ASYMMETRIC ADJUSTMENT BETWEEN CRUDE OIL AND COMMODITY MARKET. EVIDENCE FROM CORN, SOYBEANS, PALM OIL, WHEAT AND SUGAR

CHIN LIT BIN
FONG WOEI LUNN
TAN ZHI YUN
TEOH POH SHEN
YUE HUI KUEN

BACHELOR OF BUSINESS ADMINISTRATION
(HONS) BANKING AND FINANCE

UNIVERSITI TUNKU ABDUL RAHMAN

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BY

CHIN LIT BIN
FONG WOEI LUNN
TAN ZHI YUN
TEOH POH SHEN
YUE HUI KUEN

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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.

(4) The word count for this research project is 16,714 words.

Name of Student:	Student ID:	Signature:
1. CHIN LIT BIN	10ABB06516	_____
2. FONG WOEI LUNN	10ABB03313	_____
3. TAN ZHI YUN	10ABB06517	_____
4. TEOH POH SHEN	10ABB02930	_____
5. YUE HUI KUEN	10ABB06472	_____

Date:

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DEDICATION

Dedicated to

Mr. Lim Chong Heng
Supervisor who has provided useful guidance, valuable supports, constructive feedbacks and precious encouragement to us.

Team Members
Five team members who cooperate well with each other although having different opinions during the process of this research.

Thank You.

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LIST OF ABBREVIATIONS

ADF	Augmented Dickey Fuller
AECM	Asymmetric Error Correction Model
BPS	Statistics Agency
CBOT	Chicago Board of Trade
CGE	Computable General Equilibrium
ECM	Error Correction Model
GL	Gay-Lussac
KPSS	Kwiatkowski, Philips, Schmidt, and Shin
M-TAR	Momentum- Threshold Autoregressive
RFS	Renewable Fuel Standard
TAR	Threshold Autoregressive
TG	Telegram
TMO	Turkish Grain Board
USDA	United States Department of Agriculture

PREFACE

World food prices increased dramatically in year 2008, in turn created a global food crisis and caused politic and economic uncertainty in many countries. It successfully attracts the attention of researchers and scholars from all over the world and leads to the investigations on the factors of food crisis. While rising of crude oil price has been discovered as one of the main factors that caused the food crisis, people tend to look for alternative fuel as a substitute for crude oil. Due to the environmental concern for a greener Earth, the renewable fuel, which is known as biofuel had emerged as an alternative fuel.

Food commodities like corn, soybeans, palm oil, wheat and sugar are needed in the production of biofuel, as the demand for biofuel increases, it escalates the prices of those food commodities as well and lead to food crisis. While having a strong price linkages between crude oil and food commodity, this study studies the relationship between crude oil price and commodities prices.

However, previous researchers assumed that the commodity market reacts symmetrically to the crude oil price change. Yet, the market is asymmetric in reality as positive and negative shock of crude oil price bring different effect Therefore, we came about to engage in the relationship of crude oil price movements on commodities price movements with the assumption that the market is asymmetric. We decided to elect five commodities that mainly used in the production of biofuel, which are corn, soybeans, palm oil, wheat and sugar.

ABSTRACT

This study examines the effect of crude oil price on the various commodity prices namely corn, soybeans, palm oil, wheat, and sugar from 1983 to 2013 by using quarterly data. The existing literature did not emphasize on the studies of asymmetric effect from crude oil price to commodities price. This study fills this gap by analyzing if there is asymmetric in how commodities price respond to crude oil price change. On the methodological side, this study employed Asymmetric Error Correction Model (AECM) to describe asymmetric price behaviour between crude oil price and commodities price. This paper found that prices of corn, soybeans and palm oil react asymmetrically to the changes of crude oil price. In addition, the asymmetric effect of soybeans is found through TAR Model while asymmetric effect of corn and palm oil are found through M-TAR Model. It is evidenced that soybeans price react excessively to the negative shocks compared to positive shocks of crude oil price changes whereas corn and palm oil price are react significantly to both positive shocks and negative shocks caused by crude oil price change but the momentum speed of adjustments are different. The findings hence provide evidence for a better understanding on the relationship between oil price and commodities price for policy makers, farmers and investors.

Keyword: crude oil price, commodities price, asymmetric adjustment

CHAPTER 1: RESEARCH OVERVIEW

1.0 Research Background

In year 2008, the tremendous fluctuation of food prices such as wheat, rice, soybeans and corn made food crisis happened. The commodity price boom did successfully attracts a lot of awareness all over the world and it had increased the interest of researchers towards the movement of commodities prices. Figure 1.1 showed that whole world struggled from a large spike of food prices in year 2008. By June 2008, the food commodity price index had increased up to 130% and fall about 33% when came to December. The upward trend was unexpected as the index had a drastic increased and exceeded the previous commodity price index's peak in 2008 when came to April 2011. The wide price swing is unforeseeable and it brings great impacts to low income countries and developing countries as well.

The global food crisis may increase the poverty to those already-poor. The poorer household such as those female-headed household usually spent a higher proportion of their income on food and a lesser proportion on savings. The impact of rising food prices therefore made those existing poor getting poorer rather than increasing the number of 'new poor'. The probability of malnutrition among children may also increase as food prices increased. Young children are those who need rich nutrition foods the most to ensure their healthy growth, however increasing depth of poverty in household may limit their ability to have a better healthcare, education and other benefits too.

Moreover, developing countries also found their export, investment and capital flows at risk. For agricultural sector, the rising of food prices does not necessarily mean higher income for those producers and farmers. The incentives for them to produce and invest not only depend only on the prices, but also depend on the input cost. The prices for seeds and fertilizers were more than doubled after crisis. Therefore, the

poor farmers with limited access to agricultural market like lack of capital, transportation and market infrastructure may not take advantage on the increased in commodity prices. In short, the rise in food price does not reach developing country perfectly.

Since food crisis 2008, the fluctuation of food commodity prices had raised the attention of researchers and scholars. In fact, the changes of the food commodity prices are found to be affected by numerous factors including macroeconomic developments, fundamentals of demand and supply, government policies and so on.

Besides that, it is found that the financial market participants also affect the food commodity prices. Some investors would like to speculate in the food commodity contracts in order to obtain huge profit while others are looking to hedge their commodity price risk. After commodity market has been financialized, food commodity prices have become more sensitive to the surprise elements of macroeconomics news. Other than the reasons above, it is discovered that there is relationship between agricultural commodities and exchange rate because the decline in value of U.S. dollar causes the commodities relatively cheaper to other countries (Harri, Nalley & Hudson, 2009).

Demand and supply of the food commodities is another factor that affects the commodities prices. Generally, there is an increasing demand due to growing world population and income per capita. Food commodities in China have a low-income elasticity as the income for both rural and urban households are increasing at a fast pace. Next, supply of food commodity declined due to climate change that adversely affects the food price. For instance, water scarcity in Australia due to climate change can affect the exports of wheat, meat and dairy products, subsequently affect the global food prices and also global food security.

Due to food crisis 2008, some food-deficit countries had established trade-based policy to reduce the pressure of hiking global food price on domestic market. For example, China had reduced tariffs on imports and banned exports to protect food security of its own country's residents. However, such policy will affect the food security of other country that doesn't have sufficient power to execute such trade

policy (Yu, Tokgoz, Wailes & Chavez, 2011). In fact, global food commodity prices tend to increase as usual. Therefore, the food price pressure will be heavier for those poorer countries that have inadequate power to establish such trade policy.

Many researchers are interested in evaluating whether crude oil price changes can affect commodity prices changes. Baffes (2007) showed that crude oil price had affected the food commodity prices in terms of demand and supply side factors. On the supply side, crude oil price may affect the production costs and transportation costs when producing the food commodities. To be specific, production cost is made up of fertilizer and fuel that are important in producing food commodities. Transportation cost is incurred when transferring the food commodities from production to end users. Next, some food commodities can be used to produce the substitutes for crude oil, biofuel. For example, maize and sugar are used to produce bio-ethanol. On the demand side, increase in crude oil price caused an increase in disposable income for the oil exporting countries and this may affect the demand for food commodities. For example, increase in crude oil price can improve the disposable income in Middle Eastern countries and this lead to high level of consumption for some food commodities such as tea.

The relationship between crude oil prices and commodities prices had been also investigated by other researchers. Generally, high crude oil price is the major factor that drives up the commodity prices. Moreover, the relationship between changes in crude oil price and changes in commodity prices had been studied by Ji and Fan (2012), Lescaroux (2009), Nazlioglu (2011), Nazlioglu, Erdem and Soytas (2013) and Reboredo (2012).

In addition, developments in biofuel production are also considered as a main factor that caused the increase in food prices and are main factor of food crisis. Expansion in biofuel production in the U.S. and the EU is the reason why prices of grains and oilseeds have increased sharply since 2002. Biofuel production in U.S and EU were supported by subsidies, mandates and tariffs on imports since biofuel can reduce dependence on imported oil and reduce greenhouse gas emissions. However, such

government policies caused the higher increment of food commodities prices and biofuel production.

The biofuel production had affected the food prices in three ways. First, some food commodities are suitable in producing biofuels such as corn, soybeans, sugar and wheat. Second, farmers are encouraged to reduce their land for the cultivation of food commodities that are not suitable in producing biofuel such as rice. In short, these two factors have reduced the food supply and increase the food prices. Lastly, the increasing grain prices created the spark financial speculation in grain, this further increased the food prices.

According to Chang and Su (2010), substitution effect of biofuels for fossil fuel is greater when there is high crude oil price. This indicated that high food prices are due to high consumption of biofuel. However, the effect is from crude oil future to corn and soybean future but not in terms of spot prices.

In short, this paper has studied the relationship between spot crude oil prices and food commodities prices. At the same time, it also explained the important roles played by biofuel in this prices transmission.

1.1 The Rationale and Importance of Five Commodities Chosen

As an alternative of crude oil, biofuel production such as bioethanol and biodiesel are expanded in most countries around the world, especially when there is high crude oil price. Meanwhile, the expanding biofuel production can be concluded as the most important factor that caused high food prices and food crisis. Section below will discuss about the importance and rationale of commodities chosen, which prices are affected by the crude oil price due to biofuel production.

1.1.1 Corn: From Food to Biofuel

Recent years, many countries around the world had launched a lot of biofuel programs to support the biofuel production with desire to boost agricultural industries, achieve energy security, reduces greenhouse gas emissions and other reasons too. Bioethanol is a type of biofuel that derived from corn while United States is the largest producer of bioethanol.

Since the potential economic, social and environmental impacts imposed by biofuel, U.S. government had established a Renewable Fuel Standard (RFS) program, which increases biofuel production to 36 billion gallons by 2022. In addition, fiscal incentives by tax subsidiaries and regulatory instruments such as biofuel blending mandate are the main driving force of the growth of ethanol output in US. According to United States Department of Agriculture (USDA), approximately 40% of total used of corn is used to produce bioethanol. This paper can provides more information to study the price changes of corn, which is the principal commodity that used in producing biofuel in U.S.

Furthermore, China's Five Year Plan stated that reduction of reliance on fossil fuel and increased the consumption on non-fossil fuel including biofuel. In 2012, 64% of bioethanol production is from corn while 30% and 6% of the production are from wheat and cassava respectively (USDA, 2013). Even the developing biofuel industry in China can reduced its dependence on external sources of energy supply, some researchers are still paying attention to the effects of biofuel production on food security issues in China. The growing bioethanol production in China will increase the demand and prices of corn. When the prices of corn increase, the corn planting will also increase but the planting for principal food such as rice will decrease. As a result, corn price should be monitored closely because they pose severe impacts on food security.

Other than that, bioethanol production has indirect impact on livestock market. Since corn is main source of feed for livestock in U.S., increasing corn prices will increase the cost of feed for livestock. Then, livestock production may decrease due to high cost and the livestock prices might be affected at the same time (Elobeid, Tokgoz,

Hayes, Babcock & Hart, 2007). Again, this effect will be painful for rural citizens including those who have to pay high food prices and also those livestock producers who have to pay high feed costs.

To be summarized, this paper analyze the effect of crude oil prices on corn prices can provide more information and understanding for policymakers who establish bioethanol policy. Therefore, it is important for the policymakers to maintain the economic balance between food security and energy security since the fluctuation will pose significant effect for rural citizens.

1.1.2 Soybeans: Economic Impacts on Biodiesel and Grain Production

In this paper, soybeans are being studied as one of the main commodity because of its importance in the energy and agricultural sector. Firstly, soybeans are the main raw material used to produce biofuel such as biodiesel in the energy sector. With the environment friendly energy policy, conventional diesel is being replaced with biodiesel. The prices of soybeans prices are highly interrelated with crude oil prices, it signifies the importance of soybean because of rapid growth of biofuel production. The recent development of biofuel industry had made agricultural commodities such as soybean much more important than they used to be.

Secondly, soybean is also the key agricultural product for food in the world. It then leads international investors to focus on the price dynamics of food commodity in order to make investment decision and diversify risk. Specifically, soybean price hits record high because of the worst draught that hit United States, causing food crisis to happen, where food shortages saw riots happening in both high and low income country. It is the prolonged dry weather forecasted by The National Oceanic and Atmospheric Administration that support the rally, triggering speculation in the soybean prices. Hence, the price dynamics of soybean prices is vital to be studied in the paper.

Thirdly, soybeans are the also main ingredients of staple foods such as tempeh and tofu, which are the famous side dishes of Indonesia. Indonesia, which imports two-third of its soybeans had suffered from the rising cost of soybean. As reported by the Central Statistics Agency (BPS), Indonesia imported 1 million tons of soybeans in 2010, while in 2011 the volume doubled to 2.08 million tons. The skyrocketing international price of soybeans had also pushed up the domestic price of soybeans, which is at retailer level. Hence, it exerts pressure on tempeh and soybeans producers because the prices of raw material are so expensive. On the other hand, it is impossible to pass through the hike in soybean price to final users. As a result, there have been reports of the collapse of small-scale tempeh and tofu producers. Therefore, this paper studied the importance of soybeans which played the significant role of staple food as in developing country.

Not only in Indonesia, soybeans also served as an important ingredient of Asian cuisines. For instance, China, the new strong powerhouse had seen its soybeans' import had increased rapidly. It imported 30.82 million tons of soybeans in 2007, 42.54 million tons in 2009 and 52.64 million tons in 2011. Hence, it is obvious that China is over-relied on foreign imports. According to the Heilongjiang Soybean Association, the consumption of soybeans oil produced by domestic companies only accounts for about 10% of the total consumptions in the Chinese market currently. In brief, the productivity of local soybeans decreased coupled with over-reliance on imported soybean promotes scarcity, hence raising the soybean price, triggering the risk of soybean crisis.

Next, soybeans are vital because of its role of second key ingredient in poultry feed after maize. They are also the most used protein supplement and accounts for 20% to 30% of the total poultry ration. In India, the price of poultry such as chicken is increasing because of the rising cost of production from soybean. The chicken prices are partly determined by soybeans price as well. According to the Poultry Federation of India, the per capita consumption of chicken in the country is about 2.1kg and is growing by 0.5% every year. Therefore, with the rising prices of chicken, it actually severely affects the food security as people do consume chicken frequently everyday.

1.1.3 Palm Oil: Palm Oil Boom in Southeast Asia

Since crude oil is one of the major production input for agricultural commodities, the increasing trend of crude oil price has bring a large impact to agricultural and industrial sectors. Due to the growing environmental concerns as well, the world community has no choice but to look for some alternative fuel that is renewable such as biodiesel. Therefore, palm oil which is one of the famous sources of energy for the production of biodiesel will increase in price when the demand of palm oil increases.

After raising the concern of renewable fuels, 80% of the European Union's has increased in palm oil consumption between 2006 and 2012. The total palm oil consumption by EU has jumped from 4.51 million tons in 2006 to 6.38 million tons in 2012, which mean it increases up to 41% within 6 years. Furthermore, biodiesel is one of the most suitable alternatives fuels for transportation in Thailand due to its similar properties with petroleum (Pleanjai, Gheewala & Garivait, 2007). In order to reduce the losses of foreign exchange through the import of petroleum and increase the use of renewable sources, Thai government has also started to consider new source of affordable energy- biodiesel to substitute for the costly petroleum. In short, palm oil is now receiving huge demand from worldwide and the impact of crude oil price on palm oil price also arouses people attention.

Besides, the world's largest palm oil producer, Indonesia also announced their plan to increase their minimum compulsory biofuel requirement for biodiesel to 10%, which is increase to a range of 3 to 10 percent. This indicates that the demand of palm oil in Indonesia will be increase accordingly. The world's second-largest palm oil producer, Malaysia was also concerned to require a higher concentration of palm oil in the components of biodiesel. Malaysian Biodiesel Association declared that they are moving to new B7 biofuel blend that would increase the palm oil component of biodiesel to 7 percent, raise from the current 5 percent. On the other hand, in Thailand, palm oil take 10% on the production of biofuel and the percentage is expected to increase as the world is now looking of renewable sources that are more economic. So with the increasing use of biodiesel, it is important to study the palm oil price movement as more and more country get involved and interested on it.

Moreover, investigation on the palm oil price is important for those countries like Malaysia that producing raw materials (corn oil or palm oil) for renewable energy such as ethanol and biodiesel. The importance of palm-diesel has brings a significant impact towards the growth of biodiesel industry in Malaysia. As the demand of palm oil that used to produce biodiesel increases, a new dimension in commodity market in Malaysia also created in the aspect of pricing and growth of palm oil market in Malaysia. This can be showed because Malaysia is now concerning about the diversifying use of palm oil since the producing of palm-diesel will not only enlarge Malaysian domestic market but also the export market internationally (Hadi, Yahya, Shaari & Huridi, 2011).

1.1.4 Wheat: Significance in terms of Cultivated Land and Food Supply

A rapid increase in wheat price in the year of 2008 has diverted global attention to the food crisis. Wheat, the staple food for most of the world's population, is not only an economic good but also a political commodity. Global food shortage is one of the concerns among policymakers in recent years since increases in wheat prices. According to the Food and Agriculture Organization of the United Nations, 37 countries were facing food crises, and that, International Food Policy Research Institute testified in 2008 that rising prices for wheat was causing food riots in many countries. Hence, wheat will be studied as a commodity in this paper.

Many academics and policymakers pointed to the increased reliance on biofuels in industrialized economies. Increasing wheat consumption for alcohol and bioethanol production is a kind of reliance on biofuel. Wheat is the world's most widely grown crop, cultivated in over 115 nations. Annual global production of dry wheat in 2008 was estimated to be 650 Telegram (Tg) and 430 Tg of wheat is available to produce 120 Gay-Lussac GL of ethanol which can replace about 93 GL of gasoline. This paper is going to determine wheat as one of our commodities since wheat is a potential feedstock for second generation bioethanol.

Wheat is an important commodity and is consumed by households in several forms such as breakfast cereals, pasta, bread, and bakery products. In the past years, wheat price faced a lot production problems because of increasing demand and small scale inefficient farm structure result in fluctuating in supply of wheat. Studies taken since 2006 in the volatility of the real prices of food commodities and showed that the largest increase in price volatility, 29%, occurred in wheat which apparently be affected by lack supply of wheat in the market. The expected 2007 farm level crop prices showed the corn and soybean oil are the primarily ingredients used for biofuels in the U.S. Hence, it tends to increase the price of wheat which competes for the same land especially with the corn. Therefore, it is important for us to study the important of wheat price due to the massive increase in the use of corn for fuel.

Besides that, trading activities on commodity derivative markets also affects changes in wheat price since the early 2000s due to the increasing presence of financial investors and speculators. These speculators acting as essential role as they accept price risk in exchange for providing liquidity by actively trading in futures. Troester and Staritz (2013) mentioned that the average monthly volume of wheat futures contract on Chicago Board of Trade (CBOT) has grew by more than 60% from 2005 to 2006 and it continued to increase until first half of 2008. It increased again strongly from second quarter of 2009. There are two reasons can be explained the increase in volume of wheat contracts traded. One is the higher existence of speculators and financial investors. While the other one is they have a lot of shorter term perspective and active trading strategy which lead to increase the volume traded relatively in short time period. Hence, wheat price is going to be monitored in this paper as it is important for those speculators and financial investors.

1.1.5 Sugar: Biofuel and Brazilian Sugar Cane Use

Sugar is also being studied as one of the main commodities due to its importance and significance in several sectors. Firstly, sugar plays an important role in various

aspects of our daily life ranging from food and beverages to energy fuel saving. From the perspective of energy sector, the high correlation between sugar price and crude oil price is due to the extensive use of sugar in the production of biofuel. For instance, according to Citizens League for Environmental Action Now (2006), more statistical information of sugar is shown that Brazil's sugar can produce ethanol per acre amounted to 662 gallons. As the world start develops and implements the environment friendly energy policy, the crude oil is being replaced with the bio-fuel. Therefore, the development of biofuel industry has reaffirm about the importance of the sugar since it is much important than previous.

The main factors that drive the increasing trend of sugar price can be attributed to the expansion of biofuel production, high crude oil price as well as increasing demand of bio-ethanol internationally. Thus, increase in the sugar price has lead to a series of indirect domino effect especially towards the price of other commodities. The expanding production in biofuel has increased the demand for sugar and also reduces the supply of crops that competes land use with the food commodities that used in biofuel production (Mitchell, 2008). Low supply of crops is one of the factors that lead to the eruption of food crisis.

Thirdly, the fluctuations in oil market leads to similar behavior in other commodities market which are important for traders and investors. The information provided in this paper is significance for the commodities traders because around 25% of the world merchandise trade is on commodities, and for some countries, export the commodity is being an essential source of earnings. On the other hand, investors will think differently because in year 2013, the sugar price has skyrocketed for 25% and spiked 6 percent to a one- year high due to the fire swept through a terminal owned by Copersucar at the Santos port in Brazil, which are the world's top exporter as well as producer. From the dynamics price of the food commodity, they can make the investment decision and earn the profit through accurate forecasting.

In addition, the empirical behavior of sugar price is important and relevant to the commodity price cycles for policy purposes. Increase in the number and intensity of biofuel mandates contributes to the link between agricultural and energy prices. These

policy that implemented by policy makers has linking the agricultural and energy markets and directly led to the food price crisis (Nazlioglu et al., 2013). Since the production of these biofuel is dependent on supply of agricultural commodities, it is expected that there is tight market integration between energy and agricultural markets and this is important to occur in the agricultural market. Hence, the dynamics price of sugar price is vital studied in this paper.

In a nutshell, sugar is very important in the production of biofuel as it has brings a significant impact to the agricultural and energy sector. It not only vital in the energy sector but also brings the significant effect to the investors, traders as well as policy makers in this world.

1.2 Problem Statement

Previous researchers studied the relationship between crude oil price and commodities price with the assumption that the market is symmetric. Unfortunately, in reality, the market is not totally symmetric or even asymmetric as the positive shock and negative shock of crude oil price bring different effect. This is reinforced by the findings of Reboredo (2012) where policy maker should take into account the asymmetric effect of crude oil price on commodity prices.

Refer to the Figure 1.2 to 1.7 in appendix shows the evidence that relationship is asymmetric as the crude oil price and commodities price in selected period rise and fall in different motion. The food general price will increase when the global market is in bull condition while decrease when the global market is in bear condition. For instance, from year 2007 to 2009, the wheat price rises in high speed when the market is in bull; whilst from year 1998 to 2002, wheat prices decreases in the low speed when the market is in bear.

In short, the increase of crude oil prices will cause the food commodities prices to increase, yet whether the decrease of oil price will cause the food commodity price to

decrease as well or even no effect on it have not been investigated before. Therefore, this paper studies the relationship between oil price and commodity price with the assumption that the market is asymmetric.

1.3 Research Objectives

I. To investigate the relationship between crude oil price and various commodity prices, namely corn, soybeans, palm oil, sugar and wheat.

II. To show commodity prices react asymmetrically in respond to crude oil price changes.

III. To show the crude oil price and commodity prices are asymmetric in short run and long run integration.

1.4 Research Questions

I. What are the relationship between crude oil price and commodity price?

II. Is the commodity market reacts asymmetrically in respond to crude oil price changes?

III. Are crude oil price and commodity prices (corn, soybeans, palm oil, sugar and wheat) asymmetric in short run and long run integration?

1.5 Hypotheses of the Study (for quantitative research)

There are three hypotheses in this paper:

H_0: There is no relationship between oil price and commodity price.

H_1: There is relationship between oil price and commodity price.

$H_{0:}$ There is no asymmetric price transmission from oil to commodity.

H_1: There is asymmetric price transmission from oil to commodity.

$H_{0:}$ There is no dynamic relationship between long run and short run.

H_1: There is dynamic relationship between long run and short run.

1.6 Significance of the Study

Baffes (2007) and Nazlioglu (2011) involve a more aggregated level measurement such as non-energy commodity index, agriculture index or just include well-known commodities such as corn and soybean when studying the relationship between oil prices and commodity prices. In this paper, the study is carried out in a much more disaggregated level by studying the effect of oil price on corn, soybeans, palm oil, wheat and sugar for more precise findings.

This paper is vital as it suggests that there is asymmetric effect between crude oil price and commodity prices. It is different from the previous findings with the assumption that market is symmetry. Hence, it extends the past studies by taking into account asymmetric price transmission from crude oil to commodity.

The findings from this paper provide significant information to policymaker in particular biofuel policy. China is one of the countries who launched biofuel policy in order to minimize the reliance on non-renewable fuels. Policymakers have to understand well the relationship between oil and agricultural commodities when they establishing the policies in promoting biofuel production and usage. Thompson,

Meyer and Westhoff (2009) found that oil price shocks will affect the commodities price and biofuel price. These are the critical factors that have to be considered by policymakers when launch any new policy that related to biofuel.

Other than that, the findings will be useful for the users of commodities, which classified into intermediate users and consumer users. Since the five commodities are major input in producing biofuel, the commodities will be important for those intermediate users in managing and forecasting their production costs. Next, the commodities price movements are vital for rural and urban citizens as some commodities are staple foods for certain countries. In addition, corn and soybeans are feed for livestock, so the commodities will affect the livestock prices. Again, the food prices will be affected.

Moreover, the farmers are also affected as palm oil and soybean is the main crop for producing biodiesel while corn, sugar and wheat are the main input to produce bioethanol. Facing the increasing commodity prices, the farmers are desired to choose to produce those commodities for people or fuel. Instead of producing for people, farmers devoted much of the shares of the five commodities to be produced into biodiesel and bioethanol for the sake of profitability. Hence, it amplifies the impact of rising oil prices on the poor and reduces the food security.

Furthermore, this paper is important for those countries that mainly focus in the export of commodities. For instance, Brazil has relied heavily on commodity export in the past decade. Its exports have increased to 256 billion dollars, up from 118 billion dollar in year 2005. In between, more than 50 percent of the total exports are hold by agricultural and other primary products and this growth of commodity export has successfully improved Brazil's financial health. However, heavy reliance on the exports of commodities can create a significant challenge that threatens the country's economy in long-term prospect. So by understanding the movement of the commodities prices, policy makers can decide the amount of dependence on commodities export.

Hence, speculators can invest in a more rational and appropriate way to maximize profit and reduce risk. With the deepen understanding of the relationship between oil

prices and commodity (soybean) prices, investor will be able to predict the soybean price with respect to oil price. Cooke and Robbles (2009) findings also support this where financial activity in future market and speculation play an important role in the recent agricultural price boom.

1.7 Chapter Layout

This paper is organized as follows:

- Chapter 1 is research overview that sets forth introduction, research background, problem statement, research objectives, research questions, hypotheses of the study and significance of the study.
- Chapter 2 explains the literature review on how oil price affects commodity price and take into account 5 commodities such as soybean, corn, rice, wheat and palm oil.
- Chapter 3 includes data processing and identifies research methodology.
- Chapter 4 interprets the empirical findings and generates results.
- Chapter 5 emphasizes on discussion of major findings, implication and limitation of study and lastly, recommendation for future research.

1.8 Conclusion

In summary, this study is to investigate the relationship between oil price and commodity price. Moreover, the study also aims to detect if there is asymmetric effect between oil price and commodity price. This study is different from previous research as it is done on a disaggregated level by taking into account more commodities for a more accurate finding.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

This chapter reviews the critical points by previous researchers. The relationship between crude oil price and five commodities' price such as corn, soybeans, palm oil, sugar and wheat will be reviewed.

The study of crude oil price had been the interest of researchers and academicians because crude oil is one of the precious and highly demanded global commodity. Significantly, Hamilton (2009) said that world economy is at stake, as crude oil price significantly influence consumption spending and purchases of domestic automobiles. Moreover, it affects transportation, which is one of the most important and effective parameter in the world (Ekmekcioglu, 2012).

2.1 Corn: Hints of Asymmetric Effect

According the significance of corn price in both energy and food industry that discussed in chapter 1, this is vital for this paper to study the relationship between crude oil price and corn price. However, there are mixed findings and results from various studies by researchers and professionals. In addition, Gardebroek and Hernandez (2013), Nazlioglu (2011), Nazlioglu et al. (2013) and Reboredo (2012), have take in account various consideration when examining the relationship. For example, linear and nonlinear causality, symmetry assumption on the relationship, risk transfer (volatility) between crude oil and corn and so on.

First of all, Gardebroek and Hernandez (2013) and Reboredo (2012) assumed that the relationship between crude oil market and corn market is symmetry over the time. According to Reboredo (2012), corn market is neutral to the effects of oil prices

fluctuations when there is extreme upward crude oil price movement. Reboredo (2012) found that the fluctuating food price including corn price is caused by food demand and supply behaviour in agriculture market but on crude oil price movements. Other than that, Gardebroek and Hernandez (2013) unable to find any evidence that the volatility of crude oil market will affect the volatility in corn market because the different functions of corn-based bioethanol may weaken the dependence of corn price volatility on crude oil price volatility. The neutrality relationship found to be consistent with the previous studies by Nazlioglu et al. (2013). In short, there is no strong evidence to prove that oil price can affect corn price.

On the other hand, Nazlioglu (2011) has investigated linear causality and nonlinear causality relationship between world oil prices and agricultural commodity prices and found that there is no relationship between oil and agricultural commodity when the relationship is analyzed by linear Granger causality analysis. However, nonlinear Granger causality analysis shows significant relationship from oil price to corn price and the relationship are strict. Besides, Nazlioglu et al. (2013) have discovered the risk transfer from oil market to corn market on post-crisis period but not in pre-crisis period. The studies by Nazlioglu (2011) and Nazlioglu et al. (2013) do provide the signals of asymmetric relationship between oil price and corn price.

Among the studies above, researchers are less focus on taking into account the asymmetric effect when examine the relationship between crude oil and corn. The study that carried out by Ji and Fan (2012) has considered the asymmetric effect when investigated the volatility spill over between the oil market and each particular commodity market. They implied that crude oil market generated stronger effect on other commodity markets when crude oil price are high as compare to low crude oil price. Nevertheless, the study by Ji and Fan (2012) examined the asymmetric effect in terms of aggregated level analysis, which is the asymmetric response of oil market to other commodity markets. However, the study obtained by Ji and Fan (2012) does not provide evidence to show that whether there is relationship between crude oil price and specific commodity price. Hence, this paper that focus on disaggregated level

analysis can provide a clearer picture of the relationship between oil price and corn price.

Generally, the asymmetric relationship between oil price and corn price should be taken into account by policy makers. McPhail and Babcock (2012) found that ethanol policies that implied by United States generated significant impact on the price elasticity of demand and price variability for corn. By taking into consideration of asymmetric effect, they can forecast the movement of corn price based on the movement of oil price more accurately, then develop well-organized policy that benefit households and businesses in the country.

In summary, there is less evidence to show that crude oil price can affect corn price, especially with the assumption of constant relationship over time. With the strong evidence to show the relationship between crude oil price and corn price through theoretical framework, this paper make assumption that corn price is asymmetric response to crude oil price changes in order to fill the gap.

2.2 Soybeans: Asymmetric Price Linkages between Crude oil and Soybeans

In this section, the pass through of crude oil prices to prices of soybeans commodities is investigated. Nonetheless, soybeans market is heavily affected by crude oil prices, which is proved by the findings of Liu (2014) which discovered that cross-correlation coefficients between crude oil and soybeans are stronger during food crisis compared to common period. In other words, it indicates high crude oil prices are one of the contributing factors of food crisis.

The observed relationship between energy market and soybeans commodity market during the recent years had renewed interest in determining price transmission from oil prices to soybeans prices. The traditional theory explanation by Nazlioglu (2011) is an increase in the crude oil price will lead to a rise in the cost of production through

its impact on chemical, fertilizer, transportation cost. Therefore, the soybeans prices shoot up. However, the debate going on as the world moves toward environmental friendly and focusing on renewable and cheaper energy sources (Liu, 2014; Nazlioglu et al., 2013) The rationale is crude oil prices are becoming more costly and expensive; hence, biofuel emerges as an alternative resulting in the growth of soybeans based biofuel. As the demand of soybeans commodities increase, the prices of soybeans commodities also shoot up.

The relationship between crude oil and soybeans prices had been studied extensively in the past decades, yet it had resulted in mixed findings. Generally, it was divided into two distinct groups. Gilbert (2010), Nazlioglu and Soytas (2011) and Reboredo (2012) supported the neutrality hypothesis where changes in crude oil price is not being transmitted to agricultural commodity prices in short and long run. On the other hand, Baffes (2007), Chen, Kuo and Chen (2010), Liu (2014) and Nazlioglu et al. (2013) found out that crude oil price significantly influenced agricultural commodity prices. Pindyck and Rotemberg (1990) discovered that prices of unrelated commodities tend to move together in excess of what can be explained by fundamentals. As the literature review indicates that previous researchers ignore the asymmetry impact that exist between oil price and soybeans price, hence it is vital to analyse the issue from different perspective.

Unlike the previous studies, which just focuses on the relationship between crude oil and commodity prices, this paper takes a further step to analyse if there is asymmetric effect in how soybeans price respond to crude oil price. To the best of our knowledge, this study utilized the Threshold Autoregressive (TAR) Model and Momentum-Threshold Autoregressive (M-TAR) Model used to detect the evidence of asymmetric relationship. Nazlioglu (2011) mentioned in his study that while the agricultural commodity price maybe slowly adjusted to the crude oil price in the past, an increase in crude oil price maybe rapidly transmitted to the agricultural commodity price during the recent year, indicating an asymmetric price linkage between energy and agricultural market. Hence, the main objective of this paper is to study the existence of asymmetric response of soybeans prices to crude oil price.

2.3 Palm Oil: An Arguable Relationship

As the demand for renewable fuel increase, the consumption of palm oil had also been affected and the relationship of both of them has created awareness among the communities. Studies of Hadi et al. (2011) had examined the causality interrelationship between prices of crude oil and palm oil. Their result concluded that there is significant short term and long term relationship between crude oil prices and palm oil prices and the relationship was found to be positively correlated. This result is supported by Nazlioglu and Soytas (2012) as they also provide strong evidence in the impact of oil price changes towards agricultural commodity prices changed included palm oil price.

However, existing literature did not provide the same results that the relationship of crude oil price and palm oil price is relatively strong. For instance, Chuangchid, Wiboonpongse, Sriboonchitta and Chaiboonsri (2012) found that the palm oil has weak dependence on the growth of crude oil prices, in other words, it also can be said that palm oil is almost independence to the changes on the price of crude oil. Furthermore, research of Bakhat and Wurzburg (2013) that also investigate on the relationship of price between crude oil and food commodities stated that complex price link are found between crude oil and agricultural products that used for biofuel production such as palm oil. The complex relationship includes asymmetries and complex causalities, yet the evidence provided is not strong and clear enough to prove the asymmetric relationship.

Furthermore, Yu, bessler and Fuller (2006) revealed that crude oil price shocks did not have a significant influence on the changing of vegetables oil that used in biodiesel production such as soybean oil and palm oil. Similar results are found by Campiche, Bryan, Richardson and Outlaw (2007) that have conducted a study to investigate whether there is an increasing trend for the price changes in oil prices towards the price changes in selected commodities like corn, sugar, soybeans oil and palm oil. The findings support no cointegration between oil and those commodities selected.

On the other hand, the study to test whether the changes in the price of crude oil played an important role in the changes of price of vegetable oils like palm, sunflower and soybean oil has been carried out by Hameed and Arshad (2009). The result indicated that there was unidirectional relationship between crude oil price and those vegetable oils; which mean that prices of vegetable oils can be affected by crude oil prices while crude oil prices may not been affected by any price movement of vegetable oils. This relationship was consistent with the research of Ghaith and Awad (2011) that also investigate the long run relationship between crude oil and food commodities such as maize, wheat, and palm oil. Ghaith and Awad (2011) showed that there is a strong evidence of long-run relationship between crude oil and those food commodities prices and the unidirectional relationship is proved.

In short, as what have mentioned above, contradictory results were found and most of the earlier studies only focus on the changes of palm oil price when crude oil price increase, they did not put much attention on examining the changes of palm oil prices when crude oil price decrease. The price movement of oil and other commodities is assumed to be the same and less of the researchers take into account the asymmetric effect when analyzing the relationship. This paper has taken into consideration the asymmetric effect when conducting the research.

2.4 Wheat: Why Wheat can be Significant and Insignificant to Crude Oil?

Based on the introduction, it showed that there is a vast relationship between oil price movements and wheat price movements but nature of the causal link remains unclear. Among the studies, neutrality relationship between crude oil price and wheat price is supported by Nazlioglu (2011), Nazlioglu and Soytas (2011) and Zhang, Lohr, Escalante and Wetzstein (2010). Nevertheless, significant relationship is found by Chen et al. (2010); Du, Yu and Hayes (2011); Nazlioglu et al. (2013); Troester and Staritz (2013).

Nazlioglu (2011) had a result when applied weekly data and used linear Granger causality analysis. This analysis supported the neutrality hypothesis which is the oil and wheat price do not cause each other. Whereas when Nazlioglu (2011) focused on nonlinear causality analysis, there is another result to imply that surge in wheat price can be attributed to the changes in the oil prices. Since there is a mixed result from those researches, this literature will distinct into insignificant and significant relationship between oil and wheat. The significant relationship will have two linkages which are biofuel and financialisation.

Recently, interdependency between agricultural markets and energy has increased. Brazil, US, and the EU have promoted the development of biofuel production to replace non-renewable fuels with renewable energy sources because they concern to the climate change of high oil price. According to Chen et al. (2010), the change in wheat price is significantly influenced by the changes in the crude oil price because wheat commodity was competing with other commodity for bio-fuels production during the period from 3rd week in 2005 to the 20th week in 2008. Besides that, Du et al. (2011) found evidence of wheat price volatility can be explained by tightened interdependence between crude oil price and this wheat market induced by ethanol production. Nazlioglu et al. (2013) also stated that there is risk transfer from oil markets to wheat, corn, and soybean markets after commodity crisis from year 2006 to 2008 since these commodities are the key agricultural products for food and biofuels around the world. Hence, this shows an important relation between oil market and wheat market through the use of wheat in biofuel production.

Simultaneously of biofuel production impact on wheat market, trading on commodity markets has undergone a major movement related to the increasing presence of financial investors since 2000s. Troester and Staritz (2013) also stated that fundamental reason which is supply and demand seems not to be sufficient to explain the tendency wheat price whereas non fundamental factors include financialisation, tends to affect wheat prices in addition to fundamental factors.

On the other hand, other researchers have some debate on the impact of oil price on wheat price. Nazlioglu and Soytas (2011) did a research in Turkey and found out that wheat price does not significantly react to oil price in the short-run and the changes in oil prices are not transmitted to wheat price in the long-run causality analysis. This might because of relatively low energy intense production processes. Zhang et al. (2010) also found out that there is no direct relation between fuel price and wheat price when using computable general equilibrium (CGE) models and time series prices on fuels and wheat. They stated that rising sugar price emerges to be the leading cause of price inflation in wheat commodity because sugar is the world number one input for ethanol. Hence, wheat commodity price is influenced by ethanol production through its impact on sugar price.

2.5 Sugar: What Does Sugar Price and Crude Oil Price Tell Us?

Many researchers had studied about the crude oil price and commodity price such as Nazlioglu and Soytas (2011), Zhang and Reed (2008), Serra (2011), Nazlioglu and Soytas (2012) and so on. Nevertheless, they ended their research with different results. Firstly, Nazlioglu and Soytas (2011), Nazlioglu et al. (2013), Zhang and Reed (2008), Zhang et al. (2010) have supported the neutrality hypothesis where the sugar price is to be neutral to the crude oil price changes over long run. While Gilbert (2010), Zhang and Reed (2008) and Zhang et al. (2010) showed that there is no direct causal relationship between oil price and sugar price.

The previous researchers such as European Commission (2008), Gohin and Chantret (2010), Nazlioglu and Soytas (2012) and Serra (2011) found that the there is positive relationship between crude oil price and sugar price. Lastly, Ciaian and Kancs (2011) and Serra (2011) indicate there is long run relationship between crude oil price and sugar price. With the presence of these arguments, there is a need to probe and examine the issue with the different viewpoints from different investigation that made from previous researchers.

According to Nazlioglu and Soytas (2011) and Zhang and Reed (2008), they investigated the relationship between oil price and agricultural commodity price such as sugar and wheat. However, they found that sugar price is neutral to the oil price changes over the long run. This indicates that the changes in the crude oil price will not transmit to the sugar price. Besides, Nazlioglu and Soytas (2011) unable find any evidence to prove the volatility transmission between oil and sugar market. The neutrality results are made by Nazlioglu and Soytas (2011) and Zhang and Reed (2008) are same as Nazlioglu et al. (2013) and Zhang et al. (2010). In other words, they are supporting the neutrality hypothesis. The rationale behind why they strongly supported the neutrality hypothesis is due to the rising fuel price is not directly causing the inflated agricultural commodity price such as sugar price.

In addition, Gilbert (2010) and Zhang and Reed (2008) have indicate there is no direct causal relationship between oil and sugar price. For example, Zhang and Reed (2008) stated that the oil price increases do not have direct impact on agricultural commodities price especially for sugar price. The main reason behind there is no direct causal relationship between crude oil price and sugar price is due to demand growth, expansionary policy and financial developments (Gilbert, 2010).Thus, his findings is strictly supported there is no direct causality relationship between crude oil price and sugar price and this similar results are similar to those of Zhang et al. (2010), who indicate that no direct causality relationship between oil and sugar price. Hence, the previous researches have more affirmed the neutrality hypothesis.

On the other hand, Serra (2011) found that there are positive relationship between crude oil price and sugar price. This proves the existence of a dynamic link between biofuel, fuel and agricultural market. The main reason of the positive relationship between the crude oil price and commodity price is due to the cost-push effect (European Commission, 2008; Gohin and Chantret, 2010). This indicates that increase in the crude oil price will lead to the increase in the cost of production, which in the transportation cost and nitrogen fertilizers. It is explained that such situation will increase the sugar price as there is high demand for the agricultural

commodity (sugar) used in the biofuel production by increasing the demand for the biofuel globally. (Nazlioglu and Soytas, 2012)

According to Ciaian and Kancs (2011), they probe the relationship between oil price and sugar price. They declared that there is the long run relationship from oil to sugar price, but not vice versa. Serra (2011) stated the relationship between oil price and sugar price has been confirmed by other researcher such as Nazlioglu and Soytas, (2012). Besides, the paper has acknowledged that the long run price linkages between crude oil price and sugar price. In other words, when crude oil price increase, sugar price will increase as well. His acknowledgement is mainly due to the he focuses on a period in which Brazilian ethanol prices were relatively free from the public authorities. Due to these reason, his acknowledgement is truly reliable.

2.6 Conclusion

In conclusion, this paper able to provide comprehensive information between crude oil price and commodities price namely corn, soybeans, palm oil, wheat and sugar. By employing Asymmetric Error Correction Model (AECM), this paper able to fill up the gap through study the asymmetric relationship between crude oil price and the commodities price. Again, this paper has improved the literature by studying the asymmetric effect on specific individual commodity which ignored by previous researches.

CHAPTER 3: METHODOLOGY

3.0 Introduction

In this chapter, time series analysis will be used to evaluate the asymmetric effect of crude oil price on various commodities prices namely corn, soybeans, palm oil, sugar and wheat. First of all, Augmented Dickey Fuller (ADF) Test and Kwiatkowski, Philips, Schmidt, and Shin (KPSS) Test will be applied to determine the stationary status of the variables. Stationary properties of variables are vital in order to provide valid empirical results. Then, Threshold Autoregressive (TAR) Model and Momentum-Threshold Autoregressive (M-TAR) Model are employed in this paper to investigate the relationship between crude oil price and the five commodities prices. Threshold Autoregressive (TAR) Model is used to establish speed of adjustments for the effect of crude oil price towards commodities prices. Other than that, purpose of Momentum-Threshold Autoregressive (M-TAR) Model is to detect the momentum speed of adjustments of commodities prices that would be affected by changes in crude oil price. Finally, Asymmetric Error Correction Model (AECM) is applied in this chapter in order to detect the asymmetric effect on commodities prices due to fluctuations in crude oil price.

3.1 Scope of Study

This study consists of quantitative research which is used to determine the relationship between the independent variable and dependent variable from year 1983 to 2013. The dependent variables are prices of corn, soybeans, palm oil, sugar and wheat while crude oil price is the independent variable. This paper employed

quarterly data from June 1983 to March 2013, with a total of 120 observations. Moreover, all data are obtained are from the same source, which is Index Mundi.

3.2 Econometric Methods

Before estimate the time series economic model, stationarity of time series data is an essential element and must be tested. Given the assumption of Classical Linear Regression Model, the model will provide spurious results if it includes non-stationary variables. It is due to non-stationary variables will not provide unbiased standard empirical results.

In order to avoid spurious results, the time series data can be first-differenced if the variables are found to be non-stationary at level form. However, the use of first-differenced variables will reduce the low-frequency (long run) characteristics while only retain high-frequency (short run) characteristics of data. The long run characteristics and effects of lag variables are important in modeling the data. It is because there are a lot of time series data that follow random walk behavior, so there are spurious results if exclude the long run information of random walk time series data.

As a result, co-integration test can be constructed to establish the long run relationship. The long run relationship between two series variables is essential before verify whether there is asymmetric relationship between the series variables. The interpretation behind this test is if two or more series are linked to form an equilibrium relationship spanning in the long run, they will move closely together over the time and the differences between them are fixed and stationary even though the series may contain non-stationary characteristics. In short, it indicates that existence of long run equilibrium over the time among non-stationary variables are integrated to the same order.

In this paper, Augmented Dickey Fuller (ADF) Test, Kwiatkowski, Philips, Schmidt, and Shin (KPSS) Test, Threshold Autoregressive (TAR) Model, Momentum-Threshold Autoregressive (M-TAR) Model, Asymmetric Error Correction Model (AECM) are conducted to study the asymmetric relationship between commodity price and oil price.

3.2.1 Unit Root Test

Unit root test is an indispensable test before proceed to other tests during time series analysis. The unit root test is used to determine the stationary properties of the time series variables. A series is said to be stationary if the mean, variance and covariance are constant over time while it is consider non-stationary when the mean, variance and covariance change over the time period. Stationary variable is thus implies that it has no unit root whereby non-stationary variable implies that it has unit root. The test is needed to test for the presence of stationary properties in order to avoid the problem of spurious result.

Stationary time series data show that the data are time invariant and its mean and variance will not change over the sample period. On the other hand, non-stationary time series data imply that the data will change and fluctuate over the sample period. Generally, data will be forecasted appropriately if the data are stationary.

Due to time series data always contain clear movement and increasing trend over the time, so researchers have to differentiate one or more than one times to obtain stationary time series data. In this paper, all time series data that represented dependent variable and independent variable should have one unit root I(1) to achieve dynamic stationary. This implies that the long run relationships between dependent variable and independent variable are stationary when the variables are differentiated one time. Again, Augmented Dickey Fuller (ADF) Test and Kwiatkowski, Philips, Schmidt and Shin (KPSS) Test are used to identify stationarity of time series data.

3.2.1.1 Augmented Dickey Fuller (ADF) Test

The first approach that used to determine the stationarity of time series data is Augmented Dickey Fuller (ADF) Test, which developed by Dickey and Fuller in 1979. However, it is only can be used when there is large sample size.

Given the equation as follow:

$$\Delta Yt = \alpha Yt\text{-}1 + xt\,\delta + ß1\Delta Yt\text{-}1 + ß2\Delta Yt\text{-}2 + \ldots + ßp\Delta Yt\text{-}p + vt$$

Assume that the dependent variable follows an AR(p) process, the number of the lagged differenced terms of dependent variable will be included in the equation. The changes of dependent variable which consisted of constant and trend variable are determined by the independent variables that include lagged level of dependent variable, $\alpha Yt\text{-}1$, trend variable, $xt\,\delta$, total lagged of changes in dependent variables, $ßp\Delta Yt\text{-}p$ and white noise change, vt.

The null and alternative hypothesis for unit root test is:

H_0: There is a unit root.

H_1: There is no unit root.

Null hypothesis above indicates I(1) while alternative hypothesis indicates I(0). In this paper, the results obtained will be considered as dynamic stationary at I(1). In order to obtain I(1) in the level form, the p-value t-statistic must be larger than critical value so that do not reject null hypothesis. Consequently, the larger is the p-value of t-statistic value, the lower the possibility that null hypothesis will be rejected.

H_0: There are two unit roots

H_1 : There is a unit root.

In terms of first difference form of ADF Test, null hypothesis indicates I(2) while alternative hypothesis indicates I(1). In order to obtain I(1), the p-value of t-statistic must be smaller than critical value so that reject null hypothesis. The smaller is the p-value of t-statistic, the higher the possibility that null hypothesis will be rejected.

3.2.1.2 Kwiatkowski, Philips, Schmidt and Shin (KPSS) Test

Kwiatkowski, Philips, Schmidt and Shin (KPSS) Test is another unit root test that conducted in this paper in order to test the stationarity of time series data. At the level form, null hypothesis has no unit root while alternative hypothesis has one unit root. In order to achieve I(1), p-value of t-statistic must be smaller than critical value so that null hypothesis will be rejected. In terms of first-difference level, null hypothesis has one unit root while alternative hypothesis has two unit roots. In order to achieve I(1), p-value must be larger than critical than critical value so that null hypothesis will not be rejected.

The regression of KPSS is as follow:

$$Yt = xt\,\delta + \mu_t$$

The regression is formed by the residuals from the Ordinary Least Squares (OLS) regression of *Yt* on the *xt*.

The LM statistic is described as follow:

$$\text{LM} = \Sigma_T S(t)^2 / (T^2 f_0), \text{ where } S(t) = \Sigma^t_{r=1}$$

f_0 is an estimator of residual spectrum at frequency zero and *S(t)* is a cumulative residual function based on residuals.

3.2.2 Threshold Autoregressive (TAR) Model

The Threshold Autoregressive (TAR) Model is defined as:

$$\Delta\mu_t = I_t\rho_1\mu_{t-1} + (1 - I_t)\rho_2\mu_{t-1} + \sum_{i=1}^{\rho-1}\gamma_i\,\Delta\mu_{t-1} + \varepsilon_t$$

Where I_t is the Heaviside indicator function such that:

$$I_t \begin{cases} 1, & if\ \mu_{t-1} \geq \tau \\ 0, & if\ \mu_{t-1} < \tau \end{cases}$$

and τ = the value of threshold and ε_t = sequence of zero-mean, constant-variance iid random variables such that ε_t is the independent of ε_j, j < t. As for the function above, I_t relies on the level of lagged one residual, μ_{t-1}. When lagged one residual is more than tau,τ, adjustments in commodities price will be indicated by ρ_1. Furthermore, the adjustments will be modeled by ρ_2 when lagged one residual below tau, τ. In short, Heaviside indicator with dummy of 1 and 0 indicate different crude oil price's effects on commodities price respectively. TAR Model allows the degree of autoregressive decay to depend on the state of the variable of interest. Therefore the purpose of this test is to detect the effect of crude oil price change towards the changes of commodities price.

The null and alterative F- joint test for TAR Model is as follow:

$$H_0: \rho_1 = \rho_2 = 0$$

$$H_1: \rho_1 \neq \rho_2 \neq 0$$

F-joint test is used to detect the long run relationship between the dependent variable and independent variable. Null hypothesis indicates there is no long run relationship while alternative hypothesis indicates there is long run relationship. As a result, alternative hypothesis show that the dependent variable and independent variable are co-integrated.

The null and alterative F- equal test for TAR Model is as follow:

$$H_0: \rho_1 = \rho_2$$

$$H_1: \rho_1 \neq \rho_2$$

Moreover, F-equal test is used to test the asymmetric adjustment between dependent variable and independent variable. Null hypothesis indicates there is no asymmetric adjustment. On the other hand, alternative hypothesis indicates there is asymmetric adjustment.

3.2.3 Momentum- Threshold Autoregressive (M-TAR) Model

The Momentum- Threshold Autoregressive (M-TAR) Model is defined as:

$$\Delta\mu_t = M_t\rho_1\mu_{t-1} + (1 - M_t)\rho_2\mu_{t-1} + \sum_{i=1}^{\rho-1}\gamma_i\,\Delta\mu_{t-1} + \varepsilon_t$$

Where M_t is the Heaviside indicator and its function is different from TAR Model as:

$$M_t\begin{cases}1, & if\ \Delta\mu_{t-1} \geq \tau\\ 0, & if\ \Delta\mu_{t-1} < \tau\end{cases}$$

The Heaviside indicator, M_t is also depends on the level of $\Delta^{\mu_{t-1}}$. M-TAR Model is able to detect the fluctuation of data and smooth out any large changes on the series. The speed of adjustments of commodities price are measured in TAR Model while the momentum speed of adjustments in commodities price are measured in M-TAR Model. The dummy of 1 and 0 have the same explanation as in TAR Model but I_t in TAR Model is depended on lagged one residual while M_t is depended on change in lagged one residual. M-TAR Model allows a variable to display differing amounts of autoregressive decay depending on whether it is increasing or decreasing. Therefore the purpose of this test is to determine the momentum change of commodities price when there is an increase or decrease in crude oil price.

The null and alterative F- joint test for M-TAR Model is as follow:

$$H_0: \rho_1 = \rho_2 = 0$$

$$H_1: \rho_1 \neq \rho_2 \neq 0$$

Again, the null hypothesis indicates there is no long run relationship. In contrast, alternative hypothesis indicates dependent variable and independent variable are co-integrated.

The null and alterative F- equal test for M-TAR Model is as follow:

$$H_0: \rho_1 = \rho_2$$

$$H_1: \rho_1 \neq \rho_2$$

Null hypothesis indicates there is no existence of the asymmetric adjustment while it is in opposed to the alternative hypothesis.

3.2.4 Asymmetric Error Correction Model

$$\Delta CP_{t,k} = \alpha + \beta\, I\, ECM_t + \beta(1\text{-}I)ECM_t + \sum_{i=1}^{n} \Delta\beta OIL\ t\text{-}i + \sum_{i=1}^{n} \Delta\beta\ CPt\text{-}i\ ,k + \varepsilon t$$

CP = Log of Commodity Price

OIL = Log of Oil Price

I = Indicator

k = Corn, Soybeans, Palm Oil, Sugar or Wheat

In order to accurately measure the elasticity of dependent variable on independent variable, the both dependent variable and independent variable which indicate commodity price and crude oil price are transformed into logarithm form. This determines the percentage change in dependent variable per one unit of percentage change in independent variable. In addition, the lagged variables of dependent variable and independent variable should be included to detect the changes during previous periods.

From the equation above, α indicates the constant while β indicates the coefficient for dependent variable, independent variable and asymmetric effect of above and below the indicator. Lastly, Ɛt is the error term for the model.

CHAPTER 4: Interpretation

4.0 Introduction

In this chapter, the empirical results of Augmented Dickey Fuller test (ADF), Kwiatkowski, Philips, Schmidt, and Shin test (KPSS), Threshold Autoregressive (TAR) Model, Momentum-Threshold Autoregressive (M-TAR) Model, and Asymmetric Error Correction Model have been shown with interpretation.

4.1 Unit Root Tests

First of all, Augmented Dickey Fuller test (ADF), Kwiatkowski, Philips, Schmidt, and Shin test (KPSS) were conducted in order to avoid any spurious results for the estimation of model later. For Augmented Dickey Fuller test (ADF), the results obtained should be non-stationary or one unit root, I(1). One unit root can be achieved by not reject null hypothesis for level form but reject null hypothesis for first difference form. On the other hand, there is one unit root I(1) when there is reject null hypothesis for the level form and not reject null hypothesis by using Kwiatkowski, Philips, Schmidt, and Shin test (KPSS).

Table 4.1: Results of Unit Root Test (ADF and KPSS - Level Form)

	(ADF – Level Form)		(KPSS - Level Form)	
Level	Intercept	Trend and Intercept	Intercept	Trend and Intercept
Crude Oil	-0.9440(0)	-2.8079(0)	0.9526(9)***	0.2957(9)***
Corn	-0.9950(0)	-2.0848(0)	0.6056(9)**	0.2314(8)***
Soybean	-1.5398(0)	-2.3279(0)	0.5923(9)**	0.2421(8)***
Palm Oil	-1.8008(0)	-3.1407(1)	0.6276(9)**	0.1464(8)**
Sugar	-1.8140(0)	-2.6802(0)	0.5150(9)**	0.1511(9)**
Wheat	-1.6266(0)	-2.6867(0)	0.7152(9)**	0.2032(8)**

NOTE:*,**,*** indicates the rejection of null hypothesis at 10%, 5% and 1% of significance level. Number in parentheses is the number of 1 bandwidth. Lag length for the ADF unit root test are based on Akaike Information Criterion. The bandwidth for the KPSS unit test is based on the Newey- West estimator using the Default (Barlett Kernel). The unit root tests include a constant and linear time trend. The null hypothesis under ADF test is the presence of a unit root while KPSS test is stationary.

Table 4.2: Results of Unit Root Test (ADF and KPSS - First Difference)

	(ADF – First Difference)		(KPSS - First Difference)	
Level	Intercept	Trend and Intercept	Intercept	Trend and Intercept
Crude Oil	-9.8633(1)***	-10.001(1)***	0.2604(6)	0.0505(8)
Corn	-9.7172(0)***	-9.8345(0)***	0.1995(3)	0.0351(5)
Soybean	-10.8934(0)***	-10.9925(0)***	0.1167(6)	0.0384(7)
Palm Oil	-9.8191(0)***	-9.8184(0)***	0.0417(2)	0.0300(2)
Sugar	-8.0314(1)***	-8.0016(1)***	0.0754(1)	0.0434(2)
Wheat	-9.8446(0)***	-9.8449(0)***	0.1099(9)	0.04249(10)

NOTE:*,**,*** indicates the rejection of null hypothesis at 10%, 5% and 1% of significance level. Number in parentheses is the number of 1 bandwidth. Lag length for the ADF unit root test are based on Akaike Information Criterion. The bandwidth for the KPSS unit test is based on the Newey- West estimator using the Default (Barlett Kernel). The unit root tests include a constant and linear time trend. The null hypothesis under ADF test is the presence of a unit root while KPSS test is stationary.

The results of ADF test and KPSS test for level form are reported in Table 4.1 while the results of these both tests for first difference form are reported in Table 4.2. In addition, each table also reported ADF test and KPSS test in terms of intercept and also trend and intercept form. In our study, the commodities should integrate one in order to obtain one unit root, I (1).

In Table 4.1, the results presented that the p-value of all commodities for ADF test are insignificant to reject null hypothesis, which showed that all commodities have one unit root. On the other hand, results for KPSS test reported that all the p-value for commodities are significant to reject null hypothesis, which showed the commodities have one unit root. Based on the results, crude oil is significant at 1% significance level. Moreover, corn and soybean are significant at 1% for trend and intercept form and at 5% for intercept form. The results for palm oil, sugar and wheat are significant at 5% significance level.

Based on the ADF test results in Table 4.2, the p-value of all commodities are significant to reject null hypothesis at 10%, 5% and 1% significance level. This showed the commodities contained one unit root. For the KPSS test in first difference form, the results showed that no commodities are significant even at 10% significance level. In short, all the results above show the commodities have one unit root.

4.2 Threshold Autoregressive (TAR) Model

Table 4.3: Results of Threshold Autoregressive (TAR) Model (Tau= 0)

	Corn	Soybeans	Palm oil	Sugar	Wheat
Above Threshold	-0.1954*	-0.2184*	-0.2078***	-0.09260	-0.2192**
Below Threshold	-0.1658*	-0.1080*	-0.2032**	-0.1522**	-0.2410***
F-joint($P_1 = P_2 = 0$)	5.5924*	5.5953	9.8770*	4.1492	6.0825*
F-equal($P_1 = P_2$)	0.0833	1.301	0.0033	0.4273	0.0381

NOTE:*,**,*** indicates the rejection of null hypothesis at 10%, 5% and 1% of significance level.

Table 4.4: Results of Threshold Autoregressive (TAR) Model (Tau≠ 0)

	Corn	Soybeans	Palm oil	Sugar	Wheat
Above Threshold	-0.2216*	-0.2824*	-0.1689***	-0.04495	-0.1761**
Below Threshold	-0.1347*	-0.0680*	-0.2651***	-0.1967***	-0.2760***
Tau	-0.1753	0.1423	-0.3492	-0.2920	0.1516
F-joint($P_1 = P_2 = 0$)	5.9433	7.6012**	10.7034*	5.4851	6.5058*
F-equal($P_1 = P_2$)	0.7234	4.9984*	1.4026	2.9285	0.8014

NOTE:*,**,*** indicates the rejection of null hypothesis at 10%, 5% and 1% of significance level.

Threshold Autoregressive (TAR) Model is used to examine the each particular commodities price adjustments caused by positive shocks or negative shocks of crude oil price changes. In order to show asymmetric effect, F-joint and F-equal have to be significant at 10% significance level.

The hypothesis testing for F-joint is as below:

H0: ρ1=ρ2= 0 (There is no dynamic relationship between long run and short run)

H1: ρ1≠ρ2≠ 0 (There is dynamic relationship between long run and short run)

The results have to reject null hypothesis at 10% significance level in order to show that each particular commodity has long run and short run relationship with crude oil. From the results, only corn, palm oil and wheat are significant at 10% significance level when Tau equal to zero. When Tau value is determined by data, only soybeans, palm oil and wheat are significant. However, soybeans is significant at 1% significance level but palm oil and wheat only significant at 10% significance level.

The hypothesis testing for F-equal is as below:

H0: $\rho 1=\rho 2$ (There is symmetric adjustment in the relationship)

H1: $\rho 1\neq\rho 2$ (There is asymmetric adjustment in the relationship)

The results have to reject null hypothesis at 10% significance level in order to show the asymmetric adjustment of each particular commodity affected by changes in crude oil price. From the results, only soybeans is significant at 1% significance level when Tau value is determined by the data. According to results shown in Table 4.4, soybeans is the only commodity to have asymmetric effect with crude oil price changes because significant in F-joint and F-equal when Tau value equal to 0.1423.

To study the asymmetric characteristic of the market, either test statistic of above and below threshold should significant at minimum 10% significant level. According to result from Table 4.3, when Tau value is equal to zero, test-statistic of above threshold for sugar is not significant, while corn, soybeans, palm oil and wheat are significant at 10%, 10%, 1%, and 5% significance level respectively. Moreover, test statistic of below threshold for corn, soybeans, palm oil, sugar and wheat are all significant at 10%, 10%, 5%, 5% and 1% significance level respectively.

According to result from Table 4.4, when Tau is determined by data, test statistic of above threshold for sugar is not significant, while corn, soybeans, palm oil and wheat are significant at 10%, 10%, 1%, and 5% significance level respectively. Moreover, test statistic of below threshold for corn, soybeans, palm oil, sugar and wheat are all significant at 10%, 10%, 1%, 1% and 1% significance level respectively. Hence, there is enough evidence to prove that these five commodities markets are significant.

Threshold value of corn is -0.1753, this shows that when commodity price increase or decrease to -0.1753, market participants' behaviour will change but the speed of adjustment to equilibrium are different as the market is asymmetric. This is because results show that when commodity price increase to -0.1753, the speed of adjustment

to equilibrium is 22.16% while when commodity price decrease to -0.1753, the speed of adjustment to equilibrium is 13.47%.

Threshold value of soybeans is 0.1423, this shows that when commodity price increase or decrease to 0.1423, market participants' behaviour will change but the speed of adjustment to equilibrium are different as the market is asymmetric. This is because results show that when commodity price increase to 0.1423, the speed of adjustment to equilibrium is 28.24% while when commodity price decrease to 0.1423, the speed of adjustment to equilibrium is 6.80%.

Threshold value of palm oil is -0.3492, this shows that when commodity price increase or decrease to -0.3492, market participants' behaviour will change but the speed of adjustment to equilibrium are different as the market is asymmetric. This is because results show that when commodity price increase to -0.3492, the speed of adjustment to equilibrium is 16.89% while when commodity price decrease to -0.3492, the speed of adjustment to equilibrium is 26.51%.

Threshold value of sugar is not significant because it got no long run and short run with crude oil, hence no asymmetry.

Threshold value of wheat is not significant because it got no long run and short run with crude oil, hence no asymmetry.

4.3 Momentum-Threshold Autoregressive (M-TAR) Model

Table 4.5: Results of Momentum-Threshold Autoregressive (M- TAR) Model (Tau=0)

	Corn	Soybeans	Palm oil	Sugar	Wheat
Above Threshold	-0.1456*	-0.1230*	-0.1375**	-0.1128	-0.2207***
Below Threshold	-0.2123*	-0.1889*	-0.2619***	-0.1394**	-0.2441**
F-joint($P_1 = P_2 = 0$)	5.7797*	5.140	11.3253*	3.9654	6.0847*
F-equal($P_1 \neq P_2$)	0.4250	0.4604	2.4555	0.08304	0.0421

NOTE:*,**,*** indicates the rejection of null hypothesis at 10%, 5% and 1% of significance level.

Table 4.6: Results of Momentum-Threshold Autoregressive (M- TAR) Model (Tau≠0)

	Corn	Soybeans	Palm oil	Sugar	Wheat
Above Threshold	-0.5301***	-0.0460*	-0.1621***	-0.08030	-0.2024***
Below Threshold	-0.1277*	-0.2231*	-0.4467***	-0.2914***	-0.4536***
Tau	0.1320	0.0261	-0.1250	-0.1570	-0.1183
F-joint($P_1 = P_2 = 0$)	9.8522**	6.6203	14.2391*	6.0282	7.3724*
F-equal($P_1 \neq P_2$)	7.8534*	3.1903	7.38925*	3.9454	2.3640

NOTE:*,**,*** indicates the rejection of null hypothesis at 10%, 5% and 1% of significance level.

Momentum-Threshold Autoregressive (M-TAR) Model is used to study speed of adjustment of each commodities price changes caused by positive and negative oil price changes. In order to show asymmetric effect, F-joint and F-equal have to be significant at 10% significance level.

The hypothesis testing for F-joint is as below:

H0: $\rho 1=\rho 2= 0$ (There is no dynamic relationship between long run and short run)

H1: $\rho 1\neq\rho 2\neq 0$ (There is dynamic relationship between long run and short run)

The results have to reject null hypothesis at 10% significance level in order to show that speed of adjustment of each commodity price changes has long run and short run relationship with crude oil price changes. When Tau value equal to zero, only corn, palm oil and wheat are significant with crude oil at 10% significance level. On the other hand, corn, palm oil and wheat are significant with crude oil at 5%, 10% and 10% significance level respectively when Tau value is determined by data.

The hypothesis testing for F-equal is as below:

H0: $\rho 1=\rho 2$ (There is symmetric adjustment in the relationship)

H1: $\rho 1\neq\rho 2$ (There is asymmetric adjustment in the relationship)

The results have to reject null hypothesis at 10% significance level in order to show the asymmetric speed of adjustment of each particular commodity affected by changes in crude oil price. From the results, none of significant result when Tau value equal to zero and only corn and palm oil are significant at 10% significance level. According to Table 4.6, corn and palm oil are significant in F-joint and F-equal at Tau value of 0.1320 and -0.125 respectively. This shows that corn and palm oil have asymmetric effect with crude oil in terms of speed of adjustment for the price changes.

To study the asymmetric characteristic of the market, either test statistic of above and below threshold should significant at minimum 10% significant level. According to result from Table 4.5, when Tau value is equal to zero, test-statistic of above threshold for sugar is not significant, while corn, soybeans, palm oil and wheat are significant at 10%, 5%, and 1% significance level respectively. Moreover, test

statistic of below threshold for corn, soybeans, palm oil, sugar and wheat are all significant at 10%, 10%, 1%, 5% and 5% significance level respectively.

According to result from Table 4.6, when Tau is determined by data, test statistic of above threshold for sugar is not significant, while corn, soybeans, palm oil and wheat are significant at 1%, 10%, 1%, and 1% significance level respectively. Moreover, test statistic of below threshold for corn, soybeans, palm oil, sugar and wheat are all significant at 10%, 10%, 1%, 1% and 1% significance level respectively. Hence, there is enough evidence to prove that these five commodities markets are significant.

Threshold value of corn is 0.1320, this shows that when commodity price increase or decrease to 0.1320, market participants' behaviour will change but the momentum speed of adjustment to equilibrium are different as the market is asymmetric. This is because results show that when commodity price increase to 0.1320, the momentum speed of adjustment to equilibrium is 53.01% while when commodity price decrease to 0.1320, the momentum speed of adjustment to equilibrium is 12.77%.

Threshold value of soybeans is 0.0261, this shows that when commodity price increase or decrease to 0.0261, market participants' behaviour will change but the momentum speed of adjustment to equilibrium are different as the market is asymmetric. This is because results show that when commodity price increase to 0.0261, the momentum speed of adjustment to equilibrium is 4.60% while when commodity price decrease to 0.0261, the momentum speed of adjustment to equilibrium is 22.31%.

Threshold value of palm oil is -0.1250, this shows that when commodity price increase or decrease to -0.1250, market participants' behaviour will change but the momentum speed of adjustment to equilibrium are different as the market is asymmetric. This is because results show that when commodity price increase to -0.1250, the momentum speed of adjustment to equilibrium is 16.21% while when commodity price decrease to -0.1250, the momentum speed of adjustment to equilibrium is 44.67%.

Threshold value of sugar is not significant because it got no long run and short run with crude oil, hence no asymmetry.

Threshold value of wheat is not significant because it got no long run and short run with crude oil, hence no asymmetry.

4.4 Asymmetric Error Correction Model

Table 4.7: Results of Asymmetric Error Correction Model

	Corn	**Soybeans**	**Palm oil**
C	0.001902	-0.013287	-0.0023
MPLUS	– 0.297568***	0.066433	-0.1242**
MMINUS	– 0.131769**	-0.251456***	-0.3271***
$\sum_{i}^{n} \Delta Oil_{t-i}$	F=0.9728	F=2.9087***	F= 3.7781**
$\sum_{t=i}^{n} \Delta Corn_{t-i}$	F=2.2161**	-	-
$\sum_{t=i}^{n} \Delta Soybeans_{t-i}$	-	F=0.9171	-
$\sum_{t=i}^{n} \Delta Palm\ oil_{t-i}$	-	-	F=5.1586***

NOTE:*,**,*** indicates the rejection of null hypothesis at 10%, 5% and 1% of significance level.

The results of this paper are presented in the Table 4.7 above. It should be noted that both mplus and mminus are vital components in asymmetric error correction model

(ECM). If either mplus or mminus is negative and significant in the 10% significance level, it indicates that crude oil price is asymmetrically affecting the commodity price. In order to estimate the long run equilibrium relationship and asymmetric adjustment, the asymmetric error correction model includes the tests of short run dynamics between changes in crude oil and commodity prices.

According to the result above, corn market is asymmetric to the release of good news and bad news. It can be evidenced by the results in Table 4.7. Both mplus -0.2976 and mminus -0.1318 is significant at 1% and 5% significant level respectively in this model. Corn market is significantly affected by positive and negative shock but the speed of adjustment is different. The positive speed of adjustment to long run equilibrium is 29.76%. The negative speed of adjustment to long run equilibrium is 13.18%. Since mplus and mminus is different, it proves that positive shock is greater than negative shock.

In the case of soybeans market, mplus is 0.0664 and it is not significant at 10% significance level. The mminus -0.2515 is significant at the level of 1% which indicate the soybeans market's speed of adjustment of negative shock to long run equilibrium is 25.15%. Hence, soybeans market is more responsive to negative news than positive news, which evidenced the effect of asymmetric.

Moreover, palm oil market is also asymmetric to the release of good announcements and bad announcements. The mplus -0.1242 is significant at confidence level of 5% which showed that palm oil's speed of adjustment of positive news to long run equilibrium is 12.42%. With the mminus of -0.3271 significantly reject null hypothesis at 1% confidence level, palm oil market proved to be asymmetric. In short, it is learned that negative shock is greater than positive shock.

4.5 Diagnostic Checking

In this section, diagnostic checking tests are used to check the Asymmetric Error Correction Model (AECM) that mentioned in section earlier.

- CUSUM Test
- CUSUM of Squares Test

4.5.1 CUSUM Test

The CUSUM test is taken by using the cumulative sum of residuals and plots its value against the upper and lower bounds of the 95% confidence interval at each point. This paper has to ensure the cumulative sum of recursive residuals plots in between the upper and lower bound of the 95% confidence interval in order to obtain the significant result for the AECM for corn, soybeans and palm oil. The results for the CUSUM test are shown in the graphical form from Figure 4.1 to Figure 4.3 as below:

Figure 4.1: Corn (CUSUM Test)

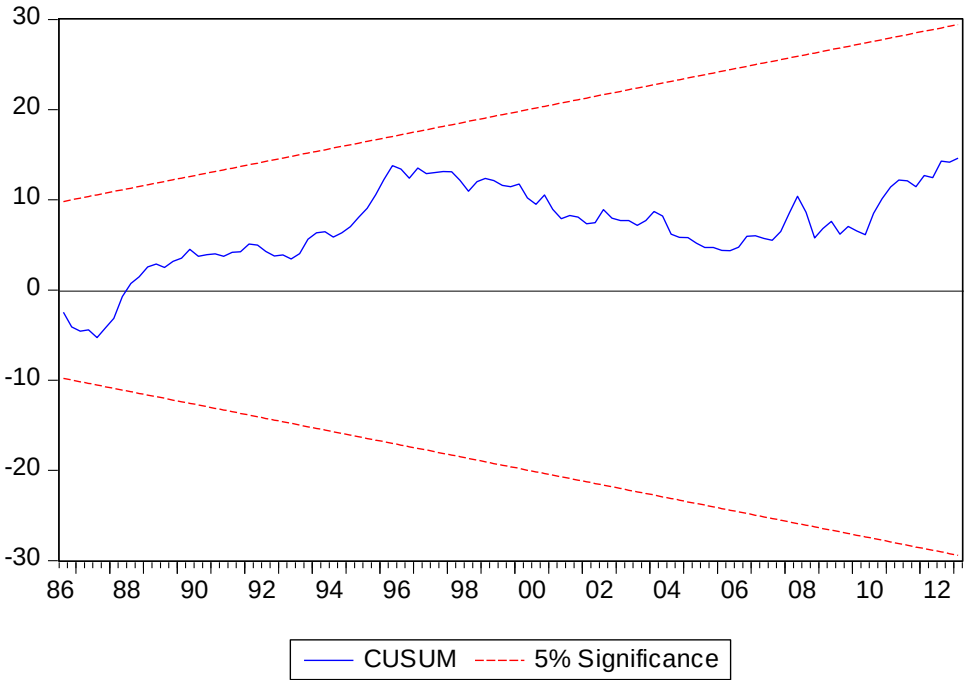


Figure 4.2: Soybeans (CUSUM Test)

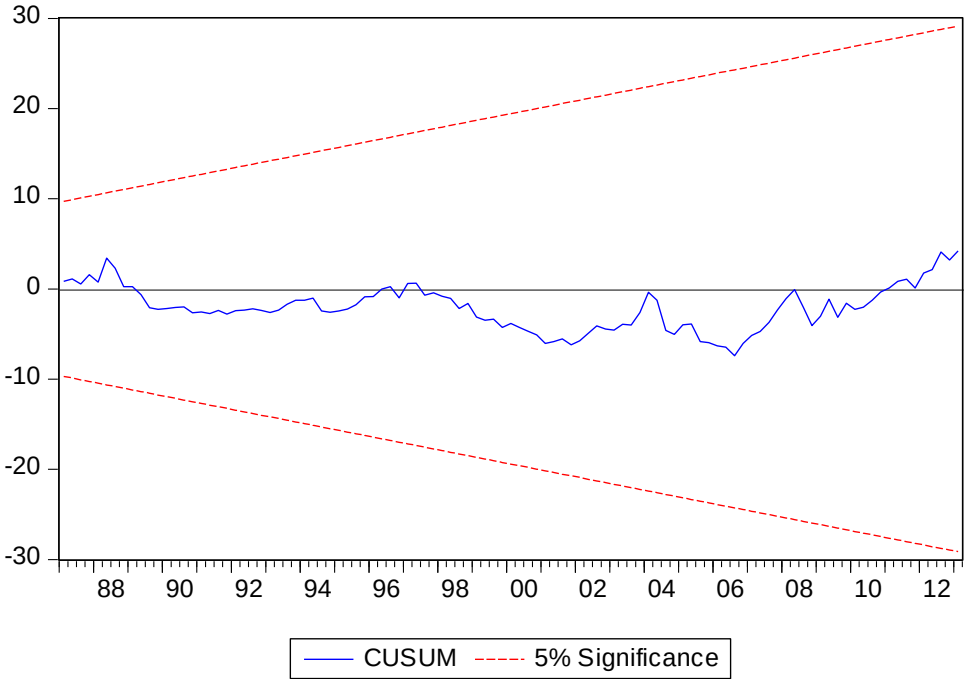
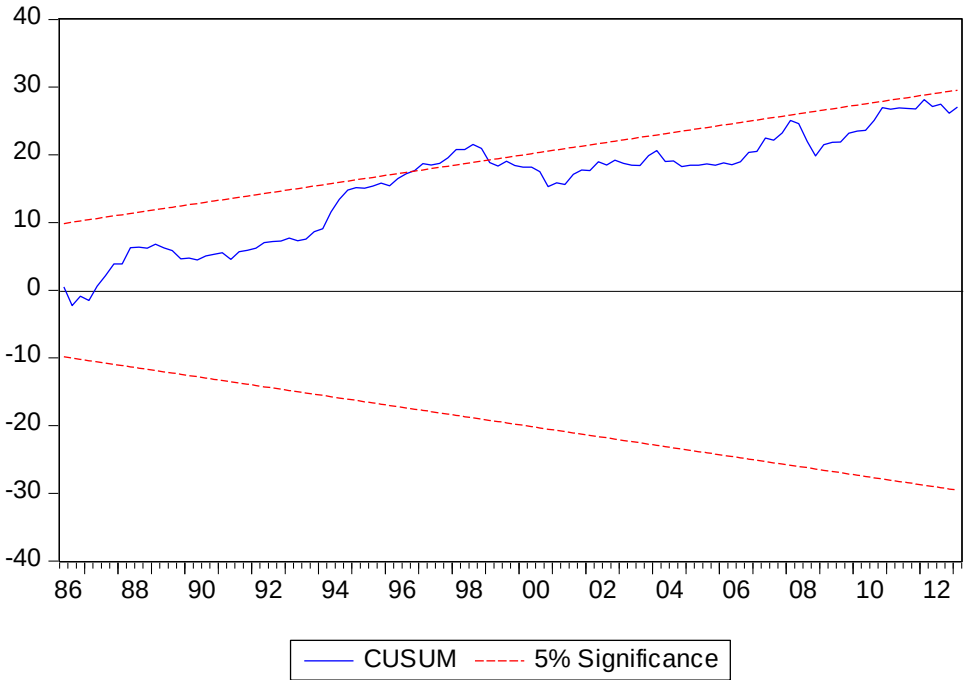


Figure 4.3: Palm Oil (CUSUM Test)



From the results shown in Figure 4.1 and Figure 4.2, AECM for corn and soybeans with crude oil are significant at 5% significance level. This shows that the AECM for these two commodities are correct and structurally stable. In addition, AECM for palm oil that presented in Figure 4.3 is not significant at 5% significance level. However, it is still in acceptable level.

4.5.2 CUSUM of Squares Test

In order to ensure the robustness of the result for CUSUM test for corn, soybeans and palm oil, CUSUM of Squares Test is used to examine the cumulative variance around the regression. The test is shown in the graphical form whereby the cumulative of variance within the boundaries of 5% of significance level. The results are shown from Figure 4.4 to Figure 4.6.

Figure 4.4: Corn (CUSUM of Squares Test)

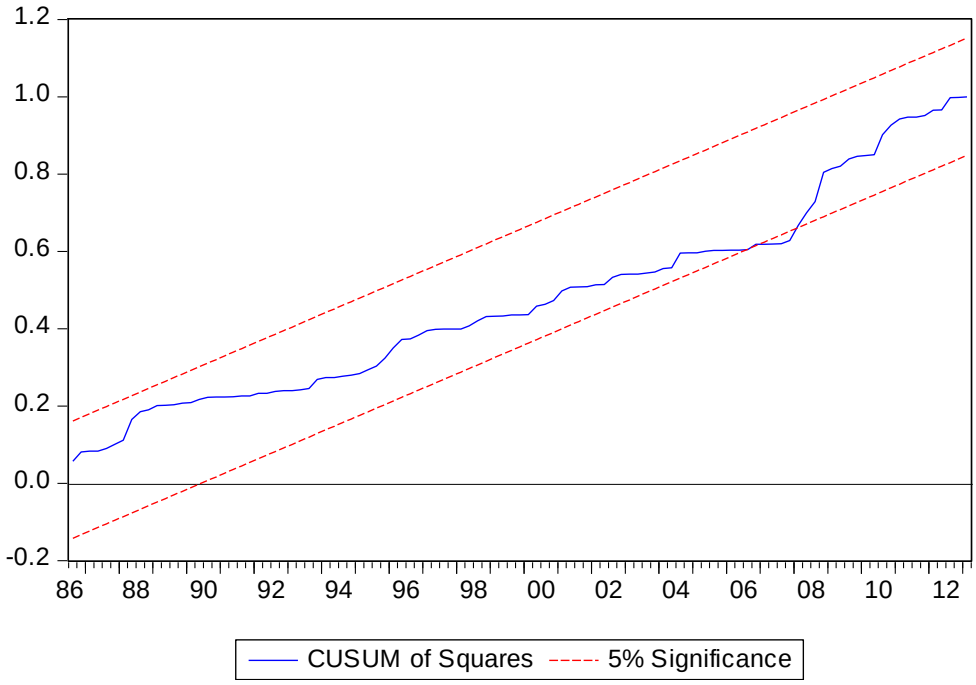


Figure 4.5: Soybeans (CUSUM of Squares Test)

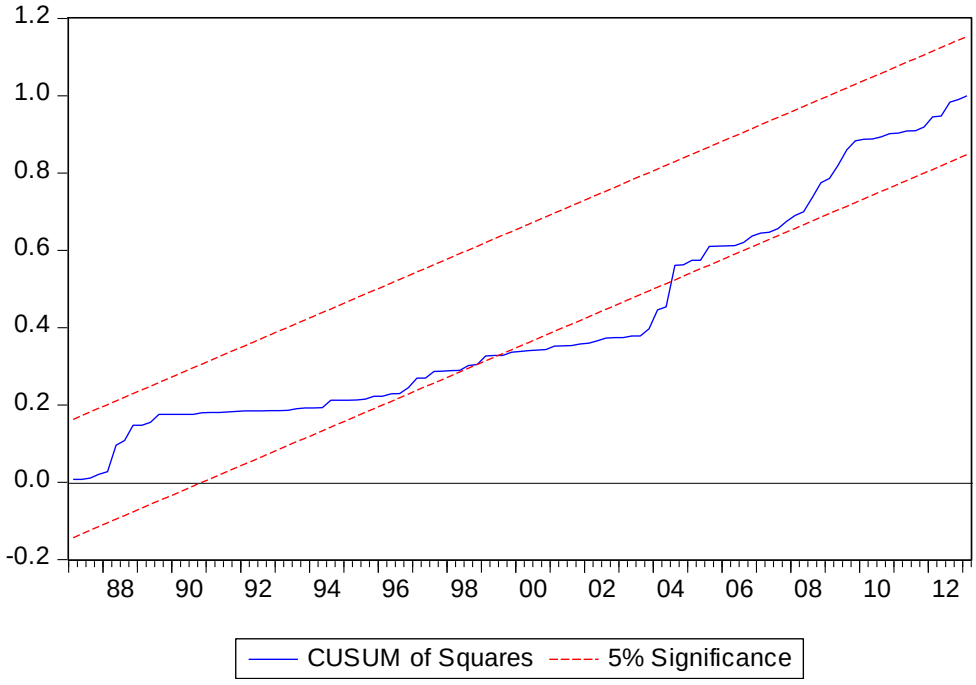
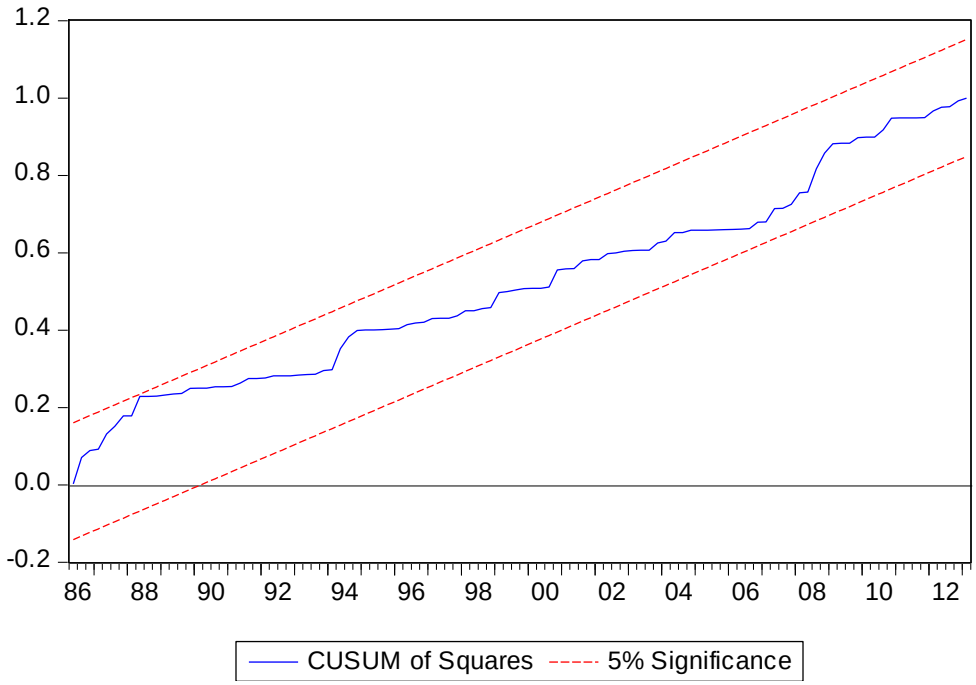


Figure 4.6: Palm Oil (CUSUM of Squares Test)



From the figures above, AECM for corn and soybeans are insignificant at 5% significance level but it is still in acceptable level. On the other hand, CUSUM of Squares Test of AECM for palm oil is significant at 5% significance level. As a result, AECM for corn, soybeans and palm oil are correct and have stable structure.

4.6 Discussion of Major Findings

Empirical results from the Asymmetric Error Correction Model showed that the prices of corn, soybeans and palm oil react asymmetrically to the fluctuation of crude oil price. Hence, it makes a contribution to the existing literatures, which only focus on symmetric relationship between crude oil price and corn, soybeans and palm oil prices. Unfortunately, this paper could not find any asymmetric effect on sugar and wheat price change due to crude oil price change.

Based on the results, this paper has found that soybeans price reacts excessively to the negative shocks compared to positive shocks of crude oil price changes whereas corn and palm oil prices react significantly to both positive and negative shocks caused by crude oil price change but the momentum speed of adjustments are different. This results are supported by the findings of Baffes and Dennis (2013), Ghaith and Awad (2011) and Nazlioglu and Soytas (2011). According to Baffes and Dennis (2013), Ghaith and Awad (2011) and Nazlioglu and Soytas (2011), there is significant relationship between crude oil price and corn, soybeans and palm oil prices respectively. However, the results found are based on the assumption that the relationship between crude oil price and each specific commodity price is symmetric, which is constant over the time.

Other than that, Baffes and Dennis (2013), Ghaith and Awad (2011), and Nazlioglu and Soytas (2011) found the significance of long run relationship between crude oil price and corn, soybeans and palm oil price. The finding of this paper is not only consistent with the findings by Baffes and Dennis (2013), Ghaith and Awad (2011), and Nazlioglu and Soytas (2011) but also found asymmetric effect between crude oil price and commodities price that extend the studies above. To be further explained, Gaith and Awad (2011) have employed Error Correction Model (ECM) in order to evaluate the long run relationship. However, this method is based on the assumption that the relationship is symmetric. To fill up the gap, this paper has employed Asymmetric Error Correction Model (AECM) to estimate the asymmetric relationship between crude oil price and corn, soybeans and palm oil prices respectively. Last but not least, this paper has revealed important information to the study by Ji and Fan

(2012) which stated that there is asymmetric effect of crude oil market on commodities market. This paper has found that the asymmetric relationship that is not only occurred in aggregated level, but also disaggregated level when examining the relationship between crude oil price and specific commodity prices such as corn, soybeans and palm oil.

Due to the strong linkages between energy and agricultural market, demand for biofuels production increases when crude oil price rises. Corn and soybeans are the main crops that used in producing biofuels, thus the prices of crude oil price is closely related with corn and soybeans price. This paper has found asymmetric long run and short run relationship between crude oil price and corn and also soybeans price. The results are inconsistent with the results obtained by Nazlioglu (2011) where crude oil price has neutrality relationship with corn and soybeans price. Nazlioglu (2011) obtained non-linear causality between crude oil price and agricultural commodity prices, which indicated that changes in crude oil price is powerful in determining future dynamics of the commodities price. However, neutrality relationship between crude oil price with corn and soybeans price show that movements in crude oil price do not directly affect agricultural commodities price.

Moreover, this result not only improve the reliability of the result obtained by Hadi et al. (2011) which found the significant long run and short run relationship between crude oil price and palm oil price, but also takes into account the asymmetric price adjustment. The findings by Hadi et al. (2011) indicated that the movements in palm oil price will affect movements in crude oil price. Moreover, palm oil price and crude oil price will move in the same direction and will only be adjusted after 2 month. This paper has strengthened the findings by Hadi et al. (2011) by proving the strong linkage between palm oil price and crude oil price. Nevertheless, rather than palm oil price affect crude oil price, this paper found that crude oil price is a vital element in determining changes in palm oil price. In addition, degree of change is not the same, which means that when crude oil price drops, the palm oil price will decrease in a percentage that is more than when the crude oil price increases.

This result contrasts with studies of Nazlioglu and Soytas (2010) who did a research in Turkey and found out that oil price do not play an important role in determining the short and long run behaviors of the wheat prices. This is because Turkish Grain Board (TMO) market intervenes in the wheat and maize sectors and the deficiency price payment policy for the selected agricultural commodities. TMO continues to impede exposure of Turkish agricultural sector to competiveness in the international markets and hence, investors and speculators could not predict the prices of wheat by concentrating on dynamics of oil price.

However, Chen et al. (2010) explained the significant relationship of the wheat price is affected by oil price changes due to the sharp increase in the price of various energy-intensive, including fertilizer and fuel, as well as transportation costs. Wheat price will decrease follow by decreasing in oil price since the production cost of wheat price decrease as well. Hence, this can be proved the symmetric relationship between oil price and wheat price.

In addition, result of Du et al. (2011) also found out that crude oil price will lead to forecasts of a large corn ethanol impact on corn prices and this corn price formation will affect the price variation on the wheat market which in turn was due to price variation in the crude oil market. Therefore, the result makes sense that corn and wheat compete for acres in some states.

Previous researchers solely tested on the long run and short run relationship between crude oil price and sugar price. Nazlioglu and Soytas (2011), Nazlioglu et al. (2013), Zhang and Reed (2008) and Zhang et al. (2010) found out neutrality relationship between crude oil and sugar. The results that obtained by them is inconsistent with the empirical result in this paper, where the relationship between sugar and crude oil is unjustified since it doesn't satisfy the preliminary assumption of F-joint test, hence we cannot proceed with F-equal test to examine if sugar is symmetry or asymmetry with crude oil. The major reasons behind sugar price has no asymmetry effect towards to crude oil price are attributed to the demand growth of the commodity used in the biofuel production, expansionary policy as well as speculative activities. (Nazlioglu et al., 2013; Zhang et al., 2010)

Due to the increasing in the prices of the crude oil, many countries start used the sugar in the biofuel production and caused it become the substitutes of the crude oil. Thus, the demand of the sugar rose rapidly while the supply lagged behind and finally putting the upward pressure on the sugar price. In addition, the mandate which is the expansionary policy has become one the reasons why sugar price has no asymmetry effect to the crude oil price. For instance, EU and United State has implemented the sugar quotas and tariffs for the sugar-producing countries such as Brazil, and this situation has caused the sugar price increase. Besides, the skyrocketing of the sugar price is due to the speculative activities in the agricultural commodity market. The speculators, investors and traders which are the players in the global financial markets view the commodity market as the alternative investment areas, thus they start to hedge and diversify their portfolio. Apparently, the active investment in the global commodity market especially in the sugar commodity market can effectively boost the sugar price.

CHAPTER 5: CONCLUSIONS

5.0 Conclusion

In this paper, the relationship between crude oil price and various commodity prices, namely corn, soybeans, palm oil, sugar and wheat is investigated. It is found that crude oil price imposes asymmetric effect on prices of corn, soybeans and palm oil. Significance of F-equal and F-joint in Threshold Autoregressive (TAR) Modal shows that soybeans price reacts asymmetrically to positive and negative shocks of crude oil price changes. Moreover, significance of F-equal and F-joint in Momentum-Threshold Autoregressive (M-TAR) Modal shows that corn and palm oil prices react asymmetrically to positive and negative shocks of crude oil price changes. This is because speed of adjustment to positive and negative shocks is different according to results from Table 4.4 and 4.6. Unfortunately, it is found that prices of wheat react symmetrically to crude oil price changes. Their speed of adjustment to positive and negative shocks is indifferent. While for sugar, it is unjustified since it doesn't satisfy the preliminary F-joint test, which means it got no long run relationship with crude oil. As a result, we can't proceed with F-equal test, hence we doesn't know if sugar got symmetric or asymmetric relationship with crude oil, so unjustified.

5.1 Policy Implications

The results from TAR, MTAR and AECM showed that corn, soybeans and palm oil market are asymmetric, which is entirely different from past studies with symmetric adjustment. Hence, investors and speculators should consider the commodities market are asymmetry and adjust their trading strategies accordingly. This paper also found out that soybean price reacts significantly to a decrease in crude oil price, compared

to an increase in crude oil price. Thus, when crude oil price decreases, investors should not overreact to the negative shock, at the same time took profit from it. Hence, they should equip themselves with good behavioral finance knowledge, so that the emotions of fear and greed won't affect them. In general, people tend to overreact when market collapse. It is better for investors and speculators should aware of this asymmetries in commodities market and make right decisions in order to reduce loss.

The asymmetric effect that exists in the relationship between crude oil price and prices of corn, soybeans and palm oil are important for parties that involved in biofuel production such as biofuel producers, exporters and farmers. It is found that an increase in corn price is larger than a decrease in corn price when crude oil price is changing, which is the asymmetric effect. Thus, such asymmetric information is vital for the biofuel producers and commodities exporter or farmer when forecasting commodities price since the changes in commodities price will directly affect their profitability and costs as well. Specifically, biofuel producers, exporters and farmers should be aware of increasing crude oil price because corn price likely will increase significantly as well, therefore affecting their revenue and cost structures.

Besides that, government and economist are encouraged to take into account the asymmetric effect when making decisions. It is found that palm oil price react excessively to negative oil shock than positive shock, therefore government should capitalize on this information to decide how much capital should be invested in commodities production. This piece of implication is very useful to government like Malaysia and Indonesia, which is the world's largest palm oil producer.

From the empirical result, it is learned that the relationship between sugar price and crude oil price is fairly weak. Thus, producers, traders, investors, users should predict the sugar price based on the intrinsic demand and supply forces that affect sugar price instead of crude oil price. Besides that, long run symmetry relationship does exist between prices of crude oil and wheat, so investors can adjust their trading strategies accordingly.

5.2 Limitation and Recommendation

The limitation of this paper is this study only concentrates on five agricultural commodities in order to examine the asymmetric relationship between crude oil price and commodity price. The findings of this paper have proved the existence of asymmetric price transmission from crude oil to commodities such as corn, soybeans and palm oil. Yet, prices of wheat react symmetrically to crude oil price changes while relationship between sugar and crude oil is still unjustified. However, the results obtained from these five commodities do not mean that it can be applied for others type of commodities as well. The result cannot guarantee that the asymmetric price linkages can be found in other commodities as well. Thus, this paper recommends future researchers to include other types of commodities in their studies such as metal commodities in order to increase the validity on the existence of asymmetric impact. Future researchers can also study the co-movement of commodities as well.

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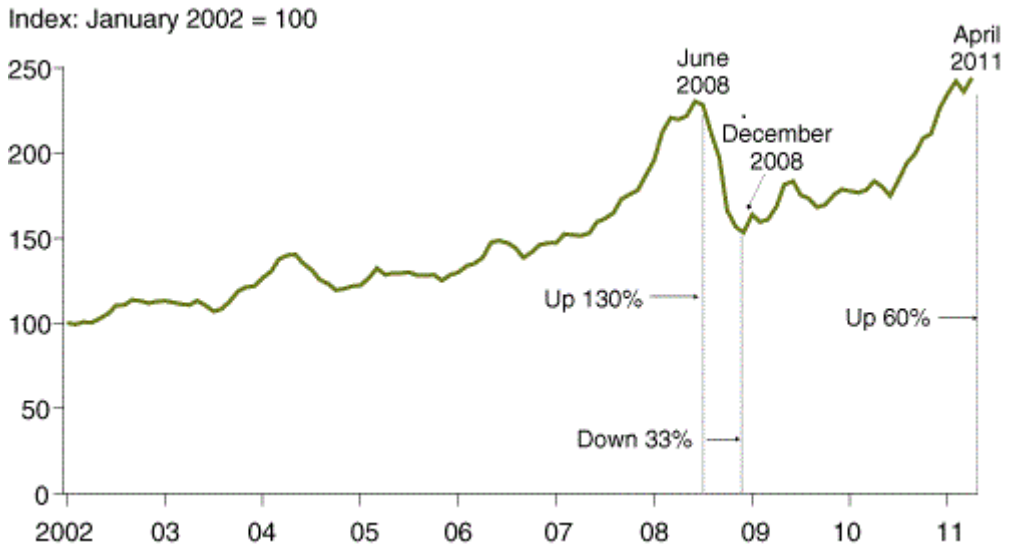
Appendices

Figure 1.1: World Food Commodity Price Index

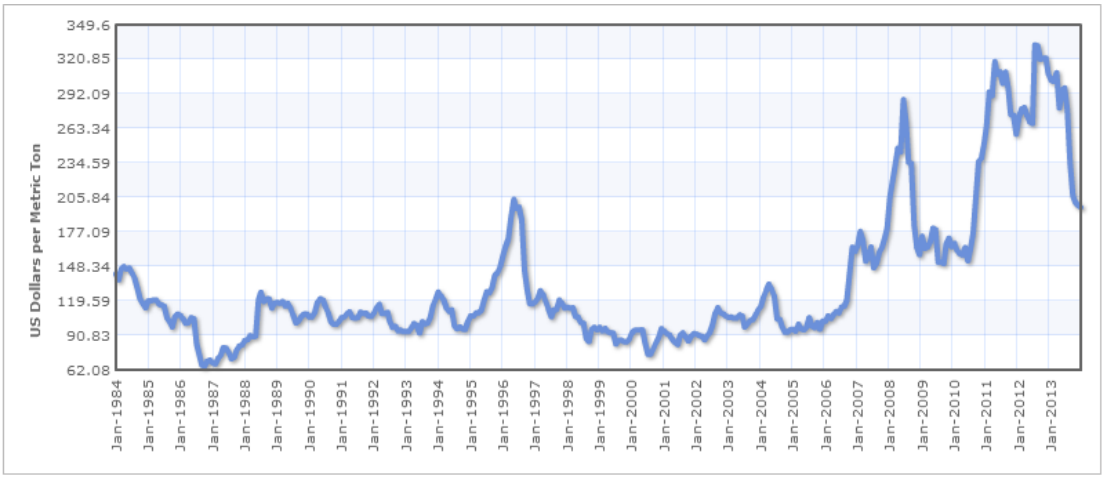


Source: USDA, Economic Research Service using International Monetary Fund, International Financial Statistic.

Figure 1.2: Crude Oil Price – US Dollars Per Barrel

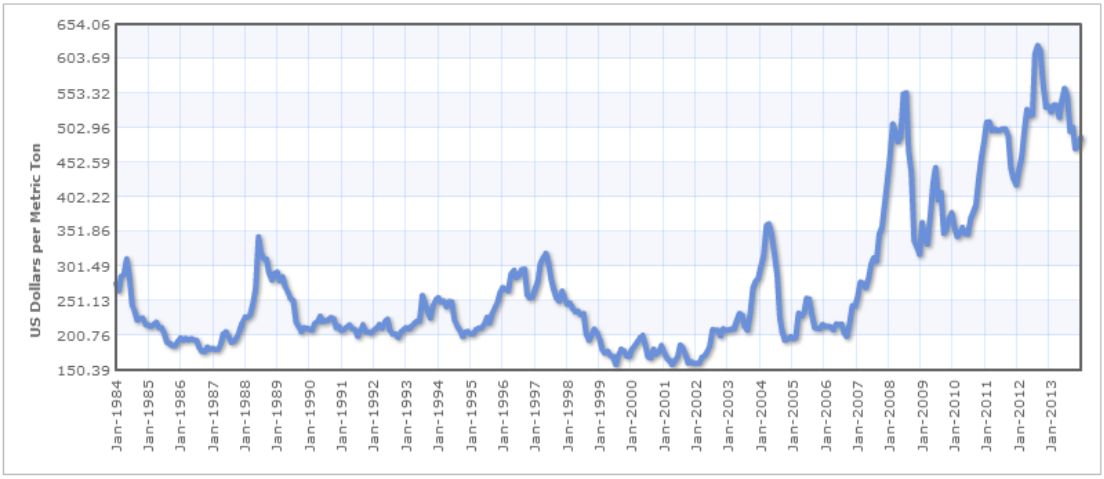
Source: Extracted from *www.indexmundi.com*

Figure 1.3: Corn Price – US Dollars Per Metric Ton



Source: Extracted from *www.indexmundi.com*

Figure 1.4: Soybean Price – US Dollars Per Metric Ton

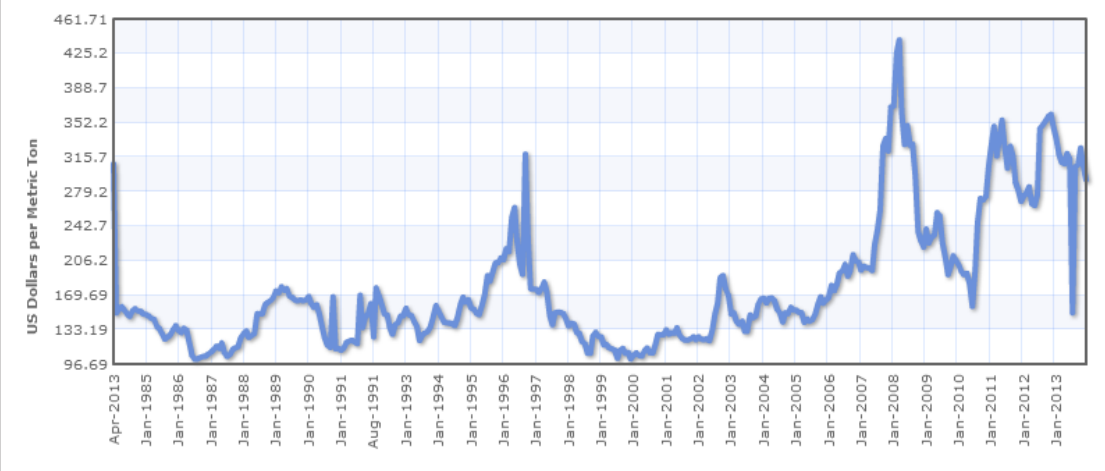


Source: Extracted from *www.indexmundi.com*

Figure 1.5: Palm Oil Price - US Dollars Per Metric Ton

Source: Extracted from *www.indexmundi.com*

Figure 1.6: Wheat Price - US Dollars Per Metric Ton



Source: Extracted from *www.indexmundi.com*

Figure 1.7: Sugar Price – US Cents Per Pound

Source: Extracted from *www.indexmundi.com*