THE VOLATILITY SPILLOVERS BETWEEN CHINA AGRICULTURAL COMMODITY AND WORLD ENERGY MARKETS DURING CRISES

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DECLARATION

We hereby declare that:

(1) This undergraduate research project is the end result of our own work and that due acknowledgement has been given in the references to ALL sources of information be they printed, electronic, or personal.

(2) No portion of this research project has been submitted in support of any application for any other degree or qualification of this or any other university, or other institutes of learning.

(3) Equal contribution has been made by each group member in completing the research project.

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GDP	Gross Domestic Product
SEJ	Solar Emergy Joules
OPEC	Organization of the Petroleum Exporting Countries
US	United States
FAPRI-MU	Food and Agriculture Policy Research Institute at University of Missouri
OLS	Ordinary Least Squares
SVAR	Structural Vector Autoregressive
SVMJ	Stochastic Volatility Model with Merton Jump
MCMC	Markov Chain Monte Carlo
AGE	Applied General Equilibrium
GTAP-E	Global Trade Analysis Project-Energy
RFS	Renewable Fuel Standard
ADF	Augmented Dickey-Fuller
VAR	Vector Autoregression
GARCH	Generalized Autoregressive Conditional Heteroscedasticity

ABSTRACT

This study examines volatility spillovers between China agricultural commodity and world energy markets across crises from January 2003 to December 2016. The results provide two findings. First, agricultural commodity returns influence energy commodity returns when China is the main producer the agricultural commodity such as wheat. In contrast, energy commodity returns will influence agricultural commodity returns when China is an importer the agricultural commodity such as soybean. However, when an agricultural commodity is neither China main production nor importer such as corn, there is bidirectional causality between agricultural and energy commodity returns. Second, during the 2015/16 energy crisis, there is a large proportion of shocks in agricultural commodities due to a shock of energy commodities and vice versa. This is due to fewer observations are included in the period and the spillovers effect has been carry forward to the next period. Based on the two findings, investor and producer should do more research about the background of the commodities market before they make further decision. The investors will have to make a tradeoff between agricultural and energy commodities depend on whether the agricultural commodities are main production of China or imported from another country. If investors plan to trade in energy commodities, China has to be the main producer of agricultural commodities. In contrast, if investors plan to trade in agricultural commodities, China has to be the main import of agricultural commodity. In addition, policy makers should anticipate the crisis before it happens as the spillover effects are still being carry forward.

CHAPTER 1: INTRODUCTION

1.1 Importance of Linkages between Agricultural and Energy Commodities

Energy prices are related to agricultural commodity prices as energy can boost the productivity of agricultural commodity. Agricultural commodities play an important role in the economic system of developing country. The interaction between energy and agricultural commodity prices has undergone a number of major structural transformations. As agricultural production becomes more mechanized and increasing of the arable land problem, energy becomes one of the main inputs as it affects the level and scale of many agricultural inputs. Therefore, the agriculture commodity price is directly affected by high volatile energy prices that in turn affected the cost of agricultural production.

On the other hand, biofuels are the substitute goods to replace the energy commodities. The emergence of biofuel production since 1973 due to geopolitical conflict, further linkages between agriculture and energy commodities arise since agricultural products are being used as input for energy production. The expansion of biofuel production has corresponded with a recent sharp rise in price for food grains, feed grains, oilseeds and vegetable oils. According to study by Baier et al. (2009), global biofuel production growth is responsible for the rises in corn, soybean and sugar prices. Therefore, the increasing integration between biofuels and agricultural commodities bring into question the effect on prices in the two markets.

1.2 Overview of Agricultural and Energy Commodities in China

Beginning in the 7500 before Christ, China has been depending on farmers in the classical millet agriculture to support the growth of its large population. The agriculture pattern of China changes along with its history. Before the forming of People's Republic in 1949, the agriculture in China is privately managed by having private ownership of properties and is only for self-sufficient purpose. Due to the China's emerging arable land issue, the agriculture production is then supported by the use of energy to boost productivity in 1980. China had increased its energy consumption from 300 MtCE (million tonnes of coal equivalent) in 1970 to 1000 MtCE in 1990 and listed as the third largest consumer of energy after The United States and Soviet Union. Large amount of energy commodities has been used in China to support the production of agricultural commodities.

China agriculture sector has contributed to 23.2 percent of the country total GDP in 1960. This percentage decreased to 8.8 percent in 2015 (WorldBank, 1960). The major agriculture productions in China are grain products such as wheat, soybeans and corn. These agriculture products contribute to 46 percent of the total China's agricultural production (Agricultural Statistics of the People's Republic of China, 1990). Wheat, soybean and corn are produced massively in China due to two reasons. First, wheat is easily grown even with water shortage and it can be stored well for years to preserve China's sustainable foods supply. Second, soybeans and corns are produced massively because both commodities are used for major feedstock and biodiesel production. Although the soybean is originated from China, its production plummeted due to Japanese invasion in 1937 and did not recover after the end of World War II. Hence, China started to import 60 percent of world soybean exports (Brown, 2013).

However, the agriculture production in China begin to faced difficulty due to the emerging arable land issue where no available land can be used to make sustainable farming of the China's main agriculture commodities. In order to support the productivity of its agricultural production, China used a large amount of energy commodities such as crude oil and natural gas to solve the emerging arable land issue.

Crude oil will be refined into diesel to support the transportation, while natural gas will be refined into fertilizers to increase the land productivity.

Since China involved in both agricultural and energy commodities market, the price of agricultural commodities in China fluctuate across crises because the volatility of agricultural and energy commodity prices will increase during the crisis period. Figure 1.1 shows fluctuation of agricultural commodity return, then Figure 1.2 (energy commodity return) is then plotted based on Figure 1.1 to show the spillovers effect between the two commodities in the case of China. After the fluctuation is identified, we observe that there are four periods exhibit high volatility of agricultural and energy returns, namely 2003/2005 energy crisis, 2007/2009 financial crisis, 2011/2013 oil crisis and 2014/2016 energy crisis.

i) *2003/2005 Energy Crisis*

In 2000, Organization of the Petroleum Exporting Countries (OPEC) reduced its production of oil which caused the international demand of oil exceeds the supply (Belaunde, 2001). The shortage of oil supply due to production cut increased the oil price and lead to energy crisis. Besides, the China energy crisis in 2004 is also caused by the faster pace of economy growth compare to the expansion of energy production. Based on Figure 1.2, the occurrence of energy crisis in 2004 then caused fluctuation in the price of wheat and soybean. Therefore, high volatility of energy returns significantly affected the agricultural returns during the 2003/2005 energy crisis.

ii) *2007/2009 Financial Crisis*

The deregulation in the financial industry was the primary cause in the 2007/2009 financial crisis. Banks are permitted to engage in hedge fund trading with derivatives, hence banks demanded for more mortgages to support the trading activities. The increase in volume of mortgage loans then result in financial crisis when bank stopped lending to each other and the value of derivatives crumbled (Amadeo, 2007). The financial crisis caused the oil price to collapse when West Texas Intermediate crude oil price drop 72% from $145.31 per barrel on 3 July 2008 to $41 per barrel on December 5, 2008 (Allen et. al., 2009). The decreasing in the crude oil prices leads to the price fluctuation in wheat, soybean and corn markets during the 2007/2009 financial crisis. The major reason of the fluctuation is the increasing demand for the production of biofeuls since it can be used as a substitution material for crude oil .

iii) *2011/2013 Oil Crisis*

Based on figure 1.1, the oil price fluctuate in 2011/2013 oil crisis. The crisis started when crude oil price rose in the fourth quarter of 2011 and then fell sharply in the first quarter of 2012. Rising of crude oil price is primarily caused by revolutions in North Africa which lead to the disruption of oil supply. Besides, a massive earthquake in Japan during 2011 destroy most of their nuclear power station hence Japan shift demand to oil. Reduce in the oil supply and increase in the demand then caused oil price surge in fourth quarter of 2011 (Odongo, 2012). The fall of oil price in first quarter of 2012 however is caused by rising oil production from the United States (US) where they produced 6 millions barrel per day and put downward pressure on the oil prices (US Energy Information Administration, 2012). Meanwhile, the agricultural commodities also experience price fluctuation during the oil crisis period but the fluctuation is not an impact of the energy crisis. The fluctuation happened is due to the poor weather condition hits the production and oversupply of grain products. However, based on Figure 1.2, the price of agricultural commodities increase because China China’s government intervene the market and increase the price support for agricultural commodity hence it is shielded from the falling of world price (Agricultural & Applied Economics Association, 2017).

iv) *2014/2016 Energy Crisis (Shortage of natural gas)*

An increase in the price of natural gas together with the decrease in the price of crude oil are identified in Figure 1.1. The increase in the natural gas price is due to increasing international demand and flat production. The international demand comes from country like Japan who subtituted oil for natural gas and companies with diesel-powered vehicles shift to compressed natural gas usage (Gain Clean Fuel, 2015). Besides, the growth of conventional gas has been declining for the past 15 years and shale gas production is halted (Berman, 2016). As a consequence, the shortage of supply lead to the increase in the price of natural gas. The drop in the crude oil price however is cause by a supply glut by non-US OPEC oil exports and increased US shale production that had led to excess capacity followed by a slowing demand of the world. Based on Figure 1.2, wheat and soybean price increased. This is because China increased in the importation of of soybean and drive the price of soybean up (Bloomberg, 2014). The increase in wheat price is due to drought that reduce the production and result in demand more than supply. Finally, corn price fell because of corn effect take place.

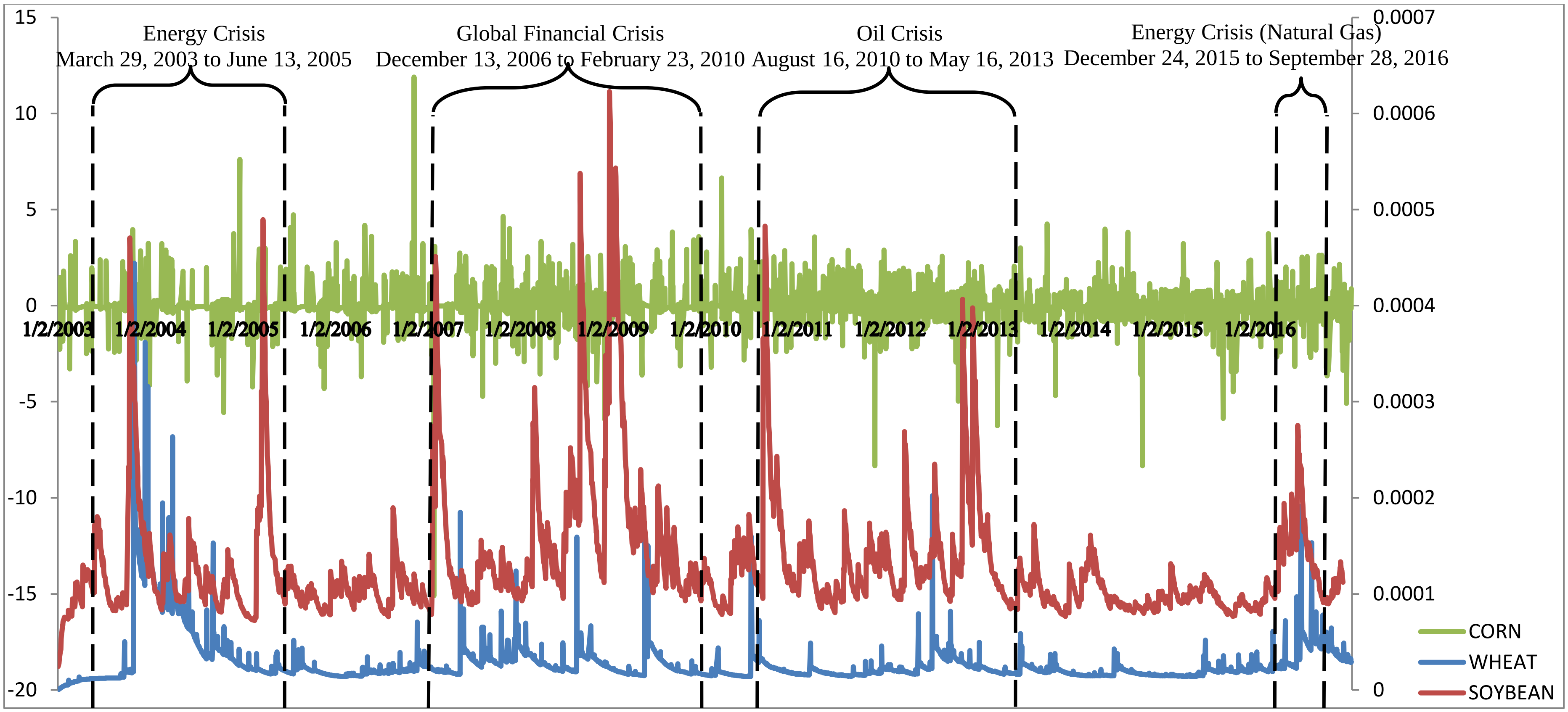

Figure 1.1: Conditional variance for wheat, corn and soybean returns, January 2003 - December 2016
Source: Bloomberg (2016)

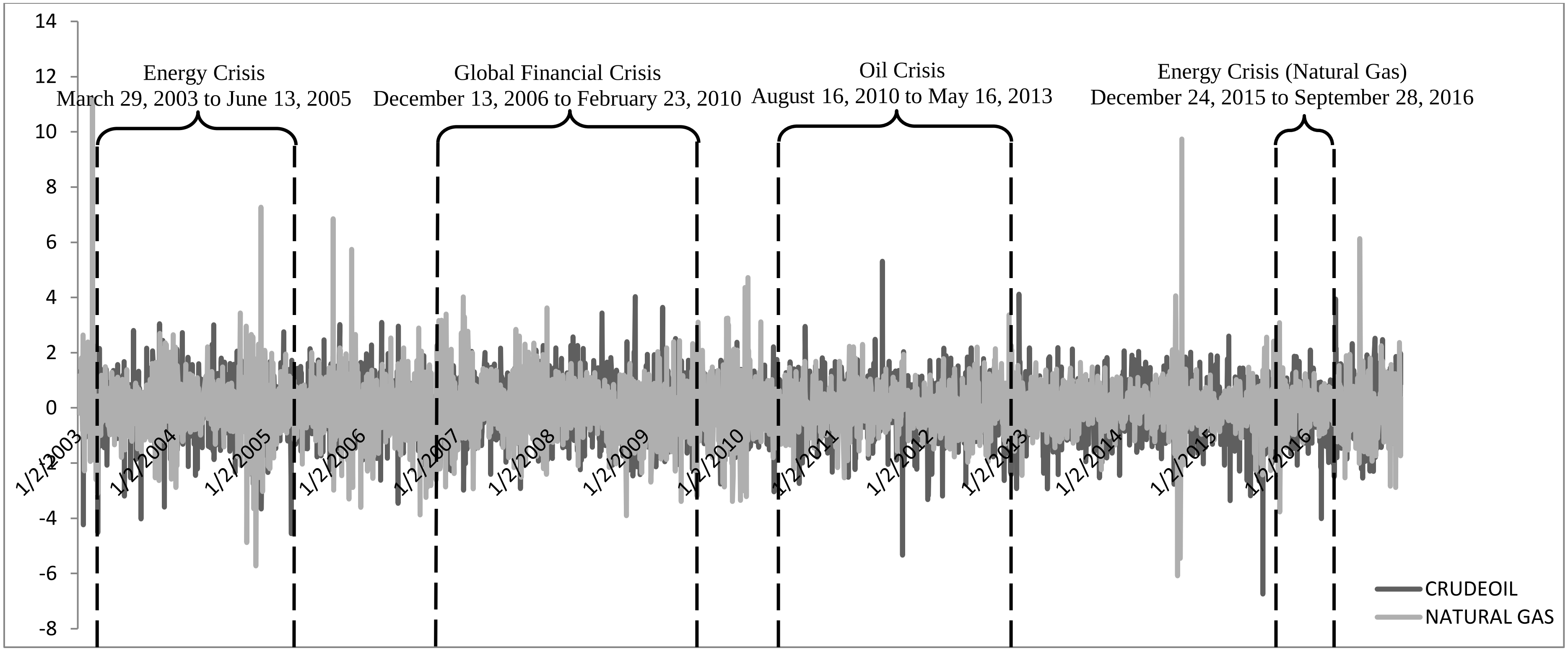

Figure 1.2: Conditional variance for crude oil and natural gas returns, January 2003 - December 2016
Source: Bloomberg (2016)

1.3 Problem Statement

China is the world's major agricultural commodities producer, its agricultural commodities production is supported using large amount of energy commodities. The energy commodities are used to increase the productivity of arable land in China, hence the emerging arable land issue caused China to increase energy consumption and became the world's largest consumer. Since China is the major agricultural commodities producer and major energy commodities consumer, we can use China agricultural commodities market to decide the volatility spillovers with the world energy commodities market across crises.

With a great change in the Chinese society, the arable land had decreased by 16,720,000 hectares due to the soil degradation result from overused of land, industrial infringement and infrastructure construction. Besides the rapid increase in China population from 0.96billion in 1976 to 1.3billion in 2015 further reduced the cultivated land per head by $800m^2$ below the world average by 25 percent (TradingEconomics, 2015). In order to solve the arable land issue, fossil fuels (coal, crude oil and natural gas) are used in China to boost the productivity of the land. For example, the use of pesticides and mineral fertilizers has been quadrupled to enhance arable land productivity and large quantity of petroluem-energy is also used to raised the yield of agriculture production and limited arable land. (China Statistical Yearbook, 2001)

Due to the emerging arable land issue, China had increased its energy consumption from 300 MtCE (million tonnes of coal equivalent) in 1970 to 1000 MtCE in 1990. This increasing consumption provides China to be listed as the third largest consumer of energy after the United States and Soviet Union. The main usage of the energies are crude oil and natural gas. The crude oil accounted for 19 percent used to produce diesel, gasoline and lubrication in the wide application of mechanical equipments with diesel engines. In 2000, a total of 57.85billion sej (Solar Emergy Joules) diesel is used, which is nearly 80 percent of the total oil used in agriculture. Meanwhile, natural gas is used in the production of chemical fertilizers which made 2 percent of total energy consumption (The Statistics Portal, 2000).

The overdependence on oil and natural gas for power generation and fertilizers production have led to serious energy insecurity in China. Therefore, China is substituting the consumption of non-renewable energy (natural gas and crude oil) with biofeuls. China is the fourth largest ethanol producers in the world after United States, Brazil and European Union (USDA Foregin Agricultural Service, 2017). The country's biofuel production had increased from 4400 metric tons of oil equivalent (MtOE) in 2001 to 2.43 million MtOE in 2015 (The Statistics Portal, 2017). The production of biofuels are done by using wheat to produce undenatured ethanol for human consumption while soybeans oil are extracted using mechanical presses, and converted to biodiesel via transesterification. Corn is the major feedstock for ethanol production in China and it will yields several by products such as corn gluten feed, corn fiber and corn oil, which are fed to livestock. However, crude corn oil may be processed for food or biodiesel purpose.

Since spillover effects exist between the agricultural and energy commodity markets, volatility in the agricultural and energy commodity markets negatively affects markets participants. For example, policy makers are unable to implement effective policies to ensure that agriculture and energy commodities have sustainable consumption. Producers experience increase in the input costs and cause losses due to fluctuation of price during crises. Investors fail to predict commodities price movement and lead to difficulty in making sound decisions.

1.4 Research Question

1. How do China agricultural commodity prices respond to shock of energy commodities across crises and vice versa?

1.5 Research Objective

1. To examine the percentage of variance proportion for energy prices can be explained by a shock of agricultural commodity prices and vice versa during crises.

1.6 Significance of Study

This study is expected to provide the findings that benefit to the following market participants.

For policy makers, understanding the dynamics of energy and agriculture commodity prices will assist them in adjusting policies accordingly across different crises. This can be done by implementing effective policies to ensure that agriculture and energy commodities have sustainable consumption.

Next, producers can make better decisions in setting the selling price of agricultural and energy commodities. The fluctuation of price during crises will increase the input costs and production costs of the producers. Therefore, producers should increase the agricultural commodity selling price when price surged and decrease the agricultural selling price when price plunged in order to prevent high cost of production during crises. These actions same applies to the energy commodities.

Finally, investors can use the information of volatility spillovers as a tool to predict the price movement of agriculture commodities against energy commodities. Hence, they can make trade-offs between both commodities in their investment decisions. For example, the fall in the price of one commodity will trigger the fall in another commodities.

1.7 Chapter Layout

The rest of the study is organized as follows. Chapter 2 provides the literature review on the linkage between energy and agricultural commodity prices. Existing findings are categorized into: (i) energy price affects agriculture price; and (ii) interdependence between energy and agriculture prices. Chapter 3 provides the explanation for the data and the methodology employed. Chapter 4 presents the empirical results. Lastly, Chapter 5 summarizes the findings and provides the limitations as well as recommendations for the future research.

CHAPTER 2: LITERATURE REVIEW

2.0 Overview

Chapter two provides the review on the linkages between price volatility for agricultural commodities and the energy commodities. The findings are categorized into the following two sections.

2.1 Energy Commodity Prices Affect Agricultural Commodity Prices

According to the study by Thompson, Mayer and Westhoff (2009) that examined how ethanol prices affected by corn yield and petroleum prices in U.S. the study uses a data from 1994 to 2014 obtain from Food and Agriculture Policy Research Institute at University of Missouri, Columbia (FAPRI-MU). OLS method used to test the effect of corn yield and petroleum price on corn and ethanol price. Besides, partially stochastic stimulations had been used to estimate the variations of both markets prices and correlativity of main criteria in the markets. The fluctuation in petroleum price has related to ethanol plant price and hence it affects the price of corn in U.S. However, price of corn not only determine by the ethanol use in agricultural but also the demand of corn in the market. Thus, their explanations had further support the relationship between agricultural and energy markets.

The study by Chang and Su (2010) investigated the price spillover effects of WTI crude oil futures on crop commodity futures. The period of corn, soybean and crude oil prices used is separated into higher and lower crude oil price period. 4 January 2000 to 10 May 2004 defined as a lower crude oil price period while 11 May 2004 to 14 July 2008 is defined as higher crude oil price period. Bivariate EGARCH model used to examine the economic substitution effect of corn and soybean with fossil fuels in both periods. In addition, they carried out the Jarque-Bera test to show the degree of leptokurtic with respect to the normal distribution, while Ljung-Box test for the significance of linear and nonlinear dependencies. The results from this study showed that during higher crude oil price period, price spillover effects from crude oil futures to corn and soybean futures is positively significant. The economic substitution effect is observed in this period due to the production costs for biofuels are comparatively higher than fossil fuels. Hence, the growing crude oil price can encourage more biofuels consumptions. They further stated that the use of corn and soybean as biofuels caused the global food crisis.

Mutuc, Pan and Hudson (2010) examined on how U.S. cotton prices react to global oil price fluctuation by. A sample period covering monthly from 1976 to 2008 for crude oil and cotton prices are used. They use a structural vector autoregressive model to indicate the demand and supply shock of U.S. cotton price in the global crude oil market. Moreover, they use Johansen trace and Saikkonen and Lutkepohl tests to estimate the long-run relationship between oil and cotton prices. Furthermore, the fluctuation of oil prices in the global market may have a large difference regarding the increase in demand or supply shocks in the crude oil market. However, this study did not state that either the supply or demand side of cotton would be affected by world oil price shocks. Their result of the study showed that changes of cotton prices affected by the increases in world oil demand due to rising global real economic activities.

Using a volatility spillover models in U.S., Wu, Guan and Myers (2010) have obtained empirical evidence of existing spillover effect from crude oil prices to corn cash and future prices based on weekly data of 1992- 2009. Based on their finding, they suggested that implementation of Energy Policy Act of 2005 has led to a large increase in crude oil price which is highest among its historical prices. Their result indicates that price of crude oil determined the corn price movement. Since producers of corn are exposed to extra uncertainties from crude oil volatility spillover, thus it leads the agricultural market to expose to the agricultural risk. Therefore, the producers are suggested to develop an improved agricultural risk management and come out with new cross hedging strategies to minimize risk. However, the strategy only provides a slightly better performance compared to traditional hedging in corn futures market solely.

In the case of U.S, Du, Yu and Hayes (2011), they study the linkage between oil price volatility and agricultural commodities markets by using a bivariate stochastic volatility model. The sample period is from 1998 to 2009 and the price of corn, wheat and crude oil are quoted on a weekly basis using stochastic volatility models. The parameters of the models are determined using Bayesian Markov Chain Monte Carlo (MCMC) methods and it provides a precise estimation for parameters of the model. Therefore, the result of the test showed that agricultural commodities are triggered by the oil price shock in U.S. because of the interrelation between both food and energy market and also the raising of commodity investment in U.S. market over the years.

Nazlioglu and Soytas (2011) examined the short and long run interdependence among global oil prices, exchange rate and agricultural commodities prices in Turkey. Toda-Yamamoto causality approach and generalized impulse responses are used to test the long run parameters using a sample period from 1994 to 2010. After applying methods mentioned previously, they found that exchange rate does not affect the relationship between oil and agricultural prices. While result of generalized impulse responses show that changes of global oil price affects agricultural commodities in short run. Hence, effect may be varied due to the different time period of economic development in a country. As the changes in world energy prices determine the degree of responsiveness of agricultural prices to energy prices.

Ahmadi, Behmiri and Manera (2016) study the effects of oil shocks towards agricultural and metal commodity price volatilities in U.S for the following periods, such as before May 2006, after May 2006, before January 2008 and after January 2008. In 2006-2008, food price tension happening in the market and U.S. Government had introduced policies in 2005 to support ethanol production. On the other hand, world financial crisis took place in 2008. They used a structural vector autoregressive framework to test the effects of oil price shock towards the volatility of agricultural commodity by using time span covering from 1983 to 2014. Their result shows that different periods, impacts of economic events and the duration of events are important determinants for economic agents such as policy makers and crop producers to make their decisions. Hence, the response of volatility agricultural commodities price towards oil price shocks is short-lived.

2.2 Interdependence between Energy and Agricultural Prices

Serra (2011) studied the volatility links between sugar, ethanol and crude oil prices for the sample period of 2000-2009. This sample period consisted of three events. First, the ethanol boom issue happed in the mid-2000s which is driven by surge in U.S. demand. Second, the reduction of ethanol demand happened since 2008 due to economic and financial crisis had cause the weakening of ethanol prices. Third, the ethanol prices recovered in 2009 as the strong increase in sugar price which had passed on to ethanol prices. The author used a semiparametric GARCH model to assess the volatility links within the Brazil ethanol industry. Based on the results, the author concluded that the ethanol, crude oil and sugar price levels are linked in the long run. For example, when there is an increase in sugar and crude oil prices, it increased ethanol prices. In terms of volatility effect, ethanol price volatility has a positive impact on sugar price volatility.

Meanwhile, the relationship between agricultural and energy commodity markets has reinforced significantly with the recent rise in biofuel production, according to the study by Hertel and Beckman (2012). Energy is one of the main agricultural production inputs. However, the rise in energy prices with policies aimed to promote energy security and renewable fuel use have encouraged the use of crop feedstock to produce biofuel. Their study tends to analyse the linkages between agricultural and energy markets under different policy regimes and how the energy price volatility affect the commodity prices. The data period in this study is from pre-biofuel era which is 2001 to 2008 and biofuel era from 2008 to 2015. They conducted the applied general equilibrium (AGE) analysis on the international trade and land use impact of biofuels. Global Trade Analysis Project-Energy (GTAP-E) model is further used to capture the potential market feedback effects across production sectors and countries. As a result, they found that the rapid biofuel production had caused the transmission of energy price volatility into agricultural commodity price variation. However, the extent of outcome depends on the policy regime in renewable energy markets hence, the authors further foresee that agricultural price volatility which particularly for biofuel feedstock may raise.

In addition, Nazlioglu, Erdem, and Soytas (2013) investigates volatility spillovers between oil and agricultural commodity markets (wheat, corn, soybean, and sugar). They separated the sample period into pre-crisis and post-crisis which is 1 January 1986 to 31 December 2015 and 1 January 2006 to 31 March 2011. In order to analyse the volatility spillovers between agricultural commodity and world oil price, they adopted the causality-in-variance test and the univariate GARCH test. They further use VAR models for both sub-periods are used to determine how and to what extent the volatility of agricultural commodity response to the shock in the volatility of oil. There ia no risk transfer between any markets before the commodity crisis (2006-2008). However, the oil market risk is transmitted to the agricultural commodity markets after the crisis. Besides, they also discovered that the volatility spillovers from wheat to oil markets during both periods. They concluded that interdependency between energy and agricultural markets has increased. However, this study suggested that despite of the energy-agricultural linkage, the financial factors such as exchange rates and interest rates might have relation to the dynamics of commodity prices. Thus, there is a need for more empirical studies to identify the impacts of various factors on agricultural prices.

According to the study by Wu and Li (2013), they examined the level of interdependence and volatility spillovers among corn, fuel ethanol and crude oil markets in China. Using univariate EGARCH and BEKK-MVGARCH models, the results based on the sample period of 2003-2012 showed that the spillover effects among these markets are asymmetric, suggesting that the price volatility in crude oil played as a leading role in influencing other markets. Besides, unidirectional spillovers exist from the crude oil market to corn and fuel ethanol markets, while bidirectional spillovers are found between corn and ethanol markets. In terms of conditional correlations, their results showed that there is a closer linkage between corn and fuel ethanol markets.

Cabrera and Schulz (2016) studied that big scale of biodiesel production has transformed the relationship between energy and agricultural commodity prices. Their study aims to examine whether spillovers exist between agricultural commodity and energy prices and how it behaves overtime across energy and food crisis. Based on a multivariate GARCH model, they concluded that in the short run, biodiesel does not influence rapeseed and crude oil price levels and it reacted to price changes in other two markets. However, in long run the prices moved along and preserve an equilibrium relationship. They further found that during the crisis period, the volatility in all the markets are extreme, which the volatility strongly increased during the unstable period. The linkage between volatility of biodiesel and crude oil and the linkage between volatility of rapeseed and crude oil are proven to increase recently. The authors recommended that the further study of investigating the direction and size of potential spillover effects in these markets.

On the other hand, Al-Maadid et al. (2017) studied the mean and volatility spillovers between energy (ethanol and oil) and six selected food prices (cacao, coffee, corn, soybeans, sugar and wheat). The BEKK representation is used to estimate the VAR-GARCH model. The sample period of January 2003-March 2015 is separated into pre 2006 food crisis period and post crisis period. Their study confirmed that food and energy prices are highly interconnected and also provided evidence that the recent movement in the world economy has significantly affected their linkages. Due to the Renewable Fuel Standard (RFS) policy introduced in the US in 2005 and the global shocks, such as the food, oil and recent financial crisis, it appeared to have an impact on the dynamic interactions between energy and food prices.

2.3 Conclusion

In this chapter, most of the past studies found that energy prices affect the agricultural prices. As shown in Table 2.1, most of the studies emphasize a linkage between both markets in the case of U.S., which is the largest trading market in the world.

Table 2.1: Summary of studies on volatility spillovers between agricultural commodity and energy markets

Author	Period	Country	Commodity	Methodology	Result
Thompson et al (2009)	1996-2014 (yearly)	U.S.	Petroleum, Ethanol, Corn	Stochastically Structural model	E → A
Chang & Su (2010)	January 4, 2000 to July 14, 2008 (Daily)	U.S.	Corn, Soybean, WTI crude oil	Bivariate EGARCH model, Jarquee Bera normal distribution test, Ljunge Box statistics	E → A
Mutuc et al (2010)	January 1975 to Febuary 2008 (Monthly)	U.S.	Cotton, Crude oil	ADF, Kwiatkowski, Philipps, Schmidt & Shin (KPSS) unit root tests, Johansen trace test, S&L test	E → A
Wu et al (2010)	1992-2009 (Weekly)	U.S.	Crude oil, Corn	ADF tests, PP tests, Johansen tests, Univariate TGARCH	E → A
Du et al (2011)	1998 – 2009 (weekly data)	U.S.	Crude oil, Corn, Wheat	Univariate SVMJ, Bivariate stochastic volatility model, Bayesian MCMC method	E → A
Nazlioglu & Soytas (2011)	1994 to 2010 (monthly data)	Turkey	Crude oil, Wheat, Maize, Cotton, Soybeans, Sunflower	Long run Granger causality, Generalized impulse responses, VAR model	E → A
Serra (2011)	July 2000 to November 2009 (Weekly)	Brazil	Crude oil, Ethanol, Sugar	Semiparametric GARCH model, Engle and Granger test, Johansen co-integration test, VECM, BEKK GARCH specification	E ↔ A
Hertel & Beckman (2012)	2001-2008; 2008-2015 (Monthly)	U.S	Ethanol, Corn	AGE, Global Trade Analysis Project-Energy model	E ↔ A

Notes: E → A indicates that volatility of world energy commodity affect the agricultural commodity; E ↔ A indicates that both commodities are interdependence; SVAR = Structural vector autoregressive; S&L = Saikkonen and Lutkepohl; ADF = Augmented Dickey–Fuller; PP = Phillips–Perron; AGE = Applied general equilibrium; SW = Shapiro-Wilk; CCC = Constant conditional correlation; DCC = Dynamic conditional correlation; VAR = Vector autoregressive.

Table 2.1: (continued)

Author	Period	Country	Commodity	Methodology	Result
Nazlioglu et al (2013)	January 1, 1986 – December 31, 2005; January 1, 2006 – March 31, 2011. (Daily)	Turkey	Oil, Wheat, Corn, Soybeans	Causality- in-variance test, Univariate GARCH VAR model	E ↔ A
Wu & Li (2013)	2003 – 2012. (Weekly)	China	Crude oil, Fuel ethanol, Corn	Univariate EGARCH model, Trivariate BEKK-MVGARCH model, Unit Root Test Granger Causality Analysis, ARCH Test	E ↔ A
Ahmadi et al (2016)	1983-2014 (Daily)	U.S.	Oil, Corn, Soybeans , Sugar , Wheat , Coffee, Gold , Silver , Copper	Structural vector autoregressive (SVAR) model, GARCH model	E → A
Cabrera & Schulz (2016)	2003 – 2012. (Daily)	Germany	Crude oil, Ethanol, Sugar, Corn, Wheat	VECM, Multivariate GARCH, Box-Ljung test, SW test, Unit root test, CCC, DCC	E ↔ A
Al-Maadid et al. (2017)	1/1/2003– 6/6//2015 (Daily)	U.S.	Oil, Ethanol, Cacao, Coffee , Corn, Soybeans, Sugar , Wheat	VAR-GARCH model, Ljung–Box portmanteau tests	E ↔ A

Notes: E → A indicates that volatility of world energy commodity affect the agricultural commodity; E ↔ A indicates that both commodities are interdependence; SVAR = Structural vector autoregressive; S&L = Saikkonen and Lutkepohl; ADF = Augmented Dickey–Fuller; PP = Phillips–Perron; AGE = Applied general equilibrium; SW = Shapiro-Wilk; CCC = Constant conditional correlation; DCC = Dynamic conditional correlation; VAR = Vector autoregressive.

CHAPTER 3: DATA AND METHODOLOGY

3.1 Data

The time-series of volatility spillovers in China agricultural commodity and world energy market is explored using weekly price data at the wholesale levels from January 2003 to December 2016. These data obtained from National Bureau of Statistics of China and Bloomberg.

We used natural gas and crude oil as our main energy commodity in our research because both energies are non-renewable energy. The main agricultural commodity we used are corn, wheat and soybean because these products are the top production in china.

The sample period used is from January 31, 2003 to December 30, 2016, which consists of 168 observations. Both agricultural commodity and energy commodity prices are converted into natural logarithmic form in order to reduce variation and obtain a stationary movement of series. The weekly data had divided into 4 periods that is 2003/2005 energy crisis (March 29, 2003 to June 13, 2005), 2007/2009 financial crisis (December 13, 2006 to February 23, 2010), 2011/2013 oil crisis (August 16, 2010 to May 16, 2013) and lastly 2014/2016 oil crisis (December 24, 2015 to September 28, 2016).

3.2 Methodology

In the first step, we use a **unit root test** to determine the energy price and agricultural price are stationary or non-stationary. We choose to perform an augmented Dickey-Fuller unit root test because it is appropriate for trending time series. In the second step, we use a simultaneously dynamic model to capture the short-run relationship between energy commodity prices and agricultural commodity prices**.** In the third step, we capture the dynamic relationship between energy price and agricultural price using a Granger causality test. The last step, we use variance decomposition to capture the effect of its individual shock and the shock of other variables.

3.2.1 Augmented Dickey-Fuller unit root test

Augmented Dickey-Fuller (ADF) unit root test is developed by David Dickey and Wayne Fuller in 1979 (Econterm, 2015) .ADF test is used to determine unit root or non-unit root and avoid regression problem. This testing is performed based on Equations (1) and (2).

Constant, no trend: $\Delta y_t = \alpha + \gamma y_{t-1} + \sum_{s=1}^{m} a_s \Delta y_{t-s} + v_t$ (1)

Constant and trend: $\Delta y_t = \alpha + \gamma y_{t-1} + \lambda_t + \sum_{s=1}^{m} a_s \Delta y_{t-s} + v_t$ (2)

The optimal lag length is determined based on with the lowest AIC and SIC for the unit root test to solve the autocorrelation problem.

The null hypothesis of a unit root can be rejected if test statistic (Equation (3)) is lesser than the lower bound critical value. The rejection on the null hypothesis implies that the series is stationary in the level form.

Test Statistic $= \frac{\breve{\alpha}}{SE(\breve{\alpha})}$ (3)

3.2.2 Vector autoregression model

We use a VAR model to capture the short-run relationship between energy and agricultural commodities based on the linear interdependencies among series that affect by the history of the other series. The model is written as Equations (4) and (5).

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{p} \beta_1 \Delta Y_{t-1} + \sum_{i=1}^{p} \beta_2 \Delta X_{t-1} + V_{1t} \quad (4)$$

$$\Delta X_t = \alpha_0 + \sum_{i=1}^{p} \beta_1 \Delta Y_{t-1} + \sum_{i=1}^{p} \beta_2 \Delta X_{t-1} + V_{2t} \quad (5)$$

where Y_t denotes as an agricultural price on week t; and X_t denotes as a energy price on week t.

3.2.3 Granger causality test

This test is developed by Granger in 1969 (Maziarz, 2015). To reject the null hypothesis of energy prices do not Granger cause agricultural prices, the test statistic (Equation (6)) is greater than the critical value from F-distribution. This rejection suggests there is an existing Granger causality from energy markets to agricultural commodity markets.

$$F = \frac{(SSR_r - SSR_u)/(k_u - k_r)}{SSR_u/(\mathrm{n} - k_u))} \qquad (6)$$

where SSR_r = sums of squared residuals related to the restricted

SSR_u= sums of squared residuals related to the unrestricted

k_u= the number of parameters in the unrestricted model

k_r= the number of parameters in the restricted model

n = the number of observations

Nevertheless, Granger causality only able to capture the dynamic relationship among energy price and agricultural price, but it does not show how long the impact between these two variable. Therefore, we have to use variance decomposition to capture the shock between time series variables.

3.2.4 Variance decomposition

Variance decomposition is used to determines how much of the forecast error variance of each of the variable under the effect of its individual shock and the shock of other variables. This method provides the percentage of a shock of energy prices can be explained by a shock of agricultural commodity prices, implying that there is a volatility spillover effect exists from agricultural commodity markets to energy markets and vice versa.

CHAPTER 4: EMPIRICAL RESULTS

4.1 Preliminary Analysis

Table 4.1: Results of ADF unit root test

	WR	CR	SR	COR	NGR
Panel A					
Constant	-4.4750***	-7.1071***	-8.1875***	-9.5875***	-9.4750***
	(4)	(0)	(0)	(0)	(0)
Constant & Trend	-4.3526***	-7.1589***	-8.2075***	-9.5153***	-9.4123***
	(6)	(0)	(0)	(0)	(0)
Panel B					
Constant	-14.8753***	-8.9010***	-8.7797***	-13.8813***	-11.6120***
	(0)	(0)	(0)	(0)	(0)
Constant & Trend	-14.8778***	-8.8765***	-8.8455***	-13.8631***	-11.5794***
	(0)	(0)	(0)	(0)	(0)
Panel C					
Constant	-11.0852***	-9.8166***	-11.5267***	-11.5467***	-11.5639***
	(0)	(0)	(0)	(0)	(0)
Constant & Trend	-11.0463***	-9.9304***	-11.4922***	-11.5515***	-11.5537***
	(0)	(0)	(0)	(0)	(0)
Panel D					
Constant	-5.2745***	-3.4682**	-5.5507***	-5.1032***	-5.8988***
	(0)	(0)	(0)	(0)	(0)
Constant & Trend	-5.9249***	-3.3520*	-5.7096***	-4.9696***	-5.8937***
	(0)	(0)	(0)	(0)	(0)

Notes: Panel A = 26/3/2003 – 13/6/2005; Panel B = 13/12/2006 – 23/2/2010; Panel C = 16/8/2010 – 16/5/2013; Panel D = 24/12/2015 – 28/9/2016. WR = Wheat returns; SR = Soybean returns; CR = Corn returns; NGR = Natural Gas returns; COR = Crude Oil returns. ***, ** & * denotes as the null hypothesis of a unit root is rejected at 1%, 5% and 10% levels, respectively. Optimal lag length is reported in ( ).

Table~~s~~ 4.1 shows the result of Augmented Dickey Fuller (ADF) unit root test of energy and agricultural commodities during crisis periods. Based on two model specifications, test statistic values indicate that the null hypothesis of a unit root process is rejected. This suggests that all series are stationary at the level form.

4.2 Descriptive Statistics

Table 4.2: Descriptive statistics

	Mean	Median	Maximum	Minimum	Std. dev.	Skewness	Kurtosis	Jarque-Bera	Observations
Panel A									
WR	0.0039	0.0000	0.0658	-0.0423	0.0144	1.8417	9.2816	194.4321***	88
CR	0.0010	0.0000	0.1344	-0.0610	0.0246	1.9088	12.240	366.5074***	88
SR	0.0018	0.0000	0.1846	-0.1221	0.0394	1.2907	8.3046	127.6090***	88
COR	0.0083	0.0116	0.1282	-0.1503	0.0505	-0.2776	3.2097	1.2918	88
NGR	0.0063	-0.0018	0.2279	-0.2044	0.0808	0.4093	3.4773	3.2925	88
Panel B									
WR	0.0034	0.0000	0.1593	-0.1503	0.0265	0.2860	23.2848	2385.0190***	139
CR	0.0017	0.0000	0.0657	-0.0645	0.0170	0.1675	6.4066	67.8610***	139
SR	0.0047	0.0033	0.0962	-0.1406	0.0382	-0.7535	5.3545	45.2600***	139
COR	0.0030	0.0166	0.2412	-0.3189	0.0760	-1.2448	8.0137	181.4866***	139
NGR	-0.0026	0.0046	0.2440	-0.2384	0.0737	-0.0479	3.9307	5.0702*	139
Panel C									
WR	0.0018	0.0000	0.0417	-0.0448	0.0096	0.0277	10.888	360.3686***	139
CR	0.0017	0.0000	0.0445	-0.0458	0.0123	0.0609	4.8099	19.0580***	139
SR	0.0025	0.0016	0.0934	-0.1176	0.0284	-0.0631	6.3381	64.6266***	139
COR	0.0018	0.0028	0.1271	-0.1590	0.0378	-0.4681	5.4768	40.6050***	139
NGR	0.0002	-0.0042	0.1922	-0.1370	0.0572	0.2067	3.1380	1.1003	139
Panel D									
WR	-0.0014	-0.0027	0.0523	-0.0464	0.0166	0.2722	6.7413	17.8667***	30
CR	-0.0034	-0.0034	0.0350	-0.0498	0.0217	-0.2693	2.8033	0.4109	30
SR	0.0080	0.0023	0.0902	-0.0809	0.0345	0.0436	3.8670	0.9490	30
COR	0.0098	0.0139	0.0867	-0.0759	0.0486	-0.2097	2.0935	1.2470	30
NGR	0.0185	0.0112	0.1179	-0.0695	0.0541	0.3050	2.1353	1.3996	30

Notes: Panel A = 26/3/2003 – 13/6/2005; Panel B = 13/12/2006 – 23/2/2010; Panel C = 16/8/2010 – 16/5/2013; Panel D = 24/12/2015 – 28/9/2016. WR = Wheat returns; SR = Soybean returns; CR = Corn returns; NGR = Natural Gas returns; COR = Crude Oil returns. The ***, ** & * denotes as the null hypothesis of a normality test is rejected at 1%, 5% and 10% levels, respectively.

In Panel A, agricultural commodity markets have a smaller standard deviation which indicates that the risk of investing in the agricultural commodity markets are lesser than energy markets.

In Panel B, energy commodity markets have a higher standard deviation which indicates that the risk of investing in the energy markets are higher compare to agricultural commodity markets. However, all the commodities in this panel are rejected at 1 percent significance level except for natural gas which rejected at 10 percent significance levels.

As observed in Table 4.2, agricultural commodity returns are always having a smaller standard deviation than the energy commodity returns. This suggests that there is a lower risk of investing in the agricultural commodity markets as compared to energy markets. As a result, agricultural commodity markets will show lower risk as compared to energy commodity markets. Surprisingly, daily returns in the natural gas market are found to be normally distributed. It is other-wise for daily returns in the crude oil market. The possible resaon to support this finding is natural gas returns faced volatility lesser than crude oil returns.

Last, we can conclude that agricultural commodity markets will always have lesser risk compare to energy commodity markets because it is further proven in Panel D where table 4.2 shows agricultural commodity markets have a lower standard deviation. which indicates that the risk of investing in the agricultural commodity markets are lower comparing to energy commodity markets. In Panel D, the null hypothesis of a normal distribution for wheat returns is only found to be rejected at 1 percent significance level, while such hypothesis for remaining agricultural commodities is failed to be rejected even at the 10 percent significance level.

4.3 Granger Causality between Agricultural Commodity and Energy Markets

Table 4.3 :Results of Granger Causality Test

	WR → COR	COR → WR	WR → NGR	NGR → WR
Panel A	1.3400	0.0625	5.4738**	0.8352
Panel B	0.0256	0.0120	1.0047	0.1626
Panel C	0.6051	0.0007	0.2920	1.3162
Panel D	0.3130	0.2147	0.1120	4.1353*
	CR → COR	COR → CR	CR → NGR	NGR → CR
Panel A	0.732522	0.0031	0.0361	0.3874
Panel B	2.907953*	2.0300	0.2264	0.8367
Panel C	0.258108	0.0707	1.0639	0.2421
Panel D	0.019956	0.2130	1.6303	2.5879
	SR → COR	COR → SR	SR → NGR	NGR → SR
Panel A	0.026582	0.0009	1.4364	0.4042
Panel B	2.502555	0.2292	0.2973	2.9557*
Panel C	1.877041	0.0702	0.8146	0.5898
Panel D	0.035810	0.5173	2.9032	1.3822

Notes: WR refers to wheat returns, COR refers to crude oil returns, NGR refers to natural gas returns, CR refers to corn returns and SR refers to soybean returns. WR → COR denotes as testing for a Granger cause from wheat returns to crude oil returns. COR → WR denotes as testing for a Granger cause from crude oil returns to wheat returns. WR → NGR denotes as testing for a Granger cause from wheat returns to natural gas returns. NGR → WR denotes as testing for a Granger cause from natural gas returns to wheat returns. CR → COR denotes as testing for a Granger cause from corn returns to crude oil returns. COR → CR denotes as testing for a Granger cause from crude oil returns to corn returns. CR → NGR denotes as testing for a Granger cause from corn returns to natural gas returns. NGR → CR denotes as testing for a Granger cause from natural gas returns to corn returns. SR → COR denotes as testing for a Granger cause from soybean to crude oil. COR → SR denotes as testing for a Granger cause from crude oil returns to soybean returns. SR → NGR denotes as testing for a Granger cause from soybean returns to natural gas returns. NGR → SR denotes as testing for a Granger cause from natural gas returns to soybean returns. ** denotes as the reject of the hyphothesis at significance level 5%. * denotes as the reject of the hyphothesis at significance level 10%.

Table 4.3 shows the result of Granger causality test between energy and agricultural commodity returns. As observed in Panel A, wheat returns Granger cause natural gas returns at the 5 percent significance level. This may due to the happening of energy crisis where the crude oil price increased and OPEC had reduced the production of crude oil. China had the most production of wheat instead of other agricultural commodities, and wheat is used to produce biofuels such as natural gas which may replace the crude oil.

As observed in Panel B, the corn returns Granger cause crude oil returns at 10 percent significance level and natural gas returns Granger cause soybean returns at 10 percent significance level. This is due to the financial crisis. When the stock market crashed, investors tend to trade soft or hard commodity in compensating their losses in the stock markets. The results show that corn returns Granger cause crude oil returns. This finding suggests that investors prefer to use the agricultural commodity returns to predict energy commodity returns before trading since corn can act as a substitution material for crude oil in producing biofuels and Granger cause the crude oil returns. Besides, we also observed an opposite Granger cause of energy commodity to agricultural commodity in the fourth period. The reason of energy Granger cause agricultural commodity in the fourth period is that natural gas used as an input of producing fertilizers to increase the productivity of agricultural commodities such as soybean hence changes in the natural gas returns will affect the returns of agricultural commodities. However, the specific relationship of natural gas Granger cause soybean is due to soybeans are imported from U.S. and India. The imported soybean has high currency and perceived risk, which tend to bring higher returns to the investor. This decision is made due to the assumption of higher risk indicates higher returns.

In Panel C, there is no existence of Granger causality among agricultural and energy commodity returns. In this period, the high fluctuations of energy prices caused the investors to stop investing in energy commodity markets and switched to agricultural commodity markets to prevent losses. Besides, the use of agricultural commodities for the production of biofuels can replace energy related commodities. Therefore, the returns for both energy and agricultural commodities will be independent.

As observed in Panel D, natural gas returns Granger cause wheat returns at 10 percent significance level. This is due to natural gas are used as fertilizer to increase the production of wheat in China. Wheat is the major agricultural commodity production in China as it has a largest proportion of production compare to other agricultural commodities. Thus, market participants will forecast the wheat returns according to the performance of natural gas returns.

Overall, we can conclude that when there are shortages of energy commodities, there will be a relationship between wheat and natural gas. This is due to the usage of natural gas as fertilizer and use of wheat to produce biofuels that can replace the energy commodities such as in Panel A and Panel D. In contrast, when fluctuations exist in energy markets, market participants will focus on agricultural commodity markets as it can be used to produce biofuels to replace energy commodities.

4.4 Spillover Effect between Agricultural and Energy Commodity Market

Table 4.4 shows the variance decomposition results for wheat and energy commodity returns of the 4th week, 8th week, 12th week, 16th week and 20th week onward forecasted error for each variable based on the VAR model.

In Panel A and Panel D, natural gas returns is explained by a shock of wheat returns is about 6.02 percent and 13.35 percent, respectively. The reason is wheat has the largest production which had been used to produce biofuels to susbtitute the usage of crude oil. When there is energy crisis, a large proportion of natural gas returns is found to be explained by a shock of wheat returns.

As oberved in Panel B, there is a small percentage proportion of shocks in energy commodity returns due to a shock increases in agricultural commodity markets and vice versa. This suggest that maerket paricipants tend to emphasize corn and soybean in their trding. As wheat is the largest production in China, a shock of heat returns is found to explain a shock in the energy markets.

In Panel C, 5.68 percent shock of wheat returns is explained by a shock in crude oil market due to the occurance of energy fluctuations. This finding suggest that crude oil returns can be used to predict the wheat returns because wheat can provide an input in producing biofuels. In Panel D, 3.06 percent shock of wheat returns is explained by a shock in natural gas market.

Table 4.4 : Variance decomposition for wheat and energy commodity returns

Market explained	Horizon (in week)	By innovation in WR	COR	WR	NGR
Panel A:					
WR	4	99.7803	0.219689	99.06317	0.936832
	8	99.7803	0.219689	99.06316	0.936843
	12	99.7803	0.219689	99.06316	0.936843
	16	99.7803	0.219689	99.06316	0.936843
	20	99.7803	0.219689	99.06316	0.936843
COR	4	1.5554	98.44456	NA	NA
	8	1.5554	98.44456	NA	NA
	12	1.5554	98.44456	NA	NA
	16	1.5554	98.44456	NA	NA
	20	1.5554	98.44456	NA	NA
NGR	4	NA	NA	6.022599	93.97740
	8	NA	NA	6.022689	93.97731
	12	NA	NA	6.022689	93.97731
	16	NA	NA	6.022689	93.97731
	20	NA	NA	6.022689	93.97731
Panel B:					
WR	4	99.91445	0.085551	99.84747	0.152535
	8	99.91444	0.085556	99.84745	0.152549
	12	99.91444	0.085556	99.84745	0.152549
	16	99.91444	0.085556	99.84745	0.152549
	20	99.91444	0.085556	99.84745	0.152549
COR	4	0.020678	99.97932	NA	NA
	8	0.020703	99.97930	NA	NA
	12	0.020703	99.97930	NA	NA
	16	0.020703	99.97930	NA	NA
	20	0.020703	99.97930	NA	NA
NGR	4	NA	NA	0.738479	99.26152
	8	NA	NA	0.738646	99.26135
	12	NA	NA	0.738646	99.26135
	16	NA	NA	0.738646	99.26135
	20	NA	NA	0.738646	99.26135

Table 4.4: (Continued)

Market explained	Horizon (in week)	By innovation in WR	COR	WR	NGR
Panel C:					
WR	4	94.31770	5.682302	99.15903	0.840966
	8	94.31770	5.682302	99.15903	0.840967
	12	94.31770	5.682302	99.15903	0.840967
	16	94.31770	5.682302	99.15903	0.840967
	20	94.31770	5.682302	99.15903	0.840967
COR	4	0.000507	99.99949	NA	NA
	8	0.000507	99.99949	NA	NA
	12	0.000507	99.99949	NA	NA
	16	0.000507	99.99949	NA	NA
	20	0.000507	99.99949	NA	NA
NGR	4	NA	NA	0.970314	99.02969
	8	NA	NA	0.970315	99.02969
	12	NA	NA	0.970315	99.02969
	16	NA	NA	0.970315	99.02969
	20	NA	NA	0.970315	99.02969
Panel D:					
WR	4	97.85434	2.145657	96.93556	3.064443
	8	97.85434	2.145657	96.93555	3.064446
	12	97.85434	2.145657	96.93555	3.064446
	16	97.85434	2.145657	96.93555	3.064446
	20	97.85434	2.145657	96.93555	3.064446
COR	4	0.781886	99.21811	NA	NA
	8	0.781887	99.21811	NA	NA
	12	0.781887	99.21811	NA	NA
	16	0.781887	99.21811	NA	NA
	20	0.781887	99.21811	NA	NA
NGR	4	NA	NA	13.34631	86.65369
	8	NA	NA	13.34634	86.65366
	12	NA	NA	13.34634	86.65366
	16	NA	NA	13.34634	86.65366
	20	NA	NA	13.34634	86.65366

Notes: Panel A = 26/3/2003 – 13/6/2005; Panel B = 13/12/2006 – 23/2/2010; Panel C = 16/8/2010 – 16/5/2013; Panel D = 24/12/2015 – 28/9/2016. WR = Wheat returns; SR = Soybean returns; CR = Corn returns; NGR = Natural Gas returns; COR = Crude Oil returns. NA denotes as not available where the shock is unable to explained by the combination of variables.

In Table 4.5, it shows the variance decomposition results for soybean returns and energy commodity returns. The results indicate that the shock of soybean returns can be explained by crude oil returns is about 11.89 percent in Panel B. The shock of soybean returns explained by natural gas returns is highest in Panel D which shows 22.44 percent. A shock in soybaean market is found to explain 4.54 percent of a shock in natural gas market.

In Panel B and Panel D, investors stopped investing in energy markets and switched to soybean markets. As soybean is one of the main import commodity of

China, investor will have high preceived risk towards this commodity because such commodity is traded with different currencies. Hence, a higher risks of investment, investors will expect a higher return from their trading on such commodity.

Meanwhile, Panel A and Panel C are found to provide the smallest proportion of shock in soybean and energy markets This is due to energy crisis had caused investors to concern more about the agricultural commodity markets and ignore the fluctuations in energy commodity markets.

Table 4.5 : Variance decomposition for soybean and energy commodity returns

Market explained	Horizon (in week)	By innovation in SR	COR	SR	NGR
Panel A:					
SR	4	97.57207	2.427927	97.05492	2.945080
	8	97.57207	2.427927	97.05492	2.945080
	12	97.57207	2.427927	97.05492	2.945080
	16	97.57207	2.427927	97.05492	2.945080
	20	97.57207	2.427927	97.05492	2.945080
COR	4	0.031291	99.96871	NA	NA
	8	0.031291	99.96871	NA	NA
	12	0.031291	99.96871	NA	NA
	16	0.031291	99.96871	NA	NA
	20	0.031291	99.96871	NA	NA
NGR	4	NA	NA	1.653281	98.34672
	8	NA	NA	1.653281	98.34672
	12	NA	NA	1.653281	98.34672
	16	NA	NA	1.653281	98.34672
	20	NA	NA	1.653281	98.34672
Panel B:					
SR	4	88.10546	11.89454	93.55052	6.449483
	8	88.10541	11.89459	93.55013	6.449866
	12	88.10541	11.89459	93.55013	6.449866
	16	88.10541	11.89459	93.55013	6.449866
	20	88.10541	11.89459	93.55013	6.449866
COR	4	1.657859	98.34214	NA	NA
	8	1.657898	98.34210	NA	NA
	12	1.657898	98.34210	NA	NA
	16	1.657898	98.34210	NA	NA
	20	1.657898	98.34210	NA	NA
NGR	4	NA	NA	0.216891	99.78311
	8	NA	NA	0.216919	99.78308
	12	NA	NA	0.216919	99.78308
	16	NA	NA	0.216919	99.78308
	20	NA	NA	0.216919	99.78308

Table 4.5 : (Continued)

Market explained	Horizon (in week)	By innovation in SR	COR	SR	NGR
Panel C:					
SR	4	98.62863	1.371373	99.12646	0.873544
	8	98.62863	1.371373	99.12646	0.873544
	12	98.62863	1.371373	99.12646	0.873544
	16	98.62863	1.371373	99.12646	0.873544
	20	98.62863	1.371373	99.12646	0.873544
COR	4	0.051193	99.94881	NA	NA
	8	0.051193	99.94881	NA	NA
	12	0.051193	99.94881	NA	NA
	16	0.051193	99.94881	NA	NA
	20	0.051193	99.94881	NA	NA
NGR	4	NA	NA	0.431821	99.56818
	8	NA	NA	0.431821	99.56818
	12	NA	NA	0.431821	99.56818
	16	NA	NA	0.431821	99.56818
	20	NA	NA	0.431821	99.56818
Panel D:					
SR	4	81.31785	18.68215	77.56194	22.43806
	8	81.31785	18.68215	77.56128	22.43872
	12	81.31785	18.68215	77.56128	22.43872
	16	81.31785	18.68215	77.56128	22.43872
	20	81.31785	18.68215	77.56128	22.43872
COR	4	1.994272	98.00573	NA	NA
	8	1.994273	98.00573	NA	NA
	12	1.994273	98.00573	NA	NA
	16	1.994273	98.00573	NA	NA
	20	1.994273	98.00573	NA	NA
NGR	4	NA	NA	4.534952	95.46505
	8	NA	NA	4.536034	95.46397
	12	NA	NA	4.536034	95.46397
	16	NA	NA	4.536034	95.46397
	20	NA	NA	4.536034	95.46397

Notes: Panel A = 26/3/2003 – 13/6/2005; Panel B = 13/12/2006 – 23/2/2010; Panel C = 16/8/2010 – 16/5/2013; Panel D = 24/12/2015 – 28/9/2016. WR = Wheat returns; SR = Soybean returns; CR = Corn returns; NGR = Natural Gas returns; COR = Crude Oil returns. NA denotes as not available where the shock is unable to explained by the combination of variables.

As observed in Table 4.6, 4.77 percent of the shock of corn returns can be explained by crude oil returns is found in Panel B. In Panel D, 9.72 percent shock of corn returns is found can be explained by natural gas returns, while 9.84 percent shock of natural gas returns explained by corn returns.

The relationship between corn and energy commodity returns exists due to the fact that corn can be used to produce biofuels which are substitute products for energy commodities such as crude oil and natural gas. In Panel A and Panel C, corn returns and energy commodity returns can only explain least of another because of the happening of previous energy crisis and the investors had learn from previous experience and they know how to handle the risk.

Table 4.6 : Variance decomposition for corn and energy commodity returns

Market explained	Horizon (in week)	By innovation in CR	COR	CR	NGR
Panel A:					
CR	4	99.96569	0.034310	99.55154	0.448462
	8	99.96569	0.034310	99.55144	0.448559
	12	99.96569	0.034310	99.55144	0.448559
	16	99.96569	0.034310	99.55144	0.448559
	20	99.96569	0.034310	99.55144	0.448559
COR	4	0.844426	99.15557	NA	NA
	8	0.844589	99.15541	NA	NA
	12	0.844589	99.15541	NA	NA
	16	0.844589	99.15541	NA	NA
	20	0.844589	99.15541	NA	NA
NGR	4	NA	NA	0.041979	99.95802
	8	NA	NA	0.041989	99.95801
	12	NA	NA	0.041989	99.95801
	16	NA	NA	0.041989	99.95801
	20	NA	NA	0.041989	99.95801
Panel B:					
CR	4	95.22661	4.773393	97.05152	2.948483
	8	95.22643	4.773569	97.05159	2.948410
	12	95.22643	4.773569	97.05159	2.948410
	16	95.22643	4.773569	97.05159	2.948410
	20	95.22643	4.773569	97.05159	2.948410
COR	4	1.875181	98.12482	NA	NA
	8	1.875288	98.12471	NA	NA
	12	1.875288	98.12471	NA	NA
	16	1.875288	98.12471	NA	NA
	20	1.875288	98.12471	NA	NA
NGR	4	NA	NA	0.166907	99.83309
	8	NA	NA	0.167004	99.83300
	12	NA	NA	0.167004	99.83300
	16	NA	NA	0.167004	99.83300
	20	NA	NA	0.167004	99.83300

Table 4.6: (Continued)

Market explained	Horizon (in week)	By innovation in CR	COR	CR	NGR
Panel C:					
CR	4	99.33439	0.665607	99.25644	0.743558
	8	99.33439	0.665610	99.25643	0.743572
	12	99.33439	0.665610	99.25643	0.743572
	16	99.33439	0.665610	99.25643	0.743572
	20	99.33439	0.665610	99.25643	0.743572
COR	4	0.052739	99.94726	NA	NA
	8	0.052741	99.94726	NA	NA
	12	0.052741	99.94726	NA	NA
	16	0.052741	99.94726	NA	NA
	20	0.052741	99.94726	NA	NA
NGR	4	NA	NA	0.179835	99.82017
	8	NA	NA	0.179838	99.82016
	12	NA	NA	0.179838	99.82016
	16	NA	NA	0.179838	99.82016
	20	NA	NA	0.179838	99.82016
Panel D:					
CR	4	97.45112	2.548876	90.27740	9.722604
	8	97.45132	2.548677	90.27739	9.722607
	12	97.45132	2.548677	90.27739	9.722607
	16	97.45132	2.548677	90.27739	9.722607
	20	97.45132	2.548677	90.27739	9.722607
COR	4	1.055277	98.94472	NA	NA
	8	1.056478	98.94352	NA	NA
	12	1.056478	98.94352	NA	NA
	16	1.056478	98.94352	NA	NA
	20	1.056478	98.94352	NA	NA
NGR	4	NA	NA	9.840622	90.15938
	8	NA	NA	9.840906	90.15909
	12	NA	NA	9.840906	90.15909
	16	NA	NA	9.840906	90.15909
	20	NA	NA	9.840906	90.15909

Notes: Panel A = 26/3/2003 – 13/6/2005; Panel B = 13/12/2006 – 23/2/2010; Panel C = 16/8/2010 – 16/5/2013; Panel D = 24/12/2015 – 28/9/2016. WR = Wheat returns; SR = Soybean returns; CR = Corn returns; NGR = Natural Gas returns; COR = Crude Oil returns. NA denotes as not available where the shock is unable to explained by the combination of variables.

. CHAPTER 5: CONCLUSION

5.0 Overview

This chapter provides a summary on major findings and implications. It further provides recommendation for the future researchers.

5.1 Major Findings

Based on the result, there are two major findings. First, agricultural commodity returns will influence energy commodity prices when China is the main producer the agricultural commodity such as wheat. In contrast, energy commodity returns will influence agricultural commodity prices when China is an importer country on soybean. However, when an agricultural commodity is neither main production or imported by China such as corn, there is a bidirectional relationship exists between agricultural and energy commodity markets.

Second, in Panel D, there is a large proportion of the shock in agricultural commodities due to the shock in energy markets and vice versa. This is due to fewer observations are included in the period and we believe that the spillovers effect has been carry forward to the next period.

5.2 Implications

Based on the above two major findings, this suggests two implications for producers, investors and policy makers. Based on the first finding, investor and producer should concern about the background of the commodities market before they make further decision. The investors will have to make a tradeoff between agricultural and energy commodities depend on whether the agricultural commodities are main production of China or imported from another country. If investor plans to make an investment in energy commodities, the investor has to make sure China is the main producer of agricultural commodities so that he/she can predict the energy prices based on the agricultural commodity returns to maximize his/her profits. In contrast, when China is the main importer in agricultural commodity instead of main producer, investor should concern more on the energy commodity returns when they planned to invest in agricultural commodities. As a result, investors can predict the price of agricultural commodity based on the returns of energy commodity.

Based on the second finding, policy makers should anticipate the crisis before it happens as the spillover effects are still being carry forward until now. Besides, policy maker also should adjust policy accordingly to the crisis in order to help market participants in agricultural and energy commodity markets in China.

5.3 Limitations

The focus of this study is only in the case of China. Therefore, the limitation of this study is a lack of comparison between China and India. The reason is India has the similarity with China because the country's main agricultural production also includes wheat, corn and soybean. However, the difference is that India is the main exporter of soybean while China is the main importer of soybean. Therefore, this study can be said to lack of information regarding the comparison of China and other countries in term of volatility spillovers between agricultural and energy commodity prices.

5.4 Recommendation for Future Research

The future direction of research is suggested to emphasize in the case of India, as different findings are expected to be found. By comparing the findings of the case of China and India, it is expected to provide related information to the relevant market participants due to the different market structures.

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