CHARACTERISTICS OF INTERNATIONAL GRAIN PRICE MOVEMENTS UNDER THE HIGH OIL PRICES
- TOWARD POLICY IMPLICATIONS -

BY

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CHARACTERISTICS OF INTERNATIONAL GRAIN PRICE MOVEMENTS UNDER THE HIGH OIL PRICES - TOWARD POLICY IMPLICATIONS -

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ABBREVIATIONS

Names of organizations

CBoT	Chicago Board of Trade
CFTC	Commodity Futures Trading Commission
EIA	Energy Information Administration
ERS	Economic Research Service (USDA)
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FAS	Foreign Agricultural Service (USDA)
IMF	International Monetary Fund
NYMEX	New York Mercantile Exchange
OECD	Organization for Economic Co-operation and Development
RFA	Renewable Fuels Association
USDA	United States Department of Agriculture

Statistical and econometric terminologies

ADF Test	Augmented Dickey-Fuller Test
AR	Autoregression
Δ	Delta (first differenced)
DF Test	Dickey-Fuller Test
ECT	Error Correction Term
LR	Likelihood Ratio
OLS	Ordinary Least Squares
Prob	Probability
VAR	Vector Autoregression

VECM	Vector Error Correction Model

Weighting units and conversions:

Cwt	Hundred weights	
	Conversions:	
		1 cwt = 100.001 pound (lb) = 0.045 metric ton
		1 metric ton = 22.046 cwt
	Ref.	*http://www.metric-conversions.org/weight*
Bu	Bushel	
	Conversions for corn:	
		1 bushel = 0.0254 metric ton
		1 metric ton = 39.3679 bushels
	Conversions for wheat and soybeans:	
		1 bushel = 0.027216 metric ton
		1 metric ton = 36.7437 bushels
	Ref.	*http://www.grains.org/conversion-factors*
Brl	Barrel	
	Conversions:	
		1 barrel = 42 U.S. gallons (U.S. Liquid Measure)
		1 barrel = 158.9873 liters
	Ref.	*http://www.eia.doe.gov/glossary/glossary_b.htm*

Others

Diff	Difference
HCM	Ho Chi Minh (city)
N/A	Not available
PSD Online	Production, Supply and Distribution Online
RFS	Renewable Fuels Standard
SUR	Stocks-to-Use Ratio
U.S.	United States
WTI	West Texas Intermediate

ABSTRACT

Monthly price data indicated that average prices of agricultural grains drastically increased from the beginning of 2006 to 2007. However, that was not an end; those grain prices continued skyrocketing and made records in first six months of 2008. Then, their prices unsurprisingly started dropping in the second half of 2008. Record high prices of the grains were made at different times and the magnitudes varied depending upon the commodities. However, a uniformed trend of price movements for all crops did exist.

Crude oil prices (West Texas Intermediate (WTI)) showed the same trend since they also escalated and reached the record high at US$145.29/barrel on July 3, 2008. Many researchers and economists considered oil prices as a factor contributing to price movements of the grains; however, none of them pointed out how much the oil price variations affected the grain prices.

This study attempts to investigate the characteristics of the global grain price movements which were driven by a series of factors during recent two years and quantify the relationships between prices of the grains and oil. Finally, according to the results, this study would provide some policy implications to countries and regions.

Daily price data of the grains and oil were collected in the period from July 2nd, 2007 to March 31st, 2009 from Chicago Board of Trade and New York Mercantile Exchange, respectively. Augmented Dickey-Fuller tests were first employed to test the stationarity conditions of all the data; Vector Autoregression models were used to identify the optimal lag lengths which were, then, applied in the Johansen approach for examining the existences of cointegrating relations; and in the Vector Error Correction Model for estimating short-run and long-run relationships. Dummy variables were also

employed in each model depending upon the grains to reflect other factors besides oil prices affecting the grain price movements.

Three main characteristics of international grain price movements in the last two years were concluded from this study. They were changes in food dietary patterns, policy interventions by countries, and price-inelastic demand and supply of the grains. Empirical analyses indicated that there were long-run relationships among prices of each grain and oil. Prices of rice, corn, and wheat increased 8.22 cent/cwt, 2.71 cent/bu, 2.00 cent/bu, respectively, when oil prices increased by one dollar a barrel; and price elasticity of soybeans to one percent change in oil prices was 0.604 percent. The key link among prices of the grains and oil was that corn and soybeans have been increasingly used as feedstock for bio-fuel productions around the world. Furthermore, the grains were substitutes with one another in terms of both planting area and consumptions; as a result, changes in prices of a certain commodity have led to changes in prices of other substitutive and competitive crops.

There existed relationships between prices of the grains and oil in the long run. Among which prices of soybeans, corn, and rice were more responsive to the changes in prices of oil than prices of wheat. Under the current bio-fuel policies, prices of oil are expected to have continuous impacts on prices of those grains in the next decade.

The grain prices remain relatively high; Asian grain producing countries should establish larger size of agricultural productions to make them more profitable, available for trade, and usable for bio-fuel productions. The subsidies to bio-fuel productions have been getting smaller which may be a pressure to the grain farmers to substantially cut down their production costs in order to make their grains competitive in this promising market.

CHAPTER 1

INTRODUCTION

1.1. Background

Monthly price data, collected through price quotations by Chicago Board of Trade, indicated that average prices of some agricultural grains including rice, corn, wheat and soybeans (hereafter, called as grains in this study) have drastically increased from the beginning of 2006 to 2007 at the increasing rates of 30 percent, 73 percent, 91 percent, and 49 percent, respectively[1]. However, that was not an end, since prices of these grains continued skyrocketing and then made all-time high records in 2008. Daily rice prices in the international markets reached its record of US$24.82/cwt (hundred weights, milled basis) on April 23, 2008, which was equivalent to an increasing rate of 127 percent in 10 months from July 2007. Similarly, daily prices of corn made a spike and following by a peak at U.S. cent 754.75/bushel on June 26, 2008, or an increasing rate of 115 percent from July 2007. In the same trend, daily prices of wheat and soybeans escalated and made records in February 2008. Wheat prices jumped up from around U.S. cent 600/bushel in early July 2007 to U.S. cent 1,280/bushel by the end of February, it was equal to 114 percent increase. Soybean prices continued skyrocketing, and reaching its record high of U.S. cent 1,658/bushel in early 2008, which was equivalent to an increasing rate of 85 percent in one year[2]. Record high prices were made at different times during the first six months of 2008 and the magnitudes varied depending upon the commodities; however, a uniformed trend of price movements for all crops did exist.

[1] Personal analyses of monthly agricultural commodity prices collected from Chicago Board of Trade (CBOT)

[2] Percentages of increasing prices were calculated from the daily price data of the grains in this study

Many factors have contributed to the spikes of the commodity prices. Factors have had both long-term and short-term effects on the price movements of these grains. Some factors reflect underlying trends of slower growth in productions and more rapid growth in demand that have contributed to a tightening of world balance and caused the remarkable low ending stocks of some grains. Rising demand for meat due to changes in food dietary patterns in some emerging and developing economies has been requiring more grains for producing animal feeds. Increasing demand for the grains by bio-fuel industry has been strengthening the trade-off between food and feed and bio-fuels for corn and soybeans, which put a strong upward pressure on the prices of these commodities and their substitutes. Some other factors which were considered as short-term shocks including declining value of the U.S. dollar, adverse weather conditions in recent years, growing foreign exchange holdings by major-importing countries (Trostle, 2008)[3], policy impositions by importing and exporting countries to avoid increases in their own domestic prices of food commodities; in other words, to mitigate the serious food inflation. Some of these mentioned factors will be discussed further in Chapter 4 as attributes to the movements of the grain prices in this study. Rather than above factors, rising crude oil prices were considered as a key factor to the skyrocketing prices of the food commodities in most of the researches, reports and journal papers of the same field.

The crude oil prices (West Texas Intermediate, WTI) steadily increased since its fall in January 2002 at US$19.48/barrel to US$74.40/barrel in July 2006. The oil prices, since then, slightly fell by January 2007, when it was also a start for an unforeseeable rise in 2007 and up to early July 2008. The record high price of oil was

[3] Trostle (Economic Research Services, USDA) included and explained its effects on the prices of agricultural commodities in his research work titled "Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices."

US$145.29/barrel on July 3, 2008, which was equivalent to the increasing rate of 151% since January 2007. Over the past few years, the bio-fuel production has grown sharply in the United States, Brazil and European Union and, to a much smaller degree in other countries. This industry has been consuming more and more grains which are traditionally used as food for humans and feeds for animals. Rising oil prices have been increasing incentives and causing the adoptions of new policies which encourage the production of bio-fuels in order to lessen dependences on imported oil. Furthermore, increasing crude oil prices have caused the price spikes of all types of fertilizers which are essential for grain crop productions, resulted in high production costs. The high oil prices were also added to the transportation costs of all steps from crop production to trade. And there were few more evidences that can prove the relationships between prices of the grains and oil. Many researchers and economists have been blaming the role of oil prices in the fluctuations of the grain prices; however, there is yet no specific study indicating the empirical relationships and impacts from crude oil prices.

High prices of energy may be a key factor for rising food prices. Energy and agricultural prices have become increasingly intertwined (J. von Braun, June 12, 2008). This research attempts to investigate the characteristics of the international grain price movements and to quantify the relationships between international grain prices and the oil prices.

1.2. Statement of problems

As mentioned above, this study attempts to state two problems which are going to be fully discussed and answered in the coming parts.

Firstly, international prices of the grains, including rice, corn, wheat and soybeans have strongly fluctuated during the period from July 2007 to March 2009. Tomek and

Robinson (1990) noted that agricultural commodity prices are more volatile than are the prices of most non-farm goods and services. In fact, there were many factors contributing to the price movements of these grains, such as rising crude oil prices, changes in supply and demand, increases in prices of the agricultural inputs, policy adoptions by major importing and exporting countries, and adverse weather, etc., among which some were unforeseeable and out of control of people. Furthermore, these grains themselves are seasonal and storable goods, thus their prices may always fluctuate in a fixed frequency during a year and strongly depending on the speculations of the commodities in the international markets. This implies prices of these grains are themselves volatile and strongly fluctuating whenever shocks happen. In nearly two years, from July 2007 to March 2009, prices of these commodities have typically reflected the volatility when all the prices dramatically increased in such more than half a year and then made their high records toward the mid 2008. High food commodity prices have caused lots of the civil and political unrests all over the world, particularly where people spend most of their incomes on food expenses. President of the World Bank Robert B. Zoellick (April 2008), said “based on a very rough analysis, we estimate that a doubling of food prices over the last three years could potentially push 100 million people in low-income countries deeper into poverty.” However, this study will not analyze the impacts of high food grain prices in last two years in full, but attempt to analyze the main characteristics of the grain price movements; simultaneously, driving-forces of the price movements would be discussed.

Secondly, crude oil prices were blamed to be responsible for its contributions to the fluctuating prices of the grain commodities. Many of researchers and economists pointed out that increases in oil prices have strongly encouraged the U.S., Brazil, European Union and few other countries to produce more bio-fuels from the grains, contributed to the rising prices of agricultural inputs for productions and transportation costs at every step from producing to trading of commodities. However, they have just mentioned crude oil prices as a factor influencing the prices of the grains, not fully discussed how much they would be responsible for. This study helps to point out or answer that question. This is core analyses in this study.

1.3. Justifications

Prices of the grains made record high in the first six months in 2008, but then dramatically declined in less than four months within the year. However, they have been remaining high as compared with prices in few years ago. According to Agricultural Outlook 2009-2018 released by OECD and the United Nations Food and Agriculture Organization (FAO), agricultural commodity prices should ease from their recent record peaks but over the next 10 years they are expected to average well above the mean of the past decade. We found that it is very interesting to study the current, short-term and long-term driving forces of the past fluctuations of the grain prices, namely the characteristics of the grain price movements. And from these results, we may make some judgments on how these prices will be in the future.

Oil prices are worth studying since its prices and prices of almost other commodities and services have been becoming more and more intertwined. Especially, oil prices appear to be influencing the prices of the grains both directly and indirectly. Knowing the nature of price movements of crude oil, its price-making factors, supply and demand conditions in the global markets, responsive policies by individual countries, etc. may help to understand the movements and relationships between these prices.

1.4. Objectives of the study

Objectives of this study were threefold. Firstly, this study used graphical analyses to investigate the characteristics of the global grain price movements which were driven by a series of forces during the last two years. Price movements of grains which in this study are rice, corn, wheat and soybeans varied depending upon their different characteristics and features, but to some extent they have been moving together in a common trend. Secondly, the correlations or relationships between prices of the grains and oil appear to exist. This study attempts to analyze the actual impacts and influences from oil prices on the prices of these grains by conducting empirical analyses. Finally, according to the results from these analyses, this study would provide some policy implications and recommendations for concerning countries and grain producers. More precisely, this study might recommend them how to deal with the fluctuations of the grain prices, mitigate the negative impacts from impositions of policies which encourage the bio-fuel productions, and also benefit from those actual conditions in the global markets.

1.5. Expected outcomes of the study

This study is expected to provide general information of the grains by which the readers can understand the current situations of the grain supplies and demands, global trades, major producers, consumers, exporters and importers, and ending stocks and stocks-to-use ratio of the each grain. In addition, this study analyzes the characteristics of the global grain price movements by graphing and generalizing most updated data. A key objective of this study is to quantify the relationships between prices of the grains and oil. A series of methodologies would be employed to figure out the price relationships of these commodities and indentify how much oil prices have contributed to the price movements of the grains. From results of the analyses on characteristics of the grain price movements and the identified relationships between prices of the grains and oil, this study provides some policy implications and recommendations to countries and grain producers to deal with, avoid unexpected impacts and benefit from the future grain price movements.

CHAPTER 2

REVIEW OF LITERATURES

There were many of studies analyzing the grain price movements in the last two or three years. Among those, studies on the factors contributing to the price movements overwhelmed, particularly studies on bio-fuel productions. However, majority of those studies were in the form of reports and notes written by researchers and analysts of local and international organizations. Only few of them were in the form of journal paper. Consequently, they analyzed and concluded mainly based on the graphical and descriptive analyses. Studies with empirical analyses were quite limited.

2.1. Analyses on time series data

Unlike the cross sectional data, analyses on time series data might cope with the problem of serial correlation. Granger and Newbold (1974), in their paper titled Spurious Regression in Econometrics, has pointed out that an OLS regression with high estimation of R^2 and low Durbin-Watson statistic may imply the dangers of autocorrelated errors; in other words, a spurious regression. Nowadays, economists have been paying special attention to this problem in their analyses on economic time series data. Gujarati (2004) has noted that the spurious regression can arise if time series are not stationary. Thus before conducting regressions, it is important to check the stationarity conditions of the variables. The most common test for identification of the stationarity is currently unit root test derived by Dickey and Fuller (1979). Direct application of regression on time series data which are not stationary might lead to the relationships among variables which, in fact, do not really exist. In a study titled “An Economic Study on the Most Important Variables Affecting World Prices for Grain

Crops" published by Journal of Applied Sciences Research in 2008, authors would like to quantify the relationships among export capacity and relative prices of the grain crops by employing OLS regression. In reality, export capacity and prices of the grain crops can have relationship; fluctuations of the prices might have immediate impacts on the export capacity of a certain country, or after one marketing year. Results of the estimations indicated that relative prices of corn, wheat and rice had impacts on the changes in export capacities of major producing and exporting countries of the grains, such as the U.S., China, India, Canada, and Vietnam. However, Durbin-Watson statistics were not reported in the study, only R^2 and probability (in the same study, regressions on cross sectional data reported clearly Durbin-Watson statistics which all seemed to indicate no serial correlations). The former estimations by using OLS regression might strongly violate the assumption of no correlation among variables. If it is the case, all the time series variables should be tested for existence of unit root before conducting the estimations. And if the test results show non-stationarity conditions of the variables, other methodologies need to be considered in order to avoid spurious regressions as pointed out by Granger and Newbold.

2.2. A rise in global food prices

There were a number of reports and researches on the rise in global food prices in the last three years starting from 2006, particularly prices of the grains. Ronald Trostle (May 2008) from ERS (USDA) has pointed out that world market prices for major food commodities such as grains and vegetable oils have risen sharply to historic highs-more than 60 percent above levels just 2 years ago. Retail food prices in many countries have also risen in the last 2 years, raising concerns around the world. Another report on the food price driving factors by Farm Foundation (July 2008) also specified the IMF's index of internationally traded food commodities prices increased 130 percent from January 2002 to June 2008 and 56 percent from January 2007 to June 2008. And many of other research works brought forward this issue for discussions right after the rise in food prices in a year ago. However, one year after that price rise, the situation was remarkably different. The grain crop productions were higher than forecasts, quieting talk of inadequate supplies, and the value of the U.S. dollar has appreciated. A global financial crisis and recession has been dominating the news, and as a result the level of food prices has dropped. However, in the same report by Farm Foundation which was released 8 months after the above issue, its authors clearly mentioned that the food price driving forces remained the same today as in July 2008.

2.3. Factors and characteristics of the grain price movements

There were many of factors contributing the price movements of the grains during the last two years, such as rising crude oil prices as incentives for bio-fuel productions, changes in supply and demand, policy adoptions by major importing and exporting countries, adverse weather, weakening U.S. dollar, etc. From different point of views and areas of interest, researchers and analysts paid their attentions to different factors and gave, even, reverse idea with those of others. After all, none of them discussed all the possible factors to the price movements of the grains.

In a policy research working paper submitted to the World Bank, Mitchell (July 2008) pointed that rapid income growth in developing countries has not led to large increases in global grain consumption and was not a major factor responsible for the large grain price increases. However, he also agreed that it has contributed to increased oilseed demand and higher oilseed prices as China increased soybean imports for its livestock and poultry industry. Both China and India have been net grain exporters since

2000, although exports have declined as consumption has increased. Global consumption of wheat and rice grew by only 0.8 and 1.0 percent per annum, respectively, from 2000 to 2007 while corn consumption grew by 2.1 percent (excluding the demand for bio-fuels in the U.S.). This was slower than demand growth during 1995-2000 when wheat, rice and corn consumption increased by 1.4, 1.4 and 2.6 percent per annum, respectively.

Mitra and Josling (January 2009) have defined the objective of an export ban as to ensure greater availability in their domestic markets at lower prices. Recent examples are Indian bans on non-basmati, basmati rice exports and the embargo placed on wheat exports by Kazakhstan, and rice export ban by Vietnam. The ostensible reason for such bans is food security and stable and low prices in the domestic markets, but in some typical situations, this might mask political motives. Low food prices might be an effective way to win political support. An export ban increases the availability of the product to domestic consumers, and domestic prices decrease to absorb this increased availability, leading to a price distortion. The exact price distortion will depend on the price elasticity of the product: if consumer demand is responsive to price changes, a smaller price decrease is required to absorb excess availability. Export bans therefore result in greater welfare loss when they are imposed on inelastic staple goods such as grains, as they require a greater price decrease to absorb the increase in domestic supply. Any export restriction is a distortion that will cause aggregate economic welfare loss in the rest of the world. Export restrictions imposed by a country will reduce supply to the rest of the world. As a result, international prices will increase, and consumer welfare will decline. However, increased prices will benefit producers in the rest of the world and increase their profits in the short run. But since this is after all a distortion, the decline in consumer welfare will always be greater than the increase in producer welfare. The question of export restrictions and export taxation has been put on the table in the Agricultural Negotiations in Doha Round (Tangermann and Josling, 2001). A number of importing countries, particularly Japan and Korea, were concerned that their food supplies could be disrupted if exporting countries restrict or tax exports. However, it has not yet been effective so far.

In general, the demand and supply of farm products, particularly basic grains and oilseeds, are relatively price-inelastic (Schnepf, January 2006). This implies that even small changes in supply can result in large price movements. As a result, unexpected market news can produce potentially large swings in farm prices and incomes. The supply elasticity of an agricultural commodity reflects the speed with which new supplies become available (or supplies available in the marketplace decline) in response to a price rise (fall) in a particular market. Since most grains are limited to a single annual harvest, new supply flows to market in response to a post-harvest price change must come from either domestic stocks or international sources. As a result, short-term supply response to a price rise can be very limited during periods of low stock holdings, but in the longer run expanded acreage and more intensive cultivation practices can work to increase supplies. On the other hand, when prices fall producers might be inclined to withhold their commodity from the market. The cost of storage, the length of time before any expected price rebound, the anticipated strength of a price rebound, and a producer’s current cash-flow situation combine to determine if storage is a viable alternative. Similarly, demand elasticity reflects a consumer’s ability and/or willingness to alter consumption when prices for the desired commodity rises or falls. Consumers consider both own-price and cross-price movements of complementary and substitute products in making their expenditure decisions. Industrial use of grains is generally less sensitive to price change since. In contrast, feed demand for grain and protein meals is far more sensitive to relative feed grain prices, since similar feed energy values may be obtained from a variety of grains. After all, distinct differences in the level and pattern of responsiveness do exist across commodities.

2.4. Relationships between prices of the grains and oil

Among factors contributing to the grain price movements, the increase in energy prices was a key one. This has increased the costs of production and the costs of transportation, and increased the incentives to produce bio-fuels and encouraged policy support for bio-fuel production. OECD-FAO (2008) has noted that bio-fuel production is one of the important factors lending strength to the grain markets over the medium term. The increase in bio-fuel production has not only increased demand for food commodities, but also led to large land use changes which reduced supplies of wheat and crops that compete with food commodities used for bio-fuels. The use of corn for ethanol grew especially rapidly from 2004 to 2007 and used 70 percent of the increase in global corn production. In contrast, feed use of corn, which accounts for 65 percent of global corn use, grew by only 1.5 percent per year from 2004 to 2007 while ethanol use grew by 36 percent per year. USDA (2008) estimated that the total use of corn for ethanol would reach 86 million metric tons in 2007/2008, which was about 11 percent of global corn production.

Mitchell (July 2008) stated that 7 percent of the global vegetable oil supplies were used for bio-diesel production in 2007 and about one-third of the increase in consumption from 2004 to 2007 was due to bio-diesel. USDA (2008) have given an estimation of 8.6 million metric tons of vegetable oil were used to produce bio-diesel in EU, the U.S., Argentina, Australia, and Brazil in 2007.

The increases in bio-fuels production in the U.S., EU and most other bio-fuel producing countries have been driven by subsidies and mandates. The U.S. has a tax credit available to blenders of ethanol of US$0.51 per gallon and an import tariff of US$0.54 per gallon, as well as a bio-diesel blenders tax credit US$1.00 per gallon. The U.S. mandated 7.5 billion gallons of renewable fuels by 2012 in its 2005 legislation and raised the mandate to 15 billion gallons of ethanol from conventional sources (corn) by 2022 and 1.0 billion gallons of bio-diesel by 2012 in energy legislation passed in late-2007. The new U.S. mandates will require ethanol production to more than double and bio-diesel production to triple if they are met from domestic production. The EU has a specific tariff of €0.192/liter of ethanol (€0.727 or about US$1.10 per gallon) and an ad valorem duty of 6.5 percent on bio-diesel. EU member states are permitted to exempt or reduce excise taxes on bio-fuels, and several EU member states have introduced mandatory blending requirements. Individual member states have also provided generous excise tax concessions without limit, and Germany for example, has provided tax exemptions of €0.4704/ (US$0.64) per liter of bio-diesel and €0.6545 (US$0.88) per liter of ethanol prior to new legislation in 2006 (Kojima, Mitchell and Ward, 2007; Global Subsidies Initiative 2008). These strong incentives and mandates encouraged the rapid expansion of bio-fuels in both the U.S. and EU.

Rice is not used for bio-fuel production, but the increase in prices of other commodities contributed to the rapid rise in rice prices. Rice prices almost tripled from January to April 2008 despite little change in production or stocks. This increase was mostly in response to the surge in wheat prices in 2007 (up 88 percent from January to

December) which raised concerns about the adequacy of global grain supplies and encouraged several countries to ban rice exports to protect consumers from international price increases, and caused others to increase imports. This idea of substitution among the grains was described by Mitchell (July 2008) in his report to the World Bank.

Land use changes due to expanded bio-fuel's feedstock production have been large and have led to reduced production of other crops. The U.S. expanded corn area 23 percent in 2007 in response to high corn prices and rapid demand growth for corn for ethanol production. This expansion resulted in a 16 percent decline in soybean area which reduced soybean production and contributed to a 75 percent rise in soybean prices between April 2007 and April 2008. While corn displaced soybeans in the U.S., other oilseeds displaced wheat in the EU and other wheat exporting countries. The expansion of bio-diesel production in the EU diverted land from wheat and slowed the increase in wheat production which would have otherwise kept wheat stocks higher. The increase was primarily in the countries that are also major wheat exporters such as Argentina, Canada, the EU, Russia and Ukraine. Oilseeds and wheat are grown under similar climatic conditions and in similar areas and most of the expansion of rapeseed and sunflower displaced wheat or was on land that could have grown wheat. The 8 largest wheat exporting countries expanded area in rapeseed and sunflower by 36 percent (8.4 million hectares) between 2001 and 2007 while wheat area fell by 1.0 percent. The wheat production potential of this land was 26 million tons in 2007 based on average wheat yields in each country, and the cumulative wheat production potential of that land totaled 92 million tons from 2002 to 2007.

CHAPTER 3

BACKGROUNDS OF THE INTERNATIONAL GRAIN MARKETS

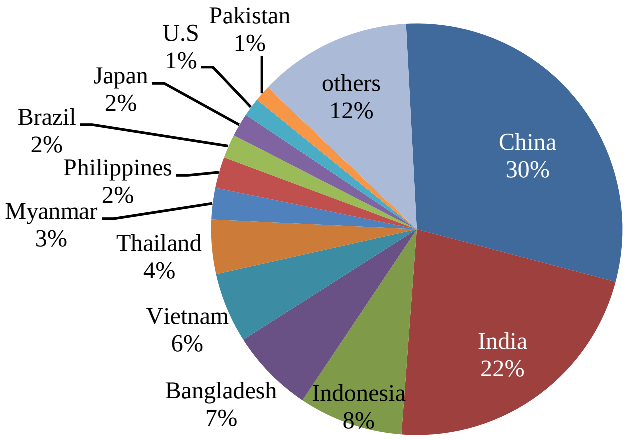
Asian countries are by far the major producers of food in the world in volume term, in which China and India are the two most important actors. However, the U.S. is seen to be the biggest single producer and exporter of food in the developed world. With significant productions of soybeans and corn, Brazil and Argentina from Latin America also play important roles in food production. European Union is least competitive in food production, except Russia who annually produces nearly 10 percent of the world wheat production and becomes the third biggest wheat exporter after the U.S. and Canada. The following parts in this chapter would attempt to bring forward the necessary background information of the grains through analyzing the statistics given in 2007. The information would not describe fully the grains, but it is expected to give a clear understanding of how the current situations of the grain are all about.

3.1. Major producers

3.1.1 Rice

Rice is the most important staple food for much of the world's population, particularly in Asia and parts of Africa and the Middle East. Rice is the second largest produced cereal, and it is being grown in all over the world, especially in Asia. Figure 3.1 shows that the top eight biggest producers were all Asian countries which accounted for more than 80 percent of the world's production in 2007. The U.S. and Brazil were only two countries outside Asia included in this list of top twelve countries in rice production. Even though, their amounts were limited, specifically rice production in the U.S. and Brazil accounted for 1.5 percent and 1.9 percent of 2007 annual rice production, respectively. China and India are among the biggest countries in the world in terms of both total land area and population, whose rice productions accounted for more than 50 percent of the world total. Rice is a staple food in Asian countries, and most of rice production is consumed within the region. That is the main reason why rice production in Asia dominates and outpaces by far all other regions in the world. And, another fact is that most of the main rice producers in the world are developing countries. This is such interesting while considering rice in the term of food with other grains, such as wheat and corn.

Figure 3. 1 Major Rice Producers (2007)

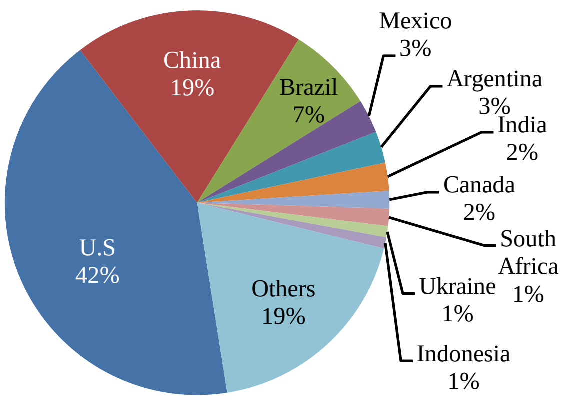


Source: PSD online for grains and oilseeds, FAS, USDA

3.1.2 Corn

Corn production was, to some extent, similar to the rice situation since its production was overwhelmed by few countries, in which productions in the U.S., China and Brazil accounted for nearly 70 percent of the world total output. However, production in the U.S. itself accounted for more than two third of that amount, equivalent to 42 percent of the total production. On the contrary to rice production which is mainly in Asia,

Figure 3. 2 Major Corn Producers (2007)



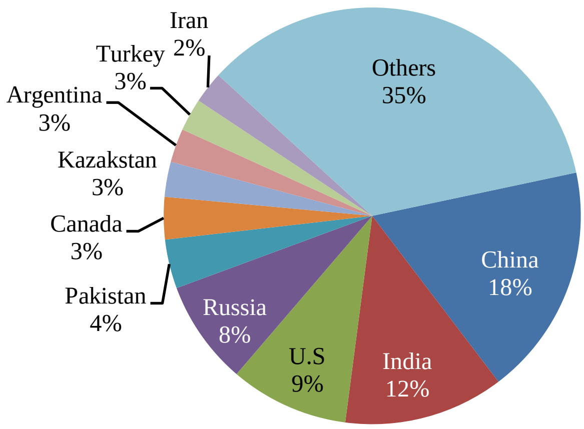
Source: PSD online for grains and oilseeds, FAS, USDA

corn is being produced mainly from America, particularly the U.S. With nearly half of the world's production is from the U.S., this country becomes the most powerful actor in the global markets for corn. A shock in corn supplies in the U.S. or impositions of new policies would strongly influence the corn prices in the markets. A fact is that the growing demand for bio-fuel production from corn in the U.S. and few European countries has immediately contributed to the escalation of corn prices in the global markets, especially from 2006 to present.

3.1.3 Wheat

Wheat production, unlike other grains, was scattered in different parts of the world, especially in big countries in terms of land area, such as China, India, the U.S., and Russia. Wheat production in those four countries accounted for nearly half of the world's output. Beside Asia and North America, European countries including Russia and Turkey are producing a significant amount of wheat annually. The U.S. farmers produced nearly 10 percent of the world's wheat, of which two third was exported to foreign countries, especially Japan, Mexico, and South Korea. Wheat is the principal food grain grown in the U.S; however, a substantial portion of 8 – 10 percent of the annual U.S. wheat crop is used as a feed grain. As a result, wheat must compete with other cereals for a place at the consumer's dinner table, while also vying with coarse grains and other feedstuffs in livestock feed markets.

Figure 3. 3 Major Wheat Producers (2007)



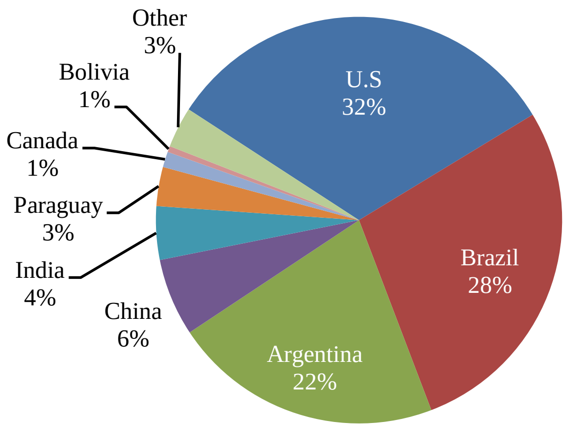
Source: PSD online for grains and oilseeds, FAS, USDA

However, according to the U.S. Department of Agriculture's baseline projections for wheat from 2005-2014, wheat planted acreage has been dropped slightly since it lost competitiveness to other U.S. crops, particularly soybeans and corn. The U.S. farmers prefer growing other crops because those alternatives are more profitable.

3.1.4 Soybeans

Soybeans originated in the Eastern Asia where it was used as food long time ago. The word "soy" is derived from the Japanese word "shoyu" (soy sauce/ soya sauce). They were first introduced to the U.S. early in the 19th century where they were first grown for hay. And now soybeans become the most important cash crops in the U.S. and the leading agricultural exports. The U.S. takes the leading role in both production and export of soybeans in the world. As in 2007, the U.S. produced more than 70 million metric tons of soybeans, of which nearly half was exported. Much of the U.S. production is either fed to animals or exported, though U.S. consumption of soybeans and other soy foods by people has been increasing. Soybean oil makes up 80 percent of edible oil consumption in the U.S. Other leading producers were Brazil, Argentina, China, and India. The figure 3.4 shows that soybean production in American countries overwhelmed all others regions, amongst which the U.S., Brazil and Argentina produced more than 80 percent of the world output in 2007.

Figure 3. 4 Major Soybean (oilseed) Producers (2007)



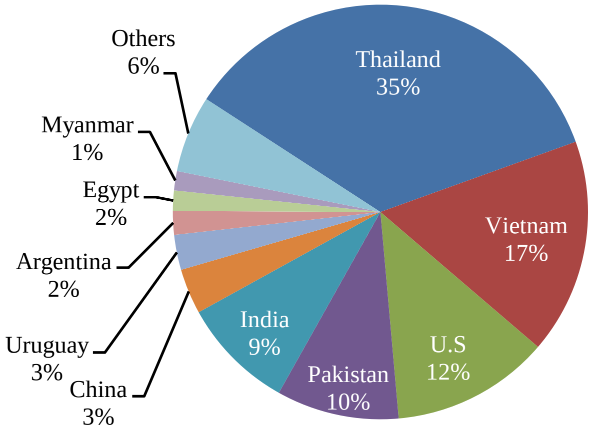
Source: PSD online for grains and oilseeds, FAS, USDA

3.2. Major exporters

3.2.1. Rice

Rice is a thinly-trade commodity. It is produced mainly in Asia, and it is mostly consumed domestically. The numerical statistics given by USDA indicated that total rice export quantity in 2007 was around 28 million metric tons, which made up only 6.6 percent of the total production of nearly 430 million metric tons. That implied the remaining 93.4 percent of rice production was consumed domestically, more particularly it was mainly consumed by its own producers. This was such a limited amount compared with other grains which were also internationally traded. That makes rice a distinguishing feature compared with other food crops. The very limited amount of rice entering global markets relative to the large level of annual world consumption makes the international rice market fairly sensitive to an unexpected production shortfall in one of the major exporting or consuming countries, particularly when the lost production must be made up by importing rice from the international marketplace.

Figure 3. 5 Major Rice Exporters (2007)



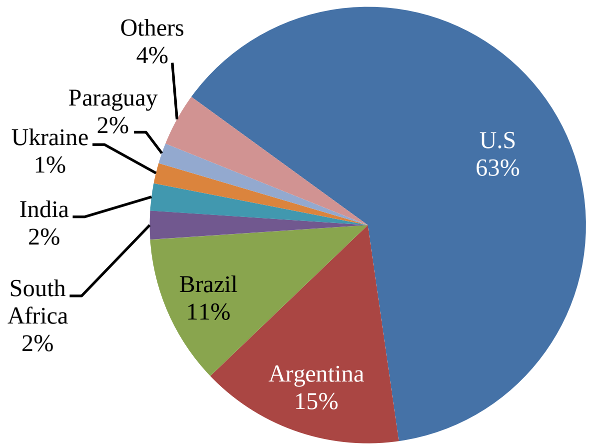
Source: PSD online for grains and oilseeds, FAS, USDA

Asia dominated rice production of the world. Figure 3.5 indicated that some countries in the region also played the most active roles in the global trading markets. Six out ten top exporting countries were in Asia, of which four countries are in the top five. Rice exporting quantity in these four countries together with the sixth-ranked country of China accounted for nearly 75 percent of the world's rice export. The U.S. rice production accounted for only 1.5 percent of the world total, even though it exported more than half of its production which was 12 percent of world's exports. As a result, it was among the world's leading rice exporting nations. Rice is not a staple food in the U.S., its per capita rice consumption is only 25 pounds per year, or more than 11 kg per year (USA Rice Federation, April 2008).

3.2.2. Corn

Corn export was less well distributed in the world. The American countries strongly dominated the world's exports. The U.S., Argentina and Brazil exported nearly 90 million metric tons out of the total world's corn export of 100 million metric tons in 2007. Of that, the U.S. exported more than two third which was equivalent to 63 percent. However, that amount accounted only less than 20 percent of the U.S. corn production, since the domestic consumption as feed was the largest portion of corn use, and corn has been being increasingly used as feedstock for ethanol production in recent years. Argentina and Brazil were two noteworthy competitors of the U.S. in the global markets. In 2007, they exported almost the remaining corn exporting amount, which was equivalent to 26 percent. Even though, China – the only Asian nation in the top-five producers, produced nearly 20 percent of the world's corn production, almost of its production was consumed domestically. Mexico is one of the biggest producers,

Figure 3. 6 Major Corn Exporters (2007)



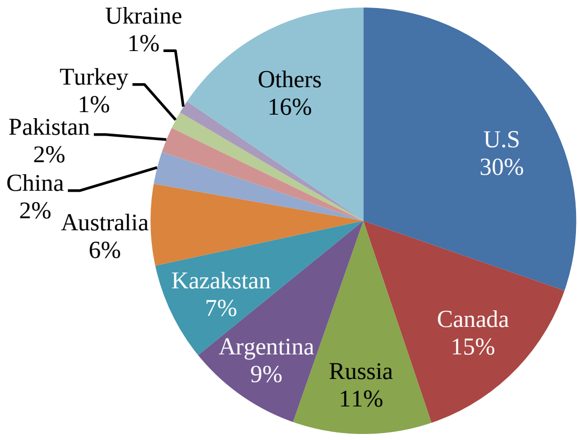
Source: PSD online for grains and oilseeds, FAS, USDA

yet it has to import corn every year from neighboring countries, particularly from the U.S. As a result, the U.S., Argentina and Brazil were three most important price takers in the global corn markets. Accordingly, the importing countries become vulnerable to any even small changes in supply or corn-relative policies in these countries. A typical example was that the growing demands for corn as a feedstock of ethanol production in the U.S. have been strongly contributing to the recent rising prices of corn in the international markets.

3.2.3. Wheat

Wheat export was well distributed as its production. This implied the strong competition in the globally trading markets for wheat. However, one noticeable fact is that Asia was least competitive in wheat exports, even though China and India were two biggest producers. The U.S. has been taking the leading role in the world's exports; however, it is facing the growing competitions from other countries, especially Canada, Russia and Ukraine who are locating in the northern hemisphere. However, the U.S. also has to compete with other two remarkable wheat producers - Argentina and Australia - who are located in the southern hemisphere where their production runs on a cycle that is offset by about six months from the U.S. cycle. As a result, Argentina and Australia have the opportunity to expand planted wheat acreage in response to supply and demand circumstances in the U.S. within the same marketing

Figure 3. 7 Major Wheat Exporters (2007)



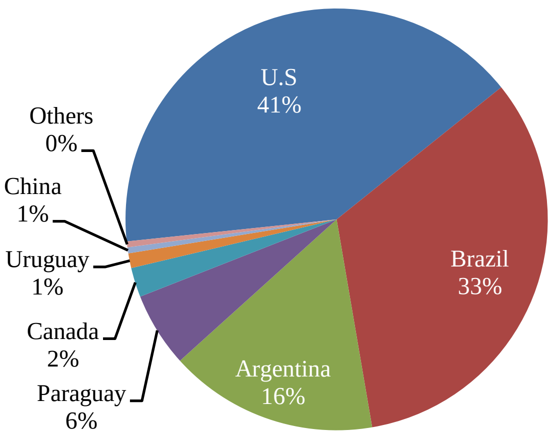
Source: PSD online for grains and oilseeds, FAS, USDA

year, dampening the potential year-to-year variability of prices in the U.S. and international markets. Argentina and Australia produce annually 16 million metric tons and 13 million metric tons, respectively, amongst which Argentina plays a very important role in the trading markets, since it exports two third of its total production annually.

3.2.4. Soybeans

The biggest soybean producers were also the leading exporters in the world. Figure 3.8 clearly shows that American countries entirely dominated the world's soybean exports. The 2007 soybean exports from the American countries accounted for 99 percent of the world's exports, it implied that almost of the soybeans traded in the global markets came from only America. The U.S. annually exports nearly half of its soybean production which accounts for more than 40 percent of the world's exports. However, exports from South America have expanded rapidly and soybean harvests in this region have set record highs nearly every year for almost a decade. Over the past 5 years, exports from this region have surpassed the U.S. foreign trade in soybeans[4]. The U.S. export share of the world soybean oil market will also tend to shrink for several years as domestic users take more of the available supplies, particularly for bio-diesel. The U.S. and Brazilian bio-diesel productions from vegetable oils, in which soybean oil

Figure 3. 8 Major Soybean (oilseed) Exporters (2007)



Source: PSD online for grains and oilseeds, FAS, USDA

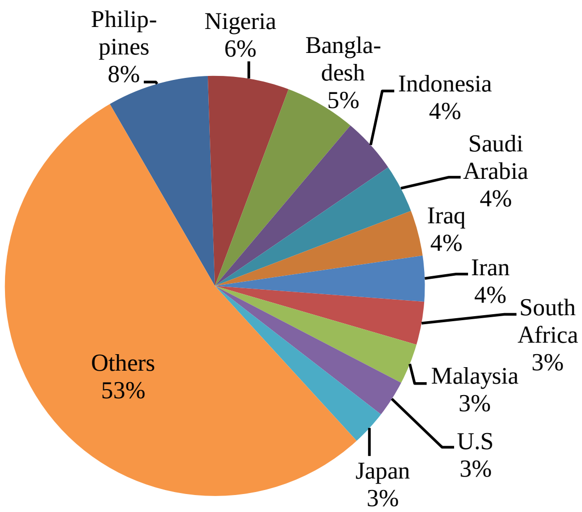
[4] USDA, Soybeans and Oil Crops: Market Outlook

is a leading feedstock, have been dramatically increased. As in the U.S., bio-diesel production had tripled in 2006 in only one year, and it continued growing rapidly in the last two years. According to a report on bio-diesel production by National Bio-diesel Board, the U.S. bio-diesel production has reached 700 million gallons in 2008, and it was estimated to be 800 million gallons in this year[5]. This may shrink the soybean oil export share of the U.S. and Brazil in the coming years; soybean oil exports from other competitors will compensate that loss in order to meet the growing demands from the major importers, especially China who is currently the biggest soybean oil importer from the U.S.

3.3. Major importers

3.3.1. Rice

Figure 3. 9 Major Rice Importers (2007)



Source: PSD online for grains and oilseeds, FAS, USDA

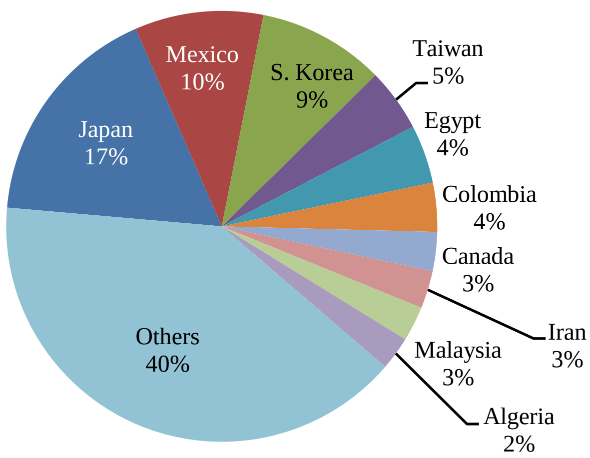
Rice import was not dominated clearly by any country, but it was spread fairly to different parts of the world. That was reasonable because it is the most important staple food in many countries, but its production is mainly in Asia. However, with strong demands for rice in the Middle East, such as Saudi Arabia, Iran, and Iraq, Asia becomes overwhelming region of rice imports. Indonesia and Bangladesh produce large amounts of rice annually. In 2007, they were the third and fourth biggest rice producers after China and India; however, they still imported more than one million metric ton of rice from other Asian countries in order to

[5] National Bio-diesel Board (June 2009), U.S. Biodiesel Production Capacity

fill up their domestic consumption. The Philippines has recently imported 2 million metric tons of rice annually, which was equivalent to around 8 percent of the world's rice import and around 20 percent of its domestic production. Consequently, there is a fact that Asia sounds to be the major market for international rice trades. Africa is becoming an emerging rice consumer, among which Nigeria was the second biggest rice importer in 2007. Countries in this continent are buying more rice of lower quality from some Asian countries. Regarding the sources of rice imports, the UNCTAD statistics (2003)[6] indicated that the rice from the U.S. and Thailand entered the markets of almost every continent; whereas rice from Vietnam, India and Pakistan was sold to merely other Asian countries and Middle East.

3.3.2. Corn

Figure 3. 10 Major Corn Importers (2007)



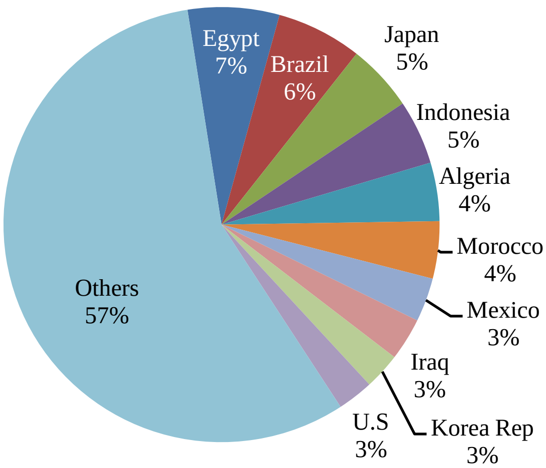
Source: PSD online for grains and oilseeds, FAS, USDA

Corn is being traded all over the world; however, the trading corn originated mainly from America, particularly the U.S. The U.S. corn is being transported to and consumed all around the world. Figure 3.10 specifies that Asia was the biggest consumer of the U.S. corn, since its importing markets in Japan, South Korea and Taiwan accounted for nearly half of its total export in the year 2007 (U.S. Department of Commerce, Bureau of the Census, 2007). From 2000 to 2007, Japan usually imported an amount of around 15 million

[6] UNCTAD (The United Nations Conference on Trade and Development), Secretariat from COMTRADE, http://www.unctad.org/infocomm/anglais/rice/market.htm

metric tons of corn from the U.S.; it became the biggest customer of the U.S. corn and the biggest corn importer in the world. The U.S. corn importing quantity by Japan accounted for an average of 30 percent of the U.S. total export during this period. South Korea has been becoming an important customer of the U.S. corn. The U.S. corn imported by South Korea has been drastically increased from 1.36 million tons in 2000 to 8. 6 million tons in 2007[7]. Mexico, even though was the fourth biggest corn producer in the world, is importing a remarkably large amount of corn from the U.S. since corn is a very important foodstuff for their widely produced traditional foods. An example was Tortillas prices and shrink corn supplies in Mexico in 2008. Tortillas is a widely consumed traditional food of the Mexican, it is made mainly from corn, or hardly from wheat. Rising prices of corn in the global markets have directly influenced the life of the Mexican people, since they have faced both high prices and low supplies of corn - foodstuff of their Tortillas.

Figure 3. 11 Major Wheat Importers (2007)



Source: PSD online for grains and oilseeds, FAS, USDA

3.3.3. Wheat

Egypt is the biggest consumer of wheat in the global markets. It buys half of its wheat import from Russia annually. A newly inked agreement on wheat contracts between these two countries will further guarantee the long-term wheat trading activities. In 2007, Brazil imported 7 million metric tons of wheat to fill up its domestic consumption of which the domestic production was only

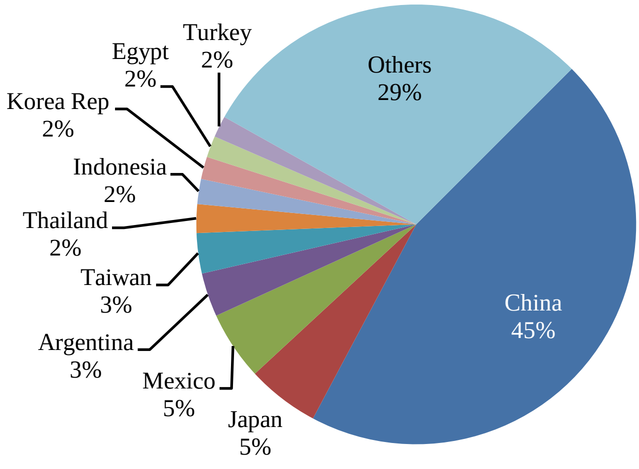
[7] Source: U.S. Department of Commerce, Bureau of the Census, *Feed Grains Database: Yearbook Tables*, 2007

one third. Argentina was the biggest Brazil's wheat seller; it normally provided more than 90 percent of Brazilian wheat imports. However, in 2009 Argentina's wheat crop production was estimated to drop almost in half this year, to 8.4 million metric tons from last year's 16 million metric tons, in reaction, Argentina has suspended export licenses which of course will strongly affect Brazilian wheat supplies. Brazilian millers have requested the Government of Brazil to temporarily eliminate the 10 percent import tariff to ensure wheat supplies and control the domestic prices in this year. This would be good opportunities for wheat from the U.S., Canada and Russia.

3.3.4. Soybeans

China is the world's largest soybean importer. It used to be the largest soybean manufacturer and exporter before 1950s. However, after entering WTO in 2001, China implemented the promise to liberalize the trade of agricultural products and cancel the import tariff barriers of some agricultural products including soybeans. Therefore, soybeans poured into China and the amount kept increasing year by year. China's soybean imports accounted for nearly half of the world's total imports. In 2007, China produced itself 13 million metric tons of soybean oil, but it had to import nearly 35 million metric tons in order to fill up its domestic need. Its soybean imports increased to more than 37 million metric tons in

Figure 3. 12 Major Soybean (oilseed) Importers (2007)



Source: PSD online for grains and oilseeds, FAS, USDA

2008[8]. China bought soybeans mainly from Brazil, the U.S. and Argentina. The soybeans entering China from these three countries accounted for around 98 percent of its total soybean imports in 2008. Japan and Mexico were other two large soybean importers, but still much far behind China. Each of them imported around 4 million metric tons in 2007 and accounted for 5 percent of the world's soybean imports.

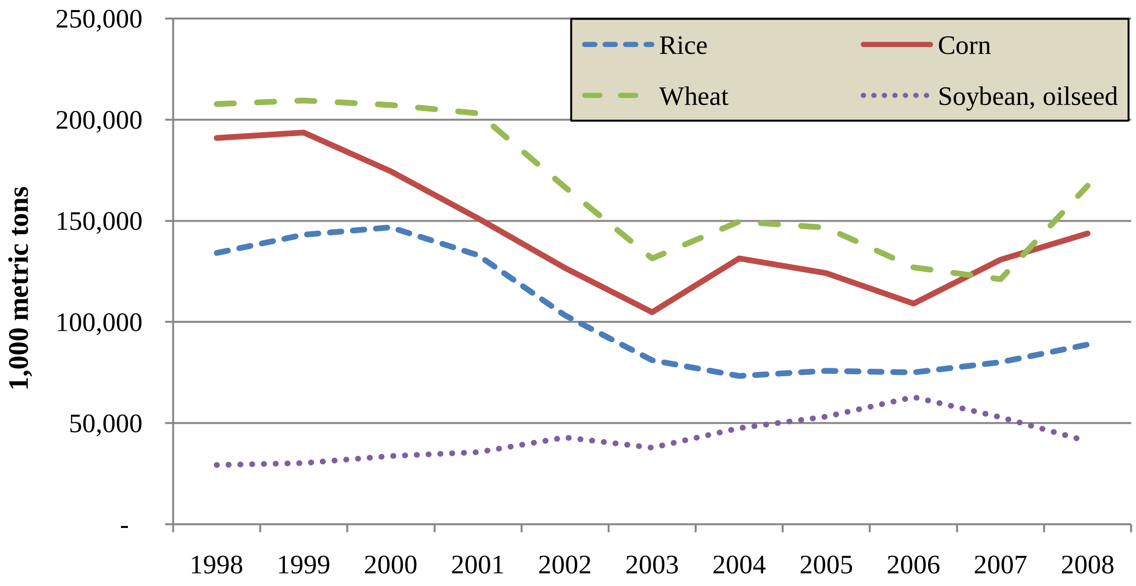
3.4. Ending stocks and stocks-to-use ratio

Ending stock is an important factor in analyzing the price movements of any products. Agricultural grain prices are relatively sensitive to the situations of their ending stocks. A report of low ending stock of a certain agricultural grain by a country who plays an important role in the global trading markets may have immediate inpacts to the prices of that grain, specifically its prices would go up in the global markets. Ending stock of a certain grain is the amount reserved as storage by the end of a marketing year. The impacts on prices of a grain might be immediate after the ending stocks are released, and prolong until the end of the current markting year or the start of a new harvest. Shortage of stock could be caused by the lower supply due to shrink in production, damaged crop by natural disasters, etc. However, it could be the reason of increasing consumptions. For example, ending stock of a grain of the current year is said to be low compared with that in the previous year which does not necessarily imply current ending stock is lower than the previous year ending stock in numerical term. Stocks-to-use ratio (SUR) is the term taking into account of both ending stock and total consumption of a grain. SUR is calculated as percentage of ending stock divided by total consumption (including exports). Currently, SUR is widely used to take into account of ending stocks with consideration of consumption.

[8] China Research and Intelligence (May 2009)

Figure 3.13 and figure 3.14 show the ending stocks and stocks-to-use ratio of the studied food grains in ten years from 1998 to 2008, respectively. Last year, when prices of the these food grains drastically increased and made all-time-high records, their low ending stocks in 2007 and some previous years were accused to be one of the factors contributing to the rising prices. Ending stocks of rice, corn and wheat show the decreasing trends in ten year period. Rice ending stock slightly increased from 1998 to

Figure 3. 13 World Grains' Ending Stocks

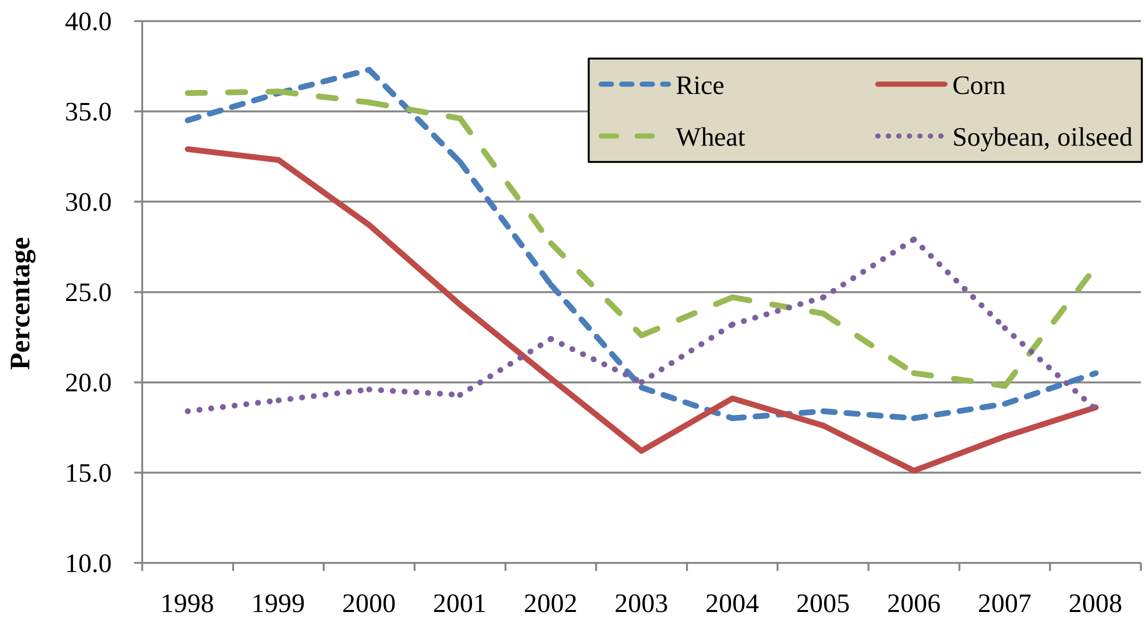


Source: Shoichi Ito, World Food Statistics and Graphics, http://worldfood.apionet.or.jp/

2000, but then it dropped quickly in four consecutive years until 2004. The trends were the same in case of corn and wheat; however, corn ending stock started dropping one year earlier than rice, whereas wheat ending stock faced a big drop starting from 2001, one year later. From 2004, rice ending stock remained low and almost unchanged, it was about 88 million metric tons in 2008. Slightly different, ending stocks of both corn and wheat increased in 2004, but then started falling back to the same amounts in 2003. Ending stocks of corn and wheat in 2007 were still quite low, only two third and more than half of those in 1998, respectively. However, the world's wheat stock was significantly improved and started recovering from last year. World's soybean ending stock shows an entirely different trend in this period. While ending stocks of other grains fell down quickly in early 2000s, that of soybeans grew, even though it was such a slight increase. And it started decreasing in the last two years, whereas those of other grains increased.

Figure 3.14 shows the stocks-to-use ratio of the food grains in the same period. Because SUR is the fraction of ending stock and total consumption, its trend would not be necessarily same with trend of the ending stock alone. In general, trends of SUR of

Figure 3. 14 World Grains' SUR



Source: Shoichi Ito, World Food Statistics and Graphics, http://worldfood.apionet.or.jp/

the grains look almost the same with trends of ending stocks alone. It implied that changing magnitudes in ending stocks and total consumptions were relatively similar and in the same directions. However, there were slight differences, for example the corn ending stock increased a little from 1998 to 1999; however, its SUR decreased, that was the reason of a much bigger increase in total consumption compared with a rather small increase in ending stock.

In general, ending stocks of rice, corn, and wheat have dropped rapidly from their peaks by the end of 1990s. Recent ending stocks were only two third of those when they were at peak. These falling trends recommended the impacts on the price spikes of the grains happening in last two years. Soybean ending stock increased consecutively from 1990s, but it started dropping in 2007 and 2008. World's soybean stock was estimated to recover to the same amount as in 2007.

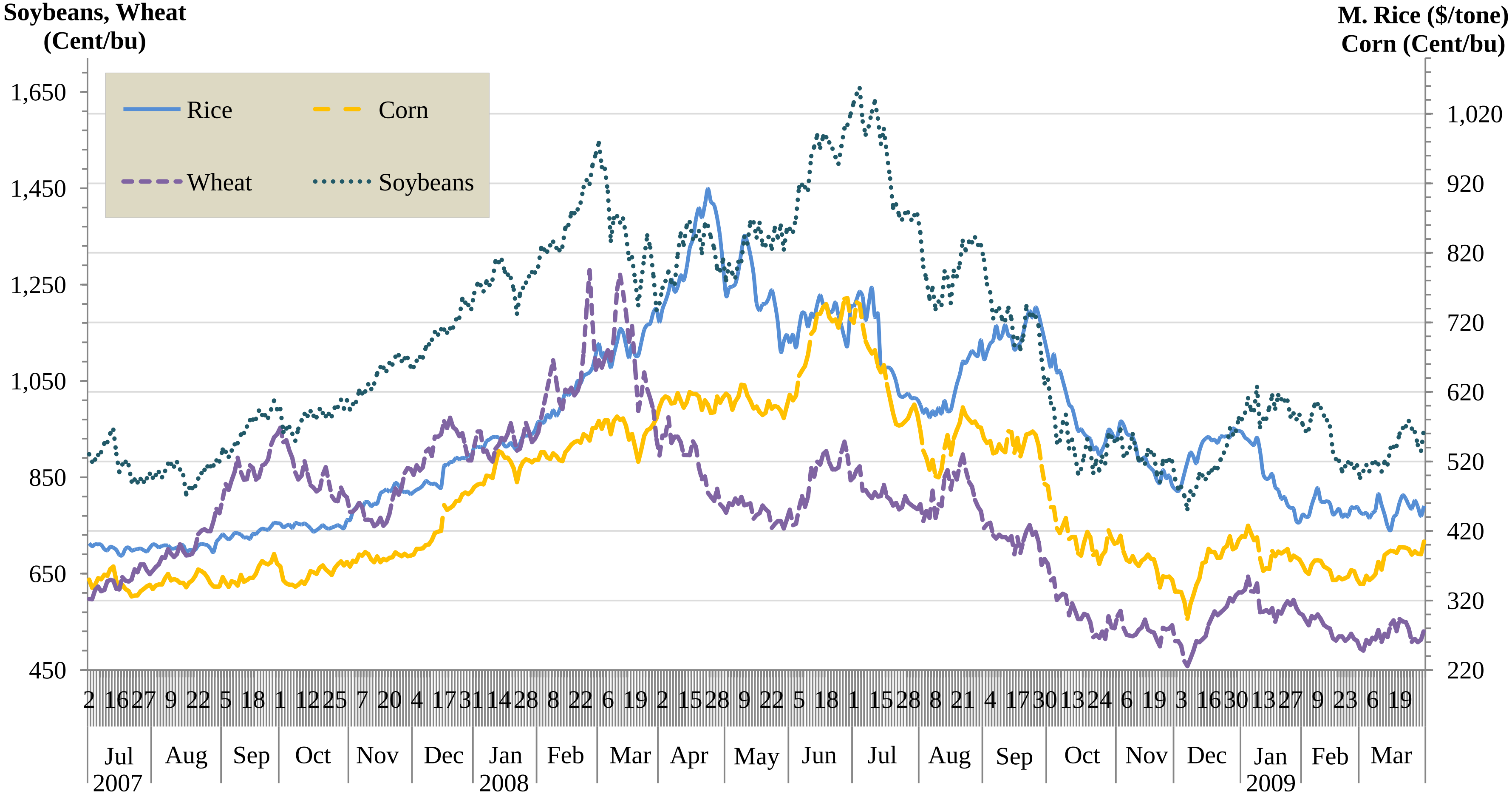
CHAPTER 4

CHARACTERISTICS OF INTERNATIONAL GRAIN PRICE MOVEMENTS

There were a number of factors that have contributed to the rise in the grain prices in the last two years. Among the most important has been the increase in oil prices which caused rising demand for producing bio-fuels from the grains. The development in bio-fuel production has not only increased demand for food crops, but also led a large land use changes which reduced supplies of the crops. Food consumption patterns have been changing, that shifts the human's preferences and tastes into consuming more meat in their daily meals, particularly in the developing countries; as a result, demand for the grains by the feed processing industry has been dramatically increasing. Policy adoptions by some governments as efforts in stabilizing the domestic food prices also contributed to the price movements of the grains in the last two years. Furthermore, demands and supplies of the grains are relatively price-inelastic. This implies that even small changes in supply can result in large price movements. This part of the study would investigate and analyze these factors as characteristics of the grain price movements during the research period, except for the factor of bio-fuel productions from the grains. This factor would be fully analyzed through empirical analyses as a key link between prices of the grains and oil in this study. There were few other factors contributing to the recent price movements of the grains, such as slow growth in production versus rapid growth in demand, adverse weather, weakening U.S. dollar, etc, which were analyzed by many of researchers and economists, even though this study would not consider these factors. Figure 4.1 shows the daily price movements of the grains including rice, corn, wheat, and soybeans which were used in empirical analyses for quantifying the relationships between prices of the grains and oil in this study. However, this chapter uses these daily price data and other available data to analyze the characteristics of the grain price movements.

Figure 4. 1 Daily Price Movements of Rice, Corn, Wheat and Soybeans in the U.S

(Daily Prices, July 2, 2007 - March 31, 2009)



*Rice prices are reported on original website in the rough rice basis in unit of US$/cwt. Milled rice price data were calculated from equation: Original data multiplied by 1000/(45.36*0.6) for 1 ton, which implies approximately equivalent to 4-percent-broken milled-rice package for U.S. No.1.*

Source: GFT - Online Futures Trading, http://futures.tradingcharts.com

4.1. Changes in food dietary patterns

Economic growths have been happening in developing countries more than a decade ago resulting in rising disposable incomes. Consequently, people have more incomes for their spending in food. They, in fact, have been requiring quality food, not just to fill up the stomach like before, and demanding more animal protein from their daily meals. Unusually rapid economic growth in China and India, with nearly 40 percent of the world's population, has provided a powerful and sustained stimulus to the demand for the grains. Feed consumptions from the grains including corn, wheat, and soybeans have been dramatically increased in nearly two decades in these two countries (table 4.1), and were by far the increases in productions and total consumptions. The economic growths are not new, since it has been starting by 1990s. However, they might be new because they happened at the time of very low stocks-to-use ratio that emerged over the past four to eight years depending on commodities. The ending stocks of the grains as shown in the table 4.1 could not reflect the general decreasing trends in the world in recent years, since both China and India were not significant traders of agricultural commodities, except that China imported large amount of soybeans and India exported some rice. Furthermore, the policies of both China and India have been policies of agricultural self-sufficiency. They have attempted to grow production to keep up with their domestic consumption. Someone might argue that price movements of the grains should not be influenced by domestic consumptions in these two countries who were not significant traders of the grains in the global markets. However, the competitions in uses of the grains with dramatic increase in demand as feed by the livestock industry, to some extent, unbalanced the trade-off in traditional consumptions of the grains. As a result, the grain prices would be influenced.

Table 4. 1 Differences in Productions, Consumptions and Ending Stocks of the Grains in China and India (1990 and 2008)

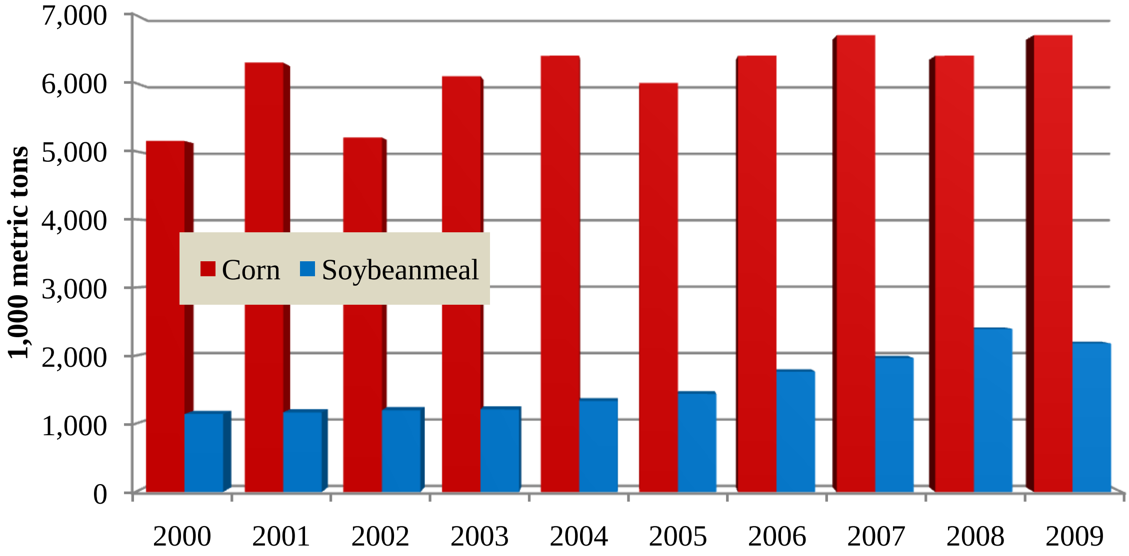
China	Corn			Wheat			Soybeans, oilseed			Soybeans, meal		
	1990	2008	*Diff*	1990	2008	*Diff*	1990	2008	*Diff*	1990	2008	*Diff*
Production	96,820	165,500	*71%*	98,229	113,000	*15%*	11,000	16,000	*45%*	3,278	32,134	*880%*
Total consumption	79,850	152,000	*90%*	102,598	102,500	*-0.10%*	9,713	50,954	*425%*	1,028	31,784	*2992%*
Food and other consumptions	26,500	42,000	*58%*	99,898	97,500	*-2.40%*	5,060	8,600	*70%*	N/A	N/A	
Feed consumption	53,350	110,000	*106%*	2,700	5,000	*85%*	750	1,750	*133%*	1,028	30,974	*2913%*
Ending stock	82,821	52,694	*-36%*	49,940	48,913	*-2%*	N/A	6,341		N/A	N/A	

India	Corn			Wheat			Soybeans, oilseed			Soybeans, meal		
	1990	2008	*Diff*	1990	2008	*Diff*	1990	2008	*Diff*	1990	2008	*Diff*
Production	8,962	18,480	*106%*	49,850	78,600	*58%*	2,602	9,100	*250%*	1,890	6,225	*229%*
Total consumption	9,261	17,600	*90%*	47,595	70,300	*48%*	2,602	9,095	*250%*	470	2,483	*428%*
Food and other consumptions	6,961	10,600	*52%*	47,395	70,200	*48%*	40	425	*963%*	40	90	*125%*
Feed consumption	2,300	7,000	*204%*	200	100	*-50%*	200	870	*335%*	430	2,393	*457%*
Ending stock	200	836	*318%*	5,805	13,910	*140%*	N/A	123		N/A	300	

Source: Shoichi Ito, World Food Statistics and Graphics, http://worldfood.apionet.or.jp

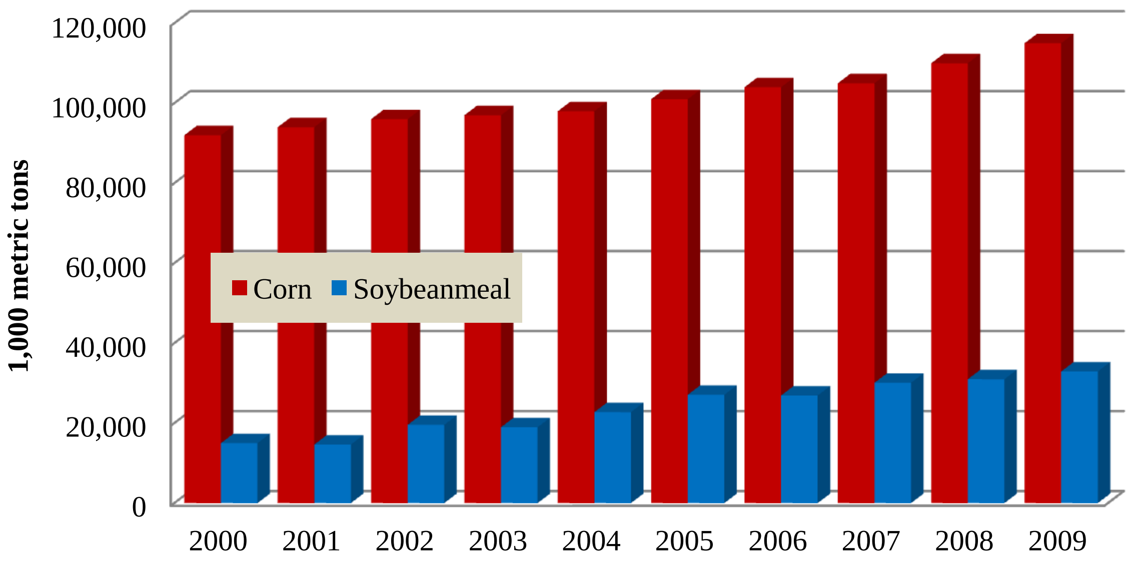
Figure 4.2 and figure 4.3 provide clear pictures of the rising demands for the grains as feed by the livestock industries in India and China. Domestic feed consumptions from corn and soybeans in these two countries both showed an increasing

Figure 4. 3 Domestic Feed Consumption in India



Source: Shoichi Ito, World Food Statistics and Graphics, http://worldfood.apionet.or.jp

Figure 4. 2 Domestic Feed Consumption in China

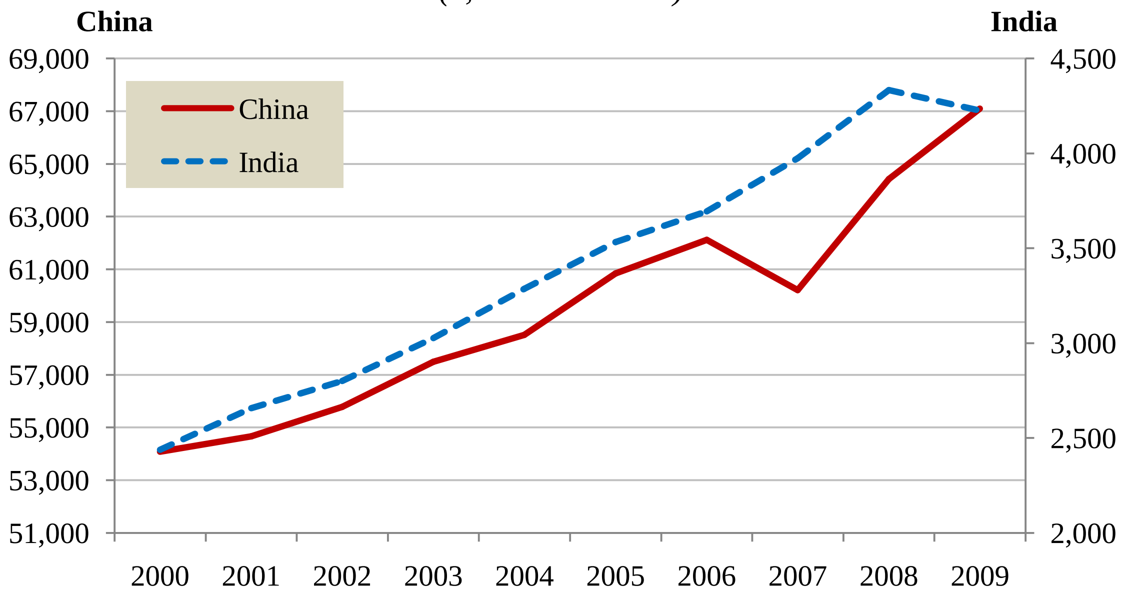


Source: Shoichi Ito, World Food Statistics and Graphics, http://worldfood.apionet.or.jp trend from 2000 to 2008. Chinese domestic consumption of corn increased by nearly 20 million metric tons from 2000 to 2008, while Indian consumption was added up more than 1 million metric tons in the same period; domestic consumptions of soybeans doubled in 2008 with respect to 2000 in both countries. Their consumptions of corn and soybeans were estimated to continue increasing in 2009, except for the soybean consumption in India.

Changes in food dietary patterns can be best explained by the meat consumptions in these two developing and large countries. People have been shifting their tastes and

Figure 4. 4 Meat Consumption in China and India*

(1,000 metric tons)



**: Chinese meat consumption includes beef, veal, swine, and broiler;*
Indian meat consumption includes beef, veal, and broiler.

Source: FAS (USDA, March 2009) PSDOnline: Grains and Pulses

preferences into consuming more meat in their daily meals. Once they have enough incomes to afford animal protein, they will require more quality food, not just to fill up the stomach as before. Domestic meat consumptions in China and India significantly escalated in ten years from 2000 to 2009 (as shown in figure 4.4). Please note that the value scales on the left and hand sides o the graph are very much different; and the meat consumption in India did not include source of swine since the data were not available. Meat consumptions in China increased by 20 percent from 2000 to 2008, whereas that in India was nearly doubled in the same period. In 2007, due to the outbreak of the swine blue ear disease which widely and seriously spread in China, its domestic meat consumption quickly dropped off from the common trend. Rising demand for feed production from soybeans in China have had great influences on their prices in the global markets, since China imports annually nearly half of the world's soybean imports.

Changes in food dietary pattern were considered as long-term factor contributing to the price movements of the grains. This factor is going to have continuous impacts on the grain prices in the global markets. Together with rising demand for the grains by bio-fuel industry, the grain's trade-off have been strongly changed, as a result, the grain supplies for food uses have to compete with other uses at higher prices. The changing and unbalanced consumptions of the grains will continue having influences on the grain prices in the coming years.

4.2. Policy interventions

Policy interventions by countries are a kind of short-term shock to the grain price movements. Objectives of the policy interventions on the grains by a certain government are mainly to secure its food security, to stabilize domestic prices, or to lessen negative impacts from rising prices in the global markets, etc. Policy interventions could be export restrictions or bans, adoptions of export taxes or export quotas, provisions of subsidy programs, crop rotation programs, etc. There are many more types of policies; however, their objectives are all to help the country itself. Policies adopted by a country are subject to support and help its producers and consumers. Consequently, policies can further harm price inflations and bad situations in the global markets. During 2007 and 2008, policy interventions played an important role and strongly contributed to short-term shocks in the grain price movements in the global markets. Price spikes, like price troughs, are not rare occurrences in agricultural markets, although periods of high prices tend to be short lived compared with periods of low prices[9], it is due to short-term factors in among which policy intervention is the key one.

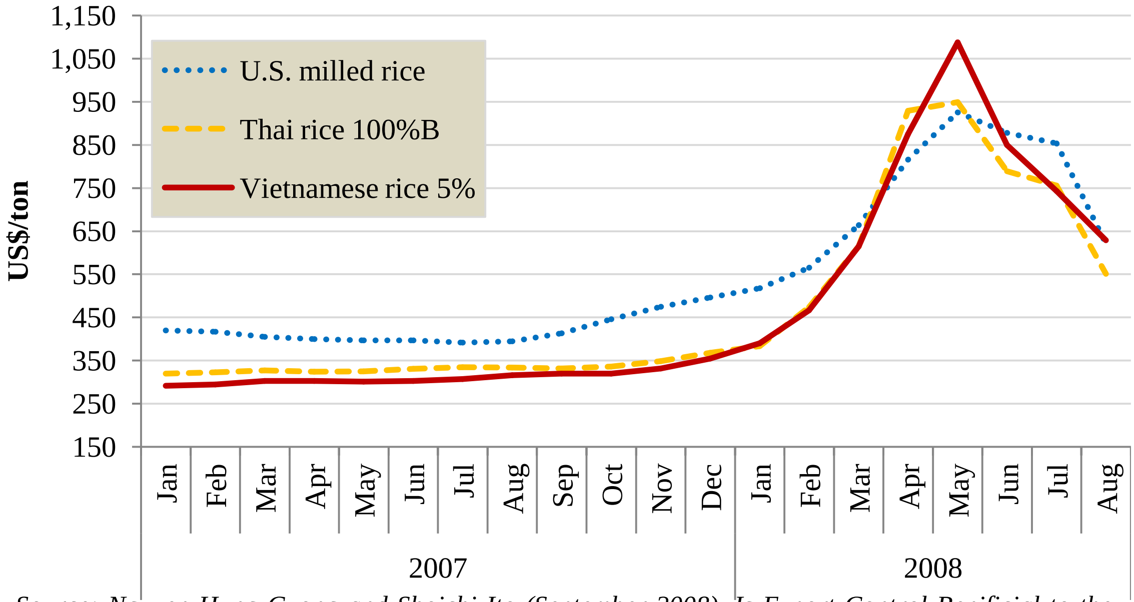
In the last two years, a number of countries have imposed export restrictions or bans and export taxes on the grain exports to contain domestic price increases. These included Argentina, India, Kazakhstan, Pakistan, Ukraine, Russia and Vietnam that adopted policies on the different grains. Argentina, Russia, Kazakhstan and Ukraine imposed export restrictions on wheat, whereas India, Pakistan and Vietnam imposed restrictions and bans on rice exports. Let's have a look at an example of Vietnam. Vietnamese government made a series of export restrictions on rice export starting from January 2008 when the global rice prices reached a record high of nearly US$600 per ton. On January 16th, 2008, Vietnam allowed signing only rice selling contracts with delivery date no later than February; in early March, rice exports with delivery data in March and April were not permitted because the exporting quantities for the first quarter already exceeded the target of 800,000 tons; on March 25, the government retargeted the total 2008 rice export down to 3.5 – 4 million metric tons which was one million metric tons lower than the set target by the end of 2007; the last effort by Vietnamese government was to impose a ban on entire rice exports starting from April 1st to the end of June 2008. Rising domestic rice prices along with dramatic increases in the global

[9] OECD (2009), *Agricultural Policies in Emerging Economies 2009: Monitoring and Evaluation*

markets and a fear of low supplies from the coming season were incentive for the government to make this series of restrictions in order to control the domestic food inflations. However, policy interventions do not always really help to achieve the objectives expected before the adoptions, but harmed and fueled the ongoing bad situations.

Figure 4.5 shows the monthly price movements of the U.S., Thai and Vietnamese rice in the global markets in the period from January 2007 to August 2008. The Vietnamese 5 percent broken rice prices were almost always lower than those of Thai 100 percent grade B rice in the global markets due to lower quality. However, Vietnamese rice prices historically went over both the U.S. and Thai rice prices starting from March till June and July in 2008, respectively. Strong demands for Vietnamese rice from the Philippines and its export ban were two main reasons for this price hike. At the same time, the Vietnamese rice export ban significantly contributed to the skyrocketing prices of rice in the international markets, especially in the period from January to the end of April in 2008. Vietnam was the second largest rice exporter in the world, thus export ban was very sensitive and had immediate impacts on the rice price movements in the markets. In imposing this export ban, the Vietnamese government targeted to secure the domestic rice need and stabilize the food prices. Right after the export ban, the domestic rice prices sounded to be well controlled till the end of April 2008 (figure 4.6). But prices of all types of rice started increasing dramatically, especially in the southern markets where produced almost of rice for domestic uses and exports. Prices of all types of rice in the domestic markets increased at the averaged rate of 130 percent in one year from May 2007 to May 2008, among which rice prices in Ho Chi Minh City and Can Tho province increased 160 percent and 140 percent, respectively. The price increases did not stop until the end of June when the ban was lifted. The export ban itself was very sensitive to both domestic and international markets, since local consumers might thought the country was running out of rice supplies. As a result, they flocked into buying rice as much as they could afford to store

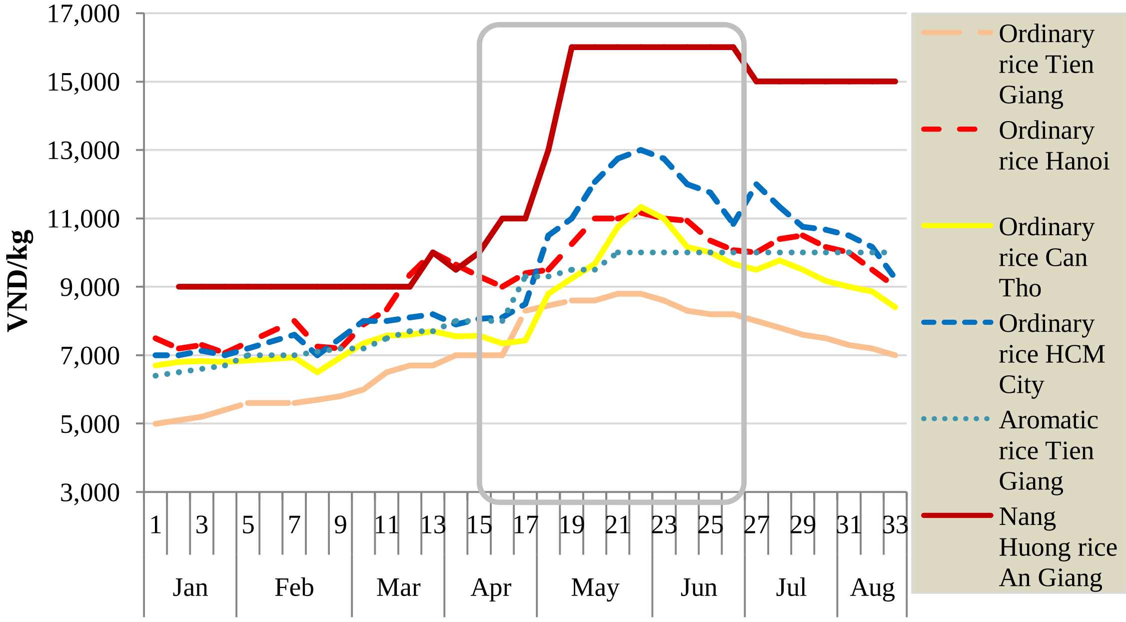
Figure 4. 5 World Rice Price Movements
(Monthly, 2007-2008)



Source: Nguyen Hung Cuong and Shoichi Ito (September 2008), Is Export Control Benificial to the Domestic Consumers?: A Case of Vietnamese Rice

for longer-term uses otherwise rice prices could continue increasing. In fact, there were rumors that Vietnam was facing a shortage of rice since the government banned its rice exports. It proved a reality that export ban was not always an appropriate tool to stabilize the domestic market prices. In the case of Vietnam, the country also lost their huge profits from rice export since it banned at the time the prices were historically high. Other countries, such as Thailand, China, used other tools to intervene into their domestic rice price inflations. When the global rice prices made a record high by the end of April, Thai domestic prices were strongly influenced; however, Thai government encouraged exporting more rice by setting a higher rice export target in 2008. It also bought rice from farmers at reasonable prices to fill up the national storages which then were used to sell out 2.1 million metric tons in the third quarter of 2008 when the domestic rice prices remained high. China did not export much rice as Thailand and Vietnam, but it imposed rice export taxes from which the budget could be used to

Figure 4. 6 Weekly Domestic Rice Retail Prices in Vietnam 2008



Source: Nguyen Hung Cuong and Shoichi Ito (September 2008), Is Export Control Benificial to the Domestic Consumers?: A Case of Vietnamese Rice

partially control the domestic rice price inflations.

Similar to rice, wheat prices also made an all-time high record in early 2008. Low world stock level of wheat was one of the main reasons for its price spike in the last year. The wheat stock-to-use ratio has fallen from 34 percent in 2000/2001 to an unexpected 18 percent in 2007/2008. Besides, export restrictions introduced by the Ukraine in 2006 and carried forward following the 2007 harvest, downward revisions of global wheat production forecasts, the rapid pace of sales by the U.S. (the main exporter) and increases in buying activity from major grain importers have recently caused wheat prices to increase sharply. And these were also reasons for some world wheat major exporters imposing export restrictions in 2007 and 2008. Typically, wheat export restriction by Argentina in February 2008 has strongly contributed to the sharp increase in wheat prices in the world markets.

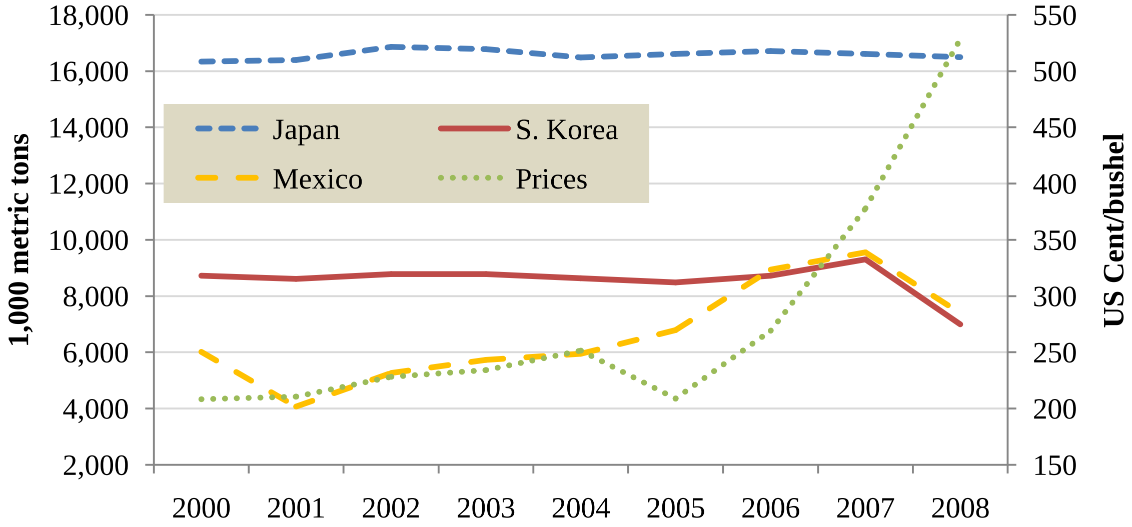
4.3. Price-inelastic demand and supply

In general, the demand and supply of farm products, particularly basic grains and oilseeds, are relatively price-inelastic. More precisely, quantities demanded and supplied change proportionally less than price changes. This implies that even small changes in supply can result in large price movements. As a result, unexpected market news or shocks can produce potentially large swings in farm prices and incomes. This price dynamic has long been a characteristic of the agricultural sector and a farm policy concern. Since most grains are limited to a single annual harvest, new supply flows to markets in response to a post-harvest price change must come from either domestic stocks or international sources. As a result, short-term supply response to a price rise can be very limited during periods of low stocks, but in the longer run expanded acreage and more intensive cultivation practices can work to increase supplies.

Data on grain imports and international prices were collected in the period from 2000 to 2008 and graphed as followings. Averaged yearly prices of the grains all show increasing trends in the last nine years, especially prices of rice and soybeans. Prices of corn and wheat dropped slightly in 2005, but then increased sharply and consecutively in the three following years. Data of the grain imports were collected for only major grain importers, for example the Philippines and Bangladesh of rice, Japan, Mexico and South Korea of corn, Egypt, Brazil and Japan of wheat, and China of soybeans. Regarding the grain major importers, please look back the previous chapter with background information of the grains. Yearly importing amounts of the grains by major importers in the world did not show any opposite trends with trends in prices during the period from 2000 to 2007. It meant that when prices of the grains, for example, increased, the grain importing amounts did not clearly decrease. Even though, trends in import quantity went along with trends in prices. Only in 2008, did the importing quantities respond to the rising prices. In the case of rice, two largest rice importers slowed down their imports in response to skyrocketing prices of rice in the global markets. However, demands for corn and wheat by two largest importers of Japan and Egypt, respectively, did not decreased or even increased more sharply when prices were spike high. China has been demanding more and more soybeans, its imports increased in a year to year basis along with the increase in prices of soybeans in the world markets.

Increasing demand for the grains and oilseeds by the industrial processing sector, whether from food or bio-fuel processing industries or from expanding livestock industry, further reinforced the general price inelasticity of demand for the grains. Industrial use of grains as feedstock is generally less sensitive to price change since the prices of the feedstock usually represent only a small share of overall production costs of the finished product. Furthermore, industrial users have generally made tremendous investments in plant equipment and machinery, and must continue to operate at some minimal level of capacity year-round as a return on that investment. This study will fully discuss the relationship between prices of the grains and oil in which bio-fuel productions from the grains were a key link. However, at this moment, it is important to know that amounts of grains being used to produced bio-fuels have been drastically and continuously increasing (for example, the amount of corn used for ethanol production in the U.S. was 6.3 percent of the total U.S.'s corn production in 2000, that amount increased by 29.75 percent in 2008). Bio-fuel industry is expected to further develop in

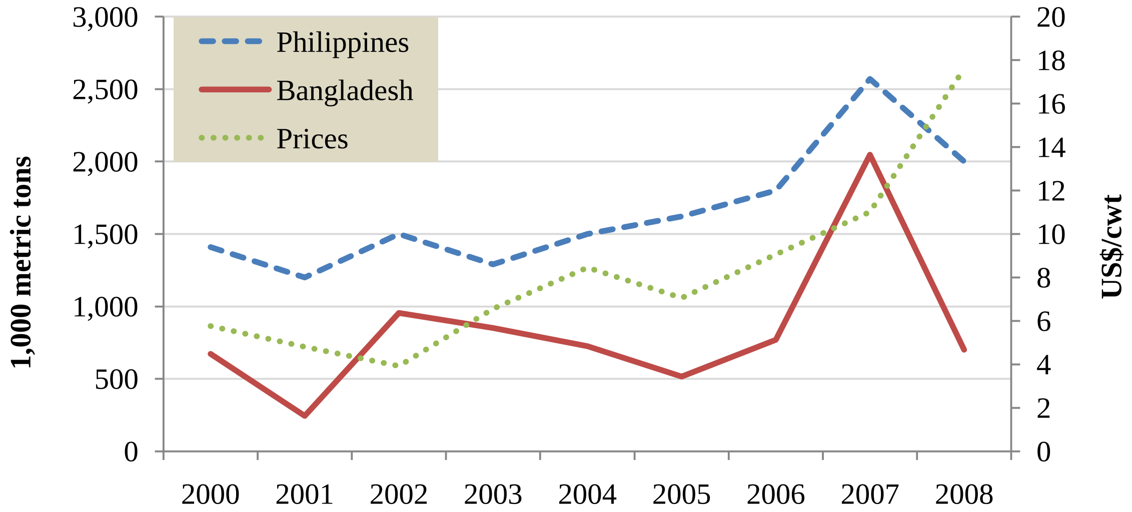
Figure 4. 7 Price-Inelastic Demand of Corn
(Imports vs Prices)



Source: Imports: Shoichi Ito, World Food Statistics and Graphics, http://worldfood.apionet.or.jp
Prices: GFT - Online Futures Trading, http://futures.tradingcharts.com

the U.S., Brazil, European Union and few other countries in the next decade, as a result demand for the grains as feedstock of the industry will also increase, even though prices of the grains are expected to stay high.

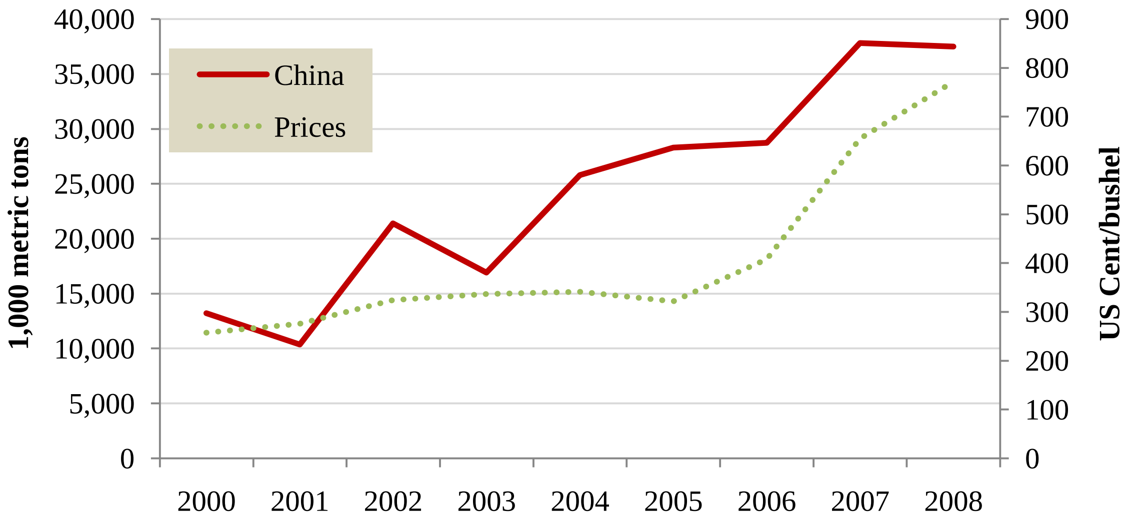
Figure 4. 8 Price-Inelastic Demand of Rice
(Imports vs Prices)



Source: Imports: Shoichi Ito, World Food Statistics and Graphics, http://worldfood.apionet.or.jp
Prices: GFT - Online Futures Trading, http://futures.tradingcharts.com

However, in terms of consumption as feed, feed demand for the grains are more

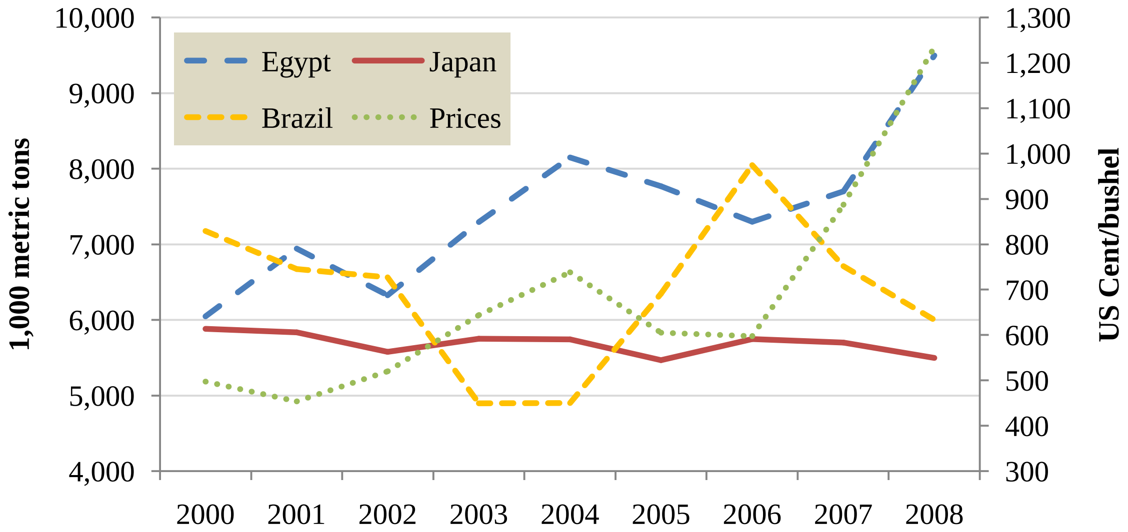
Figure 4. 10 Price-Inelastic Demand of Soybeans (Imports vs Prices)



Source: Imports: Shoichi Ito, World Food Statistics and Graphics, http://worldfood.apionet.or.jp
Prices: GFT - Online Futures Trading, http://futures.tradingcharts.com

responsive to the price changes. Substitutes in consumption as food are less competitive since humans hardly change their tastes and preferences by shifting from consuming

Figure 4. 9 Price-Inelastic Demand of Wheat (Imports vs Prices)



Source: Imports: Shoichi Ito, World Food Statistics and Graphics, http://worldfood.apionet.or.jp
Prices: GFT - Online Futures Trading, http://futures.tradingcharts.com

one grain to consuming others. In contrast, feed processors are more likely to substitute a proportion of a certain grain with others in their production, provided that substitutes can provide same values of energy. In fact, similar feed energy values may be obtained from a variety of grains. In general, inelastic demand and supply responsiveness characterizes most agricultural products. However, distinct differences in the level and pattern of responsiveness do exist across commodities. This is a characteristic of the grains long time ago. However, at the time of the price hikes of the grains, its effects were combined with those from other factors contributing to the price movements in the world markets.

CHAPTER 5

METHODOLOGIES OF DATA COLLECTIONS AND ANALYSES

5.1. Data collections

5.1.1. Sources and types of data

This study attempts to analyze the price movements of the grains including rice, corn, wheat and soybeans, and to empirically quantify the relationships between oil prices and prices of every single grain based on their daily prices. Daily price data were collected from Chicago Board of Trade (CBoT) for grains and from New York Mercantile Exchange (NYMEX) for oil prices, WTI (West Texas Intermediate), specifically Light Crude Oil which is most common used in the U.S. and world markets. Both CBoT and NYMEX are commodity futures markets in the U.S. The importance of the futures markets is such a distinguishing feature of the U.S. and international commodity markets. In the next part, futures markets will be explained in more details in order to provide further understanding of its definition and function in this study. The daily price data were started collecting from the end of October in 2007; however, data were available from July 2007. The period of the data used in this study is from July 2nd, 2007 to March 31st, 2009, which is exactly twenty one months. All the data were set by the providers under the American daily basis, which means that data were only available on the weekdays, not on the weekends and the U.S.'s national holidays. Consequently, prices of all the grains and oil are consistent. This is such an important and necessary condition for reliable and consistent results of the price data analyses.

Prices of all grains and oil used in this study were future quoting prices provided by the futures markets. In order to understand better the source and nature of the data used in this study, it is essential to provide some basic knowledge of the futures markets and its associated factor futures prices. Futures markets is widely defined as an auction market where traders buy and sell commodities/ futures contracts with delivery on a specific future date according to the terms of the contract. Futures markets are also called futures exchanges. The contract size, unit, transactional currencies and so on are different depending upon the commodities themselves and are standardized by the futures markets. For example, corn is a very typical grain of the CBoT futures markets, in which a corn contract size is of 5,000 bushels and is transacted in the U.S. cent per bushel. Futures markets function as a central exchange for domestic and international markets information and as a primary mechanism for price discovery. They delimit the specific features of commodities/ futures contracts such as nature of the commodities, quantity, quality, pricing, and delivery date. They also specify the trading currencies, and provide trading facilities to the hedgers who involve in the futures contracts. Few of the very typical facilities are historical data which are shown in charts and graphs providing evidences for hedgers to place their decisions on trading, and economic analyses as tools for better understandings of the price trends based on the supply and demand, market shocks, ending stocks, policy impositions by countries, and so on. In addition, futures markets also provide tutorials and manuals on futures trades for both beginners and experts in the area.

Futures prices were quoted for the futures contracts which are standardized contracts based on the quality, quantity and delivery time and location for the purchase and sale of commodities for future delivery[10]. The futures prices are fixed prices, to which the parties of a futures contract agree to transact on a specific date. The futures

[10] Futures contracts are defined by the Chicago Board of Trade (CBoT)

are standardized financial derivatives or forward contracts that are popularly traded for commodities. Futures prices are determined in accordance with the dynamic trends that govern the forces of supply and demand. This is typically done at a time when contracts are closed between a buyer and seller on the stock exchange. At the end of a day's trading session, the official price indicated on the exchange is known as the settlement price for that particular day. The following formula can be used to estimate futures prices:

$$\text{Future price} = \text{Spot Price} + \text{Carry Cost} + \text{Storage Cost} \qquad (5.1)$$ [11]

The spot price is the price at which an underlying instrument is traded in the cash market at any given time. In the case of grains futures, the spot price is the price at which the grains are physically available in the market. Spot prices indicate current prices, while futures prices determine the cost purchasing the instrument in the future. Carry cost is the interest that is incurred for holding the underlying instrument till the expiration of the futures. For example, if the futures contract expires after 12 months, then carry cost will be the interest that is foregone while holding the underlying instrument for 12 months. In addition to these two prominent factors, in the formula (5.1), futures prices also depend on storage cost. Storage cost is the cost associated with warehousing of physical commodities. All futures transactions are regulated by the government agencies. In the United States, the regulating body for the futures transactions is the Commodity Futures Trading Commission (CFTC), which is an independent agency of the U.S. government.

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[11] Equation (5.1) is defined by Economy Watch, http://www.economywatch.com

5.1.2. Global scope of the price data

The price data of both the grains and oil were collected as the prices available in the futures markets in the U.S. only, however, this study attempts to define the international characteristics of the grain price movements under the high oil prices. It is necessary to explain why and how analyses of these price data can provide a global view in this study. Unlike cash markets which deal with the immediate transfer of goods, a futures market is based on buying (or selling) commodity contracts at a fixed price for potential physical delivery at some future dates. Grains futures contracts are traded on several commodity futures markets in the U. S. and overseas, some well-known futures markets are Chicago Board of Trade (CBoT), Minneapolis Grain Exchange (MGE), Kansas City Board of Trade (KCBT), etc. A distinguishing feature of the U.S. and international commodity markets is the importance and the development of futures markets. Two out of the important functions of the futures markets are that they play as a central exchange for domestic and international market information, and as a primary mechanism for price discovery. Grains futures markets are platforms for everyone around the world who wants to trade, hedge or to become financial investors. Contract price movements by a futures market implicitly conveys the information about international supply and demand conditions, since it reflects domestic and international market conditions. Thus a futures market in the U.S., such as CBoT provides quoting prices of agricultural commodities which reflect the view of international market, not only the domestic markets. Crude oil prices were also collected from a commodity futures market of New York Mercantile Exchange, which is well-known all over the world as a global energy trading platform.

5.2. Methodologies of the analyses

5.2.1. Time series analysis

A time series is a sequence of observations which are ordered in time. An example of a time series of (x_1, … x_n) in which t = 1, … n means the values of variable named x are recorded in the period of time t. Time series analysis is the analysis of this type of data series. Time series analyses have been paid a special attention by many of economists in the field of financial economics in last twenty years. Then is has been followed by many researches and studies on the econometric methods and models for analyzing this type of data series. The availability of the data are becoming more and more popular, such as Gross Domestic Product (GDP) of a country, Consumer Price Index (CPI) of a country, sales of a certain product by a company, prices of commodities, etc. Many of textbooks in the field of econometrics widely describe the features, properties, characteristics and types of time series data and so on, among which Applied Econometric Time Series by Walter Enders is one of the best references for deep understanding of time series analysis. This study does not attempt to give a full explanation of the time series analysis, but a brief knowledge of this type of data to understand how the analyses went through. In this study, prices of agricultural grains and crude oil are all time series data. Consequently, methods applied for analyses are all referring to the properties and characteristics of time series data. The methodologies used in this study will be discussed further in the latter parts in this chapter.

5.2.2. Serial correlation

Serial correlation is the correlation of a variable with itself over successive time intervals. In linear regression analysis, it is assumed that the relationship between y and x can be expressed in the form:

$$y_t = \beta_0 + \beta_1 x_{t,1} + \ldots + \beta_k x_{t,k} + u_t \tag{5.2}$$

where, $\{u_t\text{: } t = 1,2, \ldots, n\}$ is the sequence of errors or disturbances. Here, n is the number of observations (time periods). And, the assumption of no serial correlation is expressed in the form:

$$\mathrm{Corr}(u_t,u_s) = 0, \text{ for all } t \neq s \tag{5.3}$$

When (5.3) is false, we say that the errors in (5.2) suffer from serial correlation, or autocorrelation, because they are correlated across time.

Serial correlation problem is very common in time series analysis. There are two types of serial correlation, positive and negative serial correlations, among which positive serial correlation is the most often case. John O' Rawlings, Sastry G. Pantula, and David A. Dickey (1998) have noted that the impact of correlated errors on the Ordinary Least Squares (OLS) results is the loss in precision in the estimates. And another primary problem associated with serial correlation is that the computed standard errors are not correct which might result in the wrong significance level of the estimate coefficients.

Serial correlation is a typical problem in only the time series regression, and it becomes the most common violation of assumptions for linear regression. For the very first attempts in this study, OLS method was applied to run the regressions of price data of every single agricultural grain with prices of oil. The Durbin-Watson statistics, which come from the most common test for serial correlation named Durbin-Watson test, of all the regression models which were in the range of from 0.20 to 0.40 indicating the presence of strong positive serial correlation. The assumption of no serial correlation of the regression was violated. It was worth to study further the problem in order to find out alternative methodologies or correction method for the problem. In other words, OLS might not be an appropriate method in analyzing the relationships between prices of the agricultural grains and oil.

5.2.3. Spurious regression

Granger and Newbold (1986) have noted that it is very common to see reported in applied econometric literature time series regression equations with an apparently high degree of fit, as measured by the coefficient of multiple correlation R^2 or the corrected coefficient R^2, but with an extremely low value for the Durbin-Watson statistic, if it is such a case, the estimation may well be spurious. In the efforts of regressing the prices of the grains and oil in this study, the results showed high R^2 (which ranged from 0.83 to 0.95), and all the regressions of the prices of every single grains on the prices of oil indicated the significance level of 1 percent; however, the relationships between prices of those commodities were not true because of low Durbin-Watson statistics. That strongly reflected a problem of spurious or nonsense regressions. Gujarati (2004) has noted that the spurious regression can arise if time series are not stationary. Stationary and non-stationary time series are discussed further in the next parts.

5.2.4. Stationarity and non-stationarity

Time series may be stationary or non-stationary. Stationary series are characterized by a kind of statistical equilibrium around a constant mean level as well as a constant dispersion around that mean level (Box and Jenkins, 1976). There are several types of stationary series. A series is said to be stationary in the wide sense, weak sense, or second order if it has a fixed mean and a constant variance. A series is said to be strictly stationary if it has, in addition to a fixed mean and constant variance, a constant auto-covariance structure. When a series possesses this covariance stationarity, the covariance structure is stable over time (Diebold, 1998). That is to say, the auto-covariance remains the same regardless of the point of temporal reference. Under these circumstances, the auto-covariance depends only on the number of time periods between the two points of temporal reference (Mills, 1990, 1993). Non-stationary series that lack mean stationarity have no mean attractor toward which the level tends over time. Non-stationary series without homogeneous stationarity do not have a constant or bounded variance. Non-stationary series are characterized by random walk, drift, trend, or changing variance. If each realization of the stochastic process appears to be a random fluctuation, the series of movements is a random walk. If the series exhibits such sporadic movement around a level before the end of the time horizon under consideration, it exhibits random walk plus drift. Drift, in other words, is random variation around a nonzero mean. This behavior, not entirely predictable from its past, is sometimes inappropriately called a stochastic trend, because a series with trend manifests an average change in mean level over time (Harvey, 1993). A short and simple explanation of stationary and non-stationary time series is that a given time series y_t is said to be stationary if its mean and variance are constant or independent of time and the value of the covariance between the two time periods depends only on the distance or gap or lag between the two time periods and not the actual time at which the covariance is computed. That is expressed in the following forms:

$E(y_t) = \mu$ Constant mean

$Var(y_t) = E(y_t - \mu)^2 = \sigma^2$ Constant variance

$E[(y_t - \mu)(y_{t+k} - \mu)] = \gamma_k$ Time independent covariance

where γ_k, the covariance (or autocovariance) at lag k, is the covariance between the values of y_t and y_{t+k}, that is, between two y values k periods apart. If $k = 0$, we obtain γ_0, which is simply the variance of y ($= \sigma^2$); if $k = 1$, γ_1 is the covariance between two adjacent values of y.

Time series y_t is non-stationary if its mean and variance are not constant or are changing over time. In other words, a non-stationary time series will have a time-varying mean or a time-varying variance or both.

Many economic time series data are non-stationary or in a more particular case, they are I(1) which means the data series become stationary after first difference process. Term I(1) can be interpreted that a time series is integrated of order one. Christopher Dougherty (2007) has noted that it is important to assess whether a time series is non-stationary before attempting to use it in a regression model. Estimation using non-stationary variables may result in a relationship called spurious relationship which does not really exist.

5.2.5. Unit roots and unit root tests

A non-stationary time series is said to be integrated to order one, or I(1), if the series of its first differences, $\Delta y_t = y_t - y_{t-1}$, is I(0). More generally, a series is integrated to order d, or I(d), if it must be differenced d times before an I(0) series results. A series is I(1) if it contains what is called a unit root. Whenever a variable with a unit root is used as a regressor in a linear regression model, the standard assumptions that we have made for asymptotic analysis are violated. As mentioned before in the part of spurious regression, estimation using linear regression may lead to spurious relationships between dependent and independent variables that do not really exist. Therefore, prior to any linear regression, it is therefore very important to be able to detect the presence of unit roots in time series. There are different ways to judge if a time series is stationary or not. A simple but not always useful method is graphical analysis in which the time series are plotted in graphs may sometimes give reasons for answering whether time series are stationary or non-stationary (or with a unit root). For this method, in the autocorrelation function of an AR(1) process, for example $y_t = \beta y_{t-1} + \varepsilon_t$, in which $\rho_k = \beta^k$ (k is number of observations), if the coefficient of ρ_k declines quite quickly to zero as k increases, the time series y_t is observed to be stationary; and on the contrary, if the coefficient declines slowly to zero, the time series y_t is judged to be non-stationary. However, formal ways to test whether a time series is stationary or non-stationary is what are called unit root tests. For these tests, the null hypothesis is that the time series has a unit root and the alternative is that it is I(0), or stationary.

A test of stationarity (or non-stationarity) that has become widely popular over the past several years is the unit root test (Gujarati, 2004). Asteriou (2007) has described a unit root test as a test for number of unit roots. Followings are steps of a unit root test:

Step 1: Test y_t (y_t is a time series variable) to see if it is stationary; if yes then $y_t \sim I(0)$, if no then $y_t \sim I(n)$; $n > 0$.

Step 2: Take first differences of y_t as $\Delta y_t = y_t - y_{t-1}$, then test Δy_t to see if it is stationary; if yes then $y_t \sim I(1)$, if no then $y_t \sim I(n)$; $n > 0$.

Step 3: Take second differences of y_t as $\Delta^2 y_t = \Delta y_t - \Delta y_{t-1}$, then test $\Delta^2 y_t$ to see if it is stationary; if yes then $y_t \sim I(2)$, if no then $y_t \sim I(n)$; $n > 0$. These steps are repeated till the variable y_t is found to be stationary. For example, if the variable y_t is found to be stationary after the step 2, $y_t \sim I(1)$, it means that y_t needs to be differenced one time in order to be stationary. Similarly, if the variable y_t is found to be stationary after the step 3, $y_t \sim I(2)$, it means that y_t needs to be differenced two times in order to be stationary, and so on.

Nowadays, the most commonly applied method for testing the unit root is the one derived by Dickey and Fuller (1979, 1981). That is called Dickey-Fuller Test, or DF Test. The key insight of the test is that testing for non-stationary is equivalent to testing the existence of a unit root, Thus the obvious test is the following which is based on the simple AR(1) model of the form:

$$y_t = \beta y_{t-1} + \varepsilon_t \quad (5.4)$$

What we need to examine here is whether β is equal to 1 (unity and hence unit root). Obviously, the null hypothesis is $\beta = 1$, and the alternative one is $\beta < 1$. The above equation can be rearranged by subtracting y_{t-1} from both sides of (5.4):

$$y_t - y_{t-1} = \beta y_{t-1} - y_{t-1} + \varepsilon_t$$

$$\Delta y_t = (\beta - 1)y_{t-1} + \varepsilon_t$$

$$\Delta y_t = \gamma y_{t-1} + \varepsilon_t \quad (5.5)$$

Then, now the null hypothesis is $\gamma = 0$ against the alternative one of $\gamma < 0$. In the case that the null hypothesis cannot be rejected, then y_t is said to have a unit root; in other words, it follows a pure random-walk model. Based on the equation (5.5), Dickey-Fuller (1979) also proposed two alternative regression equations that can be used for testing for presence of a unit root. These two derivative equations are:

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \varepsilon_t \quad (5.6)$$

$$\Delta y_t = \alpha_0 + \alpha_2 t + \gamma y_{t-1} + \varepsilon_t \tag{5.7}$$

in which equation (5.6) is called a random-walk process with a drift, α_0. Asteriou (2007) has noticed that this is an extremely important case and is often the case for macroeconomic variables. Meanwhile the equation (5.7) also allows, apart from a drift, a non-stochastic time trend in the model which is denoted as $\alpha_2 t$.

Augmented Dickey-Fuller test, known as ADF test, is an extension of DF test. ADF test allows including extra lagged terms of the dependent variable in order to eliminate autocorrelation, since the error term is unlikely to be white noise. The lag length on these extra terms is determined by different criterion based on which the lag length necessarily whiten the residuals. ADF test takes the form:

$$\Delta y_t = \gamma y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-1} + \varepsilon_t \tag{5.8}$$

And, similarly to DF test, ADF test can also be used to include a drift, α_0, or a non-stochastic trend, $\alpha_2 t$, as in the following equations:

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \sum_{i=1}^{p} \beta_i \Delta y_{t-1} + \varepsilon_t \tag{5.9}$$

$$\Delta y_t = \alpha_0 + \gamma y_{t-1} + \alpha_2 t + \sum_{i=1}^{p} \beta_i \Delta y_{t-1} + \varepsilon_t \tag{5.10}$$

Eviews statistical computer program allows practitioners to decide to run a unit root test with or without a constant, α_0, or a non-stochastic trend, $\alpha_2 t$. MacKinnon (1991) tabulated appropriate critical values for each of the above three models. These values can be easily found in many practical econometric books, or they are also generated based on the facts of the variable if it is processed by Eviews.

5.2.6. Vector Autoregression

Vector Autoregression (VAR) methodology superficially resembles simultaneous-equation modeling in that we consider several endogenous variables together. But each endogenous variable is explained by its lagged, or past values and the lagged values of all other endogenous variables in the model. VAR extends the univariate AR(p) model into the multivariate setting, so that instead of regressing one variable on its own lags, a vector of variables is regressed on their own lags. For simplicity, let's have a look at a two-variable case of y_t and x_t. The time series y_t is affected by the current and past realizations of the time series x_t sequence and let the time series x_t sequence be affected by current and past realizations of the y_t sequence. Consider a simple bivariate form of VAR model:

$$y_t = b_{10} - b_{12}x_t + \gamma_{11}y_{t-1} + \gamma_{12}x_{t-1} + \varepsilon_{yt} \qquad (5.11)$$

$$x_t = b_{20} - b_{21}y_t + \gamma_{21}y_{t-1} + \gamma_{22}x_{t-1} + \varepsilon_{xt} \qquad (5.12)$$

where, it is assumed (1) that both y_t and x_t are stationary; (2) ε_{yt} and ε_{xt} are white-noise disturbances with standard deviations of σ_y and σ_x, respectively; and (3) $\{\varepsilon_{yt}\}$ and $\{\varepsilon_{xt}\}$ are uncorrelated white-noise disturbances. Equations (5.11) and (5.12) constitute a first-order VAR since the longest lag length is unity. The structure of the system incorporates feedback since y_t and x_t are allowed to affect each other. For example, $-b_{12}$ is the contemporaneous effect of a unit change of x_1 on y_t and γ_{21} is the effect of a unit change in y_{t-l} on x_t. Note that the terms ε_{yt} and ε_{xt} are pure innovations (or shocks) in y_t and x_t, respectively. Of course, if b_{21} is not equal to zero, ε_{yt} .has an indirect contemporaneous effect on x_t, and if b_{l2} is not equal to zero, ε_{xt} has an indirect contemporaneous effect on y_t.

Equations (5.11) and (5.12) are not reduced formed equations since y_t has a contemporaneous effect on x_t and x_t has a contemporaneous effect on y_t. Fortunately, it is possible to transform the system of equations into a more usable form. Using matrix algebra, we can write the system in the compact form:

$$Bz_t = \Gamma_0 + \Gamma_1 z_{t-1} + e_t \tag{5.13}$$

where,

$$B = \begin{bmatrix} 1 & b_{12} \\ b_{21} & 1 \end{bmatrix};\ z_t = \begin{bmatrix} y_t \\ x_t \end{bmatrix};\ \ \Gamma_0 = \begin{bmatrix} b_{10} \\ b_{20} \end{bmatrix};$$

$$\Gamma_1 = \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \end{bmatrix};\quad \text{and } \varepsilon_t = \begin{bmatrix} \varepsilon_{yt} \\ \varepsilon_{xt} \end{bmatrix}$$

Equation (5.13) is a primitive form of VAR. The reduced form of VAR model which can be obtained by multiplying both sides with B^{-1} (or $\frac{1}{B}$) is shown as follows:

$$z_t = A_0 + A_1 z_{t-1} + e_t \tag{5.14}$$

where, $A_0 = B^{-1}\Gamma_0$; $A_1 = B^{-1}\Gamma_1$; and $e_t = B^{-1}\varepsilon_t$

For notational purposes, we can define a_{i0} as element i of the vector A_0; a_{ij} as the element in row i and column j of the matrix A_1; and e_{it} as the element i of the vector e_t Using this new notation, we can rewrite (5.14) in the standard VAR form as in following equations (5.15) and (5.16):

$$y_t = a_{10} + a_{11}y_{t-1} + a_{12}x_{t-1} + \varepsilon_{1t} \tag{5.15}$$

$$x_t = a_{20} + a_{21}y_{t-1} + a_{22}x_{t-1} + \varepsilon_{2t} \tag{5.16}$$

Both structural shocks can now be identified from the residuals of the standard VAR. By this time, VAR can be estimates normally as by ordinary least squares method

(OLS). The parameters from the estimation figure out the interrelationships between variables.

In this study, VAR is first applied to the variables to test the relationships; in other words, the interrelationships between the variables and then test for the optimal lag length for a VAR model based on the selection criteria such as LR: Likelihood ratio test criterion, FPE: Final prediction error criterion, AIC: Akaike information criterion, SIC: Schwarz information criterion, HQ: Hannan-Quin information criterion. The best fitting model is the one that maximizes the LR, or minimizes the FPE criterion function (in essence, the overall sum of squared residuals) or AIC, SIC or HQ. In Eviews, those criteria can be shown if one performs the test of lag structure in a VAR estimation. Secondly, VAR is used to test the coefficients of relationships between variables those which are stationary after first differencing, but not cointegrated. In practice, to figure out the effect coefficient of one variable on another, if those two variables are cointegrated in the same order and constitute a cointegrating relationship, the Vector Error Correction Model will be applied since it incorporates the cointegrating relationship of the variables. This methodology will be further discussed later.

5.2.7. Cointegration

Granger (1981) defined the concept of degree of integration of a variable that if variable z_t can be made approximately stationary by differencing it d times, it is called integrated of order d, or I(d). Many macroeconomic variables can be regarded as I(1) variables: if $z_t \sim I(1)$, then $\Delta z_t \sim I(0)$ (Δ denotes first difference). Note that I(1) variables dominate I(0) variables in economics. To illustrate, if $z_t \sim I(1)$ and $w_t \sim I(0)$, then $z_t + w_t \sim I(1)$. Consider the following equation:

$$y_t = \alpha + \beta x_t + \varepsilon_t \tag{5.17}$$

Assuming that both $x_t \sim I(1)$ and $y_t \sim I(1)$, then, generally $y_t - \beta x_t - \alpha \sim I(1)$ or $\varepsilon_t \sim I(1)$ as well, . There is, however, one important exception. If $\varepsilon_t \sim I(0)$, then $y_t - \beta x_t - \alpha \sim I(0)$, the linear combination $y_t - \beta x_t - \alpha$ has the same statistical properties as an I(0) variable. In this special case, variables y_t and x_t are called cointegrated. More generally, if a linear combination of a set of I(1) variables is I(0), then the variables are cointegrated. This concept, introduced in Granger (1981), has turned out to be extremely important in the analysis of non-stationary economic time series. And this theory is definitely the innovation in theoretical econometrics that has created the most interest among economists in the last two decades (Bent E. Sorensen, 2005).

The linear estimation of non-stationary variables may give the spurious results, as mentioned before, or only the short-run dynamic between variables. The development of the concept of cointegration in econometrics has brought about methodologies to deal with these types of time series in order to capture their long-run dynamic (relationship). This concept has been becoming commonly used since most of the economic time series are non-stationary. In general, by asking the question of whether y_t and x_t are cointegrated, we are asking whether there is any long-run relationship between the trends in y_t and x_t. Examples of possibly cointegrated series are long-term and short-term interest rates, prices of two close substitutes, and prices and wages in two related markets, etc. From the above explanation, we can imagine that two cointegrated series will not drift too far apart from each other over the long-run period. Charemza and Derek F. Deadmand (1997) said that "the fact that variables are cointegrated implies that there is some adjustment process which prevents the errors in the long-run relationships becoming larger and larger." Engle and Granger (1987) have shown that any cointegrated series have an error correction representation.

There are different methods for testing the cointegration of variables. The first approach was originally suggested by Engle and Granger (1987). It is particularly convenient for the case in which the variables appearing in the long-run relation are all I(1), or where the dependent variable is I(1), and the explanatory variables are CI(d+1, d). For simplicity the case of single explanatory variable is considered in the long-run relation in the following equation:

$$y_t = \beta x_t + u_t \qquad (5.18)$$

where, both y_t and x_t are I(1). u_t should be I(0) if the variables y_t and x_t are cointegrated, but u_t will still be non-stationary if they are not. Thus it is necessary to test if the residuals u_t in (5.18) to see whether they are non-stationary or stationary. Suppose that the coefficient β is unknown, but for its OLS estimate of $\hat{\beta}$ the Dickey-Fuller and/or Augmented Dickey-Fuller tests indicate stationarity of the OLS residuals $\hat{u}_t$ [12]. In other words, cointegration of y_t and x_t of order (1, 1) with the cointegrating vector (1, β) can be positively accepted. In fact, in a unit root test, the null and alternative hypotheses are $H_0 = \hat{u}_t \sim I(1)$ $H_1 = \hat{u}_t \sim I(0)$, respectively. If the null hypothesis is rejected, the linear combination of the non-stationary variables is stationary; in other words, the variables are cointegrated. However, this test does not indicate how many cointegrating

[12] The critical values used for this cointegration test are different from ones provided by the Dickey-Fuller of Augmented Dickey-Fuller tests by using Eviews statistical computer program. Engle and Granger (1987) have tabulated a new set of critical values for this application since the test is operating on the residuals of an estimated model rather than on raw data. These set of critical values could be found in many econometric books, one example is "New Directions in Econometric Practice, General to Specific Modeling, Cointegration and Vector Autoregression", Charemza and Derek F. Deadmand (1997)

relationships existing in the system. Thus, it is limited to use for the case of single-equation estimation. Suppose that there are k variables in a system (excluding constant term), there may be more than one cointegration relationship. Specifically, if r denotes the number of cointegrating relationships, in this case, r may be up to k-1 ($r \leq k-1$). This implies that there must have another method used to capture all the cointegrating relationships in a model of more than two variables. This is quite simple method to test the cointegration of variables; however, this method was not used in this study due to this limitation.

The second method to test the cointegration of variables is the technique based on VAR developed by Johansen (1988). This method is currently widely used and it is applicable for the estimation of more than two variables. This cointegration methodology was applied to estimate the relationships between prices of the grains and oil in this study. This methodology will be discussed in details in the coming part.

5.2.8. Vector Error Correction Model

A vector error correction (VEC) model is a restricted VAR that has cointegration restrictions built into the specification. As the VEC specification only applies to cointegrated series, it is necessary to test the cointegrating relationship of the variables prior to running the VEC model. The Johansen technique (1988) which was developed to captures cointegrating relationships of variables is considered as the most widely used method for testing cointegration. As mentioned above, this method is based on VAR model, thus this part is going to recall the understanding of VAR model which was discussed before, then explain its development in the VEC model.

Suppose that a set of g variables ($g \geq 2$) are under consideration that are I(1), and which are thought may be cointegrated. A VAR with k lags containing these variables could be set up as follows:

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + \ldots + \beta_k y_{t-k} + u_t \tag{5.19}$$

where, y_t represents vectors of variables used in the model. In order to use Johansen test, the VAR (5.19) needs to be converted into a vector error correction model (VECM) of the form:

$$\Delta y_t = \Pi y_{t-k} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + \ldots + \Gamma_{k-1} \Delta y_{t-(k-1)} + u_t \tag{5.20}$$

where, y_t represents vectors of variables used in the model, $\Pi = (\sum_{i-1}^{k} \beta_i) - I_g$ and $\Gamma = (\sum_{j=1}^{i} \beta_j) - I_g$.

We need to examine the Π matrix (containing g variables). The Π matrix contains information regarding the long-run relationships. In fact, $\Pi = \alpha\beta'$ where α will include the speed of adjustment to equilibrium coefficients, whereas β' will be the long-run matrix of coefficients. Chris Brooks (2002) has described that the test for cointegration between y_t variables is calculated by looking at the rank of Π matrix via its test eigenvalues[13]. The rank of matrix is equal to the number of eigenvalues that are different from zero. The eigenvalues are denoted as λ_i which, in the tests, are put in ascending order ($\lambda_1 \geq \lambda_2 \geq \ldots \geq \lambda_g$). If they are roots, then $1 \geq \lambda_i \geq 0$. However, the test statistics actually incorporate $\ln(1 - \lambda_i)$, rather than λ_i themselves. Suppose that, if $\Pi = 1$, then $\ln(1 - \lambda_i)$ will be negative and $\ln(1 - \lambda_i) = 0$. If λ_i is non-zero, then $\ln(1 - \lambda_i) < 0$.

[13] The eigenvalues used in the test statistics are taken from rank-restricted product moment matrices and not of Π itself.

There are two tests for cointegration under the Johansen approach, which are Trace statistic (denoted by λ_{trace}) and Maximal eigenvalue statistic (denoted by λ_{max}) and formulated respectively as:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} \ln(1 - \hat{\lambda}_i) \qquad (5.21)$$

$$\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{i+1}) \qquad (5.22)$$

where, r is the number of cointegrating vectors under the null hypothesis and $\hat{\lambda}_i$ is the estimated value for the ith ordered eigenvalue from the Π matrix. A significant non-zero eigenvalue indicates a significant cointegrating vector. Johansen approach was derived to be able to test the null hypothesis against alternative one. These two tests have different null and alternative hypotheses. Particularly, the null hypothesis of the trace test, for example, is $r = 0$ (meaning that there is no cointegrating equation between variables), then its alternative is $r = 1$ (there is one cointegrating equation between vraibles); if the null hypothesis is $r = 1$, then its alternative is $r = 2$, and so on. Whereas, the null hypothesis in the maximal eigenvalue test, for example, is $r = 0$, then its alternative is derived from $r+1$, or $r = 0+1$, and so on. Osterwald-Lenum (1992) provides a relatively complete set of critical values for the Johansen test, based on which the null hypothesis is rejected or not. If the test statistic is greater than the critical value, reject the null hypothesis that there are r cointegrating vectors in favor of the alternative.

VECM is basically the same estimation method with VAR, the only difference is the inclusion of error correction term in its specification. Once the cointegration test indicates there is one or more than one cointegrating equation, VECM is employed instead of VAR. Rather than the error correction term, VECM also reports the shor-run relationship coefficients which are the same as if computed with VAR. The cointegration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments, so that VECM is designed for use with non-stationary series that are known to be cointegrated. The VEC specification restricts the long-run behavior of the endogenous variables to converge to their cointegrating relationships while allowing a wide range of short-run dynamics. The principle behind these models is that there often exists a long-run equilibrium relationship between economic variables. In the short run, however, there may be disequilibrium. With the error correction mechanism, a proportion of the disequilibrium in one period is corrected in the next period. For instance, the change in price in one period may depend on the excess demand in the previous period. The error correction process is thus a means to reconcile short-run and long-run behavior. It relates the change in *y* to the change in *x* and the past period's disequilibria.

According to Granger, VECM can also be used to capture the long-run and short-run causality. Long-run causality is determined by the error correction term, whereby if it is significant, then it indicates evidence of long-run causality from the independent variable to the dependent variable. Short-run causality is determined with a test on the joint significance of the lagged explanatory variables.

5.3. Modeling with dummy variables

As mentioned sometime before, empirical models for estimating the relationships between prices of every single grains and oil will also include various dummy variables depending upon the price movement conditions of the grains. The main reason for inclusion of those dummy variables is that oil prices alone (if, other dummy variables were not included as estimators) cannot explain relatively well the price movements of the grains, since there were various factors causing the price fluctuations of these commodities, such as bio-fuel production from food grains and oilseed, pace between growth rates in supply and demand, adverse weather, and policy impositions by countries in their efforts of mitigating the impacts from food inflation, weakening value of the U.S. dollar, and so on. Table 5.1 below shows and explains every single dummy variable used in modeling the relationship equations between prices of grains and oil.

Different types of dummy variables with different functions in the equations were all used depending upon the price movement conditions of the commodities. Basically, three types of dummies employed as explanatory variables. They are slope dummy, intercept dummy and dummy affecting the trends in the time series data. The roles and reasons for inclusion of those dummy variables are also explained in the table.

It is important to note that all those dummy variables were used and treated as exogenous variables in the VAR models, cointegration tests, and VEC models. Tests with variables including dummy variables employed in the logarithm forms are expected to be done in another study, since someone might argue that the slope dummy variables can form the cointegrating equations with other endogenous variables that in this study are prices of the grains and oil.

Table 5. 1 Explanations of the Dummy Variables Used in the Empirical Models

Grains	Dummy variables	Period of application	Explanations
Rice	SDMEP	Jan 2, 2008 – Mar 13, 2008	is used as a slope dummy variable indicating impacts on global rice prices from impositions of the Minimum Export Price (MEP) by Vietnamese and Indian Governments.
	SDVXB	Mar 17, 2008 – Apr 23, 2008	is a slope dummy variable used to include the impacts from the Vietnamese rice export ban.
	DRICQ	Apr 23, 2008 – Mar 31, 2009	is an intercept dummy variable employed in the model to indicate the influences from new crop harvest and bumper harvest on the falling rice prices.
	DTHS	Dec 2, 2008 – Jan 15, 2009	is employed as an intercept dummy to include efforts of Thai Government in buying 4 million tons of rice to its national inventory at the end of last year.
Corn	RTDCRNQ	Jul 2, 2007 – Nov 30, 2007	is a trend variable representing the new crop harvest in main producing countries such as the U.S., China, Mexico, and India.
	SDAWLFS	May 29, 2008– Jun 27, 2008	is a slope dummy used to show the influences from adverse weather, wet weather and flooding, and the low forecast supply of corn in 2008.

Grains	**Dummy variables**	**Period of application**	**Explanations**
Wheat	RTDWHTQ	Feb 27, 2008 – Mar 31, 2009	is a trend variable expressed in the form of squared-root indicating the new crop harvest.
	SDJ_APR08	Jan 24, 2008 – Apr 1, 2008	is employed as a slope dummy variable expressing the dramatic drop of the U.S. wheat inventory and attractively weakening U.S. dollar.
	DEXRSTR	Feb 26-28, 2008; Mar 11-13, 2008	is additionally applied in the model for wheat to capture the effects from the export restrictions by some countries as reasons for the immediate price hikes in only some days in February and March 2008.
Soybeans	SDRDEM	Dec 3, 2007 – Mar 20, 2008	is a slope dummy used to include the dramatic increases in the U.S. domestic and export demand which strongly influenced soybeans prices, such as use of oils for bio-diesel production peaked in August 2007 when 376.2 million pounds of soybean oil were used for bio-diesel production, accounting for 20.6 percent of the monthly use of U.S. soybean oil.
	SDLFSLA	Dec 5, 2008 – Feb 20, 2009	is a slope dummy variable employed to evaluate impacts from the low projection of soybeans supply in Latin America.

CHAPTER 6

RESULTS AND DISCUSSIONS

6.1. Results of analyses

As mentioned before, most of the economic time series are non-stationary and therefore integrated. It is important that all the time series should be tested for their stationarity conditions before conducting any regression analyses in order to avoid resulting in spurious regressions which often report unreal relationships. In the case that the time series are non-stationary, order of integration of the time series therefore should be tested. The issue of finding the optimal lag length is very important because we want Gaussian error terms (i.e. standard normal error terms that do not suffer from non-normality, autocorrelation, heteroskedasticity etc.). Asteriou and Hall (2007) noted that the most common procedure in choosing the optimal lag length is to estimate a VAR model including all variables in levels. The time series variables of the same order of integration may be found to be cointegrated through conducting cointegration tests. Once the variables are cointegrated, the long-run relationships between them do exist. Long-run and short-run relationships, speed of adjustment of the variables to the equilibrium can be reported through running a vector error correction model on cointegrated variables. All these above steps were strictly applied in this study.

6.1.1. Augmented Dickey-Fuller tests

Augmented Dickey-Fuller (ADF) test is a unit root test. A time series variable has a unit root, it is said to be non-stationary. ADF test is allowed to test with extra lag lengths such as first difference or second difference and so on. At a certain lag length, the time series variable becomes stationary, then it is said to be integrated of that order.

For example, after first difference the time series variable becomes stationary, or unit root no longer exists, that variable is said to be integrated of order 1, or I(1).

Table 6. 1 Augmented Dickey-Fuller Tests on Variables

Variable	**On levels**		**On first difference**	
	t-Statistics	**Prob.**	**t-Statistics**	**Prob.**
Prices of rice	-1.38	0.591	-18.2	0.000
Prices of corn	-1.24	0.660	-19.3	0.000
Prices of wheat	-1.31	0.626	-19.7	0.000
Prices of soybeans	-1.31	0.626	-20.6	0.000
Prices of crude oil	-0.54	0.881	-22.1	0.000
Test critical values:	1% level		-3.45	
	5% level		-2.87	
	10% level		-2.57	

Table 6.1 reported results of ADF tests of all variables used in this study. Accordingly, all the time series variables, including prices of rice, prices of corn, prices of wheat, prices of soybeans, prices of crude oil had a unit root, therefore they were non-stationary on ADF level tests. Their t-statistics were all smaller than the critical values (in absolute term) generated by Eviews (based on the critical values derived by James G. MacKinnon (1996)). However, their t-statistics were much greater than the critical values (in absolute term) when ADF test run in first difference. These results indicated that all time series variables used in this study were non-stationary, or integrated in order 1. Therefore, employment of ordinary least squares on those variables might give unreal relationships between them. These results implied the application of cointegration test in order to define whether these non-stationary variables are cointegrated, or not.

6.1.2. VAR, Cointegration tests and VECM

The application of the cointegration test is very important since it can capture the long-run equilibriums between variables once they are cointegrated; while regressions on these variables may be able to define the short-run relationships between them. As mentioned in previous part, Johansen maximum likelihood approach was employed as a test of cointegration in this study. In fact, this is a technique based on vector autoregression developed by Johansen (1988).

Firstly, vector autoregression (VAR) was applied to all models in which prices of a single food grain was dependent variable and prices of crude oil and dummy variables were explanatory variables. Practically, VAR method can provide the short-run coefficients (short-run relationships) of the explanatory variables to the dependent variable; however, if the variables in the models are found to be cointegrated with each other, the VAR-reported results can be formed by another method which integrates the cointegrating term at the same time. This does not imply that VAR method is no longer efficient in this study, since one of its main functions is to define the optimal lag lengths of the models.

Table 6.2 showed the integrated results of both VAR models and cointegration tests. It indicated that the optimal (appropriate) lag lengths of the models were different form each other. The previous chapter has mentioned that dummy variables were used as exogenous variables in the VAR models, only prices of food grains and oil were input as endogenous variables. The optimal lag length for the model of rice prices and oil prices and dummy variables was 7, while they were 6, 2 and 5 for the models of oil prices with prices of corn, wheat and soybeans, respectively. These optimal lag lengths were determined by running a test of lag structure which is built in with the Eviews program. That test detected the most appropriate (optimal) lag length based on some different criteria. Particularly in this study, the criterion of Likelihood Ratio (LR) was selected. The lag length with the biggest value of LR would be the optimal one. LR test is an approach to test the statistical hypotheses; in other words, LR test is used to make a decision between two hypotheses. The greater LR value is, more likely the LR test reject the null hypothesis.

Table 6. 2 Results of VAR models and Johansen Cointegrataion Tests

Variables	**Null Hypo-theses**	**Optimal Lags**	**Test Statistics**			
			Trace	**0.05 critical value**	**Maximum Eigen-values**	**0.05 critical value**
Rice vs Oil	r = 0 r ≤ 1	7	38.5*** 5.60	20.26 9.16	32.9*** 5.60	15.9 9.16
Corn vs Oil	r = 0 r ≤ 1	6	29.6*** 3.42	20.26 9.16	26.1*** 3.42	15.9 9.16
Wheat vs Oil	r = 0 r ≤ 1	2	27.1*** 4.60	20.26 9.16	22.5*** 4.60	15.9 9.16
Soybeans vs Oil	r = 0 r ≤ 1	5	30.0** 3.81	25.9 12.5	26.2*** 3.81	19.4 12.5

*Note: The asterisks *, ** and *** denote significance levels at 10, 5 and 1 percent, respectively. The optimal lag length was determined by Likelihood Ratio (LR) test statistics.*

The optimal lag lengths are very important condition for the cointegration test in general, and Johansen approach and vector error correction model in particular. Boswijk and Franses (1992) emphasize that lag length is a sensitive factor in these two methods and for VAR itself. The inappropriate lag length may result in wrong estimates by those models.

The table 6.2 also reported the results of Johansen approach applied to each model. Johansen cointegration tests used both trace and maximum eigenvalue tests at the same time in order to test the number of r (cointegration equations) between variables in the models. Their hypotheses are theoretically different; however, in the above table they were specified as hypothesis of trace test alone, the results were totally not affected. Null hypotheses of $r = 0$ and $r \leq 1$ mean that there is no cointegration equation and there is one cointegration equation between variables, respectively. And, alternative hypotheses are in turn $r = 1$ $(0 + 1)$ and $r \leq 2$ $(1 + 1)$. If the trace statistic or maximum eigenvalue statistic is greater than the critical values at 5 percent level, the test rejects the null hypothesis. Some econometricians indicated that the trace test and maximum eigenvalue test sometimes report different results. Fortunately in this study, both two tests showed no conflicts in their results. Johansen cointegration test results as shown in the table 6.2 indicated that there was one cointegrating equation between variable of prices of oil and variables of prices of every single food grain at 1 percent and 5 percent significance levels. Two series are cointegrated implying that they form an equilibrium relationship spanning the long run, then even though the series themselves may contain stochastic trends (i.e., be non-stationary) they will nevertheless move closely together over time and the difference between them is constant (i.e., stationary). Specifically, prices of rice, corn, wheat, and soybeans were individually cointegrated with prices of oil; in other words, there existed long-run equilibriums between prices of food grains with crude oil prices to which those price series converged over time. Engle and Granger (1987) showed that if two series are cointegrated, then there must exist an error correction representation; and, conversely, if an error correction model (ECM) provides an adequate representation of the variables, then they must be cointegrated. That implied the application of vector error correction model in order to capture both short-run and long-run dynamics (relationships) between these cointegrated variables.

Vector error correction model (VECM), in fact, is VAR models with integration of cointegrating equation. Therefore, the cointegration test must be conducted in order to define the number of cointegrating equation prior to the application of VECM. Accordingly, VECM basically provides estimates of both VAR model and cointegration test. The estimates are the same, but the difference is that they are reported at the same time in one model (VECM). Table 6.3 shows the results derived from the VEC models. In the VECM, similar to the applications of VAR models and cointegration tests on the variables, prices of each food grain and prices of oil were employed as endogenous variables in each model. All the remaining explanatory variables, which precisely are dummy variables, were employed as exogenous variables. Thus, the VECM only reported the coefficients of dependent variables (prices of each food grain) to the changes in prices of one independent variable, specifically oil prices. As defined by the cointegration tests, there was one cointegrating equation for each model of food grain prices and prices of oil, the VECM derived the cointegrating coefficient for each cointegrating equation. The cointegrating coefficients themselves were long-run relationship coefficients on the food grain prices to the changes in oil prices. As shown in the table, coefficients accordingly were 8.22, 2.71. 2.00, and 0.604 for rice, corn, wheat, and soybean prices, respectively. These coefficients could be interpreted that prices of rice increased 8.22 cent/cwt when oil prices increased one dollar a barrel. Similarly, prices of corn and wheat increased 2.71 cent/bu and 2.00 cent/bu when oil prices increased one dollar a barrel. For the case of soybean prices, since all the variables including dependent and independent variables of both sides of the model were estimated in logarithm form, the estimated coefficient was, in fact, the price elasticity of soybean prices to changes in oil prices. The proper interpretation is that prices of soybeans increased 0.604 percent when oil prices increased one percent. The prices elasticities of rice, corn, and wheat over changes in oil prices were also calculated based on the estimated coefficients by following equation:

$$E = \text{Coefficient} \times \frac{\bar{P}_{oil}}{\bar{P}_{grain}} \tag{6.1}$$

where, E was price elasticity, $\bar{P}_{oil}$ and $\bar{P}_{grain}$ were averaged prices of oil and food grain, respectively. The price elasticities of the grains were measured in percentage regardless what the weighting units were. From the price elasticities, it was easier to specify which grain prices were more responsive to changes in oil prices rather than looking at the estimated coefficients. As shown in the table 6.3, prices of rice, corn, and wheat increased 0.465 percent, 0.505 percent, and 0.228 percent, respectively, when oil prices increased by one percent. It was clearly that prices of soybeans were most responsive to changes in oil prices. The magnitudes of responsiveness of prices of corn and rice were also relatively high, that was 0.505 percent and 0.465 percent, respectively. Prices of wheat were least responsive to changes in oil prices.

Table 6. 3 Results Derived from VECM

Panel A: Error correction terms in VECM

Variables	Rice (cent/cwt)	Corn (cent/bu)	Wheat (cent/bu)	Soybeans (cent/bu)
Crude oil (US$/brl)	8.22***	2.71***	2.00**	0.604***
Price elasticity[14]	*0.465*	*0.505*	*0.228*	*0.604*
Constant	862***	273***	688***	4.19***
ECT(-1)	-0.0586***	-0.0427***	-0.0629**	0.00564

Panel B: Coefficients of exogenous variables in VECM

Variables	ΔRice	ΔCorn	ΔWheat	ΔSoybeans
DRICQ	-18.9***			
SDMEP	0.274***			
SDVXB	0.549***			
DTHS	16.5**			
RTDCRNQ		-0.708***		
SDAWLFS		0.0652***		
RTDWHTQ			-1.13***	
SDJ_APR08			0.0762	
DEXRSTR			43.3***	
SDLFSLA				0.000202
SDRDEM				0.000227

*Note: The asterisks *, ** and *** denote significance levels at 10, 5 and 1 percent, respectively.*
Exogenous variables which were used to reflect other factors besides oil prices to the price movements of grain are all dummy variables of different types; basically they are intercept dummies, slope dummies, and trend dummies.

[14] Price elasticity was calculated by authors based on coefficients derived from the results of VECM.

The error corrections (ECT(-1)) of the grain prices were also reported by the VECM. In econometrics, the error correction was interpreted as speed of adjustment of an economic series when it deviates from the long-run equilibrium. It plays an important role in the specification of the VECM and helps to understand how much the deviations of the previous period could be corrected to converge to the long-run equilibriums in the current period. The speeds of adjustment of rice, corn, and wheat prices were positive and significant at one and five percent significance levels, whereas that of soybean prices was negative; however, it was not significant. The positive error corrections implied that the prices of three grains including rice, corn, and wheat exposed to a shock and were over the equilibriums in the lagged period, then they were corrected to converge to the long-run equilibriums. On the contrary, prices of soybeans, which exposed to a shock and were below the equilibrium, were corrected to converge to the long-run equilibrium.

The VECM also provided the coefficients of the all the dummy variables which were entered into the specifications as exogenous variables. All the dummy variables were employed to reflect the short-term shocks to the prices of the grains, such as crop harvestings, adverse weather, and policy adoptions by countries, especially those who played important roles in the world grain exports and imports. All the coefficients obtained right signs and were mostly significant that implied those dummy variables explained well their effects on the short-term price movements of the grains.

6.2. Discussions

6.2.1. Price relationships of the grains and crude oil

Many of economists and researchers considered in their studies that oil prices were one of the key factors contributing to the price movements of the grains in recent years. However, almost of them did not fully analyze, but focused on breaking down the other factors such as global changes in supply and demand, policy adoptions by countries, adverse weather, etc. There were different ways through which prices of oil might have direct and indirect influences to the grain prices. One of the typical examples which a number of researchers have been discussing in the last two year was the relationships between prices of oil and fertilizers. Canadian Fertilizer Institute – CFI (Oct 2003) notes that natural gas (methane) is essential in the production of nitrogen fertilizer products and there is simply no economic and practical alternative energy source. Costs of natural gas represent most of the costs associated with manufacturing anhydrous ammonia which is a key material for nitrogen production (Eddie Funderburg,

Table 6. 4 Increasing Rates of Fertilizer Prices July 2007 - July 2008

DAP (diammonium phosphate)	Phosphate rock	Potassium chloride	TSP (triple superphosphate)	Urea
174%	359%	167%	197%	168%

Source: The World Bank: "Commodity Price Data (Pink Sheet)," October 2008

2008). It is no secret that the main ingredient in making nitrogen fertilizers is natural gas. Prices of natural gas are partially linked to prices of oil, therefore increases in crude oil prices will lead to huge jump upwards on prices of fertilizers.

Table 6.4 shows the increasing rates in prices of some fertilizers from July 2007 to July 2008. These increases could be mostly influenced by the increases in prices of oil of around 98 percent in one year from June 2007 to June 2008[15]. This indicated that there has been an indirect and close relationship between prices of oil and food grains through their costs of production. Furthermore, agricultural activities, in general, rely on irrigation and transportation (Thida C. Hlaing and Ito Shoichi, 2008), whose operations require heavy usage of diesel and petroleum, as a result, prices of oil and grains have been becoming intertwined. However, this study would not really analyze these above and other relationships between prices of food grains and oil since other researches and studies were conducted by using both quantitative and empirical analyses to examine them, but focus on an indirect relationship that food grains have been increasingly used as feedstock for bio-fuel productions.

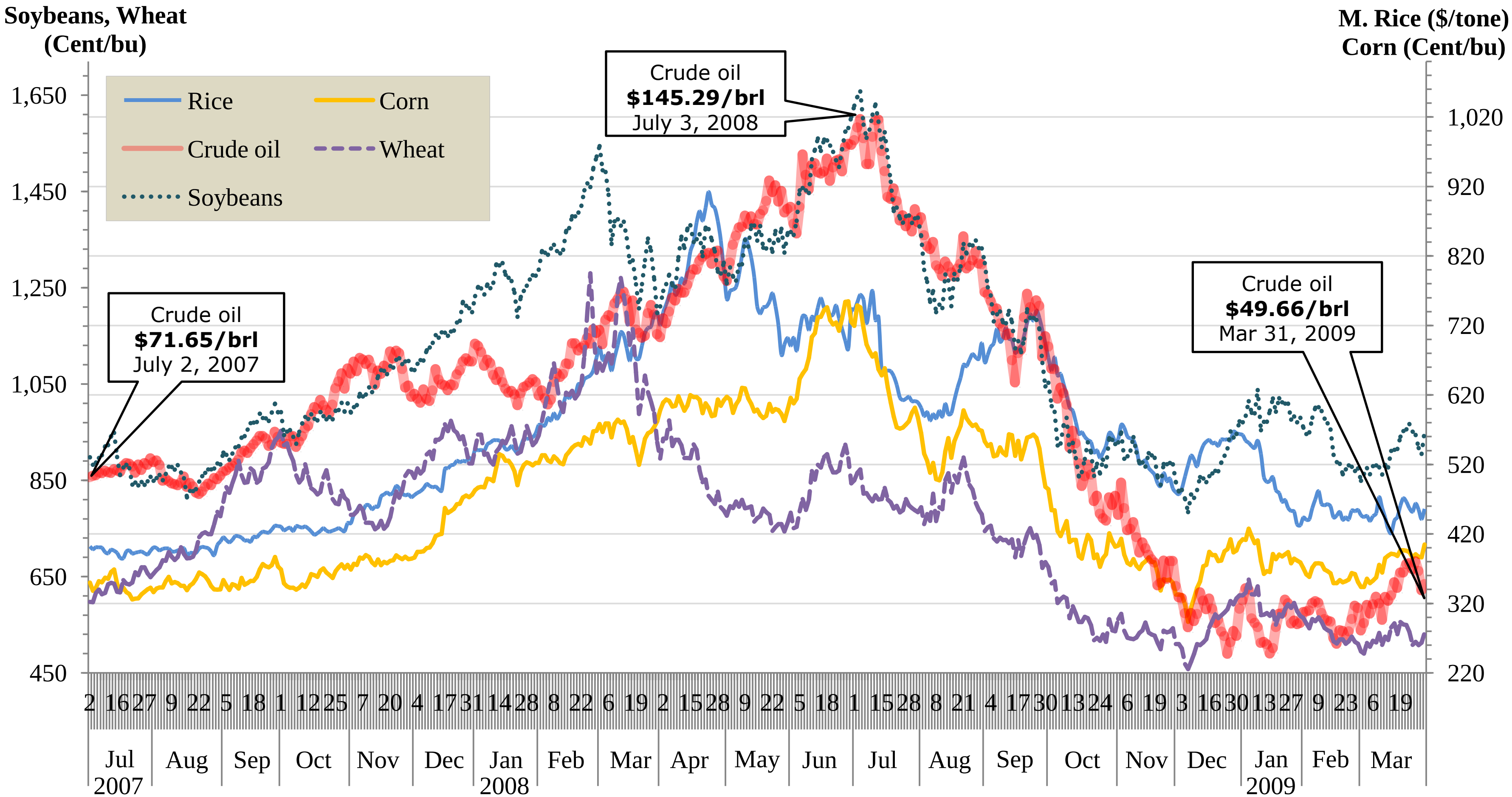
Figure 6.1 shows the daily price movements of the grains including rice, corn, wheat and soybeans and oil. Price data were daily basis and were collected from the futures markets in the U.S. as mentioned before. Duration of these price data were exactly twenty one months, from July 2, 2007 to March 31, 2009. Prices of all the grains started skyrocketing since the beginning of the period, and then made all-time record high in the first half of 2008. Record high prices of those grains were not made at the same time; however, they all showed a common rising trend. Prices of wheat dramatically dropped since March 2008, and then followed by falling prices of other three grains a few months later. By the end of March 2009, prices of these grains, except for wheat prices, remained a little higher than those at the beginning of the research period. Prices of oil which, even though, is the different commodity with the

[15] Monthly prices by New York Mercantile Exchange (NYMEX)

grains, also moved in the same way. Graphically, there seemed to have a common trend between prices of the grains and oil during this period. Many of turning points in the prices of the grains and oil happened simultaneously, or with lags of just a few days. Intuitively, they have moved up and down in the same direction and period of time. It has increased incentive to do analyses on the relationships between them, particularly how much oil price variations have influenced the price movements of the grains during this period. However, this does not imply that the analyses' results would show how much in percentage (100 percent impact from all factors) oil prices contributed to the price movements of the grains, but the analyses provided coefficients of their price relationships.

Figure 6. 1 Daily Price Movements of Oil, Rice, Corn, Wheat and Soybeans in the U.S

(Daily Prices, July 2, 2007 - Mar 31, 2009)

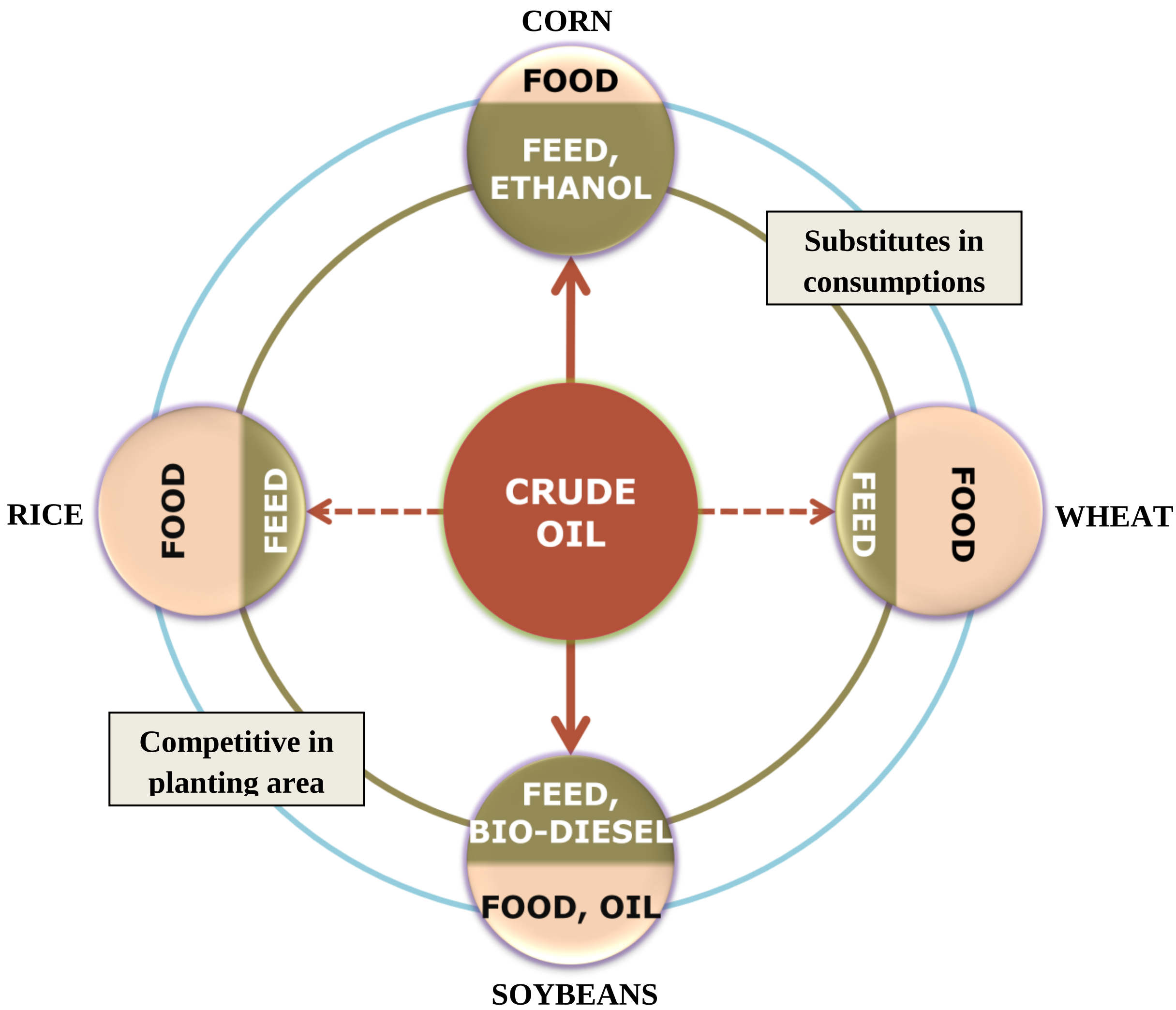


Rice prices are reported on original website in the rough rice basis in unit of US$/cwt. Milled rice price data were calculated from equation: Original data multiplied by 1000/(45.36*0.6) for 1 ton, which implies approximately equivalent to 4-percent-broken milled-rice package for U.S. No.1.

Source: GFT - Online Futures Trading, http://futures.tradingcharts.com

An idea which has come up from the beginning of the study was that oil prices had impacts on the price movements of the grains during the period of the research, since a drastically increasing amount of the grains has been being used to produce bio-fuels in parts of the world. This idea was more precisely interpreted through a designed diagram as shown in figure 6.2. Oil prices played the role of impacting factor and were surrounded by prices of all the grains. The diagram suggested that oil prices might have direct impacts on prices of corn and soybeans, whereas oil prices might have only indirect impacts on prices of rice and wheat. This idea was reasonable since corn and soybeans have been being used as feedstock for producing ethanol and bio-diesel particularly in the U.S., European Union, Brazil, and few other countries. When oil prices increased, there was a growing demand for producing renewable fuels (alternatives of fossil fuels) of which ethanol and bio-diesel have been appropriate options. Specifically, more and more corn and soybeans which were traditionally consumed as foods for human and animal feeds have been used to convert into fuels. Consequently, prices of these grains would be pushed up because of the unbalance between demand and supply. Furthermore, all of those above grains are competitive in planting area and substitutes with one another, their prices are correspondingly linked over time. An increase in prices of a grain might lead to increases in prices of other grains, since consumers change their preferences into consuming cheaper ones; especially processors are more likely to change the portions of grains used in producing animal feeds. Regarding the competition in planting area, it is important to note that farmers would not convert all their planting area of a certain crop into producing another crop, and of course planting area of one crop may not have appropriate conditions for growing others. Farmers can decide based on their knowledge of the market conditions how and which crops should be grown in their available areas in order to make them more profitable.

Figure 6. 2 Diagram of Price Relationships between Grains and Oil



6.2.2. Bio-fuel production – a link between prices of the grains and oil

Rising prices of crude oil as well as concern over potential threats to energy security have been becoming an incentive for those above mentioned countries such as the U.S., European Union, Brazil, and few others to strongly invest into finding, researching and producing alternative fuels in order to lessen their dependences on high-price imported oil. Especially, oil prices are much volatile due to its relations to some distinguishing issues such as political issues, war threats, and even monopoly in its production by some countries. That strongly encourages countries around the world to produce by themselves alternatives of oil in order to eliminate as much as possible their dependences on oil imports. This clearly indicates a straight link between prices of grains and oil. More precisely, oil prices have direct impacts to the price movements of the grains which are used to produce bio-fuels. The term *Bio-fuels* mentioned in this study refer to ethanol and bio-diesel which are being produced from corn, soybeans, and wheat (but very limited). Bio-fuels produced from other sources such as sugar cane, rapeseed, and other vegetable oils would not be discussed, since they are not grains.

It is quite important to note that bio-fuels are being produced from the grains which are traditionally used as foods for human and animal feeds, particularly ethanol production from corn in the U.S. and few European countries such as Spain, Germany and France. Growing demands for bio-fuels and rapid expansion of their productions will cause impacts on the prices of the grains which are being directly used to produce bio-fuels. Supposed that the grain productions are fixed, rising demands for them by the bio-fuel industry will surely reduce the grain supplies for food and animal feeds. Consequently, their prices in the global trading markets will increase. In reality, current growing rates in the grain productions are by far lower than that in bio-fuel productions. That implies there were immediate impacts from bio-fuel productions on the grain prices. Furthermore, many countries are embarking on ambitious bio-fuel policies through renewable fuel standards and economic incentives. As a result, both global bio-fuel demand and supply are expected to grow very rapidly over the next two decades, provided policymakers maintain their policy goals. These are long-term impacts from bio-fuel productions on the grain prices, since the producing countries have set schedules their renewable fuels standard, such as the U.S. by 2022.

The U.S., Brazil and European Union (EU 27) are three largest bio-fuel producers in the world. They supply more than 90 percent of the world's bio-fuel annually[16]. In terms of both ethanol and bio-diesel, the U.S., Brazil, and European Union produced 42 percent, 29 percent, and 18 percent of the world's bio-fuel production as of 2008, respectively[17]. Since 2007, The U.S. took the leading position of ethanol producer from Brazil. The U.S. ethanol production accounted for 93 percent of its total bio-fuel production; the remaining 7 percent was of bio-diesel. Soybean oil was by far the leading feedstock for bio-diesel production in the U.S. Other sources include canola oil, corn oil, and used cooking oils and fats. Brazil was the second biggest ethanol producer. But it produced ethanol from sugar cane, thus it will not be discussed in this study. Brazil; however, played an important role in the world ethanol trading markets, because it dominated the world's ethanol exports, for example more than one billion gallons in 2008. Brazil was among the largest producers of bio-diesel, hence its production accounts for merely 7 percent of the world's output. Soybean is also main feedstock for bio-diesel production in Brazil. Whereas, European Union remained the largest bio-diesel producer, its production accounted for 50 – 55 percent of the total world's production[18]. Bio-diesel production in European Union accounted for 80 percent of its total bio-fuel's output; the remaining 20 percent was of ethanol. Rapeseed was the

[16] The U.S. Department of Energy (DOE), September 2009, *World Biofuels Production Potential - Understanding the Challenges to Meeting the U.S. Renewable Fuel Standard*

[17] Biofuels platform, *Production of biofuels in the world in 2008 - Geographic distribution of bioethanol and biodiesel production in the world,* http://www.biofuels-platform.ch/en/home/

[18] Biofuels platform, *Production of biodiesel in the EU,* http://www.biofuels-platform.ch/en/home/

leading feedstock of bio-diesel in this region, while the ethanol was generally produced from sugar beets and wheat. Those three countries and region are the largest bio-fuel producers and they are also the largest consumers in the world. It is reasonable that only a limited amount of bio-fuels is being traded in the global markets. Brazil was the biggest ethanol exporter with more than one billion gallon (as in 2008).

It is clearly that countries around the world, especially the U.S., Brazil and European Union, are seriously pursuing the developments of renewable energies in order to lessen their dependences on oil imports. Let's have a look at the U.S. - the largest bio-fuel producer in the world. The most updated data provided by the U.S. Energy Information Administration (EIA) in June 2009 clearly showed that the U.S. is heavily dependent on imported oil and most vulnerable to a disruption of oil supplies and a surge in oil prices. The U.S. was the third biggest oil producer in the world with 10 percent of the annual world's oil supply, or 8.5 million barrels per day as in 2008. However, it consumed 19.5 million barrels per day which accounted for 25 percent of the total world's oil consumption. The U.S. had to import oil from other sources among which Canada, Saudi Arabia, Venezuela, and Mexico were its major sellers. In 2008, the U.S. imported a daily amount of more than 10 million barrels from foreign countries implying that the U.S. was a net oil importer with around 57 percent of its total consumption. President George W. Bush, upon signing the Energy Independence and Security Act of 2007 into law, said that "Today we make a major step with the Energy Independence and Security Act. We make a major step toward reducing our dependence on oil, confronting global climate change, expanding the production of renewable fuels and giving future generations of our country a nation that is stronger, cleaner and more secure."[19] As in the 2007 Energy Independence and Security Act, the U.S. has set its challenging targets for annual bio-fuel production by 2022 of which some researchers doubted about achievements. Central to this legislation was an expansion of the Renewable Fuels Standard (RFS), first enacted into law as part of the Energy Policy Act of 2005. The expansion of the RFS as shown in the table 6.5 requires the use of 36 billion gallons of renewable fuels annually by 2022. The original RFS called for 7.5 billion gallons of annual use by 2012. The target for ethanol production is 15 billion gallons by the year 2015, and then remains unchanged till 2022. Significantly, the RFS requires that 21 billion gallons of the standard must come from advanced bio-fuels, including a requirement that 16 billion gallons come from cellulosic ethanol by 2022. Even though, the U.S. is still facing the most challenging problem of technology developments for cellulosic ethanol. This legislation provides an historic opportunity for the U.S. domestic ethanol industry to demonstrate and live up to its full potential[20]. Currently, corn accounts for around 99 percent of the total feedstock for the U.S. ethanol industry. Wheat and barley are being used to produce ethanol in some ethanol plants; however, the amounts are very limited.

The U.S. and Brazil are two largest ethanol producers in the world, their productions accounted for 90 percent of the world's ethanol output in 2008 of which ethanol production of the U.S. alone accounted for more than 50 percent. Ethanol productions in the U.S. and Brazil have one common feature that they are both producing ethanol from the sources of which they are the biggest producers in the world. Those are corn and sugar cane in the U.S. and Brazil, respectively. Accordingly, the

[19] Source: Renewable Fuels Association (RFA), *Ethanol Industry Outlook 2008.*

[20] Source: Renewable Fuels Association (RFA), *Ethanol Industry Outlook 2008.*

distinguishing feature that the U.S. produces ethanol from grain (corn) is worth analyzing.

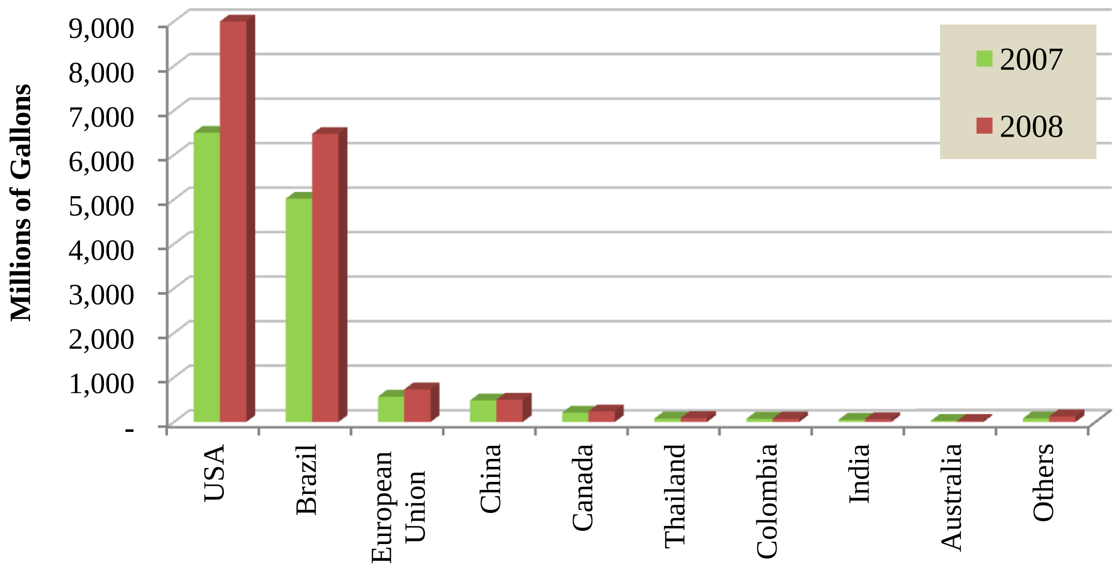
Table 6. 5 The U.S. Renewable Fuels Standard in 2007

	Billion gallons					
Year	**Renew-able Bio-fuel**	**Total Advanced Bio-fuel**	*Cellulosic Bio-fuel*	*Biomass-based Diesel*	*Undiffer−entiated Advanced Bio-fuel*	**Total RFS**
2008	**9**					**9**
2009	**10.5**	**0.6**		*0.5*	*0.1*	**11.1**
2010	**12**	**0.95**	*0.1*	*0.65*	*0.2*	**12.95**
2011	**12.6**	**1.35**	*0.25*	*0.8*	*0.3*	**13.95**
2012	**13.2**	**2**	*0.5*	*1*	*0.5*	**15.2**
2013	**13.8**	**2.75**	*1*		*1.75*	**16.55**
2014	**14.4**	**3.75**	*1.75*		*2*	**18.15**
2015	**15**	**5.5**	*3*		*2.5*	**20.5**
2016	**15**	**7.25**	*4.25*		*3*	**22.25**
2017	**15**	**9**	*5.5*		*3.5*	**24**
2018	**15**	**11**	*7*		*4*	**26**
2019	**15**	**13**	*8.5*		*4.5*	**28**
2020	**15**	**15**	*10.5*		*4.5*	**30**
2021	**15**	**18**	*13.5*		*4.5*	**33**
2022	**15**	**21**	*16*		*5*	**36**

Source: Renewable Fuels Association (RFA), Ethanol Industry Outlook 2008.

As shown in figure 6.3, ethanol has been being mainly produced in the U.S. and Brazil, and only few other countries around the world are producing, but their ethanol productions are very limited. The U.S. ethanol production grew up by nearly 40 percent in 2008 with respect to 2007, whereas productions in Brazil and European Union increased by 29 percent. Figure 6.4 specifies the total annual ethanol production in the U.S. from 2000 to 2008, and especially with mandate by 2015. The U.S. ethanol industry started operating since 1980s when its annual production was only 175 million gallons. Its production grew up gradually year by year, except for a disruption in 1996 when ethanol production dropped out from 1.4 billion gallons in 1995 down to 1.1 billion gallons. The ethanol production in the 2000 was 1.63 billion gallons, and then it increased up to 9 billion gallons in 2008. The annual growing rate during this period was around 25 percent, among which the rate was highest, nearly 40 percent, in 2008. The U.S. Energy Independence and Security Act of 2007 with the RFS was signed into law by the President as shown in both table 6.5 and figure 6.4 has proved strong a

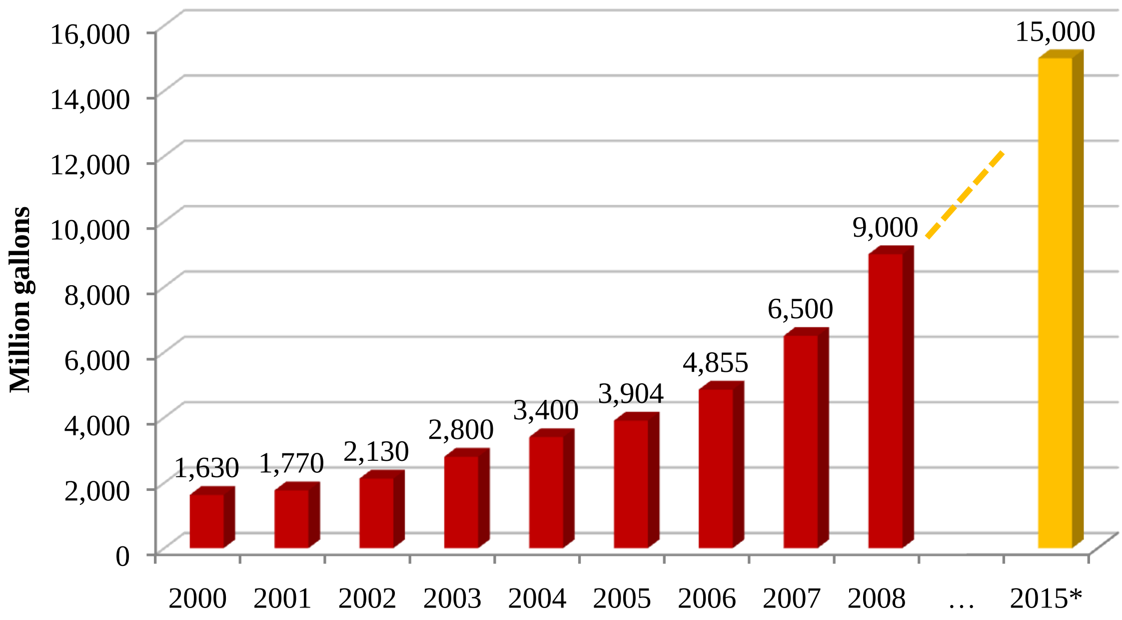
Figure 6. 3 World Ethanol Production 2007-2008



Source: Renewable Fuel Association (RFA, 2009)

commitment by the U.S. Government to reduces its dependence on oil imports through producing renewable bio-fuels. Accordingly, the annual production of ethanol alone would reach 15 billion gallons by 2015. With 99 percent of ethanol feedstock is from corn, the U.S. is going to demand more corn for its prospective ethanol production. The figure 6.5 shows the amount of corn used for producing ethanol in the U.S. from 2000 to 2008. It indicated that the amount of corn used for ethanol production increased 473 percent from 2000 to 2008, whereas the U.S. corn production, in the same period, increased only 22 percent. The total corn amount used as feedstock for ethanol production was 628 million bushels in 2000, and that drastically increased up to 3,600 million bushels in 2008. This amount of corn accounted for nearly one third of the total U.S.'s corn production. In this study, based on the available data in the period from 2000 to 2008, a calculation was made to see how many bushels corn should be used to

Figure 6. 4 Ethanol Production in the U.S. (2000-2008)

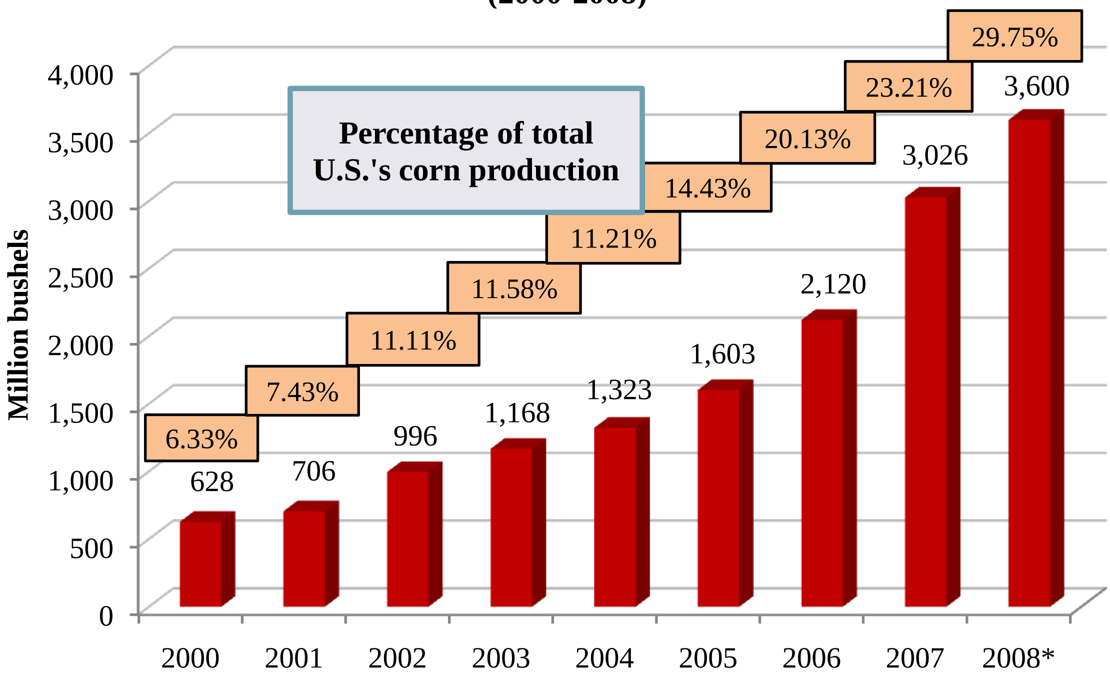


**: The U.S. mandate of ethanol production*
Source: U.S. Renewable Fuel Association

convert into one gallon of ethanol. The results indicated that an averaged amount of 2.39 bushels of corn could be used to convert into one gallon of ethanol. This conversion rate seemed to be stable during the last 9 years; the averaged corn amount used in producing one gallon of ethanol was 2.5 bushels in both 2000 and 2008. The growing rates in the U.S. corn production were not significant during the last 10 years, even though its production decreased from 13 billion bushels in 2007 down to 12.1

billion bushels in 2008[21]. Supposed that the annual U.S.'s corn production would keep unchanged by 2015, and its total ethanol production by that year would reach the mandate of 15 billion gallons, an estimation of total corn amount can be done based on the above average conversion rate. The results showed that, in order to produce 15 billion gallons of ethanol by 2015, the U.S. may have to use 6.23 billion bushels of corn, which is equivalent to 51 percent of its annual corn production. The U.S's corn

Figure 6. 5 Corn Uses for Ethanol Production in the U.S. (2000-2008)



**: Preliminary*
Source: U.S. National Corn Growers Association

production accounted for 42 percent of the world's output as of 2007; it implied that the ethanol industry in the U.S. alone might consume 20 percent of the world's corn production.

This trend of rising ethanol production using corn as feedstock is not only happening in the U.S., but few other countries in the European Union are also pursuing

[21] Source: U.S. National Corn Growers Association

this option, especially Spain, France and Germany. The oil prices have been currently remaining higher than those in early 2000s. The yearly oil price in 2000 was around US$30/ barrel, but it increased up to nearly US$98.9/barrel in 2008[22]. With this increasing trend in oil prices, countries around the world would not only continue producing ethanol, as an alternative of oil, from corn, but also may invest more money and efforts into developing new technologies for renewable bio-fuel productions from other grains. And of course, it makes oil prices have continuous impacts on prices of the grains, particularly corn at the moment. Accordingly, the link between prices of grains and oil might be stronger and stronger and intertwined. The use of corn for producing ethanol will compete directly with their higher value use for food and feed.

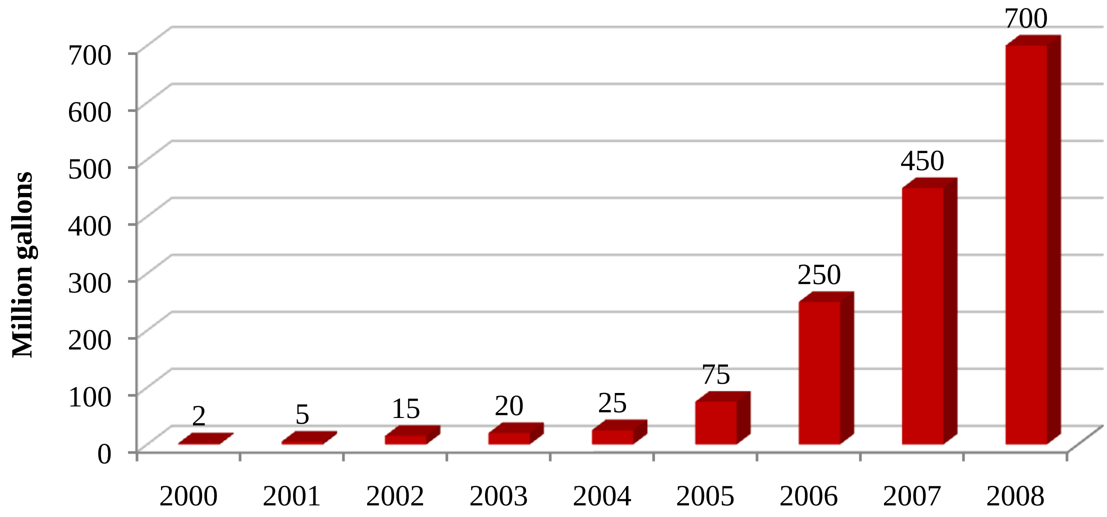
Even though the U.S. bio-diesel is being produced at limited amount comparing with ethanol, it ranked second after Germany in the world. The U.S. produced bio-diesel was 700 million gallons as of 2008, which was equivalent to 17 percent of the world's bio-diesel production. It is worth analyzing in this study, because soybeans – studied products - are the leading feedstock for the U.S. bio-diesel industry. Soybean oil is the leading vegetable oil produced in the U.S. Soybeans are by far the main source of vegetable oil production in the U.S. and likewise, bio-diesel production. In fact, almost 90% of bio-diesel produced in the U.S. was made from soybean oil. Some experts estimated that if the bio-diesel industry keeps its current momentum, over 10 percent of the U.S. soybean oil could be used for bio-diesel production in the next few years[23]. Bio-diesel is not the same thing as raw vegetable oil; rather, it is produced by a chemical process which removes the glycerin and converts the oil into methyl esters (Steve Butzen, 2006). Soybean meal as a high-protein supplement to livestock feed

[22] Source: Chicago Board of Trade
[23] Steve Butzen (2006), Crop Insight, *Biodiesel Production in the U.S*

rations has been the traditional driver of soybean production rather than oil content. However, the increased demand for soybean oil may increase its price and importance versus meal.

The bio-diesel industry has been growing rapidly in the U.S (figure 6.6), and continuous growth is expected over the next decade. The U.S. bio-diesel industry made a giant jump from 75 million gallons in 2005 to 250 million gallons in 2006, which was equivalent to a more than 230 percent increase. Its production continued increasing in two following years of 2007 and 2008 at the rates of 80 percent and 55 percent, respectively. Last year production of nearly 700 million gallons of the bio-diesel industry has made U.S. the second largest producer in the world after Germany. As being indicated in the report on "U.S. Bio-diesel Production Capacity" released on June 22, 2009 by National Bio-diesel Board, there are presently 173 companies that have invested millions of dollars into the development of bio-diesel manufacturing plants and

Figure 6. 6 Bio-Diesel Production in the U.S



Source: National Biodiesel Board (June 2009)

are actively marketing bio-diesel. The annual production capacity from these plants is 2.69 billion gallons per year. Twenty-nine companies have reported that their plants are currently under construction and are scheduled to be completed within the next 12-18 months. One plant is expanding their existing operation. Their combined capacity, if realized, would result in another 427.8 million gallons per year of bio-diesel production. However, of course, the production capacity of the plants is different from the actual number of gallons they are producing. In fact, due to current economic conditions, the capacity utilization at many of these facilities is extremely low. The U.S. bio-diesel industry is facing the pricing problem and availability of the feedstock. The drastically increasing demands for feedstock, particularly soybeans, by the bio-diesel industry have been pushing up the prices of feedstock; consequently, the industry is coping with the problem of profitability. The use of soybeans for producing bio-diesel in the U.S. will compete directly with their higher value use for food and meal.

The RFS shown in the table 6.5 indicates the increase by 1 billion gallons of the U.S. bio-diesel by 2012. The growth in production would be slower, even though the availability of producing facilities recommends the continuous increases in production in coming years. Besides, Brazil and European Union also set their mandates and prospects for their own bio-diesel productions. Specifically, Brazilian Government has recently passed a legislation that mandated a 2 percent blend of bio-diesel from oilseed crops like soybean, sunflower or castor beans (soybean oil is the leading feedstock for Brazilian bio-diesel production) in all commercial sales of petroleum diesel by 2008 rising 5 percent by 2013. Currently, Brazil has about more than 10 bio-diesel plants in operation and another 40 under construction. In addition, in 2003, the EU adopted Directive 2003/30/EC[24] on the promotion of the use of bio-fuels for transport. This bio-fuel directive urged member states to set indicative targets for a minimum proportion of

[24] http://ec.europa.eu/energy/res/legislation/doc/biofuels/en_final.pdf

bio-fuels to be placed on the market. These targets were set at 2 percent in 2005 and 5.75 percent in 2010. Although the bio-fuel progress report[25] showed that bio-fuels have doubled their market share in two years, from 0.5 percent in 2003 to 1 percent in 2005, this growth rate was not fast enough. The quantity achieved in 2005 fell short of the 2 percent reference value laid down in the Bio-fuels Directive. The report estimated that on present policies and measures, bio-fuels' share in 2010 will not rise much above 4 percent, and the bio-fuel Directive's 5.75 percent target for 2010 is not likely to be achieved. Nevertheless, bio-diesel production in the European Union is going to increase in the coming years. Even though, main feedstock for bio-diesel production in the European Union is rapeseed, not grain or soybeans as studied products in this research, it is necessary to consider since European Union has dominate power in the bio-diesel trading markets. More precisely, 95 percent of the world's exports came from European Union as in 2008[26].

Demands for grains, particularly corn and soybeans, by the bio-fuel industry have been booming in the U.S., Brazil, and European Union for about one decade. Beside the expectation of reducing environmental effects, the main reason for the boom came from oil prices. The consecutively rising prices of oil have been creating incentives for countries around the world to produce more and more bio-fuels to lessen their dependences on high-price imported oil. The current situation that the grains, particularly corn and soybeans, are being used to convert into bio-fuels has been strongly contributing to the recent price movements of the grains in the global markets.

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[25] http://ec.europa.eu/energy/energy_policy/doc/07_biofuels_progress_report_en.pdf

[26] Energy Information Administration (EIA, April 2009), *Short-Term Energy Outlook Supplement: Biodiesel Supply and Consumption in the Short-Term Energy Outlook*, Table 4. U.S. Biodiesel Exports and Imports, www.eia.doe.gov

The mandates of rapid increases in bio-fuel productions by countries and regions will make prices of oil have continuous impacts on prices of the grains, accordingly prices of the grains and oil would become more and more intertwined in the future. Specifically, the empirical analyses have proved that there were long-run relationships between prices of the grains and oil. The long-term feature makes the relationships between the grain and oil prices distinguishing with other relationships between price movements of the grains and the factors which caused short-term shocks, such as short-term changes in demand and supply, adverse weather, policy adoptions and interventions, etc. The empirical results clearly indicated that there were equilibriums between prices of every single grain and oil in the long run; in other words, they will move closely together overtime and the difference between them is constant (stationary).

6.2.3. Substitutions – a link between prices of the grains

As mentioned above, oil prices might not have direct impacts on prices of rice and wheat which are currently not being used to produced bio-fuels around the world, or if yes, their amounts are very limited. Even though, oil prices might have indirect impacts on the price movements of those two grains, since all four grains are substitutes with one another in both planting area and consumptions. This part will discuss separately these two characteristics of substitutions between the grains.

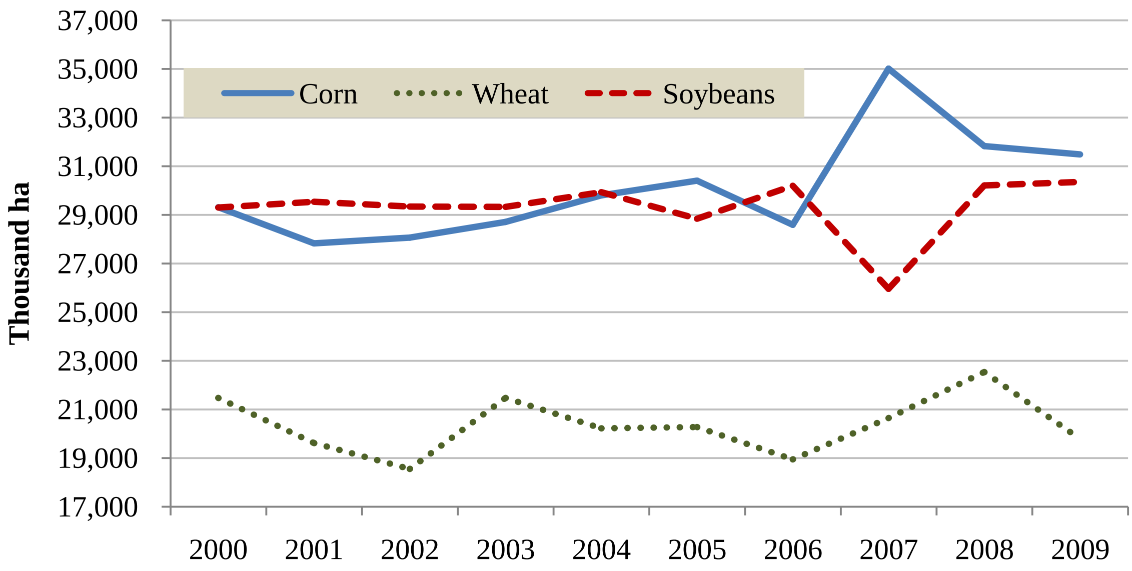
6.2.3.1. Substitutes in planting area

Firstly, it is important to note that concept of substitution does not imply conversion of overall planting area of one crop to others and vice versa. In reality, only a small portion of planting area of a certain crop might be converted into using to produce other crops. In addition, planting land of a certain crop may not be technically appropriate to grow other crops, for example the hilly land is possible for planting corn and soybeans, but might not be suitable for planting rice and wheat. Decisions on substitutions or sometimes called crop rotations are made by the farmers who own the land.

In fact, there existed rotations between food crops in the last two years. In analyzing this idea, it is best to take into account of the countries that are major producers as well as have powerful roles in the global trading markets, since the global situations have influence decisions of the farmers. In considering the substitutive feature of the grains in planting area, the U.S. sounds to be a typical example. The U.S., as mentioned in the previous part, is a major producer of corn, soybeans and wheat; and of course it is playing a very important role in the global markets as major exporter. Rice is an exceptional case for U.S. Even though, it is a main rice exporter, its rice planting area is quite limited comparing with those of other crops. Therefore, rice will not be considered as a substitute in planting area.

Figure 6.7 shows the area harvested of selected commodities including corn, soybeans and wheat in the U.S. in nearly one decade from 2000 to 2009. The data indicated that competitions between these three grains in planting area were not clear in early 2000s; however, in the last three years, the competitions did exist. Corn and soybeans are two main and most competitive crops in the U.S. Increases in planting area of one crop often result in decreases in planting area of another, and vice versa. They strongly competed with each other since 2005, when area harvested of corn decreased, that of soybeans increased. This reverse relationship happened from year to year until 2009. Since they were most competitive crops, the reduction in area harvested of one crop was almost offset by the increase in area harvested of another. This relationship was strongest in 2007 and 2008 when there was a large increase in area harvested of corn, and at the same time caused a dramatic drop in area harvested of soybeans, and the situation was reversed in the later year. Even though, competition in area between corn and soybeans was not complete in 2008, since there was a remarkable amount of area harvested was move to growing wheat. The consecutive and large increases in planting area of wheat in 2007 and 2008 seemed to perfectly offset the shrinks in corn and soybeans planting areas. Similarly, a drop in wheat area harvested in 2009 caused a slight increase in the total area harvested of corn and soybeans. The planting areas of these three commodities in the U.S. sounded to be perfectly substituted in recent years.

Figure 6. 7 Area Harvested of Selected Commodities in the U.S



Source: Shoichi Ito, "World Food Statistics and Graphics", http://worldfood.apionet.or.jp

The global marketing situations were main reason for this, since farmers decided their annual crop rotations in order to make their land more profitable. This phenomenon caused a strong link in prices of these grains. In reality, high prices of one crop will result in growth in its supplies in the coming year; accordingly supplies of other crops might be reduced in the same year. These substitutions in planting area between crops will surely cause differences in the prices movements of them with one year lag.

6.2.3.2. Substitutes in consumptions

"Today's market participants tend to be very sophisticated buyers who carefully compare the prices of different agricultural commodities in terms of their cost per unit of desired end-use characteristic," said Randy Schnepf (February 2009). The grain consumers take into account their production costs basing on selection of cheaper feedstock for their activities, of course without any major changes in their finished products. A livestock or poultry operation strives for the least-cost, balanced ration (depending on the type of animal) that includes sufficient protein, carbohydrates, fats, vitamins, and roughage. An ethanol plant may select corn based on its starch content, while a food processor may prefer corn with above-average oil content[27]. Those studied grains were substitutes in terms of consumption as both feeds and food; however, it is often the case in animal feed processing. Similar to substitutes in planting area, substitutions in consumptions do not imply the entire conversion from consuming one grain to another grain; practically, the consumers move their preferences from consuming less amount of a certain grain to consuming larger amount of another grain, if the latter is cheaper in the markets. They have to consider the best substitutes which are appropriate for operations and give relatively same contents of protein, vitamin, fats, etc. The substitutes in consumption as feed were more clearly in recent years than consumption as food. It was reasonable since humans hardly change their preferences and tastes. They often prefer a staple food which is traditionally consumed as food in a

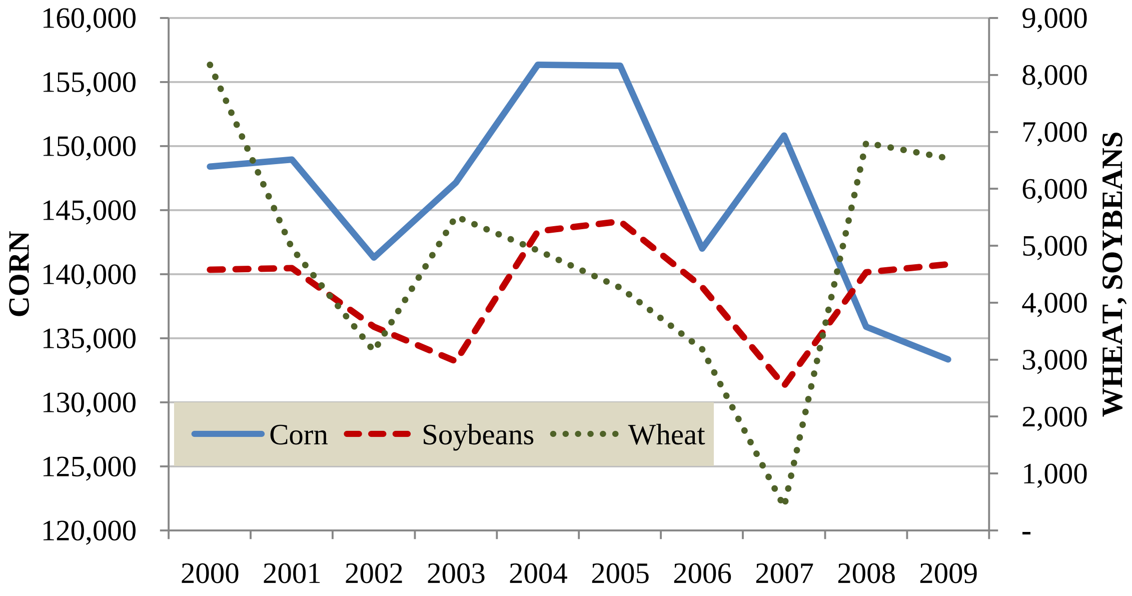
[27] Congressional Research Service, Report RL33204, *Price Determination in Agricultural Commodity Markets: A Primer*

long history. It explains the truth that demands for grains which are staple foods are inelastic to prices.

Figure 6.8 shows the total consumptions of corn, soybeans and wheat as animal feed in the U.S. in the period from 2000 to 2009. The uses of these three grains as feed in the U.S. were not competitive during the period from 2000 to 2006. This implied the small impacts from the global price movements of these grains when they were less

Figure 6. 8 Feed Uses of Selected Commodities in the U.S

(1,000 metric tons)

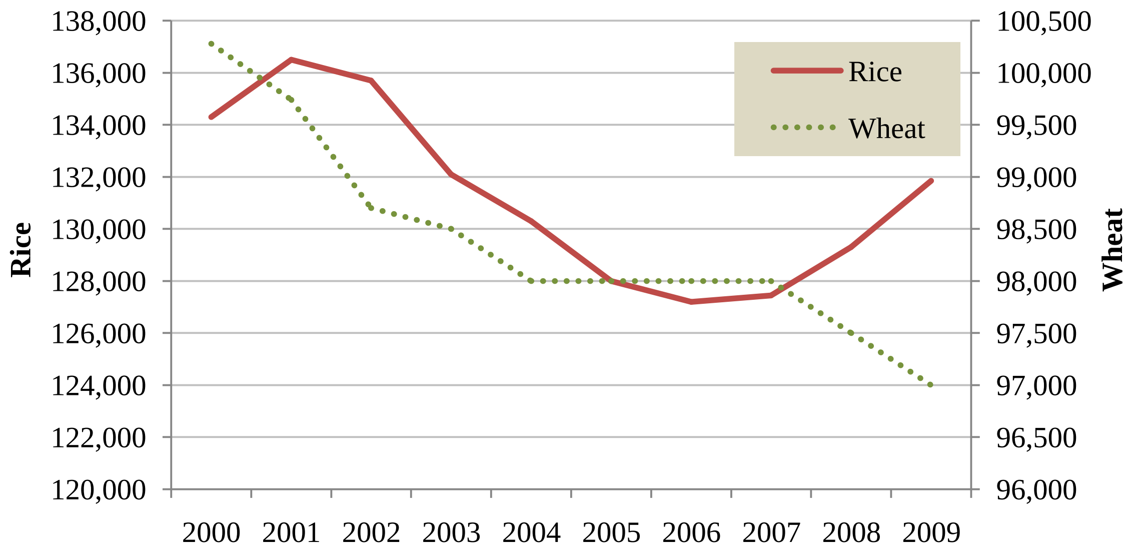


Source: Shoichi Ito, "World Food Statistics and Graphics", http://worldfood.apionet.or.jp

fluctuated. Once prices of a certain grain did not significantly move up and down comparing with other grain prices, the consumers would not change their preferences or remarkably substituted their traditional feedstock. However, the competitions in feed uses from these grains became more clearly in the last two years, when their prices started skyrocketing in the global markets. The price spike times of grains were different from each other, which strongly encouraged the feed processors to use substitutes in their operations. In the figure 6.8, it is important to note that the value scale of corn is on the left side, while that of soybeans and wheat is on the right side. These two scales are much different in terms of value, since corn is being mainly used as feed in the U.S. It suggests that a small increase, for example, in quantity of feed use from corn might cause huge drops in quantity of feed uses form soybeans and wheat. From 2006 to 2007, feed use of corn increased 8.8 million metric tons from 142 million metric tons to 150.8 million metric tons, whereas feed uses of soybeans and wheat dropped by 4.5 million metric tons. The drops in feed uses from soybeans and wheat offset more than half of the total increased quantity of corn used as feed in this country. On the contrary, quantity of corn use as feed dropped by 15 million metric tons in 2008 with respect to 2007, while those of soybeans and wheat increased by 8.3 million metric tons, of which soybean use was almost doubled from 2.5 million metric tons to 4.5 million metric tons, and wheat use increased from 418 thousand metric tons to 4.8 million metric tons from 2007 to 2008. Low prices of wheat comparing with high prices of corn in 2008 were an incentive for feed processors to shift their preferences into using more wheat instead of corn as material for their products. The increasing usage of corn for ethanol production in the U.S. may sharpen this shift in the coming years. China is also a major corn, soybeans and wheat producer in the world, however, the developments in livestock industry is increasingly demanding more and more grains for feed processing. Thus data of feed uses from the grains in China do not clearly reflect the competitions between the grains as sources for animal feed. Furthermore, China consumes domestically almost of their grain production, the price fluctuations in the global markets did not strongly influence the decisions by feed producers in using substitutes for their operations.

In terms of food uses from the grains, among which rice and wheat are most competitive, Chinese data might be best to explain the substitution situations. China is the largest rice and wheat producers and consumers in the world. Food consumption

Figure 6. 9 Domestic Consumptions as Food of Selected Commodities in China*
(1,000 metric tons)



**: Domestic consumptions of wheat as for both food and industrial purposes*
Source: FAS (USDA, March 2009), PSDOnline: Grains and Pulses,

patterns have been changing. Per capita consumptions of grains (as staple food) have been decreasing in some Asian countries, such as rice consumptions in Taiwan, Japan, South Korea, and Singapore. And China is not an exceptional case. Figure 6.9 indicated that total domestic consumptions of rice and wheat as food started dramatically decreasing since 2001. The competition between Chinese domestic consumptions of rice and wheat as food were not so clear in the period of eight years. However, starting from last year, domestic consumption of rice in China increased by nearly 2 million metric tons from 127.4 million metric tons to 129.3 million metric tons, whereas domestic consumption of wheat decreased by half a million metric tons from 98 million metric tons down to 97.5 million metric tons. The estimated data in 2009 by USDA show the continuous rise and drop in rice and wheat domestic consumptions, respectively in China. This implies there was a substitution relationship in domestic uses of rice and wheat in last year, and the situation may continue in the current year. In the case of wheat, the Chinese wheat production increased 4 million metric tons in 2008; however, its total consumption and exports decreased by a large amount (approximately 9 million metric tons) which was offset by the increasing amount of end-stock.

The characteristic of the grains that they are substitutes with one another in both planting area and consumptions has strengthened the link among their prices. Volatility in prices of a certain grain may lead to the same situations for other substitutive grain prices. Particularly, the grain growers and consumers make decisions on crop rotations on the available lands and consumptions of the grains which are more competitive in terms of prices/ costs. Corn and soybeans were two most competitive crops in planting area and feed uses, while rice and wheat competitions in food uses were not so clear. That is reasonable because human did not easily change their tastes and preferences. In this study, oil prices had direct impacts on price movements of corn and soybeans, since they have been being used as feedstock for bio-fuel productions around the world. In addition, prices of the grains were linked together due to their characteristic of substitutions in planting area and consumptions; as a result oil prices had influenced the price movements of rice and wheat, even though a very limited amount of these two grains are being used to produce bio-fuels.

CHAPTER 7

CONCLUSIONS AND POLICY IMPLICATIONS

7.1. Summary of findings and conclusions

The price movements of the grains which are rice, corn, wheat, and soybeans have recently been receiving many of interests from agricultural society, policy makers, and researchers and analysts around the world. The grain prices have started skyrocketing in the last three years, and in the near future, they are expected to stay high with respect to its average prices in the last decade. This study has conducted a series of both graphical and empirical analyses in order to specify the current situations of the international grain markets by using the most updated data; to analyze the characteristics which have strongly contributed to the recent price hikes of the grain; and quantify the long-term relationships between prices of the grains and oil. This chapter would provide summary of the key findings throughout the study and from which some conclusions and policy implications will be made.

7.1.1. International grain markets

7.1.1.1. Major actors in the grain markets

It is no secret that the major producers and traders are among the most powerful actors in the international grain markets. Any changes from the major producers and exporters in the supply side and major importers in the demand side may have great impacts on the grain price movements, since their prices are long time relatively sensitive to changes in supply and demand. However, the magnitudes of impacts are different depending upon the grains. They have distinguishing characteristics and features in their productions and demands, as well as their trading markets. Asia is among the largest producers of all the grains, particularly China and India. However, its people consume almost of their domestic grain productions, except for the case of rice. Even though, rice is a thinly traded commodity, only 6.5 percent of its world's production was traded in 2007. Soybean oilseed market in China is a typical example that China produced 6 percent of the world's total output, but it has been importing more than 60 percent its annual domestic consumption (nearly 50 percent of the world's soybean oilseed imports). Meanwhile America is the largest producer and trader of wheat, and especially corn and soybeans. Comparing with rice, larger amounts of these grains are being traded annually. They are 13 percent, 18 percent, and more than 30 percent of the world's total productions of corn, wheat, and soybeans, respectively. The U.S. is recognized as the largest grain producer and trader in the developed world, it plays a very important role of a price-making force in the global grain markets. European Union is the least competitive region in the grain markets, except for Russia, Ukraine, and Turkey who are important producers and exporters of wheat. The global price movements of the grains would be strongly influenced by any short-term shocks such as droughts and flooding, and export restrictions by their major actors. From the other side, the subsidy programs in those countries had vast long-term impacts on the grain prices, among which the U.S. subsidies to its bio-fuel blenders is a good example. Those major actors will continue having strong influences on the grain price movements in the global markets in the long run.

7.1.1.2. Ending stock and stocks-to-use ratio

Slower growth rates in both planting area expansions and yields and rapid growth in consumptions of the grains have been resulting in relatively low ending stocks with respect to those in the last decade, especially corn, rice, and wheat. Ending stocks and stocks-to-use ratio which refer to consumption as well are two important factors in price movements of the grains. In most of the cases, they are reported at the end of the marketing years of the grain or on annual basis. Any reports of those factors released by individual country or international organizations might have immediate impacts on the grain price movements in the next marketing or calendar year. In the last three years, relatively low ending stocks and stocks-to-use ratio have strongly contributed to the price hike of the grains in the global markets. And they are expected to stay low in the coming years since demands for the grains by feed processing sector and bio-fuel industry will continue increasing rapidly. In a report by OECD in 2008 on rising food prices, the demand for grains for use as feedstock was projected, under current policies, to almost double between 2007 and 2017. But the largest part of future growth in total use is explained by rising food and feed demand, particularly in countries outside the OECD area that are experiencing strong economic growth. Stocks are not expected to be fully replenished, implying that tight markets may be a permanent factor in the period of around ten coming years. This should not lead to permanently higher prices, but provides the background for more price volatility in the future.

7.1.2. Characteristics of the international grain price movements

7.1.2.1. Changes in food dietary patterns

Economic growths in developing countries have been causing rising disposable incomes of their populations. Consequently, they pay more attention to the quality food in the daily meal. More precisely, they are requiring more animal protein which they now can afford. As a result, the feed processing industry is demanding more and more grains for their productions in order to meet the requirements. China and India have been seeing as countries with the most rapid growth in grain demands for feed processing. The growth rate of these demands are lower than those by bio-fuel industry which have recently happened in the U.S., Brazil, and European Union; however, rising demand for use as feed are expected to have stable and continuous impacts on the grain price movements in the long run. This long-term trend will continue and would be even further developed in the future in almost of countries in the developing world. The demands for the grains in producing livestock will have to get stronger to cover the needs.

7.1.2.2. Policy interventions

During the last two years, a number of countries have imposed restrictions on their grain exports. In general, trade restricting policies - whether restrictions on exports or imports - have undesirable and often unintended impacts, especially in the medium and long term. Export restrictions and export taxes or quotas may provide some relief to domestic consumers in the short run, though they contribute to global grain markets uncertainty and drive international market prices further up. On the import side, protecting domestic grain producers by taxing imported products imposes a burden on domestic consumers. An overall objective of the policies imposed during the last two years was to protect and support domestic consumers and producers in mitigating negative impacts from skyrocketing prices of the grains in the global markets. However, policies might go against the objectives, and in general they make the global situations worse. The Vietnamese rice export ban in April 2008 was a good example of that policy. There were various reasons leading to its decision on the rice export ban, but one of them was bad projection of the rice supply from coming crop. One of the two key objectives of the policy was to stabilize the domestic prices. But, the average domestic prices still went up from 140 percent to 160 percent in May 2008 with respect to May

2007. Someone might argue that those prices could go up further more without the export ban. That was possible; however, the export ban itself was sensitive to the local consumers. More precisely, it transmitted information of rice supply shortage to the local consumers. This situation made the rice sector become vulnerable to even a rumor that really happened in Vietnam last year when lots of people flocked into buying and storing rice for long-term uses to avoid further increases in prices. As a result, domestic rice prices made a further jump. In general, agricultural trade policies require further reform, since they are sensitive to both domestic and international markets.

7.1.2.3. Price-inelastic demand and supply

In general, demand and supply of grains are inelastic to price changes. A large increase in prices of the grains might lead to a small reduction in quantity demanded and supplied. On the contrary, slight changes in demand and supply, as a result, would create vast impacts on the grain price movements. As shown in the figures from 4.7 to 4.10 in Chapter 4, averaged yearly prices of the grains all show increasing trends in the last eight years, especially prices of rice and soybeans. However, data of the grain imports by the world major importers did not show an opposite trends with trends in prices during the period from 2000 to 2007. The grain imports of almost all major importers even increased along with rising trends in prices. Amongst, Japan's corn imports remained relatively unchanged, even higher with respect to its imports in 2000. China has been consuming more and more soybeans, and its imports increased from year to year along with the increases in prices of soybeans in the world markets.

Increasing demand for the grains and oilseeds by the industrial processing sector, whether from food or bio-fuel processing industries or from expanding livestock industry, should further reinforced increases in the general prices of the grains.

Industrial use of grains as feedstock is generally less sensitive to price changes since the prices of the feedstock usually represent only a small share of overall production costs of the finished product. Furthermore, industrial users have generally made tremendous investments in plant equipment and machinery, and must continue to operate at some minimal level of capacity year-round as a return on that investment.

However, in terms of feed consumption, demands for the grains are more responsive to the price changes than uses for other purposes. Because feed processors can more easily substitute a proportion of a certain grain with others in their production, provided that substitutes can provide same values of energy. In fact, similar feed energy values may be obtained from a variety of grains. In general, inelastic demand and supply responsiveness characterize most of the agricultural products. Distinct differences in the level and pattern of responsiveness do exist across commodities. This is a characteristic of the grains long time ago. But, at the time of the price hikes of the grains, its effects were combined with those from other factors contributing to the price movements in the world markets.

7.1.3. Long-run relationships between prices of the grains and oil

There were a number of factors contributing to the skyrocketing prices of the grains in the last two years. However, this study focuses on quantifying the impacts from oil prices; in other words, indentifying the relationships between prices of the grains and oil by conducting empirical analyses. The empirical analyses showed that prices of every single grain was statistically cointegrated with oil prices, indicating the existence of long-run equilibriums (relationships) between prices of the grains and oil. The long-run coefficients were 8.22, 2.71. 2.00, and 0.604 for rice, corn, wheat, and soybean prices, respectively. Since the empirical analyses for soybean case used logarithm form of all dependent and independent variables, the above coefficient represents the price elasticity of soybean prices to changes in oil prices. The price elasticities of rice, corn and wheat were also calculated based on the coefficients, and they are 0.465, 0.505, and 0.228, respectively. These results indicated that prices of soybeans, corn and rice were most responsive to the changes in oil prices. Prices of wheat were least responsive to changes in oil prices. The empirical results show a fact that corn prices were strongly related to the prices of oil, because corn have been being increasingly used for ethanol productions, particularly in the U.S. This relationship is expected to continue under the current policies by the bio-fuel producers around the world, implying oil prices will have continuous impacts on prices of corn in the next decade. From these empirical results, this study comes up with an interesting conclusion that even though only a small amount of soybeans in the U.S., Brazil and European Union (as compared with corn for ethanol production) has been being used for bio-diesel production, soybean prices were directly and strongly linked with prices of oil. In addition, all these four grains were substitutes with one another in planting area and consumptions, particularly as animal feed, thus their prices were well intertwined. Changes in prices of one crop might lead to changes in prices of other substitutive and competitive crops.

7.1.3.1. Grain-based bio-fuel productions

Rising prices of crude oil as well as concern over potential threats to energy security has been increasing incentive to produce alternative fuels, among which bio-fuels are currently proper options. Rapid growth in uses of the grains for bio-fuel productions has been a key connection between prices of the grains and oil. Demands for grains, particularly corn and soybeans, by the bio-fuel industry have been booming in the U.S., Brazil, and European Union for about one decade. Conversions from the grains, especially corn, into bio-fuels have been strongly contributing to the recent price movements of the grains in the global markets. This has been seen as a new source of demand for grains and as one of the factors lifting prices to higher average levels in the future. The mandates of rapid increases in bio-fuel productions of some major producing countries and regions will make prices of oil have continuous impacts on prices of the grains, even though the increasing rate would be slower than in the past three years. Accordingly, prices of the grains and oil would become more and more intertwined in the future. OECD has released a report in which bio-fuel production from the grains was considered as a permanent factor to the grain price movements in the global markets.

7.1.3.2. Substitutions among the grains

The grains are substitutes with one another in terms of both planting area and consumptions. This is such a distinguishing characteristic among those four grains. In this study, the data of planting areas for corn, soybeans and wheat in the U.S. were employed for analyses. The analyses' results indicated that among crops in the U.S., corn and soybeans were two most competitive crops in planting area. Increases in planting area of one crop resulted in decreases in planting area of another, and vice versa. This reverse relationship happened from year to year until 2009. However, the relationship was strongest in 2007 and 2008 when there was a large increase in area harvested of corn which was offset by a dramatic drop in area harvested of soybeans at the same time, and the relationship was reversed in the later year. Even though, competition in area between corn and soybeans was not complete in 2008, since there was a remarkable amount of area harvested was moved to growing wheat. Those three grains have made relatively perfect substitutions in planting area in the U.S. recently. This phenomenon caused a strong link in prices of these grains. In reality, high prices of one crop will result in growth in its supplies in the coming year; accordingly supplies of other crops might be reduced in the same year. These substitutions in planting area between crops will surely cause differences in the prices movements of them with one year lag.

In terms of consumption, those grains have been competing with each other in the uses as feed and food. However, the competitions among the grains in consumption as feed are stronger than as food. In fact, the animal feed industries are more likely to change proportion of a feedstock by substituting with proportion of another in their process, provided that substitutes are appropriate for operations and give relatively same contents of protein, vitamin, fats, etc. The substitutes in consumption as feed were more clearly in recent years than consumption as food. It was reasonable since human hardly change their preferences and tastes. They often prefer a staple food which is traditionally consumed as food in a long history. It explains the truth that demands for grains which are staple foods are inelastic to prices. This characteristic among the grains makes their prices be permanently related with one another. Their prices will move together overtime; however, there should have lagged differences between them in a certain period.

7.1.4. Limitations

This study attempts to analyze the impacts from oil prices on the grain price movements. It concluded that oil prices had long-term impacts on the prices of the grains. However, the daily price data used in this study were collected in a period of less than two years; consequently, the results might not well analyze the impacts in a long run. Therefore, it recommends to do further studies on the relationships between prices of the grains and oil in longer period of data-set.

7.2. Policy implications

Analyses on the characteristics of the grain price movements and factors which have been influencing the grain prices imply that prices of the grains will stay relatively high in the coming decade. Asian grain producing countries should take this advantage and benefit from it. Asia is a competitive region in grain production. In fact, it is the largest grain producing region in the world, even though few American countries are large single producers of the grains, particularly corn, soybeans and wheat. However, almost of grain production in Asia is being consumed domestically, except rice of which Asia is taking the leading role in global trade, though it is a thin market. This factor partially makes it a less competitive in value gains from trading the grains. Expansions of the grain production in Asian countries should be taken into account in order to establish larger output. The expansions can mean expansions to larger planting areas and higher yields of the grain production as well as developments in technologies. However, consideration should be made to achieve optimal production costs and make the grains competitive with those originated from other regions. If it is possible, Asia can make their grains available for trades and useable for bio-fuel productions from which it can earn added values from their grain production. In the long run, rapid growths in demands for the grains by feed processing and bio-fuel industries will continue, Asia should increase their production to take off from a merely producer and benefit from these opportunities.

Prices of ethanol and bio-diesel should move in the same trend with prices of corn and soybeans which are main feedstock of the bio-fuel industry. However, their prices have been relatively stable comparing with fluctuating prices of those two grains. The main reason is that the bio-fuel producing countries are spending huge amount of money to subsidize this new industry. In fact, subsidy programs have been effective in those countries with overall objective of incentive provision for development. In the U.S. for example, there has been a tax credit program for ethanol blenders. Owning to that, ethanol blenders can receive a tax credit of U.S dollar 0.51 per gallon. However, the subsidies to bio-fuel production in general will get smaller in the future. The current large producers such as the U.S., Brazil and European Union cannot always support this industry, since it might oppose their incentive for further development. Particularly, the U.S. has been cutting down its subsidy in the form of tax credits to the ethanol blenders. The 2008 Farm Bill became law six months after the enactment of the Energy Independence and Security Act of 2007. The Food, Conservation, and Energy Act of 2008 in 2008 Farm Bill expands and amends many of the renewable energy programs originally authorized in the 2002 Farm Bill. Among which the existing ethanol blenders' tax credit of US$0.51 per gallon falls to US$0.45 per gallon in the first year following that year in which the U.S. ethanol production and imports exceed 7.5 billion gallons[28]. In fact, the total U.S. ethanol production alone, excluding ethanol imports, reached 9 billion gallons in 2008, exceeding the target of 7.5 billion gallons in the 2008 Farm Bill. Therefore, the tax credit for ethanol blenders should already fall to US$0.45 per gallon starting from the beginning of 2009. The current subsidy programs to bio-fuel production can be cut down further in the future. This should be carefully considered by corn and soybean producers, because once the ethanol and bio-diesel plants reduce their production due to smaller subsidies from the governments, this market for corn and

[28] 2008 Farm Bill, Title XV: *Trade and Tax Provisions; Subtitle C PART II — Energy Provisions*, P.L. 110-246, Sec 15331

soybeans will be narrowed down. The producers should take into account this issue from now on in order to substantially cut down the production costs. In fact, ethanol and bio-diesel have been being produced not only from corn and soybeans, respectively, but sugar cane, wheat, barley, rapeseed, etc. Corn and soybean producers have to find down solutions to keep their production costs competitive and even lower than those of other grains, vegetables and crops. Accordingly, corn and soybeans can be able to remain as leading feedstock for bio-fuel productions.

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