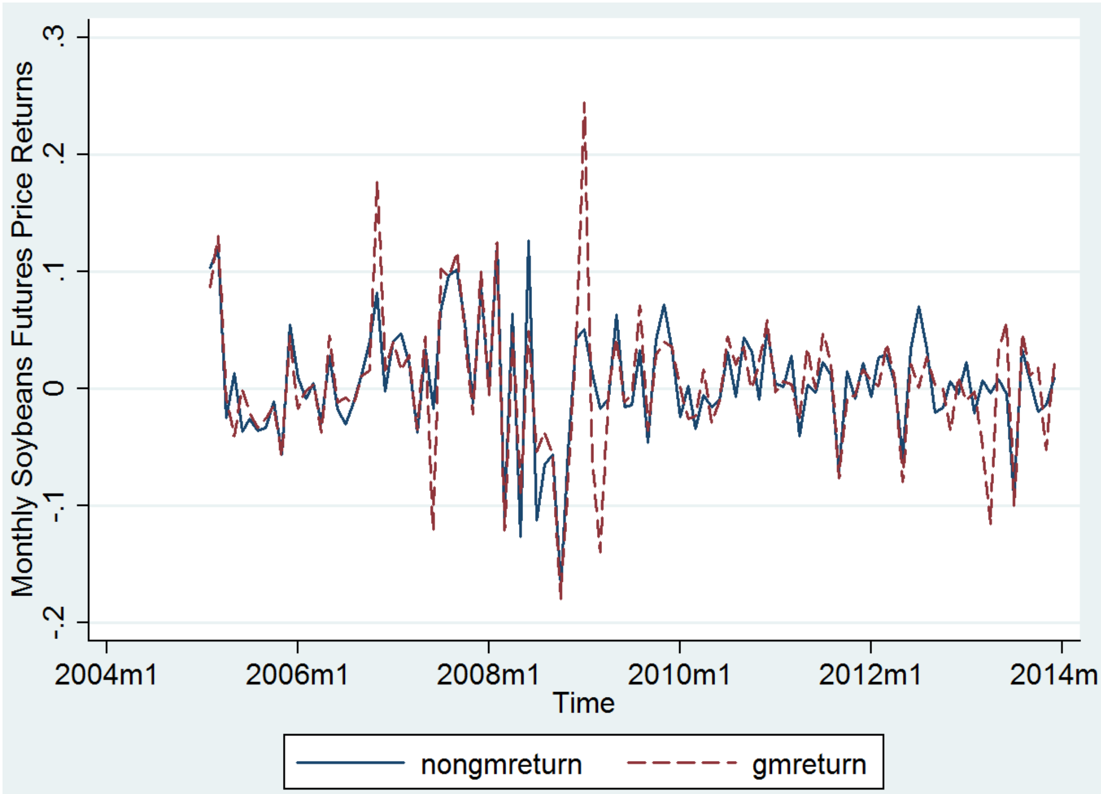


Figure 4.1. Monthly Non-GM and GM Soybean Price Returns Source: DATASTREAM

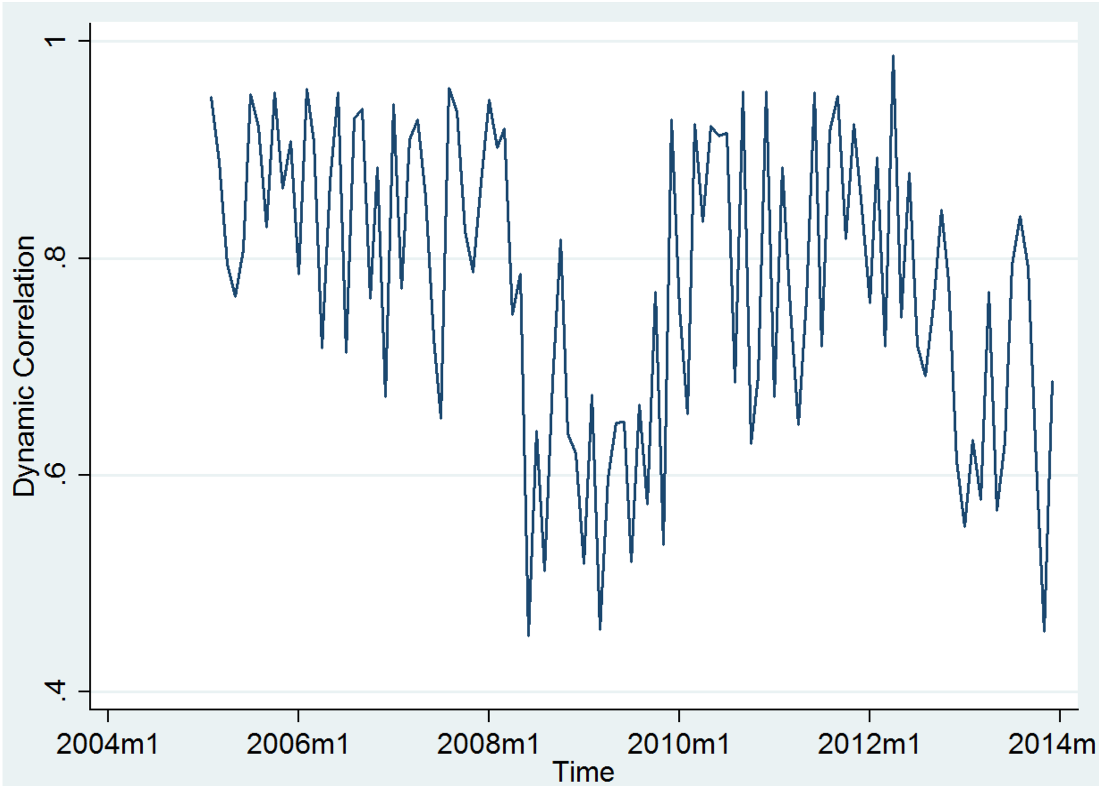


Figure 4.2. The estimated dynamic correlation coefficients between soybeans markets

CHAPTER 5

SUMMARY AND CONCLUSIONS

5.1 Summary and Conclusions

This study investigates three related issues on GM foodstuffs in the U.S. and Chinese markets. The primary objectives involve measuring college students' willingness to pay toward GM nutritionally enhanced breakfast products, testing the efficiency of Chinese soybean futures market and identifying the co-movement between non-GM and GM soybean prices in Chinese futures markets.

Public perceptions and attitudes to the introduction of emerging technologies have long been recognized as important factors in determining the likelihood of consumer support and prospective success in new product development. In the first section of this study, we described choice-modeling experiments to determine the willingness to pay of college student consumers from the U.S. and China regarding breakfast foods with GM and other attributes related with consumer benefits. Our analysis of the survey data predicts that food products made of genetically modified ingredients have a place in supermarkets in these two counties.

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. Chapter 2 examined how efficiently the DCE non-GM and GM soybean futures markets react to two contract specification changes and one law issue by testing their influence on the price premium for non-GM soybeans in the periods following the event. We implement intervention analysis to ten years of daily prices on soybean futures contracts, of which effects are considered to persist for a long period of time rather than a one-day change. The consequences of these events on the price premium were captured by an ARMA model.

Results of the intervention analysis show that premium response to each of these three events is statistically significant, and the durations are different for each event. In conclusion, the contract specification changes 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 soybeans.

Chapter 4 analyzes the dynamic conditional correlations in the returns on these two soybean prices using a multivariate DCC-GARCH model. The dynamic correlations enable a determination of whether the non-GM and GM returns are substitutes or complements, which can be used as trading strategies. Further, we analyze the impact of major economic variables on the volatility in these markets. This result provides statistical evidence that the futures prices of soybeans in China are being influenced by the increasing consumption of soybean products, the import quantity of soybeans, the trading volume in the futures market and weather conditions during the growing season of soybeans. Spillover effects were found from the non-GM market to the GM market.

5.2 Limitations and Future Research

Additional study could be improved or conducted in several directions.

First, in chapter 2, the sample we drew is a convenience sample (online respondents). Also, the sample size is relatively small. To get less biased results, larger sample sizes from the U.S. and China should be collected and analyzed.

Second, in chapter 3, the way we specify the dummy variables for the events is somewhat arbitrary, being based on preliminary analyses of the data. For more accurate estimates, more advanced models which can capture the path of the events and their impacts could be considered.

Third, in chapter 4, we include the variable "trading volume" of non-GM and GM soybean futures contracts in the variance equation in the DCC-GARCH model. This might cause an endogeneity problem, since high volatility of price often occurs when the futures market is trading large volume contracts. This problem is difficult to fix in the DCC-GARCH model. To get more accurate results, a proxy variable for trading volume may be needed.

5.3 Value of Current Research

Survey results suggest the governments and the GM food marketers have an opportunity to make extra efforts for the public to understand the benefits or usefulness from applying gene technology to produce food products, thus increasing the public's acceptance of these GM foods. The food industry could highlight the benefits, such as labelling non-GM, a decrease in the amount of pesticides applied to crops or increased nutritional values, brought by the added GM ingredients. The results obtained particularly contribute to the knowledge of the food marketing of genetically modified foods. GM food producers and marketers can develop specific marketing mixes according to the needs of the consumers to increase their profits.

The survey results are also important for policy development, decision making, and risk communication about GM foods. Because trust in the regulatory institutions of certification of the quality of food exerts a strong effect on the benefit perceptions, governments should take the responsibility of monitoring the proper functioning of the safety mechanism in producing GM foods so as to gain trust from the consuming public. Moreover, governments should increase transparency in formulating fair laws, such as labeling, and communicate more frequently and effectively with consumers. Adequate regulations, constant monitoring, and intensive research are essential to avoid possible harmful effects from beneficial GM food technology.

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 GM soybean futures market will generate a stronger interest in participating in Chinese futures trading as a mechanism to hedge international transactions and against variations in their local markets, which may arise from the growing Chinese demand and growing volume of imported GM soybeans.

Knowledge of the co-movements of soybean returns and volatilities is important in constructing optimal hedging and trading strategies, asset allocation and risk management. The price movements of soybeans influence the activity of traders in three ways. First, the price volatility will influence the level of capital or credit that will be required of dealers to buy and store crops. Second, the price level will affect the amount of capital or credits needed to maintain margin accounts for hedging activities. And finally, the price volatility will increase the risk of non-performance on producer contracts. Also, the pattern of price movements has an impact on managerial decisions of soybeans producers. First, increasing volatility will affect the level of profit and the value of the land used for production. Second, large variation of prices affects the level of revenue protection that may be prudent, and hence the cost of revenue insurance.

For practical purposes, our study will be helpful for understanding the value of other newly developed markets where the product traded is a close substitute for an existing market, such as other emerging GM products with various additional benefits.

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Appendix A

Questionnaire

Part A: Perception of GM food

1. Have you ever heard about genetically modified foods?

_Yes
_Not sure
_No

2. Where did you get your information about GM foods?

_From school
_From media, for example: TV, radio, newspaper
_From friends or other family members
Other, please specify

3. Which of the following best represents your opinion about GM foods?

_GM foods are beneficial
_GM foods are harmful
_GM foods are neither beneficial nor harmful
_Do not know/are not sure

Now you must be interested in what are GM foods! Here is some useful information:

Genetically modified Organisms (GMO) are those whose genes have been altered with DNA from other plants or animals. These organisms have been modified in the laboratory to enhance desired traits very rapidly and with great accuracy. Some of these practices are criticized by various groups as being unsafe or unnatural. Despite this, an estimated 75% of all foods purchased in America contain at least some genetically modified ingredients.

Benefits of GMO:

- faster growth, production of extra nutrients;
- improving flavor, increasing resistance to insects, disease and increasing the yield;
- New products and growing techniques;
- Increased food security for growing populations.

Controversies of GMO:

- Potential human health impacts, including allergens;
- Potential environmental impacts, including: unintended transfer of transgenes through cross-pollination, unknown effects on other organisms (e.g., soil microbes), and loss of flora and fauna biodiversity.

Ethics worry of GMO:

- Tampering with nature by mixing genes among species

Part B: Purchasing Choices

Now you already know what GMO is. In this part, you will be presented with 12 scenarios of choices about your purchasing decision of GM foods. Check the one that you would purchase in your real life. Assume there is a new breakfast cereal (toast) product in the market. Using Genetic Modification production methods, the tissues of the new cereal/toast simultaneously enhance vitamins (A, E, C and folate), lysine, and minerals (iron, selenium and zinc). (Note that the attributes of cereal/toast are all obtained using the Genetic Modification production methods.)

For breakfast, which one do you prefer?

_Cereal
_Toast

Questions for cereal lovers

Scenario 1: Based on the bundle of characteristics shown: Which of the following two cereals would you purchase?

Characteristics	Product A	Product B
Price	$4	$2.8
Genetic Modification	GM	Non-GM
Additional Nutritional Benefits improved with Vitamin, Protein and Essential Mineral	Yes	No
Brand	A Chinese Brand Name Company	A U.S. Brand Name Company
Country Where Raw Ingredients Originate from	China	U.S.
Food Quality Certification Approved by Country Agency	U.S.	None
Pesticide/Herbicide use	Grown using current Pesticide/Herbicide practices	30% less use of current Pesticide/Herbicide practices

I would purchase

_Product A
_Product B
_Neither of the two options above

Scenario 2: Based on the bundle of characteristics shown: Which of the following two cereals would you purchase?

Characteristics	Product A	Product B
Price	$4	$2.8
Genetic Modification	GM	Non-GM
Additional Nutritional Benefits improved with Vitamin, Protein and Essential Mineral	Yes	No

Brand	A Chinese Brand Name Company	A U.S. Brand Name Company
Country Where Raw Ingredients Originate from	U.S.	China
Food Quality Certification Approved by Country	None	U.S.
Pesticide/Herbicide use	30% less use of current Pesticide/Herbicide practices	Grown using current Pesticide/Herbicide practices

I would purchase

_Product A
_Product B
_Neither of the two options above

Scenario 3: Based on the bundle of characteristics shown: Which of the following two cereals would you purchase?

Characteristics	**Product A**	**Product B**
Price	$2.8	$4
Genetic Modification	Non-GM	GM
Additional Nutritional Benefits improved with Vitamin, Protein and Essential Mineral	No	Yes
Brand	A U.S. Brand Name Company	A Chinese Brand Name Company
Country Where Raw Ingredients Originate from	China	U.S.
Food Quality Certification Approved by Country	*U.S.*	*None*
Pesticide/Herbicide use	*Grown using current Pesticide/Herbicide practices*	*30% less use of current Pesticide/Herbicide practices*

I would purchase
_Product A
_Product B
_Neither of the two options above

Scenario 4: Based on the bundle of characteristics shown: Which of the following two cereals would you purchase?

Characteristics	Product A	Product B
Price	$4	$2.8
Genetic Modification	Non-GM	GM
Additional Nutritional Benefits improved with Vitamin, Protein and Essential Mineral	No	Yes
Brand	A Chinese Brand Name Company	A U.S. Brand Name Company
Country Where Raw Ingredients Originate from	U.S.	China
Food Quality Certification Approved by Country	China	China
Pesticide/Herbicide use	Grown using current Pesticide/Herbicide practices	30% less use of current Pesticide/Herbicide practices

I would purchase

_Product A
_Product B
_Neither of the two options above

Scenario 5: Based on the bundle of characteristics shown: Which of the following two cereals would you purchase?

Characteristics	Product A	Product B

Price	$2.8	$4
Genetic Modification	Non-GM	GM
Additional Nutritional Benefits improved with Vitamin, Protein and Essential Mineral	Yes	No
Brand	A Chinese Brand Name Company	A U.S. Brand Name Company
Country Where Raw Ingredients Originate from	China	U.S.
Food Quality Certification Approved by Country	U.S.	None
Pesticide/Herbicide use	30% less use of current Pesticide/Herbicide practices	Grown using current Pesticide/Herbicide practices

I would purchase

_Product A
_Product B
_Neither of the two options above

Scenario 6: Based on the bundle of characteristics shown: Which of the following two cereals would you purchase?

Characteristics	**Product A**	**Product B**
Price	$4	$2.8
Genetic Modification	GM	Non-GM
Additional Nutritional Benefits improved with Vitamin, Protein and Essential Mineral	Yes	No
Brand	A Chinese Brand Name Company	A U.S. Brand Name Company

Country Where Raw Ingredients Originate from	U.S.	China
Food Quality Certification Approved by Country	U.S.	None
Pesticide/Herbicide use	Grown using current Pesticide/Herbicide practices	30% less use of current Pesticide/Herbicide practices

I would purchase

_Product A
_Product B
_Neither of the two options above

Scenario 7: Based on the bundle of characteristics shown: Which of the following two cereals would you purchase?

Characteristics	Product A	Product B
Price	$4	$2.8
Genetic Modification	Non-GM	GM
Additional Nutritional Benefits improved with Vitamin, Protein and Essential Mineral	No	Yes
Brand	A U.S. Brand Name Company	A Chinese Brand Name Company
Country Where Raw Ingredients Originate from	China	U.S.
Food Quality Certification Approved by Country	None	U.S.
Pesticide/Herbicide use	30% less use of current Pesticide/Herbicide practices	Grown using current Pesticide/Herbicide practices

I would purchase

_Product A
_Product B
_Neither of the two options above

Scenario 8: Based on the bundle of characteristics shown: Which of the following two cereals would you purchase?

Characteristics	Product A	Product B
Price	$4	$2.8
Genetic Modification	GM	Non-GM
Additional Nutritional Benefits improved with Vitamin, Protein and Essential Mineral	No	Yes
Brand	A U.S. Brand Name Company	A Chinese Brand Name Company
Country Where Raw Ingredients Originate from	China	U.S.
Food Quality Certification Approved by Country	China	China
Pesticide/Herbicide use	30% less use of current Pesticide/Herbicide practices	Grown using current Pesticide/Herbicide practices

I would purchase

_Product A
_Product B
_Neither of the two options above

Scenario 9: Based on the bundle of characteristics shown: Which of the following two cereals would you purchase?

Characteristics	Product A	Product B

Price	$4	$2.8
Genetic Modification	Non-GM	GM
Additional Nutritional Benefits improved with Vitamin, Protein and Essential Mineral	Yes	No
Brand	A Chinese Brand Name Company	A U.S. Brand Name Company
Country Where Raw Ingredients Originate from	China	U.S.
Food Quality Certification Approved by Country	None	U.S.
Pesticide/Herbicide use	30% less use of current Pesticide/Herbicide practices	Grown using current Pesticide/Herbicide practices

I would purchase

_Product A
_Product B
_Neither of the two options above

Scenario 10: Based on the bundle of characteristics shown: Which of the following two cereals would you purchase?

Characteristics	Product A	Product B
Price	$2.8	$4
Genetic Modification	Non-GM	GM
Additional Nutritional Benefits improved with Vitamin, Protein and Essential Mineral	No	Yes
Brand	A U.S. Brand Name Company	A Chinese Brand Name Company

Country Where Raw Ingredients Originate from	U.S.	China
Food Quality Certification Approved by Country	None	U.S.
Pesticide/Herbicide use	Grown using current Pesticide/Herbicide practices	30% less use of current Pesticide/Herbicide practices

I would purchase

_Product A
_Product B
_Neither of the two options above

Scenario 11: Based on the bundle of characteristics shown: Which of the following two cereals would you purchase?

Characteristics	Product A	Product B
Price	$4	$2.8
Genetic Modification	GM	Non-GM
Additional Nutritional Benefits improved with Vitamin, Protein and Essential Mineral	No	Yes
Brand	A U.S. Brand Name Company	A Chinese Brand Name Company
Country Where Raw Ingredients Originate from	China	U.S.
Food Quality Certification Approved by Country	U.S.	None
Pesticide/Herbicide use	Grown using current Pesticide/Herbicide practices	30% less use of current Pesticide/Herbicide practices

I would purchase

_Product A
_Product B
_Neither of the two options above

Scenario 12: Based on the bundle of characteristics shown: Which of the following two cereals would you purchase?

Characteristics	Product A	Product B
Price	$2.8	$4
Genetic Modification	None-GM	GM
Additional Nutritional Benefits improved with Vitamin, Protein and Essential Mineral	Yes	No
Brand	A U.S. Brand Name Company	A Chinese Brand Name Company
Country Where Raw Ingredients Originate from	U.S.	China
Food Quality Certification Approved by Country	None	U.S.
Pesticide/Herbicide use	Grown using current Pesticide/Herbicide practices	30% less use of current Pesticide/Herbicide practices

I would purchase

_Product A
_Product B
_Neither of the two options above

Part C: More questions about your attitudes toward GM foods

Now in general, without considering particular cases, please answer the following questions:

1. Who do you think benefits more from GM foods, producers or consumers?

_Producers benefit more
_Consumers benefit more
_Both producers and Consumers benefit from GM
_Neither of them benefit from GM

2. On a scale of 0 to 10, how necessary do you think it is to produce GM foods (for example, to decrease world hunger or to reduce nutrition deficiency)? (0 means unnecessary; 10 means very necessary)

3. What effect do you think the production of GM foods can produce to the environment? (Bad effects, such as reduce the variety of species VS good effects, such as reducing the use of pesticide)

_Bad effects
_Good effects
_Neither bad effects or good effects
_Both bad effects and good effects

4. How much health risk do you think there is from eating GM foods? (0 means no risk; 10 means huge risk)

5. If you will have children or you already have children, would you let them eat GM foods?

_Yes
_No

_Do not know / Are not sure

6. Recently in California a proposition was on the ballot that would require all foods with GM ingredients to be labeled. Would you support this proposition?

_NO, it is not necessary to have mandatory labeling
_YES, it should have mandatory labeling

7. Currently in the US about 90% of soybeans, 80% of corn, and 80% of cotton grown in the US is GM. If GM wheat is approved for commercial planting in the US, would you support this approval?

_Yes
_No

8. What is your age?

9. What is your gender?

_Male
_Female

10. What is your Race?

_White/Caucasian
_African-American
_Hispanic
_Asian
_Native American
_Pacific Islander
Other, please specify

11. What is your major?

_Visual and Performing Arts-Related Majors
_Science and Math Majors
_Environment-Related Majors
_Business Majors
_Engineering & Technology Majors
_Language, Literature & Social Science Majors

12. Are you an undergraduate student or a graduate student?

_Undergraduate
_Graduate

13. What is the name of your university?

14. What is your religion?

_Christianity
_Buddhism
_Hinduism
_Islam
_Judaism
_No religion
_Other, please specify

15. What is the total yearly income in your parents' household?

_$0-$25,000
_$25,001-$50,000
_$50,001-$75,000
_$75,001-$100,000
_$100,001-$125,000
_$125,001-$150,000
_$150,001-$175,000
_$175,001-200,000
_$200,001+

16. How often do you do exercise?

_Never
_0-2 times a week
_3-5 times a week
_almost every day

17. How often do you take vitamins (or other nutrition) supplement(s) ?

_never
_0-2 times a week
_3-5 times a week
_almost every day

18. How willing are you to try new food products on the market? (0 means rarely try; 10 means always try)

19. Which food quality certification do you trust more? A Chinese agency or a US agency?

_A Chinese Agency
_A US Agency
_Both
_Neither

Appendix B

Multivariate-BEKK Model

We measure the monthly return from holding a futures contract on month t as

$$r_t = 100 \times (\ln F_t - \ln F_{t-1}), \qquad \text{(B.1)}$$

where F_t is monthly settlement price of the futures contract on month t. The mean equation of monthly returns is then defined as a function of its past values and a random disturbance term. Denoting the vector of mean returns by R_t, the bivariate GARCH in matrix form is given by:

$$R_t = \mu + \sum_{i=1}^{p} R_{t-i} + \mu, \quad \mu_t \sim MVN(0, H_t), \qquad \text{(B.2)}$$

where R_t is a 2×1 vector consisting of $r_t{}'s$ of each commodity, p is the order of autoregressive process, and μ_t is the disturbance vector. The conditional covariance matrix of the disturbance term is then given by:

$$H_t = C'C + A'\mu_{t-1}\mu'_{t-1} + B'H_{t-1}B + G'GX_t, \qquad \text{(B.3)}$$

where H_t is a 2×2 symmetric matrix with variances on the diagonal and covariances off the diagonal. C is a 2×2 lower triangular matrix of constants, A is a 2×2 matrix of ARCH parameters, B is a 2×2 matrix of GARCH parameters and G is 2×2 lower triangular coefficient matrix on the exogenous variables X_t. The matrices are as follows:

$$H_t = \begin{bmatrix} h_{11,t} & h_{12,t} \\ h_{12,t} & h_{22,t} \end{bmatrix},\ C = \begin{bmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{bmatrix},\ A = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}, B = \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix},\ G = \begin{bmatrix} g_{11} & 0 \\ g_{21} & g_{22} \end{bmatrix}$$

where the subscripts 1 and 2 represent, respectively, non-GM soybean and GM soybean. Matrix manipulation yields the conditional variance equations shown as:

$$h_{11,t} = c_{11}^2 + c_{21}^2 + a_{11}^2 u_{1,t-1}^2 + a_{21}^2 u_{2,t-1}^2 + 2a_{11}a_{21}u_{1,t-1}u_{2,t-1} + b_{11}^2 h_{11,t-1} + b_{21}^2 h_{22,t-1} + 2b_{11}b_{21}h_{12,t-1} + (g_{11}^2 + g_{21}^2)X_t \quad \textbf{(B.4)}$$

$$h_{22,t} = c_{22}^2 + a_{12}^2 u_{1,t-1}^2 + a_{22}^2 u_{2,t-1}^2 + 2a_{12}a_{22}u_{1,t-1}u_{2,t-1} + b_{12}^2 h_{11,t-1} + b_{22}^2 h_{22,t-1} + 2b_{12}b_{22}h_{12,t-1} + g_{22}^2 \quad \textbf{(B.5)}$$

For both soybeans we estimate a bivariate GARCH BEKK model with lagged returns included in the mean equations. Conditional variance equations include ARCH and GARCH parameters as well as exogenous variables that might have an impact on volatility. Table B.1 presents the coefficient estimates and their p-values for the variance equations given in (B.4)-(B.5).

Appendix B.1 GARCH-BEKK Results for non-GM and GM soybean futures

Mean Eq.	**Non_GM**	**GM**
Constant	-0.067	-0.087
	(0.788)	(0.678)
Rt-1	0.024	0.021
	(0.000)	(0.000)
Variance Eq.	**Var(Non_GM)**	**Var(GM)**
Constant	2.102	2.254
	(0.002)	(0.001)
$u_{1,t-1}^2$	0.311	0.283
	(0.201)	(0.031)
$\mu_{2,t-1}^2$	0.030	0.162
	(0.801)	(0.207)
$\mu_{1,t-1}\mu_{2,t-1}$	0.297	0.223
	(0.003)	(0.101)
$h_{11,t-1}^2$	0.263	0.281
	(0.012)	(0.032)
$h_{22,t-1}^2$	0.274	0.236
	(0.003)	(0.061)
$h_{12,t-1}$	0.374	0.402
	(0.004)	(0.088)
Crisis	1.873	2.836
	(0.004)	(0.000)
FX	0.659	-5.384
	(0.827)	(0.284)
IPI	-6.933	-6.928
	(0.482)	(0.483)
Non_GMVol	1.236	1.721
	(0.000)	(0.000)
GMVol	0.182	0.171
	(0.068)	(0.050)
Stock/use	3.916	5.115
	(0.002)	(0.057)
Production	-10.894	-24.182
	(0.211)	(0.000)
Import	-3.167	-2.110
	(0.002)	(0.001)
Oil	4.293	-0.442
	(0.321)	(1.003)
Planting	-1.132	-0.281

	(0.991)	(0.346)
Growing	-1.884	-1.286
	(0.065)	(0.023)
Havesting	0.112	0.182
	(0.278)	(0.862)
LLF	-572.724	
LR	245.776	
	(0.000)	
Lyung-Box Q	46.335	63.476
	(0.064)	(0.032)

Note. The estimated coefficients on each term in the equation and their p-values are presented. LLf refers to loglikelihood function value. Likelihood ratio (LR) test statistics and its p-value for the null hypothesis of no exogenous variables in variance equations are given. Lyung-Box Q statistics and their p-value for the test of independence of the model residuals are presented.