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Factors influencing price volatility on soybeans futures prices

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LIST OF ABREVIATIONS

ADF	Augmented Dickey-Fuller Test for unit-root
AIC	Akaike's Information Criterion
AR	Autoregressive
ARCH	Autoregressive Conditional Heteroskedasticity
BSIC	Bayesian Schwarz Information Criterion
CARD	Center for Agricultural and Rural Development
CBOT	Chicago Board of Trade
CFTC	Commodity Futures Trading Commission
CIT	Commodity Index Trader
CME	Chicago Mercantile Exchange
CONAB	*Companhia Nacional de Abestecimento do Brasil*
COT	Commission of Traders
DGP	Data Generating Process
ECM	Error Correction Model
ERS	Elliot, Rothenberg and Stock Test for unit-root
FAO	Food Agriculture Organization
FRED	Federal Reserve Economic Data
GARCH	General Autoregressive Conditional Heteroskedasticity
GDP	Gross Domestic Product
I(0)	Integrated of order 0
I(1)	Integrated of order 1
IATP	Institute for Agriculture and Trade Policy

IFPRI	International Food Policy Research Institute
INTA	*Instituto Nacional de Tecnología Agropecuaria de la Argentina*
LM	Lagrange Multiplier
MA	Moving Average
MAD	Mean Average Deviation
MAPA	*Ministerio da Agricultura, Pecuaria e Abastecemento do Brasil*
OECD	Organization of Economic Cooperation and Development
PIMCO	The Pacific Investment Management
MAGyP	*Ministerio de Agricultura, Ganadería y Pesca de la Argentina*
SDD	Historical Standard Deviation
SEC	Securities Exchange Commission
USDA	United States Department of Agriculture
WASDE	World Agricultural Supply and Demand Estimates

ABSTRACT

Recent unexpected changes (mid-2007- Aug 2011) in agricultural commodity markets have led stakeholders to ask if the volatility of futures prices currently observed are still the result of traditional fundamentals. Consequently, the purpose of this research was to identify those factors that affect monthly soybeans futures price volatility. To accomplish this study, four relevant factors are explored. First, the integration between energy and agricultural markets is accounted for via oil spot prices, as well as a dummy variable to account for the shift in the U.S renewable fuel policy since 2007. Second, the increasing consumption of commodities from China is analyzed by measuring their imports of soybeans from Argentina, Brazil, and the U.S. Third, U.S monetary policy is examined by including a U.S dollar index compared to currencies from China (Yuan), Brazil (Real), and Argentina (Peso), which are the main producers, consumers and traders of soybeans. Finally, financial speculation is analyzed by the number of speculative funds (mutual and index funds) available for public investors.

Evidence was found that the variability of oil spot prices, soybean imports to China, and the number of index funds are able to explain monthly soybeans future price volatility, from September 2006 to August 2011. Although U.S renewable fuel policy is included in the analysis, there is no statistical evidence of its influence on monthly soybeans futures prices. Similarly, there is no evidence that the U.S dollar index and the number of mutual funds are able to explain past values of soybeans futures price volatility. Excessive volatility in futures price may cause problems for those utilizing futures markets in their business operation, as well as for consumers. While the increasing risk has led to inefficient resource allocation for producers, merchandisers, and speculators, high prices have influenced the food security of developing countries with lower

incomes, i.e. affecting the ability of lower income households to get access to soy products for human consumption.

CHAPTER 1. INTRODUCTION

A common question among stakeholders involved in futures markets is why have the future prices of agricultural commodities been both high and volatile from 2006 to 2011, relative to previous periods. According to a report by the Chicago Mercantile Exchange (CME 2008), the monthly average price volatility (expressed on annual basis) in 2008 for soybeans, corn, and wheat reached record levels of 54, 41, and 73 percent, respectively.

The implications of future price movements in agricultural markets are crucial for those utilizing futures markets in their business operation. In general, research indicates that since the storability component does not affect the integration between spot and futures prices, the latter are unbiased predictors of spot prices (Yang et al. 2001), which is better known as price discovery. Price discovery, under true supply and demand conditions, states that the future price close to expiration converges to the spot price, a basic condition for an efficient hedge (Holbrook 1953; Brooks and Chance 2010). Price discovery and hedging efficiency are the primary purposes of futures markets and the reasons why understanding futures price movements are crucial to stakeholders in the global agri-food and fiber supply chain.

This excessive variability in futures and spot prices has caused problems not only for futures market participants, but also for consumers. While increasing risk has led to inefficient resource allocation for producers, merchandisers, and speculators, it also has the potential to limit access to food in developing countries that depend on imports and have lower incomes (OECD 2011).

The debate surrounding high agricultural commodity futures prices has received special attention by economists (Baffes 2007; Karali and Power 2009; and Babcock 2011) in recent years. Factors such as the integration of energy and agricultural markets, macroeconomic conditions, and financial speculation all have been identified as key drivers of commodity price volatility (Masters and White 2008; Mitchell 2008; Irwin et al. 2008, 2009, 2010; Tangermann 2011).

Increasingly, evidence is mounting, that the integration of energy and agricultural markets is driving high commodity prices (the Food Agriculture Organization (FAO) 2007; Tangermann 2011). First, the variable cost of production, on average, between 35 and 40 percent in 2010, for soybeans, corn, and wheat, has significantly increased from their 1999 levels due to the increase in fuel and fertilizer cost. Over the above-mentioned period, this cost (part of variable cost of production) increased by 148, 123, and 154 percent for soybeans, corn, and wheat, respectively (the U.S Department of Agriculture (USDA) 2011). Second, the consumption of biofuels, particularly in the U.S, has affected stocks and inventories of agricultural commodities. Mitchell (2008) asserts that between 70 to 75 percent of the increase in commodity prices is due to the increase of biofuel consumption between 2006 and 2008.

While the link between expanded biofuel consumption, oil prices, and agricultural commodities is tough to dispute (Babcock 2011; Tangermann 2011), recent findings suggest that macroeconomic conditions are also drivers of high commodity prices (Karali and Power 2009). Hailu and Weersink (2011) emphasize that the rapid macroeconomic developments in emerging economies, China in particular, are drivers of commodity price volatility. Tangermann (2011) states that this rapid economic growth has created additional demand for commodities, which has lowered stocks to use ratios (18, 23, and 26 percent, on average, for wheat, soybeans, and corn between 2001 and 2010) (USDA 2011), thereby increasing the prices of agricultural commodities.

From 1999 to 2004, soybean consumption in China could be meet by importing less than 50 percent of their consumption, by 2011 however, they were importing more than 70 percent of the soybeans they consumed (USDA 2011). These imports typically come from the major soybeans exporting countries of Argentina, Brazil, and the United States. It should be emphasized that Brazil, Argentina and the U.S will account for roughly 90 percent of world's soybean exports in 2011 (USDA 2011). More importantly, in 2011, China will account for 60 percent of world's soybeans imports. A consequence of this rapid increase is that soybean stocks to use ratios have decreased significantly. For example, in 2008 when soybeans futures prices reached a record level, world soybean stocks to use ratios decreased to 19 percent, which was 5 percent less than the previous five years on average (USDA 2011).

Other macroeconomic variables, such as the strength/weakness of the U.S dollar have also been mentioned when analyzing commodity market price variability. Helbling et al. (2008) indicate that a weak U.S dollar affects commodity prices because they are typically priced in the U.S dollar, which in turn increases interest in futures contracts as instruments of protection against inflation relative to bonds, currencies, and stocks (Steil 2006). Charlebois and Hamann (2010) indicate that prices of commodities, including soybeans, could grow by 14 percent, on average, between 2008 and 2011 because of a weak U.S dollar.

The most controversial factor thought to influence commodity price volatility is financial speculation. Masters and White (2008) assert that it is not a coincidence that commodity prices are high, given the increase in financial speculation in commodity markets. They emphasize that the purchases of futures contracts, including soybeans, by index funds i.e. the Standard and Poor's Goldman Sachs Commodity Index (S&P-GSCI) and the Dow Jones Commodity Index (DJ-USB) have increased significantly since 2003 (more than 8 times, on average). Conversely, others such as the Commodity Futures Trading Commission (2008) and Irwin et al. (2009, 2010, 2011) strongly reject the hypothesis that either individual and/or institutional speculators have caused the high commodity prices currently being observed. Indeed, they indicate that financial speculation is just a fallacy in the search for reasons behind high commodity prices.

Despite the inconclusive findings regarding financial speculation and high commodity prices, very few studies on the subject of financial speculation, examine the influence of the number of mutual and index funds dedicates to commodities and available for public investment. O'Hara (2006) claimed that while investors typically do not maintain a set position in future markets, they are however exposed to commodity markets through mutual funds that track commodity indices. In fact, from 1997 to 2004, only two funds, the Oppenheimer Real Asset (QRAAX) and the Pacific Investment Management Real Return Strategy (PCRAX) funds, invested in commodity futures markets through commodity indices. By 2011 however, mutual funds that tracked commodity indices had increased to nineteen. Likewise, from 1991 to 2002, there was only one commodity market index fund (Reuters Commodity Research Bureau (TR/J CRTB)), but by 2011 there were six.

1.1 Problem Statement

Recent literature has advocated the need for finding the reasons behind increased price volatility in commodities such as soybeans. Factors such as, the integration between energy and agricultural markets, macroeconomic conditions, and the excessive financial speculation, have all been considered when examining price movements in agricultural markets. This research examines the influence of four relevant factors on monthly soybeans futures prices. First, oil spot prices and U.S renewable fuel policy since 2007 (a dummy variable), second, soybean consumption in China (as measured by imports as a proxy of unmet domestic consumption), and third, the U.S dollar index value against the Argentinian Peso, Brazilian Real, and Chinese Yuan, and finally, the number of mutual and index funds in commodity markets.

1.2 Justification

This study focuses on the volatility of soybean futures prices because of their importance to producers, traders, investors, and food policy makers. Commodity price variability has implications for risk management, asset pricing and allocation, and food security, particularly for consumers with low incomes (Diebold 2007; Masters and White 2008; Smith 2011; and U.N Food Program 2011).

As noted by Masters and White (2008) the primary purpose of futures markets are price discovery and hedging efficiency, each of which is affected by excessive variability in commodity prices. Since hedging is one of the main reasons that participants use futures markets in their business operation, any analysis that contributes to better understanding of periods of high volatility in commodity markets could help to improve managerial decisions.

Academic and policy analyses often focus on price returns rather than volatility (Gilbert and Morgan 2010). The analysis of volatility, as a measure of risk, is crucial for resource allocation and asset pricing since it provides valuable characterization for the determinants of volatility (Diebold 2007). Price volatility affects the estimated level of profit, land value, cost of insurance to protect revenue, the needs of credit and/or capital to buy and storage, and manage risk of agricultural commodities (Irwin and Good 2009).

Finally, the volatility of soybeans futures prices is a concern for policy makers. According to the Earth Policy Institute (2011), high commodity prices have the greatest impact in developing countries, since their populations typically spend between 50 and 70 percent of their total income on food. The understanding of factors influencing price volatility in agricultural commodity markets contributes to establish policies, such as international commodity agreements and regulations of futures markets (Tangermann 2011) focused to protect vulnerable consumers. Moreover, volatility has implications for domestic agricultural policies, i.e. the U.S Farm Bill which accounts for market price movements when calculating farm subsidies.

1.3 Objectives

The overriding objective of this research is to identify those factors that influence price volatility in soybeans futures prices. To accomplish this objective, this research will analyze if monthly soybeans futures price volatility is influenced by oil prices, U.S renewable fuel policy (a dummy variable), soybean consumption in China, the U.S dollar index value against currencies from three countries: Argentina (Peso), Brazil (Real), and China (Yuan), and financial speculation (as measured by the number of mutual and index funds tracking commodity markets).

1.4 Data and Procedure

This empirical study uses daily soybeans futures prices data (Soybeans yellow #2 contract in USD/bushel), obtained from the Chicago Board of Trade (CBOT) between January 1999 and August 2011 to compute monthly soybeans futures price volatility. Since different contracts are considered, this study employees the contract with the closest settlement date, which is called the nearby futures contract (last day of trading) to construct a time series from January 1999 to August 2011.

The integration between energy and agricultural markets is accounted for via oil spot prices, obtained from the Federal Reserve Economy Data (FRED) between January 1999 and

August 2011, as well as a dummy variable to account for the shift in the U.S renewable fuel policy. This shift in policy occurred in 2007, and called for the use of at least 21 million gallons of fuel obtained from cellulosic ethanol and other advanced biofuels. This policy increased the interest in the production of agricultural commodities such as soybeans, and corn to produce biofuels (Sissine 2007).

The role of China is addressed by analyzing its consumption of soybeans imports. This variable is measured as the summation of monthly imports from Argentina, Brazil, and the United States to China, as a proxy for unmet domestic consumption in China. This data is obtained from the U.S Department of Agriculture, the Secretary of Agriculture of Brazil, and the Secretary of Agriculture of Argentina from January 1999 to August 2011. Moreover, the influence of the U.S monetary policy on the monthly soybeans future price volatility is analyzed by including a U.S dollar index (January 1999 = 100). This index is based on the value of the U.S Dollar compared to the Real (Brazil), Peso (Argentina), and Yuan (China), which are the main countries related to the production, commercialization, and consumption of soybeans. This U.S dollar index is computed as the average of relative index for each currency, which is the arithmetic mean of the U.S dollar price relatives, compared to three currencies (Neustadtl 2011). The data utilized to compute this index is obtained from FRED and the Central Bank of Argentina between January 1999 and August 2011.

Financial speculation is measured by the number of mutual and index funds dedicated to investing in commodities and available for public investors. These data are accounted and aggregated by the month and year in which these mutual and index funds were available for public investors. For example, if a mutual or index fund was available for public investors since February 2010 and a second one since April 2010, then, the first mutual or index fund is accounted from February to March 2010 as one. From April 2010, however, two mutual or index funds are accounted for that year. The data is obtained from the Securities Exchange Commission (SEC) and the public information provided by the companies who offered mutual and index funds between January 1999 and August 2011.

The procedure used to determine whether the variables discussed above influence monthly soybeans future price volatility is Granger Causality, which can be utilized for, stationary I(*0*), stationary and non-stationary (as a long as the causal variable can be written in first differences), and/or non-stationary cointegrated variables I(*1*). Since the data generating process (DGP) of the variables being analyzed in this research is unknown, conventional statistical procedures are performed to test for stationarity, order of integration, and cointegration, if any. More specifically, this research follows the procedure suggested by Elliot, Rothenberg, and Stock (ERS) (1996) to analyze the DGP. In general, this procedure seeks to test for unit-root by preselecting a constant in the presence of either a constant and/or a trend, and it is used to detrend the data. This methodology ensures that there is statistical evidence, that the data follows a covariance stationary process, either at levels or at the first differences.

Once DGP is defined, Granger Causality, a common procedure to test for causality, is performed on either cointegrated or non-cointegrated variables by using F and/or t-tests. Cointegration means that all the variables must be integrated of the same order I(*1*) and their residuals are stationary. If the variables are not cointegrated, but they are stationary, Granger Causality still can be performed using similar tests. Non-stationary variables can also be tested by F and/or t-tests as a long as the variables can be written in first differences. The central objective of the Granger causality methodology is providing statistical evidence that past values of variables are able to explain past values of other variables. This research asks if past values of oil spot prices, a U.S dollar index, U.S renewable fuel policy, China soybeans imports and the number of speculative funds in a given year are able to explain past values of monthly soybeans future price volatility.

1.5 Thesis Outline

The reminder of the research is organized as follows. Chapter two contains the literature review, which highlights the recent empirical analysis related to factors affecting price variability in agricultural commodity markets, as well as the role of futures markets in both the agricultural and non-agricultural economy. Chapter three provides a detailed description of the methodology utilized. Chapter four provides the results of the empirical analysis. Finally, chapter five highlights the implications of this research for the agricultural supply chain as well as future research in this area.

CHAPTER 2. LITERATURE REVIEW

The first part of this chapter provides a review of agricultural futures markets, while the second part introduces a discussion that summarizes studies on the recent changes in these markets. Finally, the third part contains a summary of the conceptual framework utilized to analyze price variability in commodity markets.

2.1 Futures Markets Background

According to Brooks and Chance (2010) futures markets are used by producers and buyers in various agricultural commodity markets (wheat, corn, and soybeans) as a way to lock in prices for some specific time in the future. Futures exchanges exist to offer contracts, whose stakeholders seek one or more to the followings benefits: risk management, financial stability, cost management, and profit opportunities (the Chicago Board of Trade (CBOT) 2005). These benefits summarize the primary purpose of futures markets, which are price discovery and management risk (Masters and White 2008).

2.1.1 Price Discovery and Risk Hedge

The popularity of futures markets, as centralized markets since the 1980s, has allowed many agricultural market participants to use them as management tools (Platts 2007). Factors such as the high cost of transportation, geographical dispersion across markets, and high variability between regional spot prices, are the reasons that agricultural commodity stakeholders are interested in futures markets (Masters and White 2008). The main advantage of futures markets is their ability to serve as indicators of future supply and demand conditions (price discovery), which allows for efficient hedging (Holbrook, 1953). The Commodity Futures Trading Commission (CFTC) (2011) describes the price discovery function, as the way through which users (traders) define spot prices based on the movements of futures prices.

In general, theory suggests (equation 2.1.1) that the price of a future contract (f_t) is the spot price (S_0) compounded to the expiration (T) at the risk-free rate (r)

$$(2.1.1)\ f_t(T) = F(0,T) = S_0(1+r)^T$$

(Brooks and Chance 2010). Nevertheless, any storable commodity is also affected by other costs, such as storage costs (s). According to Kenkel (2008), storage cost includes grain shrinkage, moisture loss, electricity for elevators, convenience yield (inventories that allow reducing marketing transaction costs), insurance, turning and aeration equipment, and fumigation expenses.

Furthermore, most investors, who provide liquidity in futures markets, are risk averse and expect a risk premium for participating in the market; this can be thought of as the additional return expected to justify taking the risk of investing in futures contracts (Brooks and Chance 2010). Thus, the future price would be the summation of these factors that influence storage cost, the interest compounded on the spot price ($iS_0 = S_{0(1+r)}{}^T$), and the risk premium (equation 2.1.2).

$$(2.1.2)\ f_t(T) = iS_0 + (\theta)$$

where the combination of the interest compounded on the spot price and the storage costs is referred to as the cost of carry (θ) or carry charge (Brooks and Chance 2010).

Since the storage component does not affect the cointegration and usefulness of futures markets in predicting cash prices (Yang et al. 2001), the future price and the interest rate would be unbiased predictors of cash price (price discovery) in most cases for storable commodities (Zapata and Fortenbery 1991, 1995). The price discovery function under true supply and demand conditions allows that the future price close to expiration converge to the spot price, which is the basic condition for hedging efficiency (Holbrook 1953; Brooks and Chance 2010).

The convergence between futures prices and spot prices is known as the basis (the difference between the future price and cash price). If the basis is negative, then under supply and demand conditions it should reflect the carry charge costs (Schnepf 2008); else, arbitrage takes place, which allows holding long and short positions (spreads) in nearby contracts to be profitable (Irwin et al. 2009). Increasing arbitrage could cause artificial demand; and hence, high prices (Masters and White 2008).

From 2006 to 2008, the price discovery function and the basis for most agricultural commodities have showed poor performance (Irwin et al. 2009). The predictable pattern of the basis (measured as the R-squared from a linear regression) has decreased significantly, which affects hedging efficiency. Data by Irwin et al. (2009) indicate that for the periods 2001-2005 and 2006-2008, hedging efficiency decreased from 87 to 28 percent in corn, 78 to 26 percent in soybeans, and 44 to 16 percent in wheat, as a result of increasing price volatility in the futures markets.

Schnepf (2008) asserts that the variability of some commodities, such as corn, wheat, and soybeans reached record levels in 2008. Indeed, the monthly average price volatility (expressed on an annual basis) as reported by the CBOT (2008) in 2008, reached 73 percent in wheat, 41 percent in corn, and 54 percent in soybeans. This poor convergence has considerably reduced the advantages of futures markets (Karali and Power 2009), which hastens the need to understand what factors drive futures price volatility.

2.2 Factors Influencing Price Variability

Although there is no consensus about the magnitude of factors influencing price variability, analysts assert that the unexpected changes from mid-2007 to 2010 in agricultural commodity futures prices is due to three relevant factors. First, the increasing integration between energy and agricultural markets, second, the role of macroeconomic variables in the supply and demand balance (Guidry 2006; Mitchell 2008; Karali and Power 2009), and finally the composition of traders operating in the futures markets (Gosh 2008).

2.2.1 The Role of Energy Markets in Agricultural Commodities

In recent years, there has been special interest regarding the relationship between energy markets and agricultural commodity prices. The strong interest in renewable fuels, particularly in U.S and Europe, and the number of inputs used in agricultural production that are fuel and oil derivatives are reasons for analyzing the effects of energy markets on price variability in commodity markets.

2.2.1.1 High Crude Prices

According to Guidry (2006) and Von Braun et al. (2008), high crude oil prices have pushed up the prices of inputs used in production agriculture operations. Cost related to fertilizers and fuels, which are oil derivatives, have risen approximately 46 percent, on average, for soybeans, corn, and wheat, from 2005 to 2011. These variable costs account, on average, for 25, 49 and 52 percent of total variable production costs for soybeans, corn, and wheat, respectively (Table 1).

Table 1. Fuel and Fertilizer Costs for Selected Commodities.

	1999 - 2001	2002 - 2004	2005 - 2007	2008 - 2010	Average
Soybeans (USD)	15.78	15.81	26.93	39.02	24.38
Variable cost share	20%	20%	28%	30%	25%
Corn (USD)	71.39	73.02	109.82	159.86	103.52
Variable cost share	44%	45%	53%	55%	49%
Wheat (USD)	27.66	31.84	47.03	70.38	44.23
Variable cost share	46%	49%	55%	60%	52%

Source: USDA (2011).

Campiche et al. (2007) and Harris et al. (2009, 2010) both examined the price relationship of major commodities (corn, soybeans, sugar, sorghum, and cotton) and oil prices.

They found that a co-integrating relationship exists between major commodities and oil prices, from 2006 through 2009. Studies by Chen et al. (2010) indicate that the percentage change in soybeans price due to 1 percent change in oil price was approximately 27 percent, on average, from January 2005 to May 2008.

Baffes (2007), Taheripour and Tyner (2008), and Saghaian (2010) assert that there is also a link between crude oil and agricultural commodity prices. Data by Mitchell (2008) asserts that the crude oil prices are responsible for about 12 and 15 percent of high agricultural commodity prices (2007-2008). Charlebois and Hamann (2010) argue that agricultural commodity prices could increase by 10 percent for corn and soybeans and 7 percent for wheat, given projected crude prices from 2008 to 2011.

Du et al. (2009) in analyzing the correlation between crude oil prices and agricultural commodities prices find that the price changes in wheat, corn, and soybeans are highly integrated with oil prices shocks. While they do not find statistical significance from November 1998 to October 2006, there is statistical significance from October 2006 to January 2009. These results occur because of the market instability experienced in wheat, corn, and soybeans prices, which began in the fall 2006 (Irwin and Good 2009). According to Trostle (2008), this instability is the direct result of the strong interest in biofuels produced from agricultural commodities.

2.2.1.2 Renewable Fuels Interest

There is little doubt that the global production of biofuels has expanded considerably in recent years (Tangermann 2011). The biofuels market has begun to utilize a significant portion of planted acres for those crops that can be used to produce biofuels, which has resulted in low stock to use ratios for these commodities (Organization for Economic Cooperation and Development (OECD) 2010). In the U.S, ethanol is made from corn, while biodiesel is derived from soybeans (Babcock 2011). In 2008, according to data from the U.S Department of Agriculture (2011), the price of corn and soybeans reached record levels in part because they were used to produce ethanol and biofuel. Consequently, the world stocks to use ratios for these commodities, approximately 19 percent for both, were 5 and 2 percent lower than the average between 2003 and 2007.

The impact of biofuels consumption on the price of agricultural commodities has reached magnitudes about 30 and 40 percent between 2007 and 2008 (Perrin 2008; Tangermann 2011). They emphasize that the prices of biofuel feedstocks, including corn, vegetables oils, and sugar are higher today because the increasing production of biofuels, which in turn creates increased competition for agricultural acreage. The Center for Agricultural and Rural Development (CARD) (2007), the Food and Agriculture Organization (FAO) (2007), and the International Food Policy Research Institute (IFPRI) (2007) indicated that biofuel production was responsible for approximately 26 percent of the increase in soybeans prices, between 2006 and 2007.

The impact of biofuels production and demand, on agricultural commodity prices, is under debate (Tangermann 2011). Conley and George (2008), Muhammad and Kebede (2009), and Hertel and Beckman (2010) stated that the emerging biofuel market would cause structural changes not only in the acreage of agricultural commodities allocated to biofuel production, but also in the transmission of volatility from energy markets to agricultural commodities prices. Data by Mitchell (2008) asserts that between 70 to 75 percent of the increase in food prices from 2006 to 2008 is due to the increase in the bio-fuel utilization of agricultural commodities during that same period.

2.2.1.3 Soybeans Futures Price Volatility and Energy Markets

Increasingly evidence shows that the co-integration between energy and agricultural markets also has implications on the price variability of agricultural commodities. Guidry (2006), the Food Agriculture Organization (FAO 2008), Saghaian (2010), and Tangermann (2011), conclude that there are two reasons to argue for price volatility due to the integration between energy and agricultural markets. First, many of the inputs used in the agricultural production (fertilizer and fuels) are oil derivatives; thus, fluctuating oil prices raises the volatility of production costs, which pass through to commodity price volatility. Second, high oil prices promote interest in biofuels, which result in competition for the use of soybeans and affects stock to use ratios.

Table 2. Monthly Soybeans Futures Price Volatility and Oil Spot Prices.

	Jan 1999 - Feb 2002	Mar 2002- Apr 2005	May 2005- Jun 2008	Jul 2008 - Aug 2011	CAGR
Soybeans Futures Price Volatility	14%	20%	18%	22%	4%
Oil Spot Prices (USD/barrel)	24.91	35.42	73.72	78.75	9%

Source: CBOT (2011) and USDA (2011). Note: CAGR denotes compounded annual growth rate.

Table 3. Annual World Soybeans Stock to Use Ratio

	1999-2001	2002-2004	2005-2007	2008-2011	CAGR
World Soybeans Stock to Use Ratio	19%	22%	25%	23%	1%

Source: CBOT (2011), USDA (2011). Note: CAGR denotes compounded annual growth rate.

Over the period January 1999 to August 2011, the compounded annual growth rate (CAGR) of soybeans futures price volatility reveals an increase of 4 percent, while the oil spot price a 9 percent (Table 2). Although the monthly futures price variability in soybeans and oil spot prices generally increased in the same direction, for the period 2005-2007 this did not hold true (Figure 1). This likely occurred since the world soybeans stock to use ratio observed over that period (Figure 2) reached a record level of 25 percent due to a record level of production register in the 2005-2007 period (Table 3). This production was 13 percent more than 2002-2004 (USDA 2011).

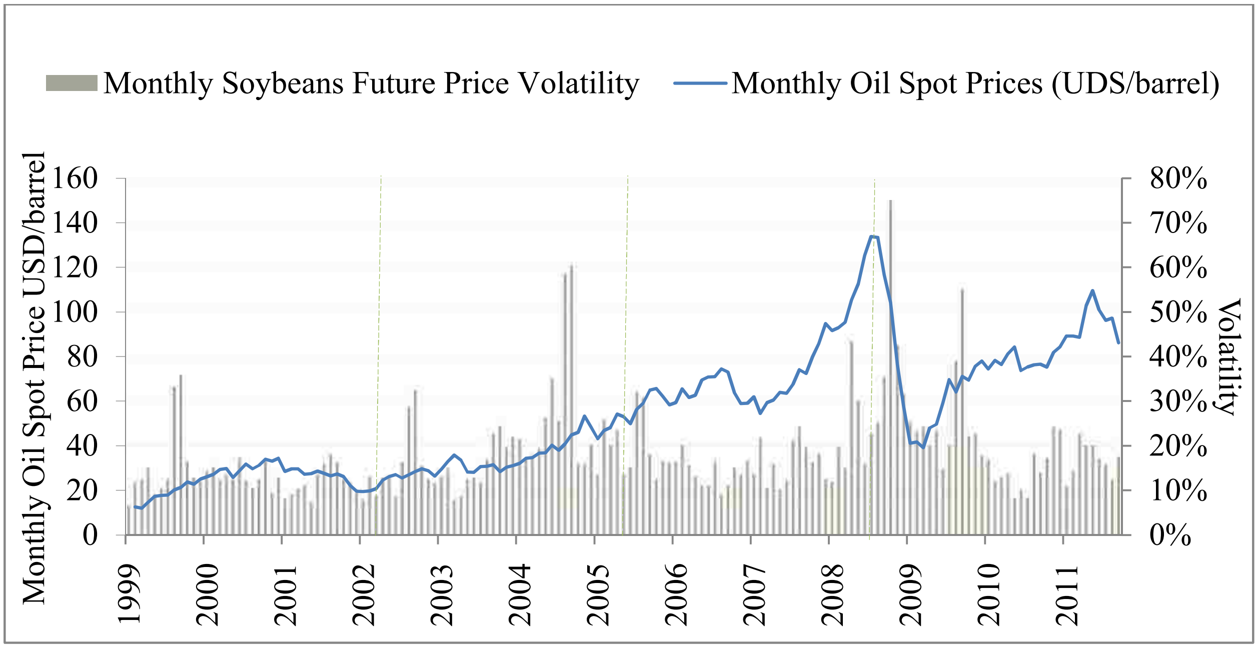

Figure 1. Monthly Oil Spot Prices and Soybeans Futures Price Volatility.
Source: CBOT (2011) and FRED (2011).

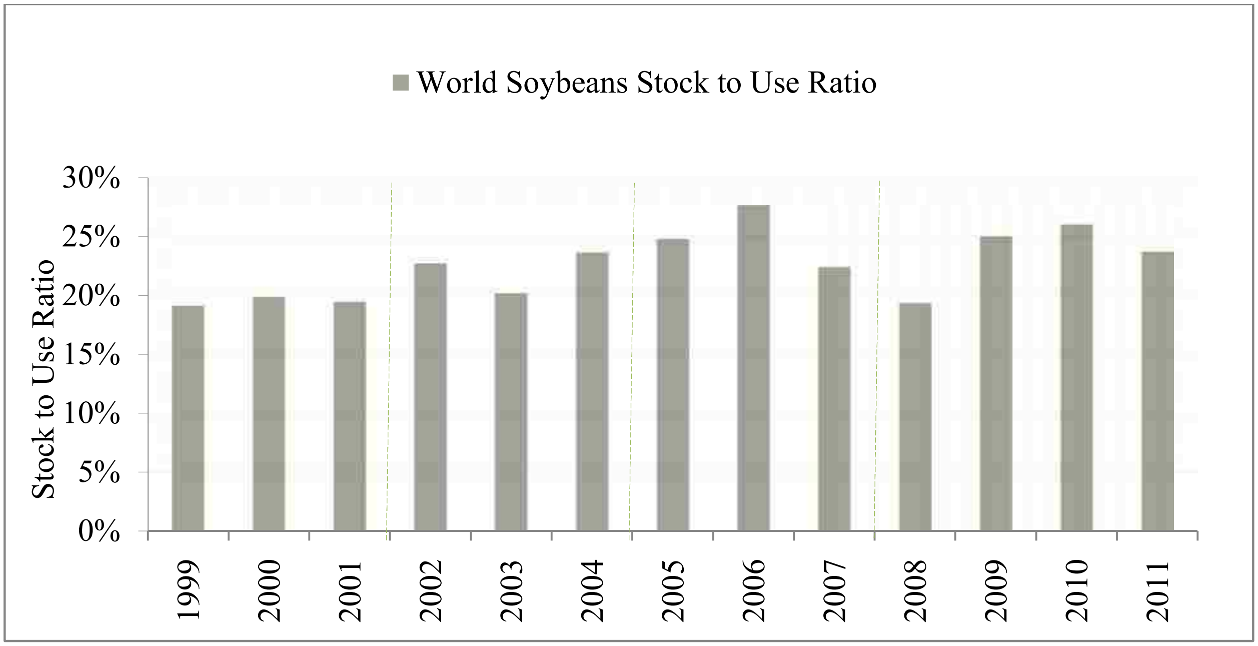

Figure 2. Annual World Soybeans Stock to Use Ratios.
Source: CBOT (2011), USDA (2011).

Although the effect of the biofuel policy in the U.S is not implicit in Figure 1, Trostle (2008) indicates that for most commodities, the increasing consumption of biofuels began to occur in the fall of 2006. Clearly, after 2006, the volatility started to increase until reaching a peak value in August 2008.

2.2.2 The Role of Macroeconomic Conditions in the Supply/Demand Balance

In addition to the previous factors, evidence suggests that macroeconomic conditions are also key drivers of commodity price volatility (Karali and Power 2009). Surprisingly little is known about the relationship between commodity market volatility and economic fundamentals (Viesser 2009). Studies on volatility have suggested that there is significant evidence of integration between stock market volatility and the movements of macroeconomic fundamentals, such as the rate of inflation, Gross Domestic Product (GDP), currency exchange rates, and industrial production (Schwert 1989; Engle et al. 2008). These findings have been used as the basis for arguing that certain macroeconomic variables influence the volatility of agricultural markets (Hailu and Weersink 2011)

For instance, Karali and Power (2009) assert that for most commodities volatility increases significantly with inflation and economic growth, but decreases with the risk-free rate. Hamilton and Lin (1996) assert that volatility in commodity prices appears to be higher during recessions. Schnepf (2008) argues that there is a linkage between the long-run commodity prices and macroeconomic variables, such as population and per-capita income. For example, both, the 1997 Asian crisis and the 2008 U.S financial crisis contributed significantly to price declines in most international commodity markets.

Helbling et al. (2008) examine the links of macroeconomic factors, such as the U.S. dollar/Euro exchange rate to commodity price. They conclude that because most commodities are priced in U.S dollars, and that this exchange rate has continuously declined since 2002 (Piesse and Thirltle 2009), the demand for agricultural futures contracts has increased, as instruments of protection (against inflation), relative to stocks, bonds, or currencies (Steil 2006). The weakness of the U.S dollar compared to major currencies, such as Yen (Japan), Euro (Europe Union), Yuan (China), and Real (Brazil) is responsible for approximately 20 percent of the increase in food prices between 2002 and 2008 (Mitchell 2008).

Despite the increasing evidence regarding the role of macroeconomic factors on agricultural commodity prices, there is limited empirical analysis on the relationship between macroeconomic variables and commodity price volatility. The evidence from Piesse and Thirltle (2009), Tangermann (2011), Hailu and Weersink (2011) assert that the increase in well-being of countries such as China, contributes significantly to the increase in consumption of food products produced from commodities. This increase in consumption lowers the stock to utilization ratios of agricultural commodities, similar to those observed in the 1970s, thereby increasing price volatility in commodity markets.

As Tangermann (2011) notes that since the demand for commodities from developing countries, increases rapidly as their economies grow (measured by the GDP); the demand elasticity becomes more elastic in the short-run. Furthermore, because of the nature of agricultural commodity production, supply response to a higher demand is limited, thereby creating a more inelastic supply in the short-run. Consequently, a more elastic demand curve combined with a more inelastic supply curve results in higher agricultural commodity prices.

The rapid economic growth in China (GDP of 9.5 percent, on average, over last 10 years; World Bank 2011) has fueled China's growing demand for agricultural commodities, including soybeans. Data from the U.S Department of Agriculture (2011) indicates that the domestic soybean production in China accounted for roughly 50 percent of its total consumption from 1999 to 2004 (Table 4). In 2011[1] however, only 25 percent of consumption could be meet with domestic production (Figure 3). This increasing deficit has been replaced by imports from countries such as Argentina, Brazil, and the U.S. These countries are responsible for 80 percent of the world soybeans production and 90 percent of the world exports. More importantly, China has been accounted roughly for 60 percent of the world imports from 2009 to 2011 (USDA 2011).

Table 4. Annual Soybeans Production to Consumption Ratio in China.

	1999-2001	2002-2004	2005-2007	2008-2011	CAGR
Production/Consumption	58%	45%	32%	25%	-7%

Source: USDA (2011). Note: CAGR denotes compounded annual growth rate.

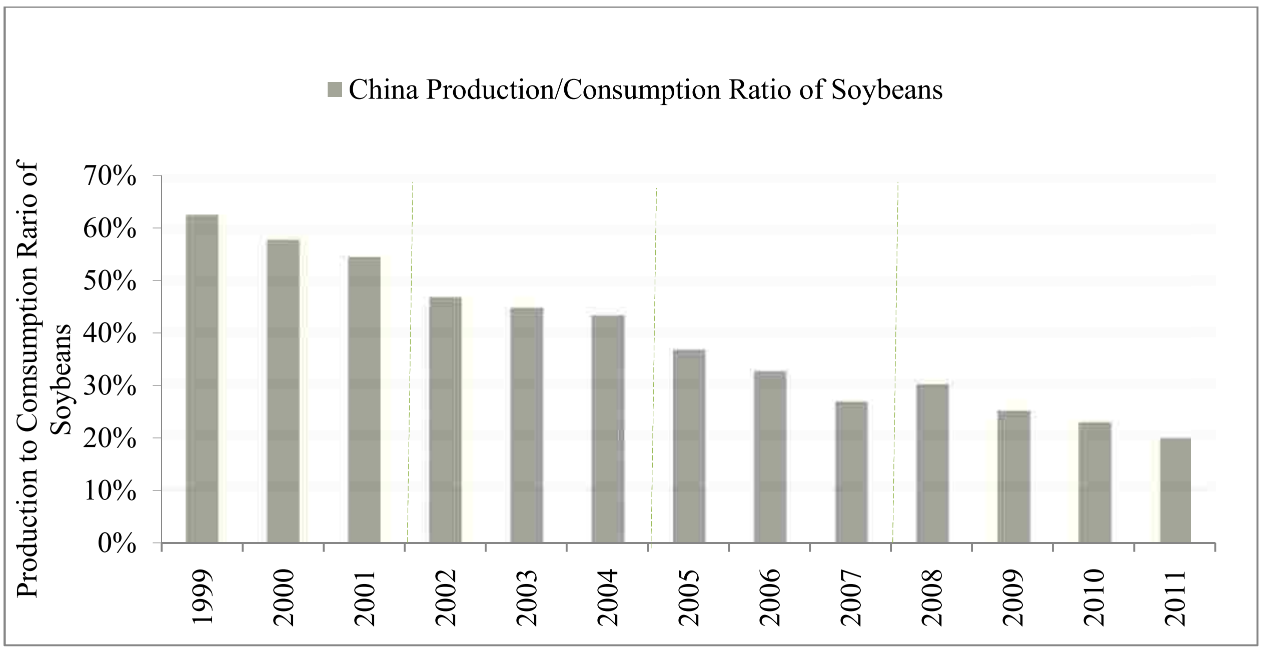

Figure 3. Annual Production/Consumption Ratio of Soybeans in China.
Source: USDA (2011).

2.2.2.1 Soybeans Futures Price Volatility and Macroeconomic Factors

According to Tangermann (2011), macroeconomic conditions particularly in China are key drivers of commodity price volatility. Furthermore, Hamilton and Lin (1996) assert that the

[1] The annual soybeans production to consumption ratio in 2011 is estimated by the USDA (2011).

volatility is higher during recessions. Figure 4 introduces the nominal annual growth of GDP in China and the U.S. Over the period 1999-2011[2], annual volatility of soybeans increased at a rate of 4 percent, and China GDP growth in 1 percent. Over that same period, U.S GDP decreased by 10 percent (Table 5). During the period 2008-2011, the annual growth of GDP in the U.S and China is declining while soybean price volatility is increasing.

Table 5. Annual Soybeans Futures Price Volatility, China and U.S GDP.

	Jan 1999 - Feb 2002	Mar 2002- Apr 2005	May 2005- Jun 2008	Jul 2008 - Aug 2011	CAGR
Growth of U.S GDP	5%	5%	6%	1%	-10%
Growth of China GDP	8%	10%	13%	10%	1%

Source: CBOT (2011), FRED (2011) and IFM (2011). Note: CAGR denotes compounded annual growth rate.

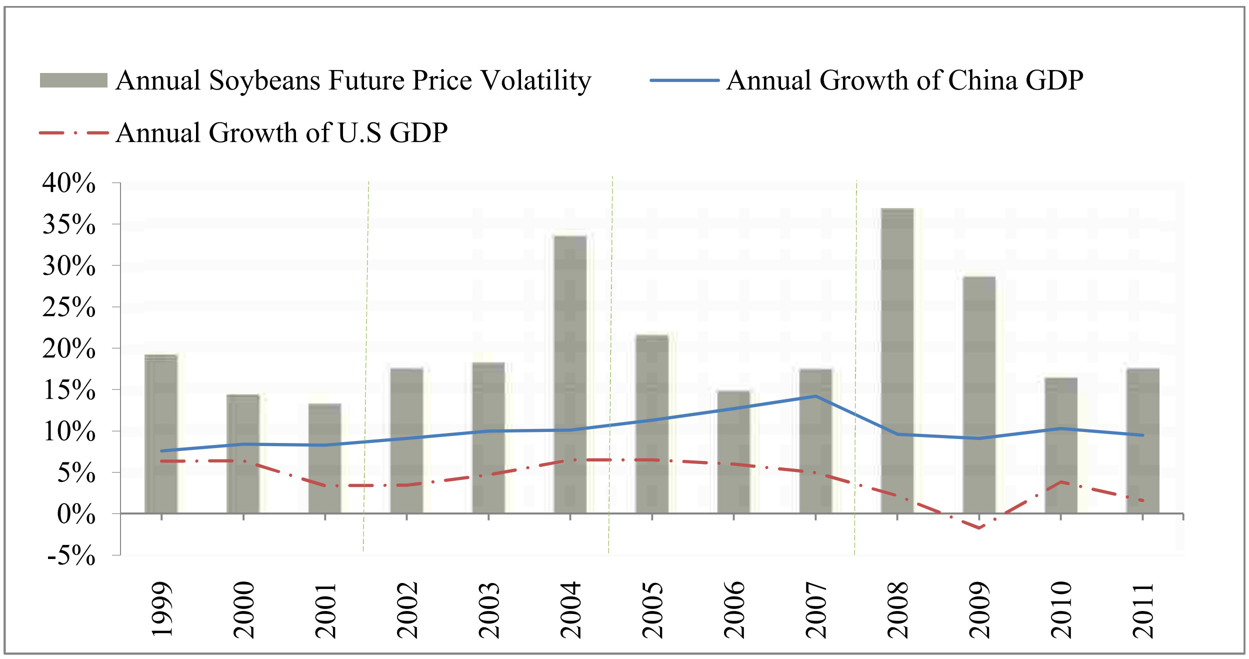

Figure 4. Annual Growth of China and U.S GDP and Soybeans Futures Price Volatility. Source: CBOT (2011), FRED (2011) and IFM (2011).

Trostle (2008) also asserts that the increasing volatility of commodity prices, is also influenced by the strength/weakness of the U.S Dollar. Figure 5 illustrates the monthly U.S dollar index, which accounts for three currencies, Argentina (Peso), Brazil (Real), and China

[2] The Annual U.S and China GDP in 2011 are estimated by the IFM (2011).

(Yuan). Furthermore, Figure 6 illustrates the monthly soybeans imports of China from Argentina, Brazil and the U.S from January 1999 to August 2011.

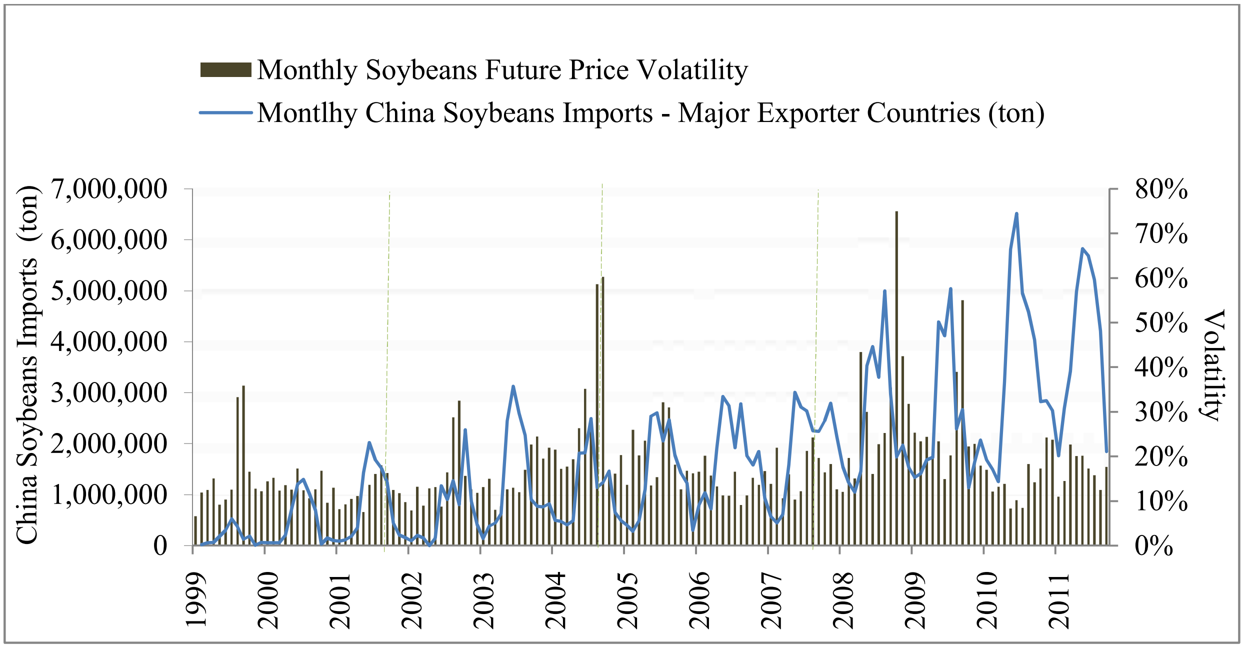

Figure 5. Annual China Soybeans Imports and Soybeans Future Price Volatility.
Source: CBOT (2011), SAGyPA (2011) and MAPA (2011).

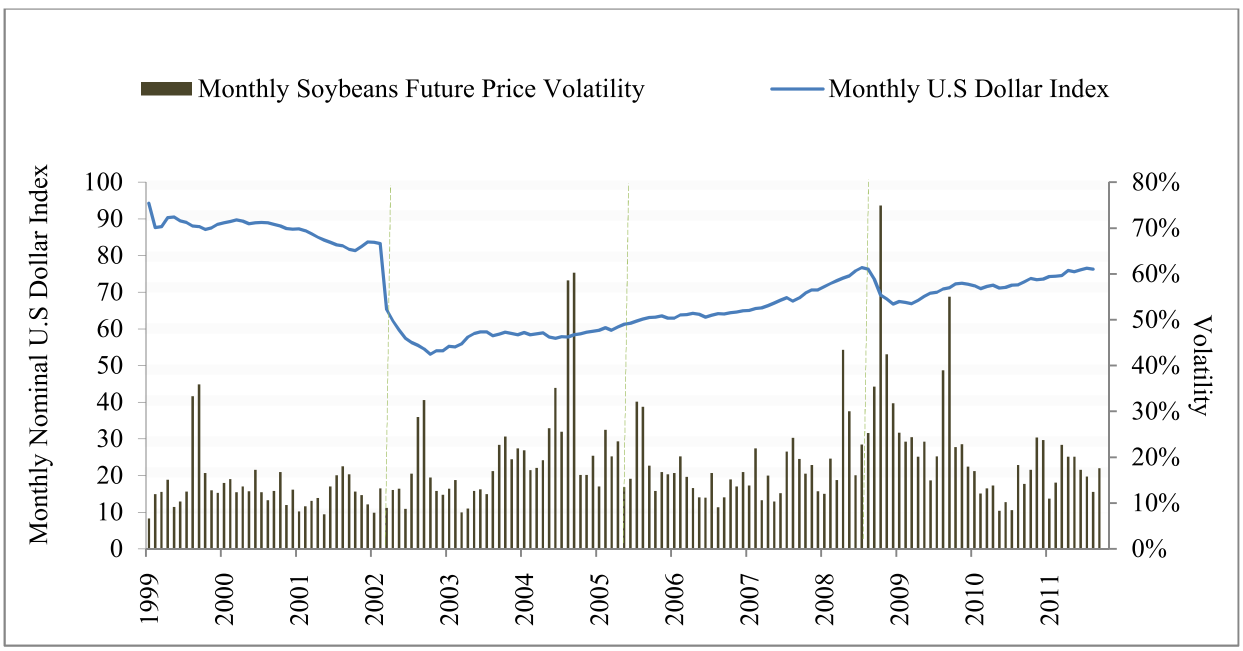

Figure 6. Monthly U.S Dollar Index and Soybeans Futures Price Volatility.
Source: CBOT (2011) and FRED (2011).

Over the January 1999 to August 2011 period, the compounded annual growth rate (CAGR) of the U.S dollar index decreased at a rate of 1 percent (Table 6) and the monthly imports of soybeans increased 16 percent (Table 7). In general, as the U.S dollar index declines, both imports of soybeans to China and the soybeans futures price volatility increases.

Table 6. Monthly U.S Dollar Index.

	Jan 1999 - Feb 2002	Mar 2002- Apr 2005	May 2005- Jun 2008	Jul 2008 - Aug 2011	CAGR
U.S Dollar Index	87	58	66	72	-1%

Source: CBOT (2011) and FRED (2011). Note: CAGR denotes compounded annual growth rate.

Table 7. Monthly China Soybeans Imports.

	Jan 1999 - Feb 2002	Mar 2002- Apr 2005	May 2005- Jun 2008	Jul 2008 - Aug 2011	CAGR
China Soybeans Imports (ton)	456,870	1,074,653	1,901,821	3,164,505	16%

Source: CBOT (2011), SAGyP (2011), and MAPA (2011). Note: CAGR denotes compounded annual growth rate.

2.2.3 The Role of Financial Speculation in the Open Interest Composition

The role of financial speculation on commodity prices is the subject of much debate in the financial and agricultural economics literature. Competing opinions exist on whether there is any impact at all. Institutions such as the Institute for Agriculture and Trade Policy (IATP) (2008) and the Food and Agriculture Organization (FAO) 2008 indicate that speculation has pushed commodity prices out of the reach of lower income households. On the other hand, the increasing interest of speculators in futures contracts as opposed to bonds, currencies, and stocks (Steil 2006) increases price volatility in agricultural commodity markets (Guidry 2006).

Brooks and Chance (2010) note that open interest (the total number of contracts traded in a day) is compounded by hedgers and speculators in general, but each group has different purpose. The hedger group includes those participants who have a position in the spot (cash) market and the futures markets, for commercial purposes (Commodity Futures Trading Commission 2011), while the speculator group includes individuals who attempt to profit by guessing the direction of the market. This last group contains sub-classifications, traditional and non-traditional (Master and White 2008). Traditional speculators take long and short positions (spreads), while non-traditional speculators only hold long positions, i.e. index funds and mutual funds. The latter have received special attention in recent years due to their increasing participation in and likely influence on futures markets.

Studies by Masters and White (2008), Gosh (2008), Petzel (2009), and Tang and Xiong (2009), examine the open interest composition. They assert that the unleveraged futures position index funds (long only) have created an artificial demand for commodities. Their findings emphasize that the net flows invested (as reported by the Commodity Index Trader) for several firms, such as the Dow Jones AIG Commodity Index (DJ-USB), the Standard & Poor's Goldman Sachs Commodity Index (S&P-GSCI), and the Power-Shares Dutch Bank Agricultural Index (DB-AGI) have increased considerably. Between the S&P-GSCI and the DJ-USB the net flows invested increased from approximately $25 billion in 2004 to $62 billion in 2008 (Masters and White 2008). These two index funds accounted for 63 and 32 percent of the total Commodity Index Trader (CIT) positions in 2008, respectively.

Table 8. Index Speculator and Futures Prices Change.

	Index Speculator (IS)				Futures Price Change
	Units	Jul-03 (1000)	Jul-08 (1000)	IS Change	Jul-03 and Jul-08
Corn	Bushel	242,561	2,313,370	> 8.5 times	+ 214%
Soybeans	Bushel	81,028	910,400	> 10 times	+ 160%
Wheat	Bushel	166,738	106,006	> 5 times	+ 177%

Source: Master and White (2008).

To put into perspective the increasing interest of speculators in futures contracts, between 2003 and 2008, the purchases of futures contracts by index funds were more than eight times, in corn, ten times in soybeans, and five times in wheat (Table 8). Over that same period, the price of corn, soybeans, and wheat almost doubled (Masters and White 2008). Gosh (2008) claims that this change occurred when the Commodity Futures Trading Commission (CFTC) deregulated, i.e. traders no longer had to disclose their holdings for each commodity and/or maintain specified position limits to prevent market manipulation.

Anecdotally, these popular index funds contain commodities, including corn, soybeans, and wheat as part of their constituent weights (Table 9). This evidence leads researches to conclude that financial speculation is a key driver of higher than expected commodity price volatility, i.e. volatility that is not in line with supply and demand conditions (Masters and Whites 2008).

Table 9. Constituents Weights of Major Index Funds.

	DJ-USB	S&P- GSCI	DBA-AGI	Reuters CRB	Rogers ICI	
	31-12-2010	31-05-2011	31-03-2011	31-03-2011	31-03-2011	Average
Corn	8.01%	4.30%	12.50%	6.00%	13.02%	8.77%
Soybeans	7.26%	2.70%	12.50%	6.00%	6.42%	6.98%
Wheat	4.22%	3.80%	6.25%	1.00%	13.02%	5.66%

Other studies contradict the idea that financial speculation is a driver of commodity price volatility observed from 2006 to 2010. Bryant et al. (2006), Gorton et al. (2007), the Commodity Futures Trading Commission (2008), Buyuksahin and Harris (2009), and Irwin et al. (2009, 2010, and 2011) also analyzed the volume of speculation in the open interest composition. They examined either the expansion of nearby spreads, the magnitude of index funds as reported by the Commodity Index Trader (CIT), or the non-commercial long positions as reported by the Commission of Traders (COT). Their findings, categorically assert, that there is in-sufficient evidence to conclude a linkage between excessive financial speculation and price volatility in commodity markets.

Studies related to financial speculation and the prices of agricultural commodities use a variety of data, such as an index speculator, which is computed as a ratio of the long-only positions and the dollar value of a future contract (Masters and White 2008), and index funds

(Irwin et al. 2009, 2010). However, none of them makes inferences about the number of speculative funds, i.e. mutual and index funds that track agricultural commodities available for public investment (Table 10).

Table 10. Number of Mutual and Index Funds.

	Mutual Funds	Ticker	Month	Launch Year
1	Oppenheimer Commodity Strategy Real Asset	QRAAX	03	1997
2	PIMCO Commodity Real Return Strategy	PCRAX	06	1997
3	Credite Suisse Commodity Return Strategy	CRSAX	12	2004
4	DWS Enhanced Commodity Strategy	SKNRX	02	2005
5	Rydex Commodities Strategy	RYMEX	05	2005
6	Fidelity Series Commodity Strategy	FCSSX	10	2005
7	Goldman Sachs Commodity Strategy	GSCAX	03	2007
8	Invesco Balanced-Risk Commodity Strategy	BRCNX	04	2008
9	ING Goldman Sachs Commodity Strategy	IGCPX	07	2008
10	Coxe Commodity Strategy	CXCMF	06	2008
11	JP Morgan Highbridge Dynamic Commodity	HDCSX	01	2010
12	Direxion Commodity Trends Strategy	DXSCX	03	2010
13	Eaton Vance Parametric Structured Commodity	EIPCX	04	2010
14	MFS Commodity Strategy	MCSAX	06	2010
15	Jefferies Asset Management Commodity Strategy	JCRAX	06	2010
16	Russell Commodity Strategy Fund	RCSCX	06	2010
17	HC Capital Trust - The Commodity Real Strategy	HCCAX	07	2010
18	Harbor Commodity Real Return Strategy	HACMX	09	2010
19	Arrow Commodity Strategy	CSFFX	12	2010
	Index Funds	Ticker		Launch Year
1	Reuters Commodity Research Bureau	TR/J CRB	04	1986
2	S&P Goldman Sachs Commodity Index	S&P-GSCI	07	1992
3	Dow Jones Commodity Index	DJ-USB	06	1998
4	Rogers International Commodity Index	RICI	01	1998
5	Deutsche Bank Commodity Index	DBC	03	2003
6	Van Eck Cm Commodity Index Fund	COMIX	04	2010

For the period 1997-2004, only two mutual funds, the Oppenheimer Real Asset Fund (QRAAX) and the Pacific Investment Management Real Return Strategy Fund (PCRAX), invested in commodity futures markets through commodity indices. By the end of 2010 however, the number of mutual funds that tracked commodity indices had increased to fifteen. Likewise, from 1991 to 2002 there was only one commodity market index fund (Reuters Commodity

Research Bureau), but by the end of 2010, this number had increased to five (Standard and Poor's (S&P-GSCI), Dow Jones (DJ-USB), Rogers International (RICI), and Deutsche Bank Commodity Index (DBC)) (Table 10). Anecdotally, as the number of mutual funds that tracked commodity indices increased, so did their investments under management[3]. According to the Security Exchange Commission (SEC) (2011) investments by mutual funds in commodities soared from 13.8 to 24.8 billion dollars, on average, between 2005 and 2010 (Table 11).

Table 11. Investments of Mutual Funds

	Schedule of Investments	Number of Mutual Funds	USD Billions	PIMCO (PCRAX)	OPPENHEIMER (QRAAX)	FIDELITY (FCSSX)
2005	2nd SEM	3	12.2	84%	5%	5%
2006	1st SEM	3	15.4	74%	12%	13%
	2nd SEM	5	17.9	69%	8%	20%
2007	1st SEM	7	18.5	69%	7%	23%
	2nd SEM	7	20.3	67%	7%	26%
2008	1st SEM	8	23.3	66%	7%	27%
	2nd SEM	8	17.9	68%	8%	24%
2009	1st SEM	8	18.1	68%	4%	28%
	2nd SEM	8	21.3	66%	6%	29%
2010	1st SEM	12	23.1	69%	7%	24%
	2nd SEM	15	26.6	72%	6%	22%

Source: SEC (2011)

Consequently, this research asks if the number of mutual and index funds investing in agricultural commodities are capable of explaining price volatility in the soybeans futures market. *A priori* expectations suggest that as more and more of these investment vehicles become available to several public, they are more likely to incorporate them in their investment portfolios.

2.2.3.1 Soybeans Futures Price Volatility and Financial Speculation

A variety of data has been used to examine the influence of financial speculation on commodity price variability, such as non-commercial long-only position as reported by the COT

[3] The assets under management denote the dollar value of the portfolio being management.

and the CIT, and spreads positions. However, the conclusions reported are inconclusive. Figure 7 illustrates the average monthly soybeans future price volatility (expressed on an annual basis) and the monthly average non-commercial long-only positions as reported by the COT between 1999 and 2010. Over the period, the monthly soybeans future price volatility and the long-only positions increased at an annual rate of 5 and 14 percent, respectively (Table 12).

Table 12. Monthly COT Non-commercial Long Positions.

	Jan 1999 - Feb 2001	Mar 2002- Apr 2005	May 2005- Jun 2008	Jul 2008 - Aug 2011	CAGR
Non-Commercial Long-only Positions.	27,129	53,497	108,141	138,471	13%

Source: CBOT (2011) and CFTC (2011). Note: CAGR denotes compounded annual growth rate.

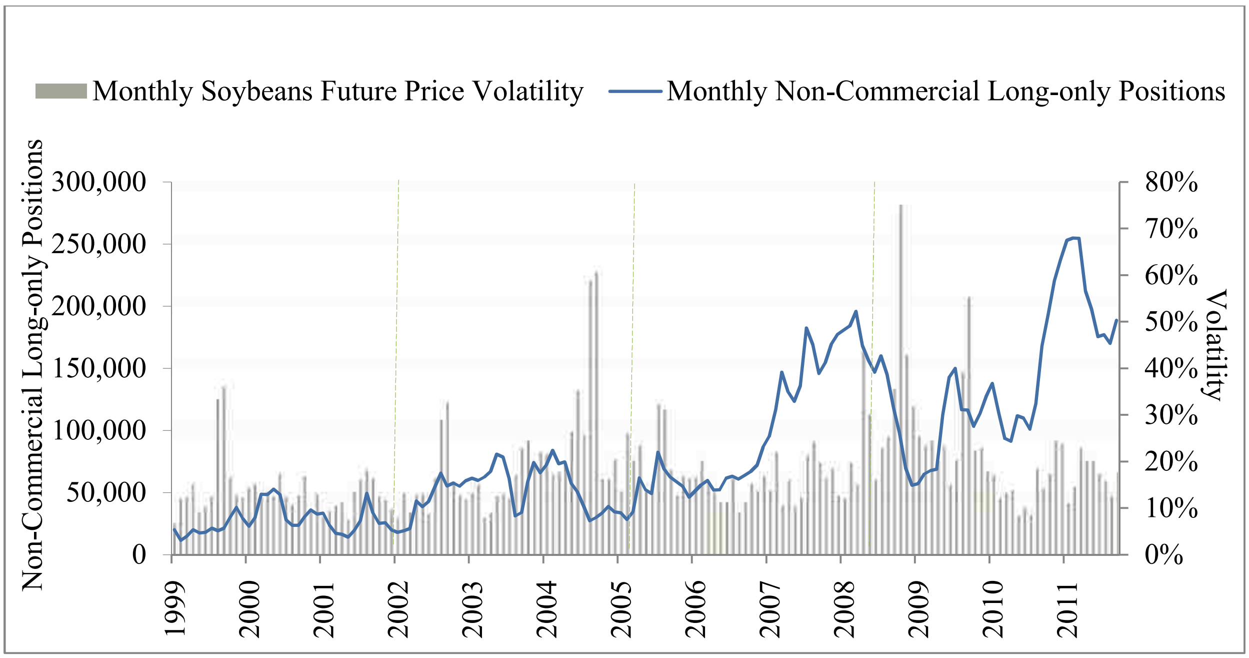

Figure 7. Monthly Non-Commercial Long-only and Soybeans Futures Price Volatility. Source: CBOT (2011), and CFTC (2011).

2.3 The Economic Framework of Commodity Market Models

According to Robledo (2002), grain markets have attracted considerable interest of scholars since 1940s. The study of Labys (1973), Labys and Pollak (1984), Tomek and Myers (1993), and Tomek (1997) provide significant evidence of the evolution of this literature. In general, they assert that the main components of commodity markets are subjected to commodity demand, supply, inventories, and prices. The demand for a commodity depends on its price, per capita income, population, and export demand, while the supply component depends on crop yields, technology, levels of export/imports, and weather conditions.

The specific economic relationships that explain commodity demand and supply are derived from the economic theory of consumer demand and production, inventory relationships are derived from the partial adjustment to equilibrium theory, and price relationships are derived from the competitive or noncompetitive nature of markets (Nerlove 1958). As exposed in the previous Chapter, this research explores four relevant variables that influence soybeans futures price volatility, oil spot prices, U.S renewable fuel price, U.S dollar index, China soybeans imports (a proxy of unmet consumption), and the number of mutual and index funds, each of them are explained by consumer demand and supply theory (Robledo 2002).

The supply function is more concerned with the responses of output to one or more prices, as opposed to the production function, which describes the relationship between output and various inputs. The static supply schedule of an individual firm, derived from the theory of production to describe commodity behavior is illustrated by equation 2.3.1

$$(2.3.1)\ q_t^{(s)} = f(p_{1,t}, p_{2,t}, w_{1,t}, \ldots, w_{k,t}, u_t^{(s)})$$

where $p_{1,t}$ is the price of the commodity of interest, $p_{2,t}$, refers to the prices of inputs to the production process or to prices of other commodities closely related in production, $w_{1,t}, \ldots, w_{k,t}$, are noneconomic determinants, such as technological or institutional/political factors, and $u_t^{(s)}$ is a stochastic disturbance term (Labys 1973).

Certain commodity models require that a distinction be made between country or domestic demand/supply and country exports. Some models may focus their attention on the demand of a given commodity for exports, while others on the supply for exports. This research is concerned for the demand of exports. Export equations as well as other factors such as exchange rates, prices of competing countries, and stocks in the competing exporter countries can be included following the theories of demand or supply behavior. The empirical specification of demand relationships is referenced in the literature as ad-hoc or partial demand specification. The early history of empirical demand analysis is marked not by an attention to theory but by the extensive use of single equation methodology centered on the measurement of elasticities. According to Keynes (1993) and Garcia and Leuthold (1997), elasticities are easily too understood and can be directly derived from parameters of a linear regression.

2.4 Modeling Price Volatility

Although, there are a variety of models utilized to analyze factors influencing price volatility, academic and policy analyses tend to focus on integration, cointegration and/or error correction (Table 13). Examples of co-integration analysis relevant to this study include Harris (2009) who analyzed the effect of speculative funds on commodity prices. Similarly, Campiche et al. (2009) examined co-integration between food and oil prices. Likewise, Irwin et al. (2011) analyzed the impact of index funds on futures markets, and Yang et al (2001) studied storability effects on futures markets using a Granger Causality test.

The developments in co-integration theory by Engle and Granger (1987) has provided a framework to examine the explicit relationships between futures markets and variables, such as spot prices, interest rates, storability, speculative funds, and oil prices. Co-integration analysis implies that equilibrium holds except for a stationary, finite variance disturbance even-though the series are non-stationary and have infinite variance (Engle 1986). For instance, if the tails of the distribution are fat, then the central limit is not a useful approximation to the true distribution and co-integration analysis fails (Ozgu, 2010). Unfortunately, tests used to define presences of finite variance, such as the Wilcoxon Mann-Whitney, the Normal, and the Sign-Median tests are non-parametric, which may lead to misspecification of the model since they utilize the rules of probabilities, instead of a defined statistical distribution, such as normal distribution.

The main purpose of this study is identifying those factors that influence soybeans futures price volatility. By definition, volatility seeks to capture the strength of the (unexpected) return variation over a given period of time (Andersen et al. 2005). The Error Correction Model (ECM) is useful to explain the relationship between non-stationary and co-integrated variables, but it is focused on a time-varying mean process (Hill et al. 2008), which implies that the variance is constant over time. This does not hold true for a time-varying volatility. Thus, prior to modeling volatility, the data generating process (DGP) must be defined, to avoid spurious regressions (Hill et al. 2008) and to ensure the principle of parsimonious (simple models are usually preferred to complex models) (Diebold 2007).

Table 13. Summary of Methodology Applied on Recent Empirical Analysis.

Year	Author(s)	Methodology	General Findings
1993	Zapata and Fonterbery	ECM	The futures prices are unbiased predictor of cash prices for storable commodities (corn and soybeans) for some crop years, but no for others since it depends entirely on the time series properties of the cost of carry.
1995	Zapata and Fonterbery	ECM	The interest rate co-moves to futures prices and cash prices.
2001	Yang et al.	ECM	The storability component of commodities does not affect the effectiveness of futures prices as predictors of cash prices.
2007	Campiche et al.	Johansen and Jesulius cointegration	High oil prices are co-integrating to high commodity prices.
2008	Mitchell	Partial Equilibrium Analysis	The macroeconomic variables, among others, have affected price changes in agricultural commodities.
2008	Irwin et al.	GARCH	There is not empirical evidence of causality between Index funds and agricultural commodity prices.
2009	Irwin et al.	R-squared as measured of hedging efficiency	Poor convergence of agricultural commodity prices since 2006.
2009	Karali and Power	GARCH	The macroeconomic factors, such as GDP also affects the volatility of storable commodities.
2009	Tiang and Xiong	Cross-sectional Analysis	Cointegration between Index funds and agricultural commodity prices
2009	Tiang and Xiong	Cross-sectional Analysis	There is not empirical evidence of causality between Index funds and agricultural spreads price.
2010	Harris	Granger Causality	There is not statistical evidence that the price volatility experienced by futures markets is caused by speculative funds.
2010	Charlebois and Hamann	Vector Autoregressive	Higher prices for corn, soybeans and wheat around 14 percent, in average, from 2008 to 2011 due to high oil prices.
2010	Saghaian	Granger Causality	Cointegration between ethanol, oil and soybeans prices.
2010	Hertel and Beckman	Applied General Equilibrium	The production of bio-fuels strengthens the transmission of energy price volatility on agricultural commodity price variation.
2011	Irwin et al.	Granger Causality	There is not empirical evidence of causality between Commodity Index Trader (CIT) and recent commodity prices.

Note: Error Correction Model (ECM) and General Autoregressive Conditional Heteroskedasticity (GARCH).

CHAPTER 3. METHODOLOGY

The first part of this chapter introduces the elements of modeling volatility in agricultural commodities. The second part provides the tools for recognizing the data generating process (DGP). The third part introduces the specific model used to examine soybeans futures market volatility as a function of oil spot prices, U.S renewable fuel policy, imports of soybeans to China, the U.S dollar index value against major currencies, and financial speculation.

3.1 Modeling Volatility

3.1.1 Volatility in Agricultural Commodities

According to Diebold (2007), volatility is crucially important in economic and financial contexts since it has implications for risk management, asset allocation, and asset pricing. Moreover, many production decisions are made well in advance of product sales, and there generally exists an uncertainty about the price that will be received for products when sold in the market at a future date (OECD 2009).

Four kinds of volatility are commonly found in the literature, historical volatility (standard deviation, coefficient of variation, and mean absolute deviation), implicit future volatility, realized volatility, and General Autoregressive Conditional Heteroskedasticity (GARCH) volatility (Andersen et al. 2005; European Commission 2009; Matthews 2010). Historical volatility is derived from past prices, and it provides an indication of how volatile past prices have been. Implicit futures volatility corresponds to the markets' expectation on how volatile a price will be in the future, measured via a commodity's option price (Smith 2011). Realized volatility, also derived from past observations, is usually estimated based on high frequency data (intraday) and provides a consistent nonparametric estimate of price volatility that is obtained over a given discreet interval. Finally, GARCH volatility proposed by Engle and

Bollerslev (1986), and discussed by Taylor (1986) is based on the conditional variance of the residuals. Since this research examines volatility from historical nearby daily futures price data, it utilizes the historical volatility measure.

Several historical volatility measurements have been used in the literature with most of them employing measures based on price levels (OECD 1991). Likewise, most studies have focused on the standard deviation of prices or on the coefficient of variation of the logarithmic price. The main advantage of these estimators is that they do not depend on the unit of measurement.

Some authors, such as Gilbert (2006), Jacks et al. (2009), and Gilbert and Morgan (2010) used the standard deviation of the first difference of the logarithmic value of prices, while others such as Cuddy and Della Valle (1978) and Matthews (2010) used a de-trended series to compute volatility. The advantage of the first computation is its simplicity, relative to the second, because the de-trended method requires the estimation of a trend. A central issue with the de-trended series methodology is that the volatility measure may depend on the choice of the de-trending technique. For instance, Cuddy and Della Valle (1978) proposed a corrected coefficient of variation, based on linear and log-linear trend.

Torero and Hernandez (2010) utilize the mean absolute deviation on logarithmic returns, as a measure of volatility to examine if past values of futures price in agricultural commodities (soybeans, wheat, and corn) are able to explain the volatility of spot prices (Crain and Lee 1996). They do not provide any justification for why this type of volatility measurement should be used. Ederington and Guan (2004) in forecasting volatility of stocks utilized an adjusted mean absolute deviation (MAD) of logarithmic returns, in order to compare this value to the historical standard deviation (SDD) and GARCH volatility. They note that one of the main advantages of using

MAD, as a measure of volatility, is its simplicity to be computed by standard tools i.e. excel. Moreover, the estimator provides a better forecast of volatility than SDD, while still being as useful as the GARCH volatility measure.

Consequently, this research utilizes the historical volatility of the standard deviation of the logarithmic returns for three reasons. First, it is a unit free measurement, second for low volatility levels, it is approximately equal to the coefficient of variation (Gilbert and Morgan 2010), and finally it is a type of volatility utilized for conventional models to price options i.e. the Black-Scholes Merton. The historical volatility estimator used in this research is expressed in equation 3.1.1.1 and 3.1.1.2.

$$(3.1.1.1)\ R_t = ln\ (P_t / P_{t-1})$$

$$(3.1.1.2)\ V_t = \sqrt{252/n}\ \sum_{i=0}^{n-1} r^2{}_{t-i}$$

where R_t represents the logarithm returns, P_t denotes price at time t, and V_t denotes the annualized standard deviation of the logarithm returns and r_t is the deviation of the logarithm returns from the mean.

3.2 The Data Generating Process

Time series data is used by many groups to analyze a variety of problems, such as macroeconomists studying the behavior of national and international economies, financial economists analyzing the stock market, and agricultural economists in predicting supply and demand for agricultural products. Time series analysis is particularly important to financial markets because of the quantity of data available and because it is common for time series data not to follow a covariance stationary process. Diebold (2007) states that a series is a covariance stationary process, if its mean and variance are stable or constant over time.

3.2.1 The Seasonal Component and Stationarity

Although it is common to test for stationarity directly via the raw data, some such as Moledina et al. (2003) suggest that before testing for covariance stationarity, the predictable components of the price process, such as seasonality and inflation, should be removed, leaving only the stochastic component. Hanawa and Tomek (2000) however, suggest that deflated data could change the original properties of the data, producing illogical results. Since deflated data for commodity prices could change the properties of the original data, this research considers the Bureau of Census methodology, which is a variant of the X-11 procedure (Shiskin et al. 1967). This procedure is widely used because it generally provides satisfactory results in the seasonal adjustment of historical data (Wallis 1983). The X-11 method uses a set of centered moving averages to estimate the seasonal components.

The X-11 seasonal adjustment assumes that the main components of a time series (seasonality, trend, and cycles) of a time series follow a multiplicative (equation 3.2.1.1), and additive (equation 3.2.1.2), or a log additive model (equation 3.2.1.3). This methodology is consistent to the method proposed by Dibold (2007), he considers two approaches to remove the seasonal component: the first being an additive model (equation 3.2.1.1), and finally a multiplicative model (equation 3.2.1.3),

$$(3.2.1.1)\ y_t = Sn_t * Tr_t * Cl_t * \varepsilon_t$$

$$(3.2.1.2)\ y_t = Sn_t + Tr_t + Cl_t + \varepsilon_t$$

$$(3.2.1.3)\ log(y_t) = log(Sn_t) + log(Tr_t) + log(Cl_t) + \varepsilon_t$$

where y_t denotes the unadjusted series: the volatility of soybeans futures (SPV_t), the volatility oil spot prices (OPV_t), U.S renewable fuel policy, the volatility of the U.S dollar index value against major currencies (UDI_t), soybean imports to China (CSI_t), and the number of speculative fund (mutual and index funds) (NSF_t). Sn_t is the seasonal term, Tr_t the time trend, Cl_t the cycle term, and ε_t the error term. For the additive and log additive model the idea is that, the seasonal deviations are the same each year, while for the multiplicative models the seasonal component grows with y_t.

Selection of the appropriate seasonal method is based on a plot of the actual data (Terrell 2011). If the monthly volatility of soybeans future price increases by the same amount each month over the period, then an additive method will be applied. In this case, dummy variables for each month will be added to the model as indication of seasonality (Diebold 2007); while for the multiplicative model, seasonal factors are computed based on the moving average ratio method, which is calculated as an index of the average ratio to its moving average.

In order to ensure robust results, this research will use the Inverse Autocorrelation Function (IACF) to provide information about seasonal patterns on the raw and adjusted series. An IACF generally indicates seasonal patterns better than the Partial Autocorrelation Function. If the spikes in an IACF are outside of the percent confidence intervals (95 percent in this research), it is a clear indication of seasonality. It should be noted that the methodology used to remove the seasonal component, if any, from the data utilized in this study, follows a deterministic approach.

3.2.2 The Unit-root Test and Integration

Once the seasonal component is removed based on a X-11 method, the unit root test is applied to test if the time-series data follows a covariance stationary process (Hill et al. 2008). A common procedure used in literature to test for unit root is the augmented Dickey-Fuller (ADF) test, which is based on an Autoregressive (AR) model, usually referred to the random walk equation. Although this test has been commonly utilized, its statistical power is very low (Enders

2010). A central issue with the ADF test is that includes a deterministic constant (α) and trend (λ_t), while y_{t-1} in the random walk is a stochastic process (equation 3.2.2.1).

$$(3.2.2.1)\ \Delta y_t = \alpha + \lambda_t + \gamma\, y_{t-1} + \sum_{i=1}^{m} \beta_i \Delta y_{t-i} + \varepsilon_t$$

Since the least squares procedure is unable to separate the stochastic process from the deterministic portion correctly, the trend and constant are poorly estimated in the presence of a unit root. To resolve the issue when testing for unit root using ADF, Enders (2010) proposes two methods with more power. The first being the Schmidt and Phillips (1992) procedure, and the second is the Elliot, Rothenberg, and Stock (1996) procedure.

Schmidt and Phillips (1992) called their test a Lagrange Multiplier (LM) test, which is estimated is two-steps. First, the trend coefficient (λ_t) is estimated using the regression in equation 3.2.2.2,

$$(3.2.2.2)\ \Delta y_t = \lambda_t + \varepsilon_t$$

where the ε_t (error term) does not interfere with the estimation of the trend. The result of the previous procedure is an estimated of the slope of the time trend. The coefficient is then used to detrended the series (equation 3.2.2.3), which ensures that the initial value of detrended series is zero

$$(3.2.2.3)\ y_t^d = y_t - (y_1 - \lambda) - \lambda_t.$$

Second, a variant of the augmented Dickey-Fuller test is estimated, using the detrended series as stochastic term y^d_{t-1} (equation 3.2.2.4).

$$(3.2.2.4)\ \Delta y_t^d = \alpha + \gamma\, y^d_{t-1} + \sum_{i=1}^{m} \beta_i \Delta y^d_{t-i} + \varepsilon_t$$

The null hypothesis of a unit root $\gamma = 0$ is tested. Enders (2010) claims that once the trend is estimated appropriately, it is possible to detrend the data and execute the unit-root test.

Elliot, Rothenberg, and Stock (ERS) (1996) assert that it is possible to enhance the power of the unit root test by estimating a model using a process similar to first differences. They also use a two-step procedure where a constant (α) is preselected[4] close to unity in its value and the stochastic term (y_{t-1}) is subtracted from y_t as in equation (3.2.2.5), where ε_t is a stationary error term.

$$(3.2.2.5)\ \tilde{y}_t = (1 - \alpha)\alpha_1 + \lambda_1[(1\text{-}\alpha)t + \alpha] + \varepsilon_t$$

The first step in obtaining estimates for α_1 and λ_1 is via the ordinary least squares (equation 3.2.2.6),

$$(3.2.2.6)\ \tilde{y}_t = \alpha z_{1t} + \lambda z_{2t} + \varepsilon_t$$

where ($1\text{-}\alpha$) denotes z_1 (constant term) and z_2 represents the deterministic trend $\alpha\ (1 + \alpha)t$. Then, using these coefficients detrend data are obtained to set up an equation as 3.2.2.7.

$$(3.2.2.7)\ y_t^d = y_t - \alpha - \lambda_t$$

The second step is to estimate the basic ADF regression in the form of equation 3.2.2.8 without a constant.

$$(3.2.2.8)\ \Delta y_t^d = \gamma\, y^d_{t-1} + \sum_{i=1}^{m} \beta_i \Delta y^d_{t-i} + \varepsilon_t$$

The null hypothesis $\gamma = 0$ can be rejected if it is found a unit root. Enders (2010) suggests selecting the lag structure based on the Schwartz criterion. This research also utilized the Akaike criterion and R-squared as indicator of the lag structure (Diebold 2007).

If the unit-root tests described above reveal that the variables are non-stationary, a test for the order of integration (I) has to be performed to determine the number of differences necessaries to make the variable stationary (Hill et al. 2008). The test for order of integration states the null hypothesis $\gamma = 0$ in equation 3.3.2.8. This test is performed until the null

[4] ERS reported that the value of α that seems to provide the best overall power is $\alpha = (1\text{-}7/T)$ for the case of intercept and $\alpha = (1\text{-}13.5/T)$ if there is an intercept and trend (Enders 2010).

hypothesis cannot be rejected. The above-mentioned procedures will help ensure that the DGP of the variables (SPV_t, OPV_t, UDI_t, CSI_t, NMF_t, and NIF_t) used in the context of this research follow a covariance stationary process, either at the levels or at the differences.

3.3 Testing for Causality

3.3.1 Granger Causality Test

The linear Granger Causality is a standard technique to examine whether past values of an independent variable can explain current values of a dependent variable, conditional on past values of the dependent variable (Hernandez and Torero 2010). This analysis can be used to determine whether a series is able to forecast another (Irwin 2011). In the context of this research, the Granger Causality test examines whether the variability of soybeans futures prices (SPV_t) at time t is related to the past variability of oil spot prices (OPV_t), U.S renewable fuel policy (a dummy variable) (RFP_d), the imports of soybeans from China (CSI_t), as proxy of unmet domestic consumption, the variability of the U.S dollar index value (UDI_t), and the number of mutual and index funds (NSF_t).

The standard model to test for Granger Causality is expressed in equation 3.3.1.1.

$$(3.3.1.1)\ y_t = \alpha + \sum_{i=j}^{m} \beta_{ij} y_{t-i} + \sum_{i=j}^{m} \gamma_{ij} X_{t-i} + \varepsilon_t$$

where y_t denotes soybeans futures price volatility and X_t is $(x_1, x_2, \ldots x_k)$ a vector, which represents the independent variables used to explain soybeans futures prices in this research. Examples of this type of panel approach to analyze price returns and price volatility are performed by Torero and Hernandez (2010) and Irwin (2011), respectively. They examine causality of price volatility in agricultural markets based on cash prices and financial speculation, respectively.

According to Enders (2010), if all variables in equation 3.4.1.1 are stationary, the direct way to test Granger Causality is via a standard F-test, with the restriction that $\beta_{ij} = \gamma_{ij} = 0$. This restriction implies that the variables in question do not explain y_t. The model contains both, non-stationary and stationary variables, a *t*-test is more appropriate. For example, equation 3.3.1.2 introduces a combination of I(*1*) and I(*0*) variables,

$$(3.3.1.2)\ y_t = \alpha + \beta_{11}y_{t-1} + \beta_{12}y_{t-2} + \delta_{21}x_{t-1} + \delta_{22}x_{t-2} + \varepsilon_t$$

where y_t denotes monthly soybeans future price volatility and X_t is ($x_1, x_2, ...x_k$) a vector of variables that explain y_t. If y_t is I(*1*) and x_t is I(*0*), then the coefficients of x_t are stationary at levels, and y_t is stationary at the first differences. Since the variables are stationary at different orders of integration, the appropriate method to test for linear Granger causality is a *t*-test with a null hypothesis that $\delta_{21} = 0$ or $\delta_{22} = 0$, which are coefficients on stationary variables, and/or *F*-test to test the hypothesis $\delta_{21} = \delta_{22} = 0$. Hence, the test utilized to determine whether x_t Granger causes y_t can be performed using the *t* or *F*-test. Although it is possible to use *t*-test to test $\beta_{11} = 0$ or $\beta_{12} = 0$, Enders (2010) notes that is not possible to use *F*-test to test $\beta_{11} = \beta_{12} = 0$. He suggests using *F*-test only if the causal variable appears as a first difference. Use of first differences for I(*1*) variables is only appropriate if the variables in question are not cointegrated. If the variables are cointegrated, the system cannot be written in first differences; hence, causality tests cannot be performed using *t*-test or *F*-test.

3.3.2 Testing for Cointegration: The Engle-Granger Methodology

Although the linear Granger test discussed above is useful to explain causality between the volatility of soybeans futures prices and the factors examined in this study, this test is not appropriate when the variables cannot be written in first differences and are cointegrated. According to Hill et.al (2008), if a linear combination of variables generates residuals of order I(*0*) (stationary), then it is said that the variables are cointegrated. Hill et al. (2008) describes co-integration as the process whereby y_t and x_t have similar stochastic trends, which implies that they never diverge too far from each other. In addition, he states that by examining for cointegration, spurious regressions can be avoided when analyzing non-stationary variables.

A popular test for a single cointegration is the Engle and Granger test (1987). To apply this procedure, first the variables must be tested for their order of integration (Enders 2010). The ERS test for unit root previously discussed is used to infer the number of unit roots, if any, in each variable. If the variables are stationary, this procedure is not applicable. Moreover, if the variables are integrated of different orders, it is concluded that they are not cointegrated (Enders 2010).

Once the integration test is performed, a regression of the linear combination between y_t and x_t is performed in order to obtain the residuals in equation 3.3.2.1,

$$(3.3.2.1)\ \hat{e}_{t\,t} = y_t - \beta_1 - \beta_2 x_t$$

where $X_t\,(x_{1t,}\, x_{2t} \ldots x_{kt})$ denotes a vector of I(*1*) regressors. Since the $\hat{e}_t$ sequence is a residual from a regression, there is no need to include an intercept term (Enders 2010). To take into account autocorrelation an augmented form, equation 3.3.2.2 is introduced,

$$(3.3.2.2)\ \hat{e}_t = \gamma \hat{e}_{t-1} + \textstyle\sum_{i=j+1}^{m} \beta_{ij} \hat{e}_{t-i}$$

where $\Delta\hat{e}$ is the first differences of the residuals. If the null hypothesis $\gamma = 0$ is rejected, it is concluded that the residual sequence is stationary and the variables are cointegrated, than the error-correction model is estimated as in equation 3.3.2.3 and 3.3.2.4. Although, this system shows two variables y_t and x_t, it can be extended to add more variables, where β_1 is the parameter of the cointegrated vector given by equation 3.3.2.5, ε_{yt} and ε_{xt} are white-noise disturbances (which may be correlated with each other) and $\alpha_{1,}\ \alpha_{2,}\ \alpha_{y,}\ \alpha_{x,}\ \alpha_{11}(i),\ \alpha_{21}(i),$ and $\alpha_{22}(i)$ are all parameters.

$$(3.3.2.3)\ \Delta y_t = \alpha_1 + \alpha_y[y_{t-1} - \beta_1 x_{t-1}] + \textstyle\sum_{i=1}^{n} \alpha_{11}(i)\Delta y_{t-i} + \sum_{i=1}^{n} \alpha_{12}(i)\Delta x_{t-i} + \varepsilon_{yt}$$

$$(3.3.2.4)\ \Delta x_t = \alpha_1 + \alpha_x[y_{t-1} - \beta_1 x_{t-1}] + \sum_{i=1}^{n} \alpha_{21}(i)\Delta y_{t-i} + \sum_{i=1}^{n} \alpha_{22}(i)\Delta x_{t-i} + \varepsilon_{xt}$$

$$(3.3.2.5)\ y_t = \beta_0 + \beta_1 x_t + e_t$$

Engle and Granger (1987) proposed a variation to resolve the issue of the cross-equation restrictions involved in the direct estimation of equations 3.3.2.6 and 3.3.2.7. Since $\hat{e}_{t-1}$ is the magnitude of the deviation from the long-run equilibrium in period (*t-1*), it is possible to use it to estimate the cointegrated system (equations 3.4.2.6 and 3.4.2.7).

$$(3.3.2.6)\ \Delta y_t = \alpha_1 + \alpha_y\, \hat{e}_{t-1} + \sum_{i=1}^{n} \alpha_{11}(i)\Delta y_{t-i} + \sum_{i=1}^{n} \alpha_{12}(i)\Delta x_{t-i} + \varepsilon_{yt}$$

$$(3.4.2.7)\ \Delta x_t = \alpha_1 + \alpha_x\, \hat{e}_{t-1} + \sum_{i=1}^{n} \alpha_{21}(i)\Delta y_{t-i} + \sum_{i=1}^{n} \alpha_{22}(i)\Delta x_{t-i} + \varepsilon_{xt}$$

Since the previous system is written in first differences, the methodology applied to test for linear Granger causality based on the *F* and t-test can be performed.

3.4 Data Definitions

Table 14. Data Definition

Title	Series ID	Source	Frequency	Units	Date Range
Soybeans Future Price Volatility	SPV_t	CBOT	M	Percentage	1999:01 to 2011:08
Oil Spot Price Volatility: West Texas Intermediate	OPV_t	Dow Jones & Company	M	Percentage	1999:01 to 2011:08
U.S Renewable Fuel Policy	RFP_d		N/A	Since January 2007 = 1; otherwise 0	1999:01 to 2011:08
China Soybeans Imports	CSI_t	MAPA, SAGyP and USDA	M	U.S ton	1999:01 to 2011:08
U.S Dollar Index Volatility	UDI_t	FRED and Central Bank of Argentina	M	Percentage	1999:01 to 2011:08
Number of Mutual and Index Funds in Commodity Markets	NMF_t NIF_t	SEC and Funds Prospectus[a]	M	1 Company = 1	1999:01 to 2011:08

Note: M denotes Monthly. (a) see Table 10.

CHAPTER 4. RESULTS

The first section of this chapter summarizes the descriptive statistics of the data. The second part introduces the results for the data generating process (DGP), more specifically the unit-root test. The third part provides the results of the Granger causality analysis.

4.1 Descriptive Statistics of the Data

Table 15. Descriptive Statistics of the Data

	Full Sample: 1999:01 – 2011:08					
	SPV_t	OPV_t	UDI_t	CSI_t	NMF_t	NIF_t
Mean	0.185	0.371	0.042	1,649,462	6	5
Median	0.161	0.324	0.036	1,374,366	5	6
Maximum	0.749	1.149	0.210	6,519,075	19	4
Minimum	0.076	0.13	0.108	0,000	1	1
Std. Dev.	0.102	0.164	0.029	1,449,217	6	0
Skewness	2.604	2.132	2.919	1.159	1	2
Kurtosis	11.945	8.412	14.428	3.985	2	0
Observations	152	152	152	152	152	152
	Subsample 1: 1999:01 – 2006:08					
	SPV_t	OPV_t	UDI_t	CSI_t	NMF_t	NIF_t
Mean	0.170	0.367	0.040	932,561	2	4
Median	0.144	0.334	0.030	687,587	2	4
Maximum	0.603	0.945	0.178	3,127,804	6	5
Minimum	0.076	0.189	0.013	0	1	4
Std. Dev.	0.091	0.125	0.028	855,710	2	1
Skewness	2.623	1.802	2.633	0.888	1	0
Kurtosis	11.792	7.765	12.153	2.659	3	1
Observations	92	92	92	92	92	92
	Subsample 2: 2006:09 – 2011:08					
	SPV_t	OPV_t	UDI_t	CSI_t	NMF_t	NIF_t
Mean	0.207	0.377	0.044	2,718,938	12	5
Median	0.180	0.299	0.039	2,292,591	12	5
Maximum	0.749	1.149	0.210	6,519,075	19	6
Minimum	0.083	0.13	0.019	445,632	6	5
Std. Dev.	0.113	0.211	0.029	1,498,297	4	0
Skewness	2.524	1.933	3.356	0.747	0	1
Kurtosis	11.137	6.26	17.415	2.627	2	2
Observations	60	60	60	60	60	60

Note: SPV_t is monthly soybeans future price volatility, OPV_t denotes monthly oil spot price volatility, UDI_t represents monthly U.S Dollar index volatility, CSI_t is monthly China soybeans imports, NMF_t denotes number of mutual funds, and NIF_t is number of index funds.

Table 15 contains the summary statistics for the data being analyzed in this research. The data was also divided into two subsample periods, the first being from Jan 1999 to Aug 2006, and the second from September 2006 to August 2011. The criterion utilized to split the data is based on the findings by Trostle (2008). He claims that the market instability in agricultural commodities began in the Fall 2006. The reasons for this instability include the increasing integration between energy and agricultural markets, U.S monetary policy, and the increasing consumption of agricultural commodities from developing countries such as China. All of these are examined in this research.

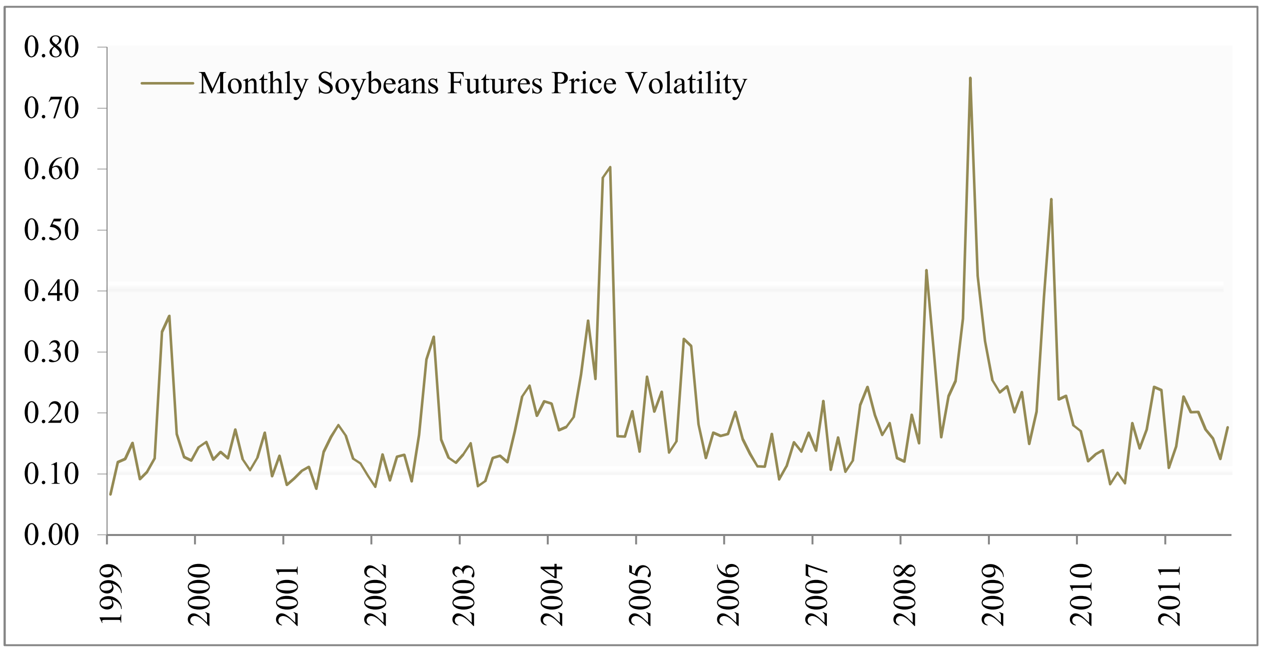

Figure 8. Monthly Soybeans Futures Price Volatility.
Source: CBOT (2011).

Based on the results from the descriptive statistics and Figure 8, it is clear that nearby soybeans futures price volatility increased not only in terms of the monthly mean, but also in terms of the monthly standard deviation. From January 1999 to August 2006, the mean was 17 percent, and the standard deviation 9 percent, but between September 2006 and August 2011; these parameters were 20 and 11 percent, respectively. Although there has been an increase from the first period to the second period, the coefficient of variation has remained relatively constant at 54 and 55 percent, respectively. This result suggests that over the period the soybeans futures price has maintained a relatively consistent level of risk.

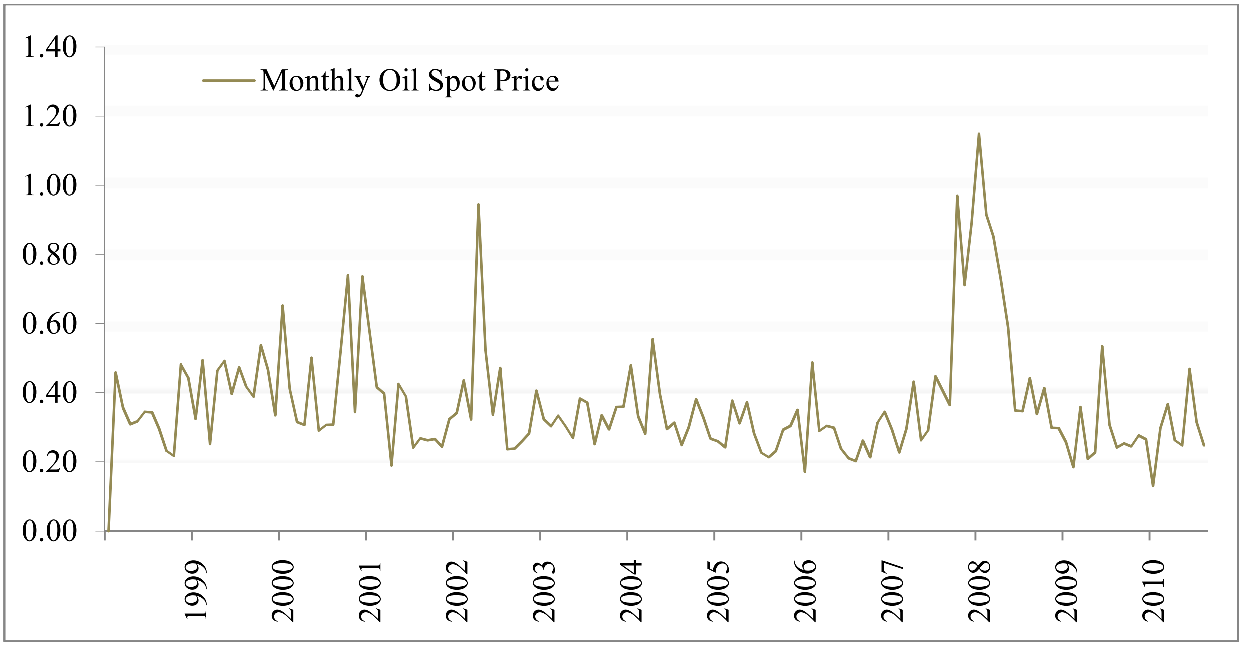

Figure 9. Monthly Oil Spot Price Volatility.
Source: FRED (2011).

Figure 9 illustrates the monthly oil spot price variability from January 1999 to August 2011. Over that period, the monthly oil price volatility experienced an increase in the mean and standard deviation. From subsample 1 to subsample 2, these parameters went from 37 to 38 percent, in terms of the mean and from 13 to 21 percent, in terms of the standard deviation.

The U.S dollar index variability in Figure 10 increased from 4.00 to 4.50 percent in the mean and from 2.80 to 3.00 percent in the standard deviation. Figure 11 illustrates the monthly soybeans imports to China from January 1999 to August 2011. Over the January 1999 - August 2006 and September 2006 – August 2011 period, the mean of this variable grew from 933,000 tons to 2,719,000 tons, with a standard deviation of 855,000 and 1,500,000 tons, from the first to the second subsample. Finally, Figure 12 introduces the number of speculative funds (mutual and index funds) from January 1999 - August 2006 and September 2006 – August 2011 period. Over that period, the mean went from 2 to 12, and the standard deviation from 4 to 5, respectively.

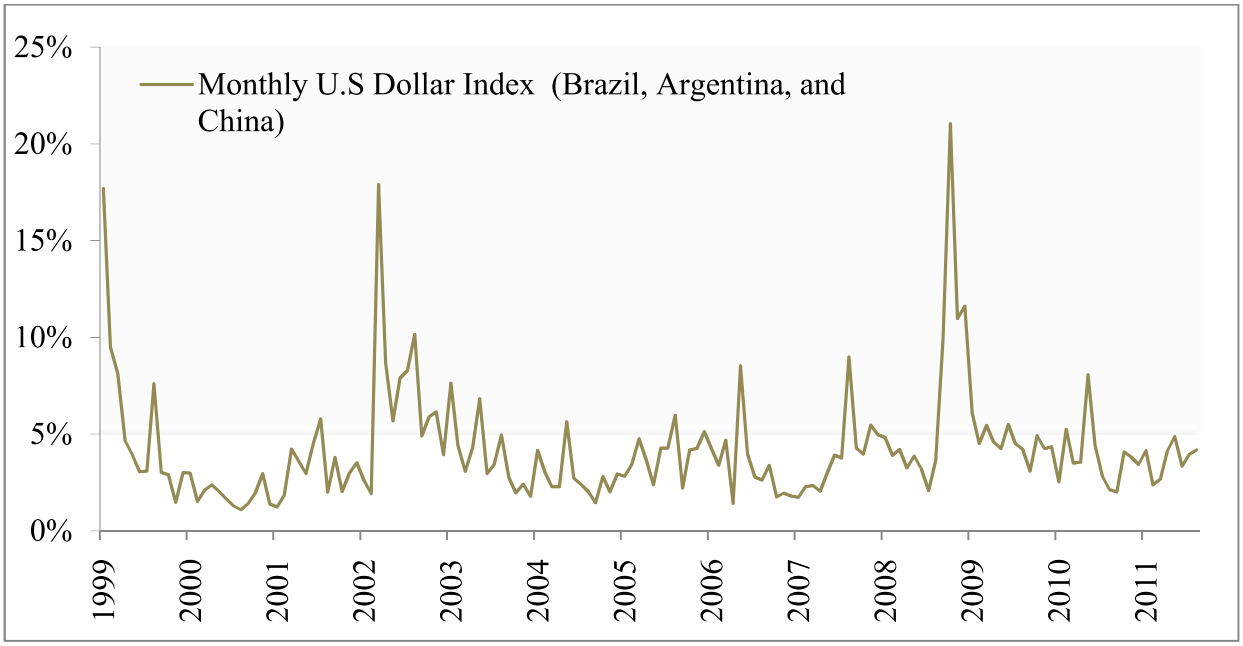

Figure 10, Monthly U.S Dollar Index Volatility (Brazil, Argentina, and China).
Source: FRED (2011) and BCA (2011).

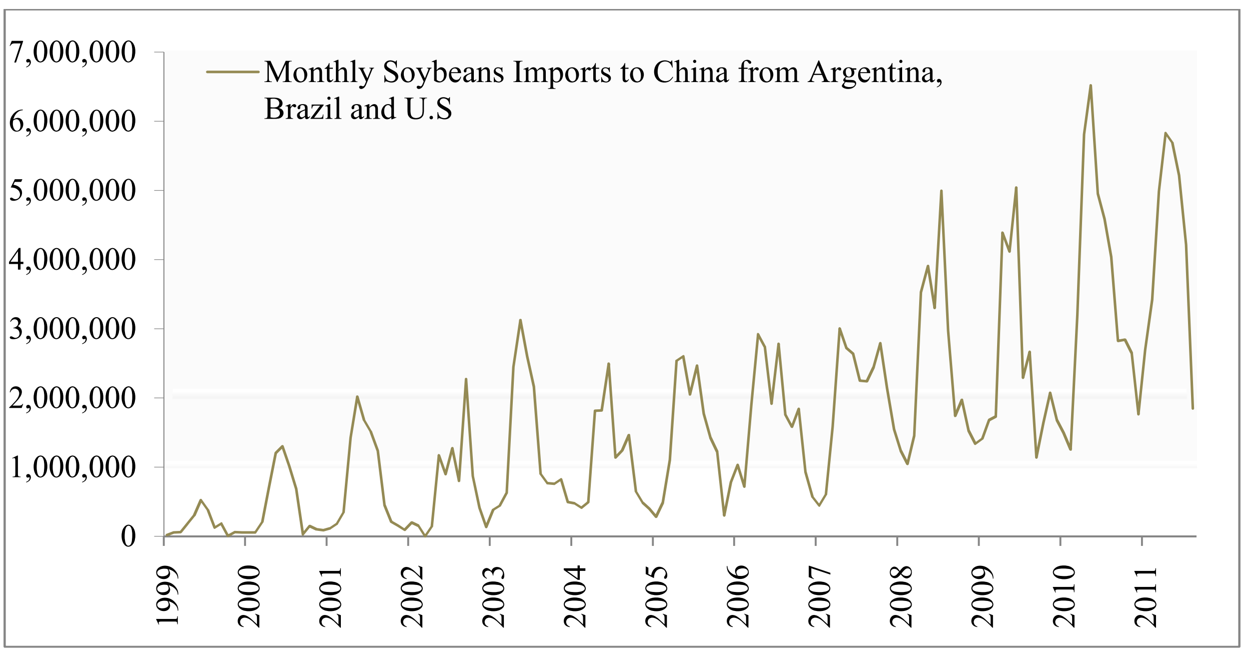

Figure 11. Monthly Soybeans Imports to China.
Source: MAPA (2011), USDA (2011), and SAGyP (2011).

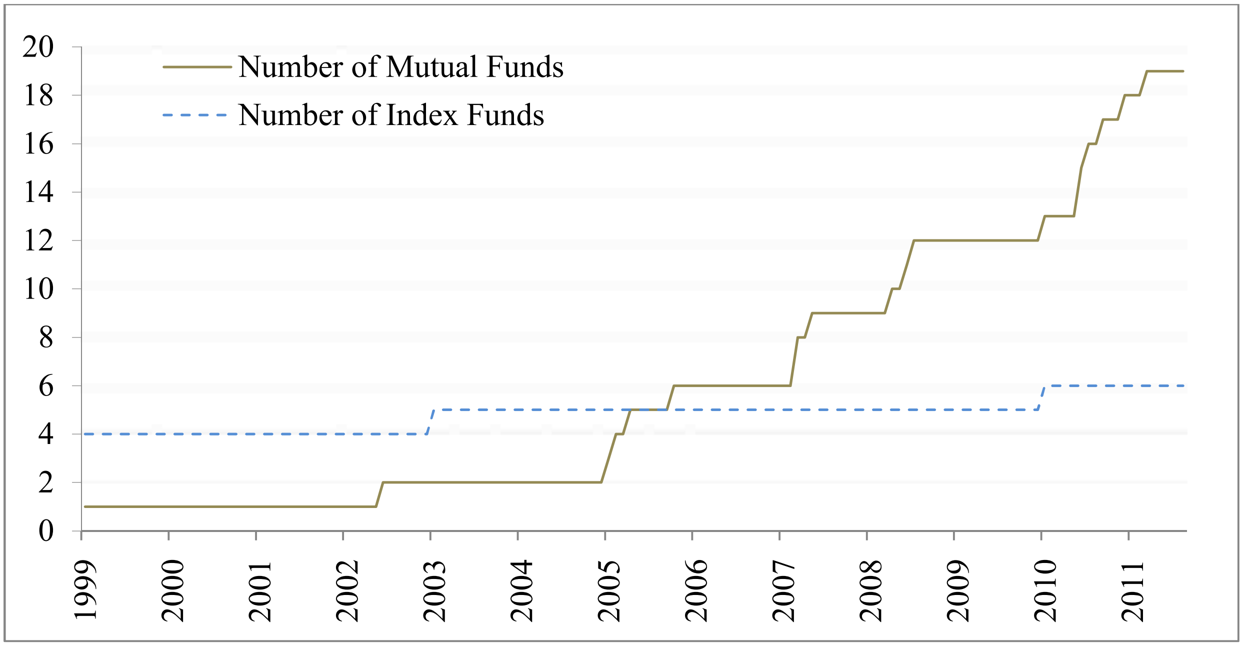

Figure 12. Number of Mutual and Index Funds Available for Public Investors.

In addition to the descriptive statistics, the correlation matrix can be found in Table 16. The correlation between monthly soybeans futures price volatility and the variables being analyzed by this research is less than 16 percent, on average, which denotes a weak relationship between each other. However, the correlation between each pair of variables changes from subsample 1 to subsample 2, being stronger for the oil spot prices, China soybeans imports and the number of index funds. These results suggest *a-priori* expectations that oil spot prices, U.S dollar index, and the number of index funds should influence monthly soybeans futures prices, are likely true.

A second element observed from the correlation matrix is that none of the pairs monthly soybeans futures prices and the variables examined in this research exhibit a correlation greater than 0.80. According to Hill (2008), if the variable being used in an econometric model exhibit a correlation value greater than 0.80, collinearity is present and the least squares estimator is not defined.

Table 16. Correlation Matrix.

	SPV_t	OPV_t	RFP_d	UDI_t	CSI_t	NMF_t	NIF_t
Full Sample: 1999:01 - 2011:08							
SPV_t	1.000						
OPV_t	0.160	1.000					
RFP_d	0.191	0.041	1.000				
UDI_t	0.211	0.227	0.073	1.000			
CSI_t	0.085	-0.125	0.607	-0.008	1.000		
NMF_t	0.174	-0.012	0.869	0.070	0.738	1.000	
NIF_t	0.152	-0.144	0.650	-0.070	0.685	0.827	1.000
Subsample 1: 1999:01 - 2006:08							
	SPV_t	OPV_t	RFP_d	UDI_t	CSI_t	NMF_t	NIF_t
SPV_t	1.000						
OPV_t	-0.306	1.000					
RFP_d							
UDI_t	0.012	-0.198		1.000			
CSI_t	0.136	-0.210		-0.057	1.000		
NMF_t	0.086	-0.301		-0.007	0.529	1.000	
NIF_t	0.313	-0.185		-0.144	0.508	0.690	1.000
Subsample 2: 2006:08 - 2011:08							
	SPV_t	OPV_t	RFP_d	UDI_t	CSI_t	NMF_t	NIF_t
SPV_t	1.000						
OPV_t	0.492	1.000					
RFP_d							
UDI_t	0.427	0.609		1.000			
CSI_t	-0.163	-0.178		-0.078	1.000		
NMF_t	-0.020	-0.013		0.030	0.544	1.000	
NIF_t	-0.321	-0.282		-0.172	0.500	0.814	1.000

Note: SPV_t is monthly soybeans future price volatility, OPV_t denotes monthly oil spot price volatility, RFP_d is U.S renewable fuel policy, UDI_t represents monthly U.S Dollar index volatility, CSI_t is monthly China soybeans imports, NMF_t denotes number of mutual funds, and NIF_t is number of index funds.

4.2 The Data Generating Process

4.2.1 The Seasonal Component

As discussed previously, before testing for unit-root, the seasonal component, if any, should be removed, leaving only the stochastic process (Moledina et al. 2003). To examine the seasonal component of each variable utilized in this research, this study employed the Autocorrelation Function (ACF) and the Inverse Autocorrelation Function (IACF) (Appendix I). In addition, Terrell (2011) suggests analyzing the data in terms of the means by season

(Appendix V). Graphical inspection of the ACF, IACF, and the means by season for monthly soybeans futures price volatility, oil spot prices and China soybeans imports suggest the presence of a seasonal component.

Clearly, some of the spikes in the IACF (Figure 13, Appendix I) of monthly soybeans futures price volatility, lag 1 through 12, are outside of or relatively close to the confidence interval band of 95 percent, which suggests the presence of seasonality. These spikes occur in February, March, June, and November and can be attributed to the nature of soybean production in Argentina, Brazil, and the U.S. According to the USDA (2011), in 2011, Brazil, Argentina, and the U.S account for 90 percent of the total volume of world soybeans exports, while China accounts for 60 percent of the total world soybeans imports.

Table 17. Planting and Harvest Seasons for Soybeans.

Month	U.S	Brazil	Argentina	China
January				
February		H		
March		H	H	
April	P	H	H	P
May	P	H	H	P
June	P		H	P
July	P			
August				
September			P	H
October	H	P	P	H
November	H	P	P	H
December	H	P	P	

Source: USDA (2011), CONAB (2011), INTA (2011). Note: P denotes planting, and H is harvest.

Table 17 contains a diagram of the plating and harvest seasons for soybeans in these countries. The seasonality of February and March is explained by Brazilian and Argentinean soybean production, both of which are in the latter half of harvest season. With market attentions in the U.S planting season by March/April higher, prices tend to increase around June, which explains seasonality of soybeans futures price volatility for these months. Once post-harvest sells begins in the U.S (October/November) the soybeans futures prices tend to decrease compared to the prices of the rest of year, explaining the spike in the IACF for November. These results are also observed in the means by season (Figure 31, Appendix V) since the monthly average volatility decreases in February, increases from March to June, and decreases in November.

The oil spot price volatility IACF (Figure 14, Appendix I) shows a clear spike beyond the 95 percent confidence interval for March, and three large spikes for April, June and November into the confidence interval (lags 1 through 12). During the spring, inventories of gasoline increase prior to the US driving/vacation (summer season), this consumption of gas explains the spikes for these months. Finally, an increasing demand for oil inventory occurs prior to winter, particularly in November, and declines into December as refiners do not make purchases to avoid year-end inventory tax, which explains the spikes of November. These results are also observed in the means by season (Figure 32, Appendix V) since the oil price variability tends to increase in February, decrease in June, and increase in November.

The IACF (Figure 16, Appendix I) of monthly China soybeans imports from Argentina, Brazil, and the U.S illustrates that there are two large spikes (lags 1 through 12), the first being in May and June, and the second in October and November. These results are compared to the means by season (Figure 36, Appendix V) and they show that May and June are the month with higher imports, while October and November are the months with lower imports. Table 17 helps to explain import behavior, since a higher portion of imports occur right after post-harvest in Brazil and Argentina (March to June), while China is plating their soybean crop. During October and November, only the U.S is able to supply sufficient imports to china. After those months, China is able to utilize domestic production.

The remaining variables, the U.S dollar index and the number of mutual funds, do not exhibit spikes that extend beyond the 95 percent confidence interval, which suggests that there is no statistical evidence of seasonality on these variables. Therefore, this study employs an X-11[5] seasonal adjustment method on the monthly soybeans futures prices, oil spot prices, and soybeans imports to China. The X-11 methodology was developed by the U.S. Bureau of the Census in 1965 and uses filters to seasonally adjust data and estimate the components of a time series. The X11 procedure makes additive or multiplicative adjustments and creates an output data set containing the adjusted time series and intermediate calculations. Table 18 contains the means by month for the variables in question, for both, the raw and the seasonally adjusted series.

Table 18. Seasonal Adjustment.

Month	Raw Series	X-11	Raw series	X-11	Raw series	X-11
	SPV_t		OPV_t		CSI_t	
January	0.169	0.181	0.400	0.381	757,936	1,720,510
February	0.148	0.192	0.369	0.375	809,481	1,648,571
March	0.178	0.185	0.409	0.349	1,361,856	1,684,890
April	0.153	0.194	0.378	0.375	2,673,767	1,600,964
May	0.150	0.189	0.354	0.350	2,919,018	1,605,308
June	0.179	0.181	0.336	0.379	2,663,675	1,691,617
July	0.251	0.166	0.291	0.375	2,391,130	1,681,762
August	0.270	0.174	0.323	0.376	1,715,458	1,566,154
September	0.217	0.186	0.402	0.381	1,360,817	1,555,831
October	0.184	0.190	0.367	0.373	1,247,001	1,641,592
November	0.173	0.191	0.418	0.371	972,233	1,558,378
December	0.146	0.191	0.413	0.376	746,453	1,608,567

Note: SPV_t is monthly soybeans future price volatility, OPV_t denotes monthly oil spot price volatility, CSI_t is monthly soybeans imports to China. X-11 is the seasonal adjustment method developed by by the U.S. Bureau of the Census in 1965.

In order to obtain robust results (a seasonal adjustment could change the properties of the data), this research analyzed the Inverse Autocorrelation Function (IACF) and the Autocorrelation function (ACF) for both, the raw and adjusted series (Appendix II). Clearly, the

[5] The methodology utilized to obtain seasonal series is deterministic.

IACF of China soybeans imports and the soybeans futures price volatility, Figure 19 and 21, in Appendix II, do not exhibit spikes beyond the 95 percent confidence interval. The behavior of the IACF for the adjusted series of these variables exhibit similar patterns to that of the raw series. When analyzing oil spot prices, in terms of the raw and adjusted series, the IACF still exhibit spikes beyond the 95 percent confidence interval. Based on the analysis of the IACF, it is seems that the seasonal component persists in both, the raw and adjusted series. Bell and Hillmer (1984) assert that often the seasonal and the Autoregressive Moving Average (ARMA) coefficients are best identified jointly. In such as circumstances, it is best to avoid using seasonally adjusted data (Enders 2010). Therefore, this research utilizes both, the raw and adjusted series of monthly soybeans futures price volatility, monthly oil spot prices, and soybeans imports to China for further steps.

4.2.2 Stationarity and Integration

Once the seasonal component was analyzed, the test for unit-root is performed based on the methodology proposed by Elliot, Rothenberg, and Stock (1996) and using the General Least Squares (GLS) procedure. Table 19 summarizes the results for this test, for both the levels and returns for the variables in question. The null hypothesis of the test states that the time series process is non-stationary i.e. has a unit-root. The maximum lag structure analyzed is six, and the minimum Schwartz Bayesian Information Criterion (SBIC) is used to select the appropriate number of lags. This criteria does not assume a true, but unknown, DGP, and is given by

$$(4.2.2.1)\ SBIC\ (p) = ln\ \left| \textstyle\sum_u (p) \right| + 2lnlnT/T\ (pG^2)$$

where p is the number of lags of the endogenous variables, $\left| \sum_u (p) \right|$ is the determinant of the matrix of variance and covariance of the residuals of the model of interest when estimated, *p*, *T* is the sample size, and G represents the number of endogenous variables. The estimates $\acute{p}$ for p is chosen so that the SBIC is minimized.

The critical values employed to test the null hypothesis of unit root are those tabulated by Mackinnon (1996) in the case of a constant (α) and by Elliot, Rothenberg, and Stock with a constant and a trend ($\alpha + \lambda$). The preselected constant to detrend the data is *1-7/T* in the case of an intercept (α) and *1-13.5/T* in the case of an intercept and trend ($\alpha + \lambda$).

Table 19. Elliot, Rothenberg and Stock (ERS) Test for Unit-root

		Levels		Returns	
	Seasonal Adjustment	α	$\alpha + \lambda$	α	$\alpha + \lambda$
SPV_t	N/A	-5.595***	-6.506***	-12.325***	-12,323***
SPV_t	SA	-3.436***	-6.889***	-12.530***	-13.041***
OPV_t	N/A	-3.479***	-3.843***	-3.364***	-5.521***
OPV_t	SA	-2.948***	-3.806***	-4.769***	-7.422***
UDI_t	N/A	-1.952**	-3.469**	-12.848***	-12.605***
CSI_t	N/A	1.756	-1.729	-2.819***	-0.624
CSI_t	SA	-0.868	-2.766*	-10.265***	-13.549***
NMF_t	N/A	1.999	-0.535	-5.752***	-6.045**
NIF_t	N/A	0.392	-2.270*	-8.499***	-8.594***

Note: ***, **, * denotes significance at 1, 5, and 10 percent respectively. N/A is no apply, SA is seasonal adjustment, (α) represents constant, (λ) is a linear trend, and (α + λ) denotes constant and linear trend. The DF-GLS (ERS) Mackinnon (1996) critical values for no trend and constant are: 1% = -2.580; 5% = -1.942; 10% = -1.615. The DF-GLS (ERS) Elliot, Rothenberg, Stock (1996) critical values for trend and constant are: 1% = -3.518; 5% = -2.979; 10% = -2.680. The seasonal adjustment method employed is X-11, which is a deterministic procedure.

Table 19 presents the results of the ERS test. At a significance level of 0.05, the test rejects the hypothesis null of unit root, for both seasonal and raw series, for SPV_t, OPV_t, and UDI_t at levels, which indicates stationarity (*I(0)*). On the other hand, at a significance level of 0.05, the test fails to reject the hypothesis null of unit-root test for CSI_t, NMF_t and NIF_t at levels, indicating non-stationarity (*I(1)*). These results are similar to those provided for a graphical inspection of the Autocorrelation Functions (ACF) of the raw and adjusted series at levels and returns (Appendix I through IV). Clearly, the ACF for the levels version of the variables decays slowly for the soybeans futures price volatility (Figure 13, Appendix I), the oil spot prices

(Figure 14, Appendix I) and the U.S dollar Index (Figure 15, Appendix I). In contrast, the ACF does not decay for China soybeans imports (Figure 16, Appendix I), number of mutual funds (Figure 17, Appendix I), and the number of index funds (Figure 18, Appendix I). When looking at the first difference for the raw and adjusted series, the ACF for all the variables decays slowly (Figure 22 through 30, Appendix III and IV). These results reveal that it is not possible to use the level series in the estimation of the regressions for the Granger causality analysis since the order of integration is different across variables. However, based on the test for unit-root and the ACF, the variables are stationary on the first-difference. Thus, this research utilizes the first difference of the variables to test for Granger causality. This methodology is supported in the literature by Hsiao and Hsiao (2006) who utilized Granger causality analysis to define causality between the exports, GDP, and foreign direct investment (FDI) in East and Southeast Asia.

4.3 Testing for Causality

As discussed in Chapter 3, the linear Granger Causality test can be utilized on variables that are stationary and/or non-stationary and non-cointegrated. In addition, the test can be performed on variables that are non-stationary and I(*1*) cointegrated. Enders (2010) noted that if there is a combination of I(*1*) and I(*0*) variables, it is possible to test for causality as a long as the causal variables are stationary and/or can be written on first differences. Similarly, he claims that multivariate models such as a Vector Autoregressive (VAR) model can also be utilized to test for granger causality. However, in order to use a VAR model, evidence that one or more of the variables used in the system are endogenous, typically called dependence, has to be provided.

To provide statistical evidence of dependence across the soybeans futures price volatility, oil spot prices, U.S renewable fuel policy, U.S dollar index, soybeans imports to China, and number of mutual and index funds, this research examined the bivariate cross-correlation functions. From the results in Table 29 through 52, in Appendix VI and VII, the dynamic relationship in most cases for each pair of variables is weak. However, since some spikes of the cross-correlation function extend beyond the 95 percent confidence interval, it can be inferred that their contemporaneous correlation is statistically significant. Thus, the variables examined in this study are endogenous, and therefore, a multivariate time series model must be employed to test for Granger Causality. In addition, the results shown in Table 20 reveal that the null hypothesis of unit-root on the residuals cannot be rejected for any series, which implies that the variables are not cointegrated.

Table 20. Elliot, Rothenberg, and Stock (ERS) Test for Unit-root on the Residuals.

		Levels		Returns	
	Seasonal Adjustment	α	α + λ	α	α + λ
$^{a}e_t$	S/A	-0.873	-2.207	-0.080	-1.548
$^{b}e_t$	N/A	-0.935	-2.193	-0.081	-1.545
$^{a}e_t$	S/A	-0.832	-2.118	-0.079	-1.642
$^{b}e_t$	N/A	-0.783	-2.166	-0.085	-1.540

Note: ***, **, * denotes significance at 1, 5, and 10 percent respectively. N/A is no apply, SA is seasonal adjustment, (α) represents constant, (λ) is a linear trend, and (α + λ) denotes constant and linear trend. The DF-GLS (ERS) Mackinnon (1996) critical values for no trend and constant are: 1% = -2.580; 5% = -1.942; 10% = -1.615. The DF-GLS (ERS) Elliot, Rothenberg, Stock (1996) critical values for trend and constant are: 1% = -3.518; 5% = -2.979; 10% = -2.680. The seasonal adjustment method employed is X-11, which is a deterministic procedure. (a) denotes that the U.S renewable fuel policy is included, while (b) does not include the U.S renewable fuel policy variable.

Based upon the above-mentioned results, this research utilizes a VAR model to test for Granger Causality. This procedure is also employed by Hsiao and Hsiao (2006) who examined causality between the exports, GDP, and foreign direct investment (FDI) in East and Southeast Asia. The model utilized for this study is expressed in equations 4.3.1 through 4.3.6.

$$(4.3.1)\ \Delta SPV_t = \alpha + \sum_{j=1}^{m} \gamma j\, \Delta SPV_{t-j} + \sum_{j=1}^{m} \beta j \Delta X_{t-j} + \phi_j RFP_d + \varepsilon_t$$

$$(4.3.2)\ \Delta OPV_t = \alpha + \sum_{j=1}^{n} \gamma j\, \Delta SPV_{t-j} + \sum_{j=1}^{m} \beta j \Delta X_{t-j} + \phi_j RFP_d + \varepsilon_t$$

$$(4.3.3)\ \Delta UDI_t = \alpha + \sum_{j=1}^{n} \gamma j\, \Delta SPV_{t-j} + \sum_{j=1}^{m} \beta j \Delta X_{t-j} + \phi_j RFP_d + \varepsilon_t$$

$$(4.3.4)\ \Delta CSI_t = \alpha + \sum_{j=1}^{n} \gamma j\, \Delta SPV_{t-j} + \sum_{j=1}^{m} \beta j \Delta X_{t-j} + \phi_j RFP_d + \varepsilon_t$$

$$(4.3.5)\ \Delta NMF_t = \alpha + \sum_{j=1}^{n} \gamma j\ \Delta SPV_{t-j} + \sum_{j=1}^{m} \beta j \Delta X_{t-j} + \phi_j RFP_d + \varepsilon_t$$

$$(4.3.6)\ \Delta NIF_t = \alpha + \sum_{j=1}^{n} \gamma j\ \Delta SPV_{t-j} + \sum_{j=1}^{m} \beta j \Delta X_{t-j} + \phi_j RFP_d + \varepsilon_t$$

where SPV_t is the monthly soybeans future price volatility and γ its coefficient, X_t is a vector of stationary regressors at returns and β_t their coefficients, which for this research are the volatility of oil spot prices (OPV_t), the U.S dollar index (UDI_t), the soybeans imports to China (CSI_t), and the number of mutual (NMF_t) and index funds (NIF_t). RFP_d is the U.S renewable fuel policy (a dummy variable) and ϕ its coefficient.

Before testing for Granger causality, the lag structure of the model must be determined, as well as the empirical adequacy of the selected model. Table 21 and 22 contain the results of the lag structure with best performance for both, the adjusted and raw series. The number of lags selected is based on the performance of the Akaike Information Criterion (AIC), which is given by equation 4.3.7.

$$(4.3.7)\ AIC = e^{(2k/T)} \frac{\sum_{t=1}^{T} e_t^2}{T}$$

where e is the error variance, k denotes degrees of freedom, and T is the simple size. It should be noted that smaller values of AIC are preferred. The central idea of this criterion is analyzing the model performance out of the sample by penalizing the degrees of freedom (Diebold 2007). According to work by Ventzislav and Lutz (2001), for VAR models, the AIC tends to be more accurate with monthly data compared to the SIC. The lag length selection started with the biggest length of six lags to the smallest length of one lag. Thus, the criterion utilized to select the appropriate lag is based on the smallest value of the AIC statistic.

The minimum AIC for the full sample when examining both the adjusted and raw series with and without a renewable fuel policy dummy variable, occurs at lags of 2 and 5, respectively. For subsample 1 and 2 of the adjusted series the best number of lags occurs at lag of 4 and 5, respectively. The minimum AIC for subsample 1 and 2 of the raw series occurs at lag of 4 and 6, respectively.

Table 21. AIC Values for the Lag Structure (Adjusted Series).

Period	1	2	3	4	5	6
1999:01 - 2011:08	20.1722	20.0625*	20.1798	20.1938	20.3044	20.4365
1999:01 - 2011:08	25.4105	25.1745	25.2383	25.1213	25.0532*	25.0605
1999:01 - 2006:08	23.1816	22.8237	22.8164	22.7568*	23.0041	23.081
2006:09 - 2011:08	27.5111	27.4704	27.7323	27.0963	26.7144*	26.83

Note: * denotes the statistic value with the best performance, (a) renewable represents fuel policy included, and (b) renewable fuel policy excluded.

Table 22. AIC Values for the Lag Structure (Raw Series)

Period	1	2	3	4	5	6
1999:01 - 2011:08	24.5611	24.4242*	24.4839	24.4537	24.4705	24.6812
1999:01 - 2011:08	26.6661	26.364	26.3123	26.2006	26.1208*	26.1802
1999:01 - 2006:08	24.7149	24.3852	24.4987	24.0851*	24.2325	24.4478
2006:09 - 2011:08	28.457	28.3649	28.2537	27.7217	27.3513	27.2709*

Note: * denotes the statistic value with the best performance, (a) renewable represents fuel policy included, and (b) renewable fuel policy excluded.

The empirical adequacy of the selected model is determined with two statistics. First, the Ljung-Box (LB) Q-statistic developed by Ljung and Box (1979), a joint test for the significance of the first *m* residual autocorrelations $r_k = \sum_{t=k+1}^{T} \hat{e}_{t-k} / \sum_{t=k+1}^{T} \hat{e}_t^2$ and is given by equation 4.3.8

$$(4.3.8)\ LB\ (m) = T(T+2)\sum_{k=1}^{m}(T-K)r_k^2 \xrightarrow{a} \chi^2_{m-p}$$

Second, a simple Lagrange Multiplier (LM) test statistic for Autoregressive Conditional Heteroskedasticity (ARCH) effect is also employed. This statistic is employed on the residuals given by equations 4.3.9

$$(4.3.9)\ \hat{e}_t^2 = \gamma_0 + \gamma_1\ \hat{e}_t^2 + \varepsilon_t$$

where $\hat{e}_t^2$ is the square of the residuals and ε_t is the error term. The null hypothesis states that $\gamma_1 = 0$ or no ARCH effect. The LM statistic utilized to test for heteroskedasticity is asymptotically and follows a $\chi^2_{(k)}$ distribution (Robledo 2002).

Table 23. Ljung-Box Q-statistics for each equation of the Soybeans Futures Price Volatility Model (Adjusted Series).

	SPV_t		OPV_t		UDI_t		CSI_t		NMF_t		NIF_t	
Full Sample[a]: 1999:01 - 2011:08												
Q(4)	10.509	(0.032)	3.804	(0.433)	2.547	(0.636)	11.269	(0.024)	9.742	(0.045)	0.145	(0.998)
Q(8)	12.458	(0.131)	6.244	(0.620)	8.177	(0.416)	11.797	(0.161)	15.722	(0.047)	0.280	(1.000)
Q(12)	20.375	(0.060)	13.228	(0.353)	9.770	(0.636)	18.761	(0.095)	19.012	(0.088)	0.577	(1.000)
Q(16)	26.794	(0.043)	21.794	(0.150)	13.686	(0.622)	20.650	(0.192)	21.112	(0.174)	0.883	(1.000)
Q(20)	27.541	(0.120)	22.540	(0.312)	15.378	(0.754)	27.042	(0.134)	22.907	(0.293)	0.984	(1.000)
Full Sample[b]: 1999:01 - 2011:08												
	SPV_t		OPV_t		UDI_t		CSI_t		NMF_t		NIF_t	
Q(4)	10.551	(0.032)	3.776	(0.437)	2.468	(0.650)	11.157	(0.025)	12.351	(0.015)	0.133	(0.998)
Q(8)	12.475	(0.131)	6.209	(0.624)	8.217	(0.413)	11.696	(0.165)	19.396	(0.013)	0.350	(1.000)
Q(12)	20.573	(0.057)	13.183	(0.356)	9.799	(0.634)	18.768	(0.094)	23.203	(0.026)	0.579	(1.000)
Q(16)	27.163	(0.040)	21.744	(0.152)	13.732	(0.619)	20.701	(0.190)	25.553	(0.061)	0.959	(1.000)
Q(20)	27.880	(0.112)	22.494	(0.314)	15.402	(0.753)	27.062	(0.134)	26.442	(0.152)	1.041	(1.000)
Subsample 1: 1999:01 - 2006:08												
	SPV_t		OPV_t		UDI_t		CSI_t		NMF_t		NIF_t	
Q(4)	15.288	(0.005)	6.650	(0.156)	5.890	(0.208)	11.269	(0.024)	13.733	(0.008)	0.655	(0.957)
Q(8)	19.295	(0.012)	11.400	(0.180)	9.232	(0.323)	11.797	(0.161)	23.616	(0.003)	1.440	(0.994)
Q(12)	40.747	(0.006)	16.211	(0.182)	10.124	(0.605)	18.761	(0.095)	28.307	(0.005)	2.201	(0.999)
Q(16)	49.308	(0.012)	22.848	(0.118)	14.139	(0.588)	20.650	(0.192)	29.231	(0.022)	4.122	(0.999)
Q(20)	53.077	(0.039)	24.280	(0.230)	15.624	(0.740)	27.042	(0.134)	30.301	(0.065)	4.448	(1.000)
Subsample 2: 2006:09 - 2011:08												
	SPV_t		OPV_t		UDI_t		CSI_t		NMF_t		NIF_t	
Q(4)	4.696	(0.320)	6.064	(0.194)	18.643	(0.001)	3.678	(0.437)	7.342	(0.119)	29.910	(0.000)
Q(8)	6.428	(0.599)	11.525	(0.174)	30.933	(0.000)	5.209	(0.624)	15.796	(0.045)	38.907	(0.000)
Q(12)	16.018	(0.190)	21.327	(0.046)	38.726	(0.000)	11.183	(0.356)	24.713	(0.016)	40.816	(0.000)
Q(16)	19.465	(0.245)	29.709	(0.020)	43.766	(0.000)	19.744	(0.152)	28.931	(0.024)	48.025	(0.000)
Q(20)	27.764	(0.115)	43.667	(0.002)	60.262	(0.000)	22.494	(0.314)	36.671	(0.013)	50.390	(0.000)

Note: Q(#) denotes the number of lag at which the p-value, in parenthesis, is evaluated. The numbers without parenthesis represent Q-statistic values. (a) renewable represents fuel policy included, and (b) renewable fuel policy excluded. SPV_t is monthly soybeans future price volatility, OPV_t denotes monthly oil spot price volatility, UDI_t represents monthly U.S Dollar index volatility, CSI_t is monthly China soybeans imports, NMF_t denotes number of mutual funds, and NIF_t is number of index funds. The values in parenthesis are *p*-values.

Table 24. Ljung-Box Q-statistics for each equation of the Soybeans Futures Price Volatility Model (Raw Series).

	SPV_t		OPV_t		UDI_t		CSI_t		NMF_t		NIF_t	
Full Sample[a]: 1999:01 - 2011:08												
Q(4)	9.576	(0.048)	3.820	(0.431)	3.817	(0.431)	14.396	(0.006)	8.721	(0.069)	0.187	(0.996)
Q(8)	11.386	(0.181)	10.218	(0.250)	6.377	(0.605)	38.373	0.000	14.733	(0.065)	0.269	(1.000)
Q(12)	19.495	(0.077)	11.322	(0.502)	8.649	(0.733)	79.387	0.000	17.804	(0.122)	0.574	(1.000)
Q(16)	21.717	(0.153)	13.615	(0.627)	12.467	(0.711)	94.057	0.000	19.060	(0.266)	0.666	(1.000)
Q(20)	22.172	(0.331)	14.405	(0.809)	15.164	(0.767)	112.090	0.000	23.193	(0.279)	0.870	(1.000)
Full Sample[b]: 1999:01 - 2011:08												
	SPV_t		OPV_t		UDI_t		CSI_t		NMF_t		NIF_t	
Q(4)	0.418	(0.981)	0.448	(0.978)	1.494	(0.828)	5.191	(0.268)	3.833	(0.429)	1.048	(0.902)
Q(8)	0.776	(0.999)	7.561	(0.478)	8.636	(0.374)	13.597	(0.093)	5.810	(0.669)	1.924	(0.983)
Q(12)	7.807	(0.800)	9.012	(0.702)	11.245	(0.508)	26.492	(0.009)	9.917	(0.623)	3.436	(0.992)
Q(16)	10.608	(0.833)	13.084	(0.667)	12.302	(0.723)	29.947	(0.018)	12.673	(0.697)	3.681	(0.999)
Q(20)	12.603	(0.894)	13.951	(0.833)	16.958	(0.656)	37.471	(0.010)	17.871	(0.596)	7.732	(0.994)
Subsample 1: 1999:01 - 2006:08												
	SPV_t		OPV_t		UDI_t		CSI_t		NMF_t		NIF_t	
Q(4)	3.817	(0.431)	8.065	(0.089)	18.743	(0.001)	8.721	(0.069)	14.807	(0.005)	3.540	(0.472)
Q(8)	6.377	(0.605)	14.416	(0.072)	30.014	(0.000)	14.733	(0.065)	19.666	(0.012)	8.412	(0.394)
Q(12)	8.649	(0.733)	15.794	(0.201)	31.577	(0.002)	17.804	(0.122)	27.845	(0.006)	12.189	(0.431)
Q(16)	12.467	(0.711)	21.544	(0.159)	33.441	(0.007)	19.060	(0.266)	31.467	(0.012)	18.390	(0.302)
Q(20)	15.164	(0.767)	28.772	(0.092)	36.716	(0.013)	23.193	(0.279)	32.392	(0.039)	20.924	(0.402)
Subsample 2: 2006:09 - 2011:08												
	SPV_t		OPV_t		UDI_t		CSI_t		NMF_t		NIF_t	
Q(4)	6.391	(0.172)	10.683	(0.030)	4.574	(0.334)	24.231	(0.000)	16.286	(0.003)	36.732	(0.000)
Q(8)	17.698	(0.024)	24.752	(0.002)	10.367	(0.240)	27.815	(0.001)	22.936	(0.003)	45.793	(0.000)
Q(12)	29.250	(0.004)	30.592	(0.002)	20.077	(0.066)	29.108	(0.004)	28.522	(0.005)	57.421	(0.000)
Q(16)	30.693	(0.015)	33.547	(0.006)	22.775	(0.120)	45.510	(0.000)	36.673	(0.002)	62.625	(0.000)
Q(20)	39.182	(0.006)	39.974	(0.005)	32.740	(0.036)	79.305	(0.000)	44.538	(0.001)	72.997	(0.000)

Note: Q(#) denotes the number of lag at which the p-value, in parenthesis, is evaluated. The numbers without parenthesis represent Q-statistic values. (a) renewable represents fuel policy included, and (b) renewable fuel policy excluded. SPV_t is monthly soybeans future price volatility, OPV_t denotes monthly oil spot price volatility, UDI_t represents monthly U.S Dollar index volatility, CSI_t is monthly China soybeans imports, NMF_t denotes number of mutual funds, and NIF_t is number of index funds. The values in parenthesis are *p*-value.

Table 25. Test of no ARCH effects of the Residuals of the Selected Model (Adjusted Series).

Period	SPV_t		OPV_t		UDI_t		CSI_t		NMF_t		NIF_t	
[a]1999:01 - 2011:08	0.072	(3.248)	0.486	(0.486)	0.898	(0.016)	0.019	(5.503)	0.556	(0.347)	0.868	(0.028)
[b]1999:01 - 2011:08	3.848	(0.050)	0.465	(0.495)	0.017	(0.897)	5.372	(0.021)	0.048	(0.827)	0.028	(0.867)
1999:01 - 2006:08	0.036	(4.386)	4.497	(0.034)	0.048	(0.826)	0.308	(0.579)	4.718	(0.030)	0.004	(0.949)
2006:09 - 2011:08	0.063	(0.803)	0.002	(0.962)	0.001	(0.972)	2.864	(0.091)	0.061	(0.806)	0.889	(0.346)

Note: The number in parenthesis represent p-values, while the numbers without parenthesis are LM statistic values. (a) renewable represents fuel policy included, and (b) renewable fuel policy excluded. SPV_t is monthly soybeans future price volatility, OPV_t denotes monthly oil spot price volatility, UDI_t represents monthly U.S Dollar index volatility, CSI_t is monthly China soybeans imports, NMF_t denotes number of mutual funds, and NIF_t is number of index funds. The values in parenthesis are *p*-value.

Table 26. Test of no ARCH effects of the Residuals of the Selected Model (Raw Series).

Period	SPV_t		OPV_t		UDI_t		CSI_t		NMF_t		NIF_t	
[a]1999:01 - 2011:08	0.486	(0.486)	0.156	(0.693)	0.328	(0.567)	0.900	(0.343)	0.253	(0.615)	0.028	(0.866)
[b]1999:01 - 2011:08	0.003	(0.954)	0.004	(0.949)	0.002	(0.963)	0.001	(0.975)	0.037	(0.848)	0.054	(0.817)
1999:01 - 2006:08	0.112	(0.738)	0.073	(0.787)	0.002	(0.961)	1.220	(0.269)	0.494	(0.482)	0.015	(0.904)
2006:09 - 2011:08	0.090	(0.764)	5.406	(0.020)	1.324	(0.250)	0.055	(0.814)	0.086	(0.769)	0.063	(0.802)

Note: The number in parenthesis represent p-values, while the numbers without parenthesis are LM statistic values. (a) renewable represents fuel policy included, and (b) renewable fuel policy excluded. SPV_t is monthly soybeans future price volatility, OPV_t denotes monthly oil spot price volatility, UDI_t represents monthly U.S Dollar index volatility, CSI_t is monthly China soybeans imports, NMF_t denotes number of mutual funds, and NIF_t is number of index funds. The values in parenthesis are *p*-value.

As shown previously, Table 23 and 24 contain the LB Q-statistics for the adjusted and raw series of each equation, respectively. Using a significance level of 0.01, the model rejects the presence of autocorrelation, which means that misspecification of the model is not an issue except for subsample 2 in equations such as CSI_t, NMF_t, and NIF_t where the autocorrelation is persistent. The results of the LM test and the *p*-values are found in Table 25 and 26. At a significance level of 0.01, the null hypothesis of no ARCH effects cannot be rejected. Therefore, the model does not exhibit heteroskedasticity. Thus, based on the test for unit-root and the adequacy of the model, it is concluded that a test for Granger Causality can be performed on the first difference of the variables, using a VAR model. The VAR model is also appropriate since , since there is no autocorrelation or heteroskedasticity present in the residuals.

To test for Granger causality, regressions were performed for each sample period, taking into account the results of the lag structure. It should be noted that the residuals of these regressions do not exhibit serial autocorrelation or heteroskedasticity. A *F*-test was utilized to test the hypothesis of no causal link between the variables in this study explored and monthly soybeans future price volatility. The test states the linear restriction $\beta_j = 0$□$_j$ and $\Phi_j = 0$□$_j$. In an efficient market, the null hypothesis of no autocorrelation ($\gamma_j = 0$□$_j$) will be also fail to be rejected.

The results found in Table 27 reveals that for the full sample period of the adjusted series, irrespective of whether the U.S renewable fuel policy is included, past values of soybeans futures price volatility, oil price variability, and the numbers of index funds are significant at a level of 0.05. When, looking at the first sample period, past values of soybeans futures price volatility and number of index funds are significant at the level of 0.05. Finally, for subsample 2, the soybeans futures price volatility is explained by its own lags, oil spot prices, soybeans imports to China, and the number of index funds available for public investors are significant at the level of 0.10.

Table 27. Granger Causality Analysis for Monthly Volatility of Soybeans Future Prices (Adjusted Series).

$$\Delta SPV_t = \alpha + \sum_{j=1}^{m} \gamma_j \Delta SPV_{t-j} + \sum_{j=1}^{m} \beta_j \Delta X_{t-j} + \phi_j RFP_d + \varepsilon_t$$

		Full Sample[a]		Full Sample[b]		Subsample 1		Subsample 2	
		1999:01 - 2011:08		1999:01 - 2011:08		1999:01 - 2006:08		2006:09 - 2011:08	
ΔSPV	$\square\ \gamma = 0$	14.620	(0.000)***	8.930	(0.000)***	7.180	(0.000)***	2.710	(0.039)**
ΔOPV	$\square_j \beta_1 = 0$	1.276	(0.283)	2.030	(0.299)	2.967	(0.019)	1.279	(0.080)*
RFP	$\square_j \phi = 0$	0.333	(0.717)						
ΔUDI	$\square_j \beta_2 = 0$	0.731	(0.484)	0.436	(0.823)	2.084	(0.121)	0.368	(0.866)
ΔCSI	$\square_j \beta_3 = 0$	7.264	(0.001)***	2.769	(0.021)**	1.071	(0.386)	2.594	(0.046)**
ΔNMF	$\square_j \beta_4 = 0$	0.538	(0.585)	0.638	(0.671)	0.745	(0.593)	0.705	(0.624)
ΔNIF	$\square_j \beta_5 = 0$	4.244	(0.016)**	2.719	(0.023)**	2.915	(0.021)**	2.220	(0.078)*

Notes: ***, **, * denotes 1, 5 and 10 percent of significance. (a) is the U.S renewable fuel policy included and (b) renewable fuel policy excluded. The lag structure utilized to perform the regressions for full sample[a] is 2, full sample[b] is 5, subsample 1is 4, and subsample 2 is 5.

Table 28. Granger Causality Analysis for Monthly Volatility of Soybeans Future Prices (Raw Series).

$$\Delta SPV_t = \alpha + \sum_{j=1}^{m} \gamma_j \Delta SPV_{t-j} + \sum_{j=1}^{m} \beta_j \Delta X_{t-j} + \phi_j RFP_d + \varepsilon_t$$

		Full Sample[a]		Full Sample[b]		Subsample 1		Subsample 2	
		1999:01 - 2011:08		1999:01 – 2011:08		1999:01 – 2006:08		2006:09 - 2011:08	
ΔSPV	$\square_j\ \gamma = 0$	5.890	(0.004)***	5.820	(0.000)***	8.540	(0.000)***	3.480	(0.012)**
ΔOPV	$\square_j \beta_1 = 0$	2.916	(0.058)**	1.614	(0.162)	1.016	(0.406)	1.663	(0.094)*
RFP	$\square_j \phi = 0$	0.565	(0.721)						
ΔUDI	$\square_j \beta_2 = 0$	1.191	(0.570)	0.329	(0.894)	1.289	(0.284)	1.069	(0.408)
ΔCSI	$\square_j \beta_3 = 0$	9.697	(0.007)***	4.308	(0.001)***	4.911	(0.002)**	3.080	(0.022)**
ΔNMF	$\square_j \beta_4 = 0$	0.080	(0.334)	0.522	(0.759)	0.115	(0.977)	1.392	(0.259)
ΔNIF	$\square_j \beta_5 = 0$	3.463	(0.000)***	1.379	(0.237)	1.187	(0.325)	3.004	(0.025)**

Notes: *, **, *** denotes 1, 5 and 10 percent of significance. (a) is the U.S renewable fuel policy included and (b) renewable fuel policy excluded. The lag structure utilized to perform the regressions for full sample[a] is 2, full sample[b] is 5, subsample 1is 4, and subsample 2 is 6.

Since the properties of the data could change using seasonal date, Table 28 contains the results of the Granger Causality analysis for the raw data. The results are similar to those obtained for the adjusted series, except that the oil spot price is also able to explain monthly soybeans futures prices volatility when the U.S renewable fuel policy is included, from January

1999 to August 2006. This result is likely occurring because of an increase from two to four of the lag length. Thus, past values of monthly soybeans futures prices can be explained by the variability of oil spot prices, soybeans imports to China and the number of index funds.

CHAPTER 5. SUMMARY AND CONCLUSIONS

This study attempts to identify those factors that influence the price volatility of soybeans futures prices. The literature reports that for most agricultural commodities the economic principles of supply and demand have been affected by non-fundamental factors. In general, research indicates that the increasing integration between energy and agricultural markets, the increasing consumption of commodities from developing countries, U.S monetary policy, and financial speculation are factors that merit investigation when looking at drivers of commodity price. This research builds upon the existing literature by examining the influence of the volatility of oil prices, U.S renewable fuel policy, soybeans imports to China, the U.S dollar index, and the number of mutual and index funds available for public investment in a given month, on soybeans futures price volatility. To accomplish this study, linear Granger causality was utilized.

5.1 Summary

Recent literature suggests that a key driver of agricultural commodity prices is the increasing integration between energy and agricultural Markets. The results of this research reveal that there is statistical evidence that oil prices are able to explain monthly soybean futures price volatility from January 1999 to August 2011. These results agree with those obtained by Taheripour and Tynes (2008), Mitchell (2008), and Saghaian 2010, but disagree with those obtained by Du et al. (2009), who concluded that there is no statistical evidence that the oil prices affect the variability of soybeans prices. The results are supported by the close relationship of oil prices and the derivatives being used as inputs (fuel and fertilizers) in the production of soybeans (Tangermann 2011).

Furthermore, the results of this study indicate that there is no statistical evidence that U.S renewable fuel policy explains monthly soybeans futures price volatility, a result that concurs with the findings of Babcock (2011). These results suggest that even if the policy were eliminated, soybeans price volatility would still be observed at very high levels. This occurs because biofuels production accounts for a very small percentage of the world acreage allocated to the production of grains and oilseeds, less that 1.5 and 9 percent, respectively (Baffes and Haniotis 2010; Tangermann 2011).

The literature also reports that macroeconomic conditions have allowed developing countries, such as China, to consume more commodities. Expansion of consumption in these countries has likely affected the price of several commodities, including soybeans. The results of this study reveal that there is insufficient evidence to show that soybeans imports to China influenced monthly soybeans futures price volatility between January 1999 and August 2006 period, but there is strong statistical significance that this increasing consumption explains soybeans futures price volatility between September 2009 and August 2011 period. These results likely occur because of the significant increase in consumption of soybeans imports by China since the fourth quarter of 2006. Data from the USDA (2011) indicates that for every 10 tons of soybeans consumed in China between 1999 and 2005 period, 5 tons were produced domestically, but by 2006, this number has dropped to 2.5 tons. The increasing deficit has been replaced by imports from Argentina, Brazil, and the U.S. These countries export approximately 90 percent of the world's soybeans. More importantly, China will consume 60 percent of all exported soybeans by 2011.

Previous research also indicates that the value of the U.S dollar is likely to be a key driver of agricultural commodity prices. Helbling et al. (2008) assert that because most commodities are priced in U.S dollars, which has continuously depreciated since 2002 (Piesse and Thirtle 2009), the demand for agricultural futures contracts has increased. This research utilized a U.S dollar index, which is computed based on the currencies from the main participants in the soybeans market, Argentina (Peso), Brazil (Real), and China (Yuan). The hypothesis that monthly soybeans futures price volatility is driven by the U.S dollar index strength/weakness for all sample periods is rejected. This result is supported by the findings of Balcombe (2010) who analyzed the effect of the U.S dollar/Euro exchange volatility and the soybeans futures prices. An additional reason that the U.S dollar index does not influence monthly soybeans futures price volatility is that the currencies included in this index move relatively at the same peace of the U.S dollar. This behavior suggests that these countries (Argentina, Brazil, and China) have maintained a monetary policy that allowed keeping their competitiveness, and therefore, their level of exports.

Finally, a variety of financial data has been used to examine the influence of financial speculation on commodity price variability, including the non-commercial long-only position and spread positions. The conclusions reported in the literature about the influence of financial speculation on agricultural commodity prices are conflicting. None of the previous studies makes inferences about the number of speculative funds such as mutual and index funds available for public investment. This research examined the number of mutual and index funds as possible drivers of monthly soybeans futures price volatility. The results reveal that while there is no statistical evidence that the number of mutual funds influence the monthly soybeans future price volatility irrespective of the sample period, there is significant evidence that the number of index funds available for investment can explain price volatility of soybeans, from January 1999 to August 2011. Currently commodity index funds are viewed as a separate asset class, i.e. public investors using futures contracts to rebalance and diversification their portfolios (Baffes and Haniotis 2010). By investing in these index funds, these investors, who are continually moving in and out of these funds are creating artificial demand for commodity derivatives; and consequently, increasing price volatility of soybeans futures.

The lack of significance around the number of mutual funds is a consequence of the inability to measure the actual investments of these funds in agricultural commodity markets, where index funds must disclose their positions via the Commodity Futures Traders Commission (CFTC). In addition, the constituent weights of mutual funds over time, which means the proportion allocated to commodities, compared to the entire value of the portfolio, is typically small.

5.2 Implications and Conclusions

A common question among stakeholders involved in futures markets is if the movements of prices recently observed are no longer consistent with known fundamentals. This research answers this question by providing statistical evidence that the futures prices of soybeans are being influenced by the increasing consumption of soybeans in China, the variability of oil prices, and the increasing number of commodity index available for public investors. Soybeans price volatility has important implications for producers, traders, and consumers.

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

Since the purpose of futures markets is to aide in managerial decisions by obtaining expectations of price movements, these results would be the basis for future research in the area, particularly is it relates to forecasting soybeans futures price volatility. In that vein, the price volatility could be forecasted take into account the results obtained from this research, but could also include other factors such as weather, inventories, and stock to use ratios. The expectations of prices can be used to place a production hedge before or during the growing period for the crop. In addition, producers can use the expectation of soybeans prices for storage hedges.

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APPENDIX I: AUTOCORRELATION FUNCTIONS (RAW DATA)

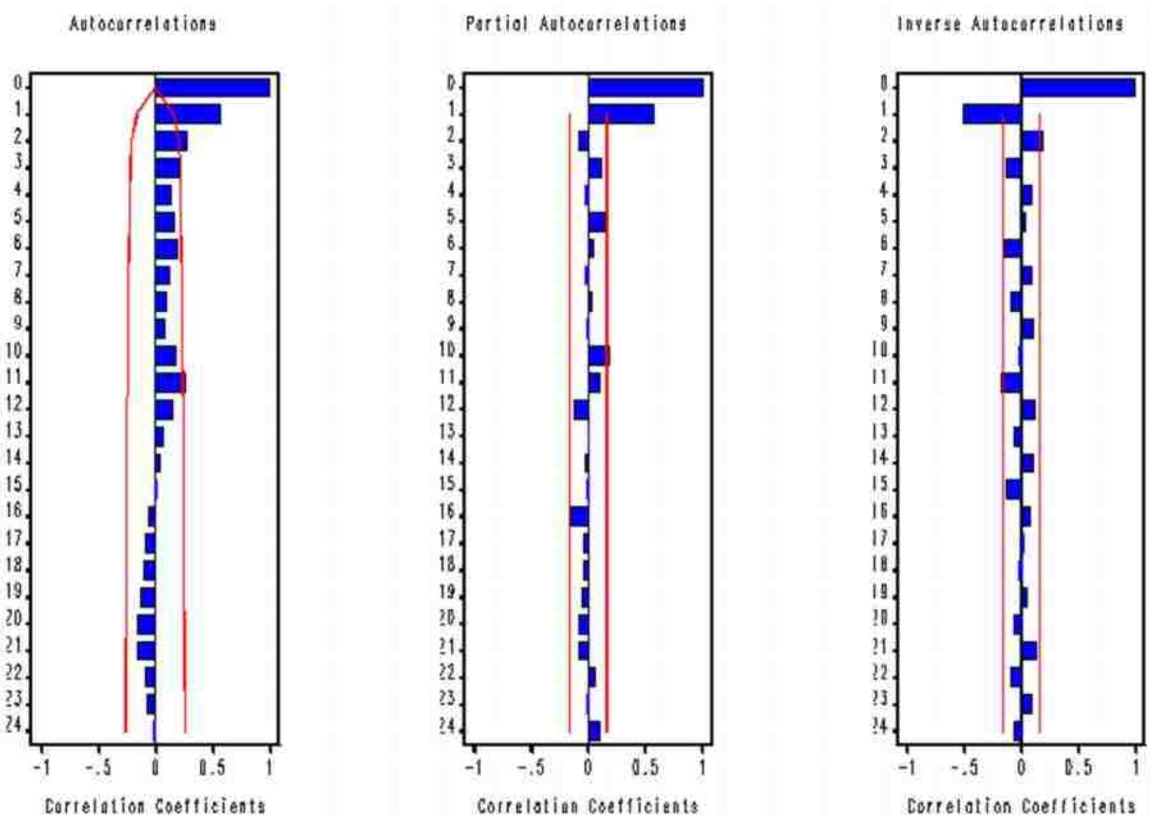

Figure 13. Monthly Soybeans Futures Price Volatility Autocorrelation Functions.
Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, less than one, is useful to explain the absence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

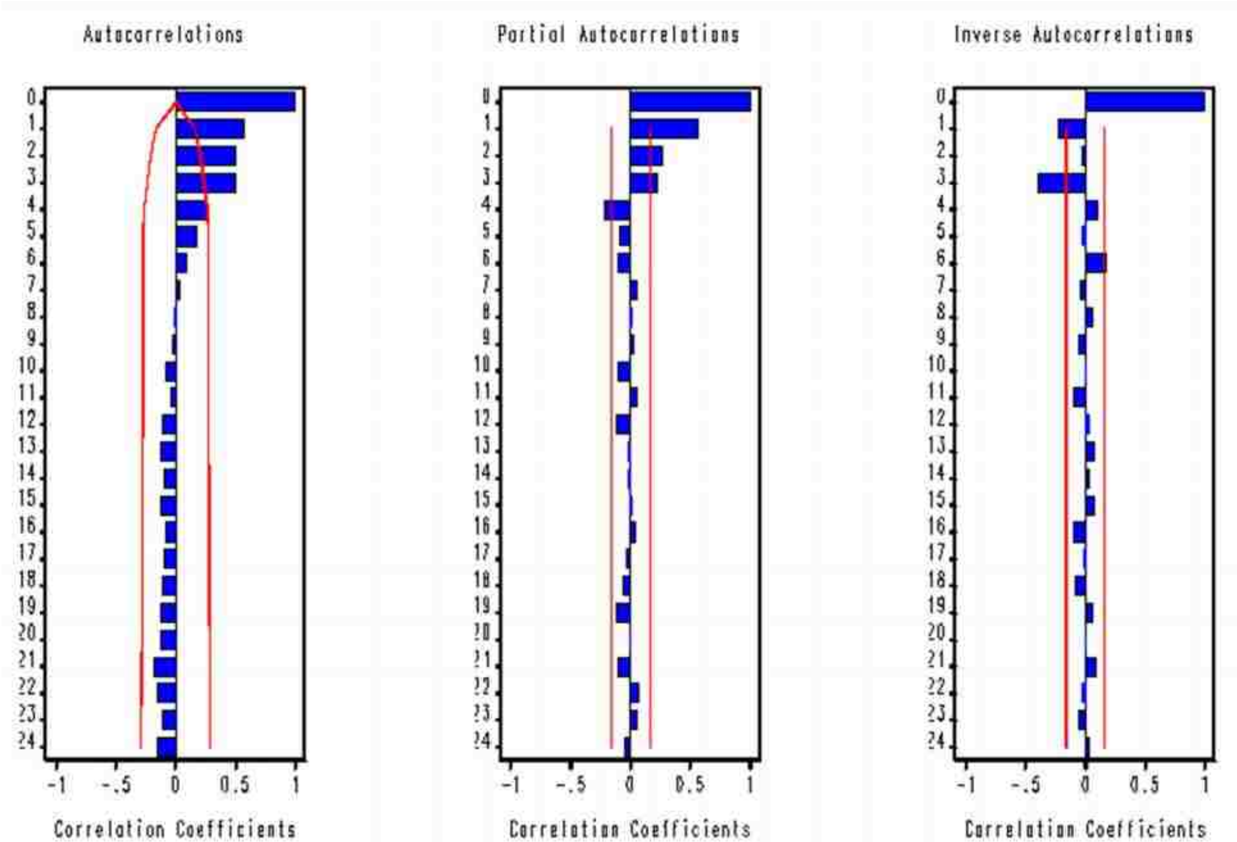

Figure 14. Oil Spot Price Volatility Autocorrelation Functions.
Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, less than one, is useful to explain the absence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

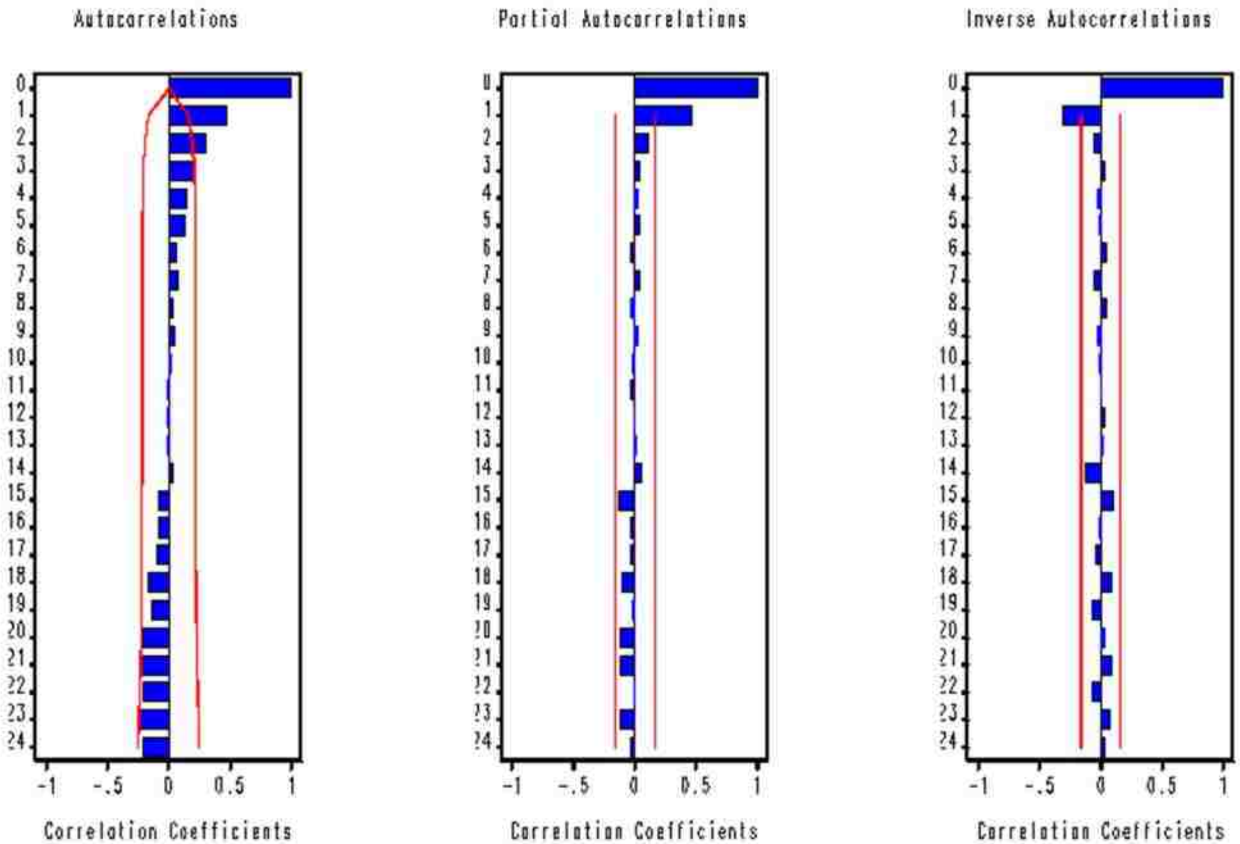

Figure 15. U.S Dollar Index Autocorrelation Functions.

Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, less than one, is useful to explain the absence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

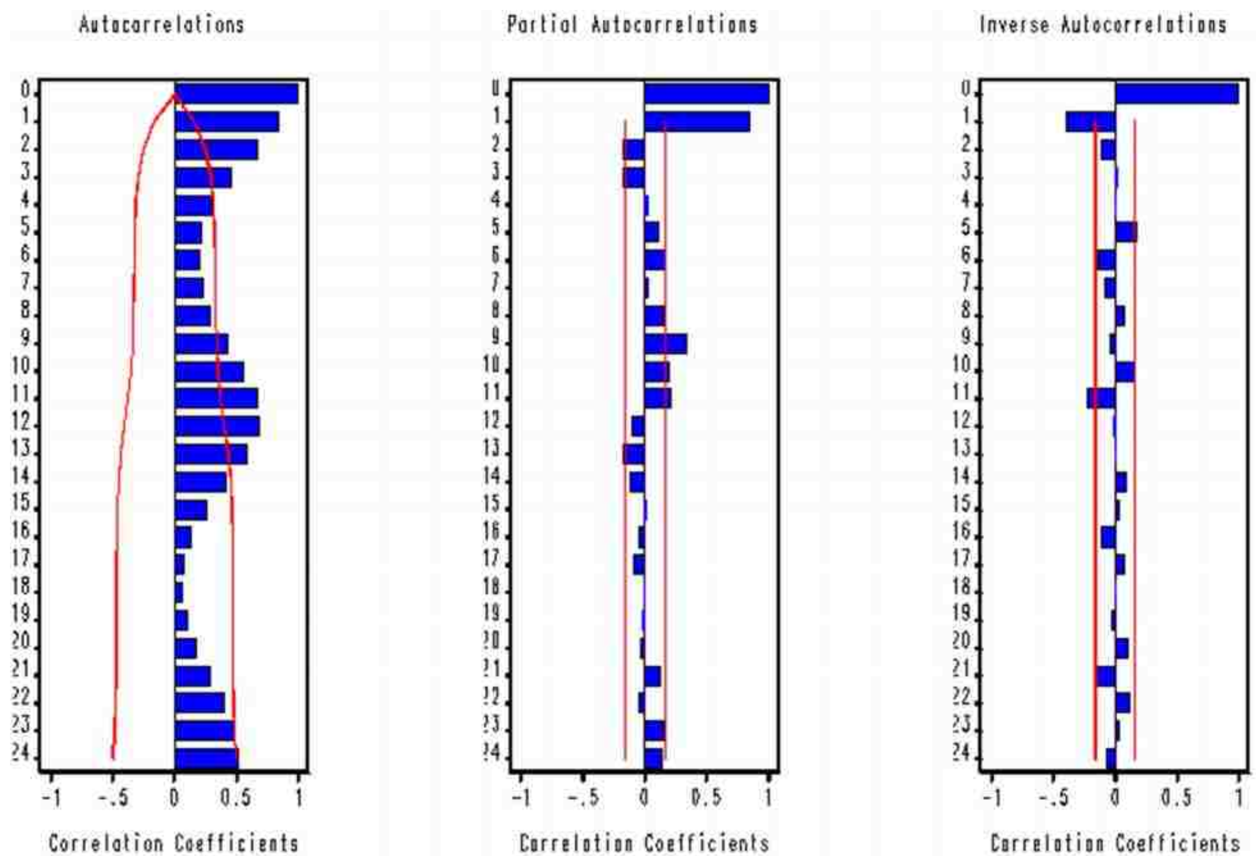

Figure 16. China Soybeans Imports Autocorrelation Functions.

Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, close to one, is useful to explain the presence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

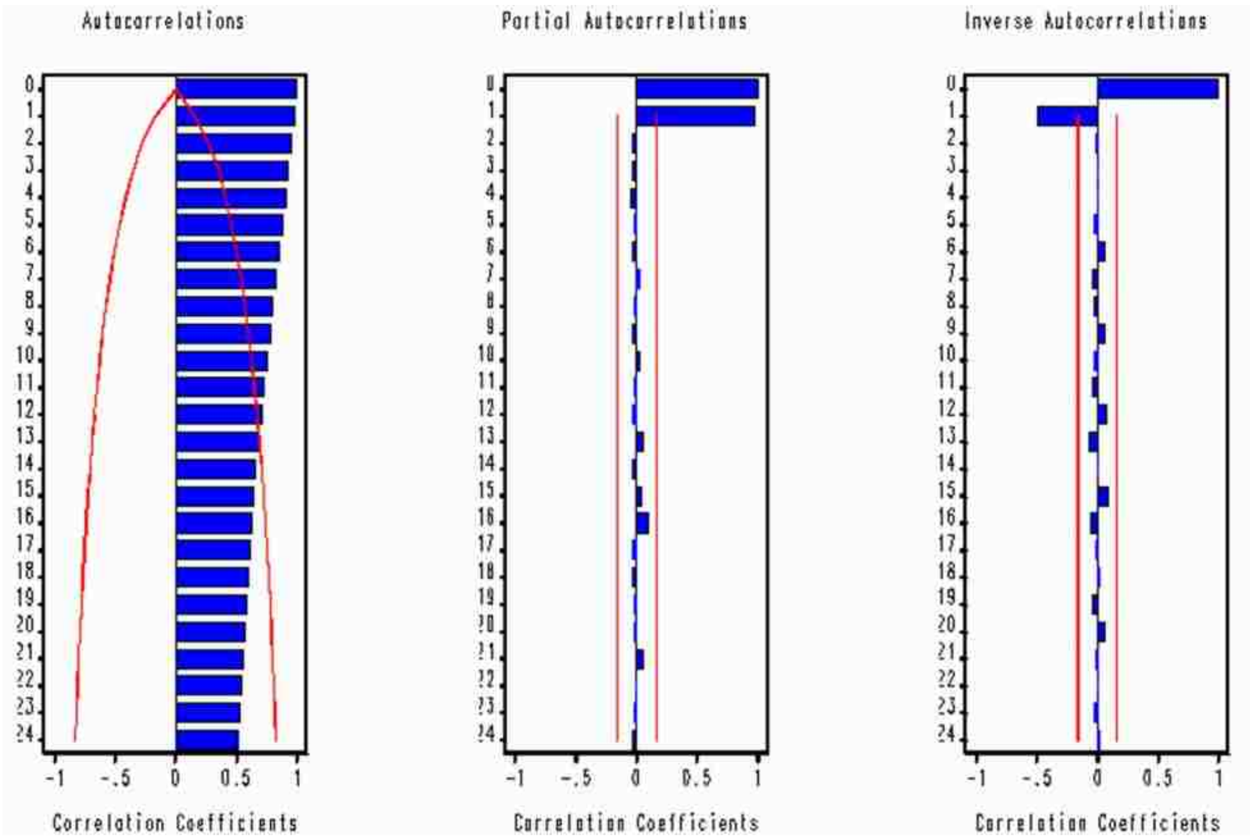

Figure 17. Number of Mutual Funds Autocorrelation Functions.

Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, close to one, is useful to explain the presence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

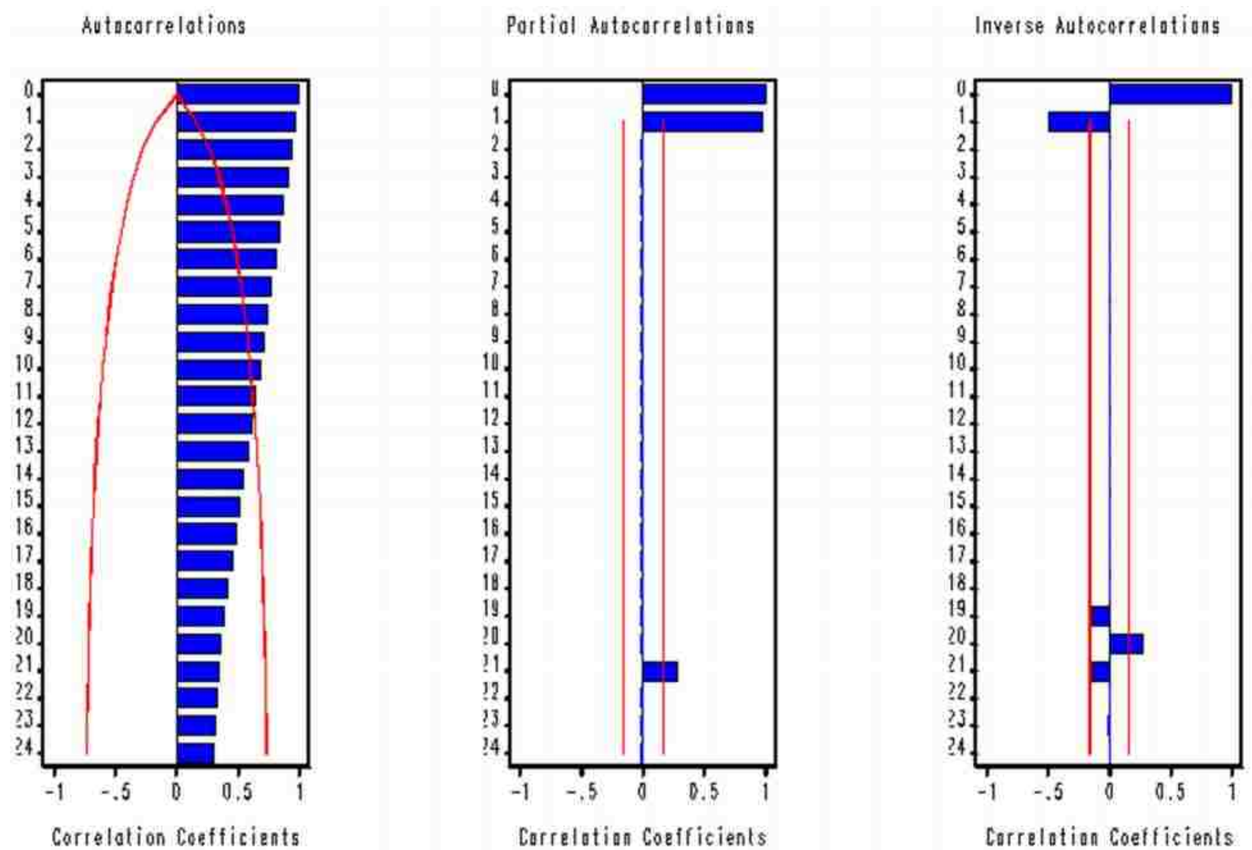

Figure 18. Number of Index Funds Autocorrelation Functions.

Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, close to one, is useful to explain the presence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

APPENDIX II: AUTOCORRELATION FUNCTIONS (ADJUSTED SERIES)

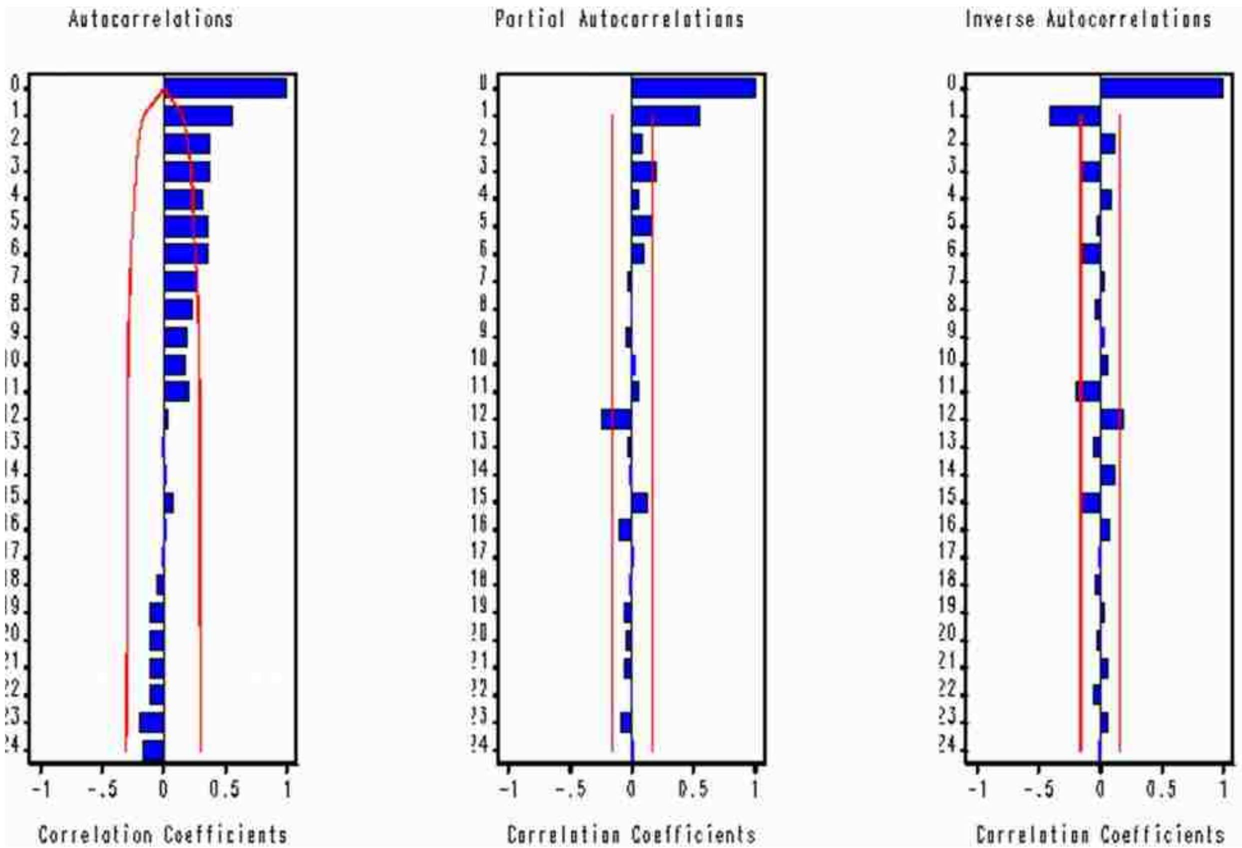

Figure 19. Soybeans Futures Price Volatility Autocorrelation Functions (Adjusted Series).
Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, less than one, is useful to explain the absence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

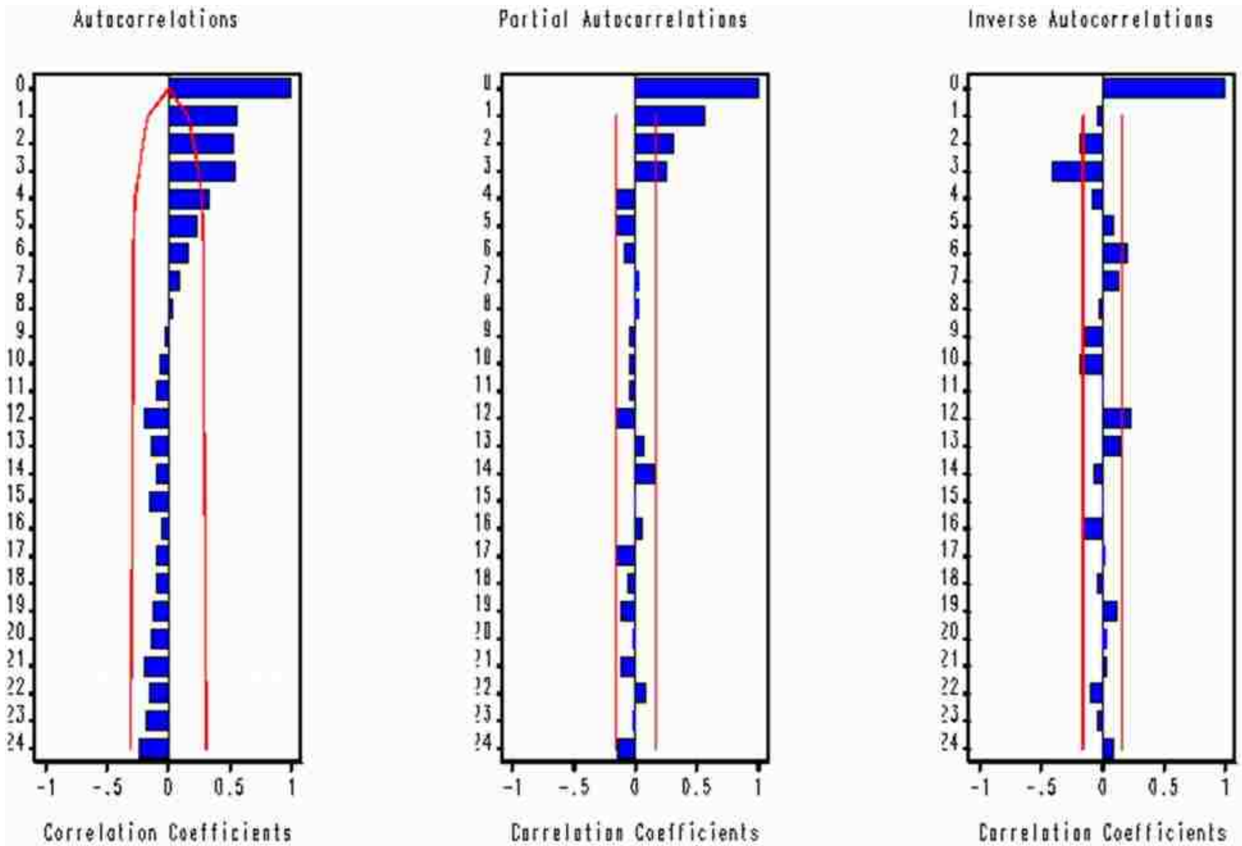

Figure 20. Oil Spot Price Volatility Autocorrelation Functions (Adjusted Series).
Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, less than one, is useful to explain the absence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

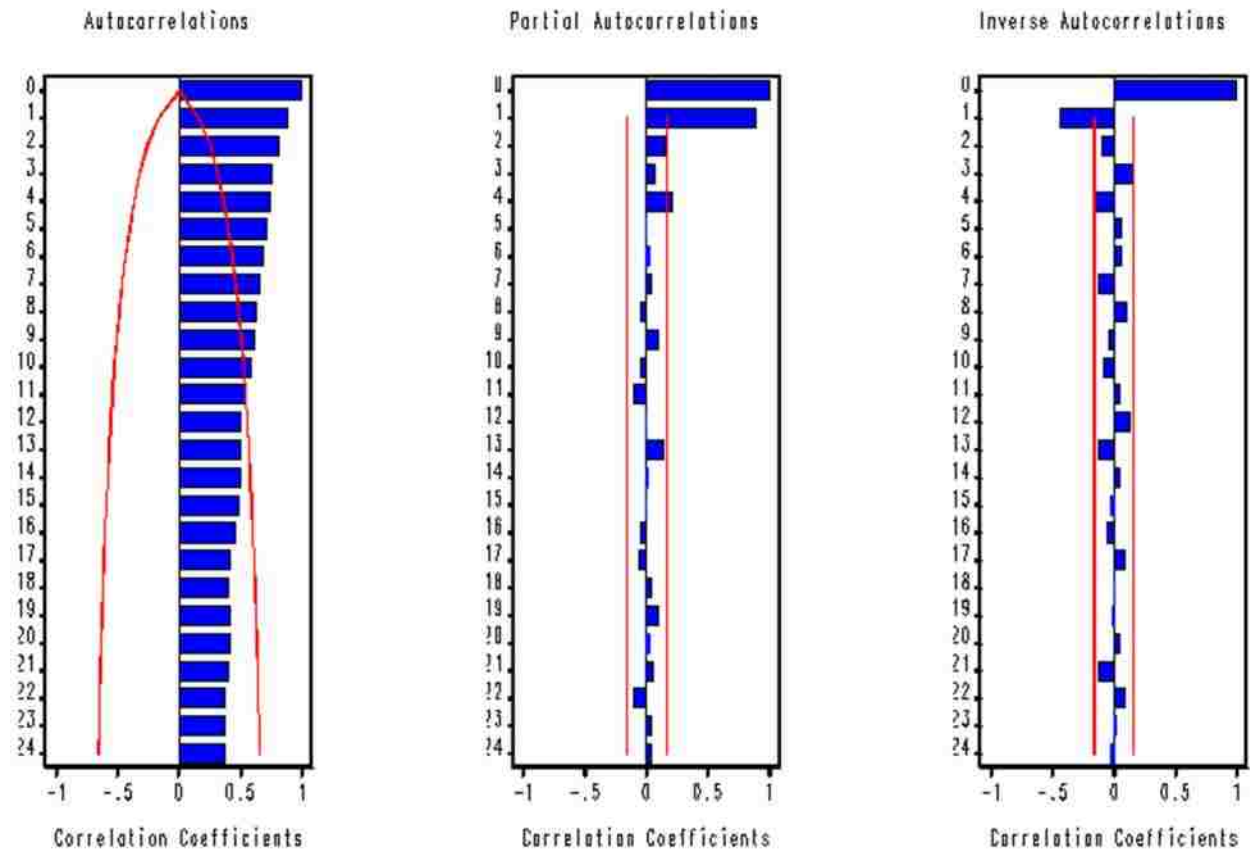

Figure 21. China Soybeans Imports Autocorrelation Functions (Adjusted Series).

Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, close to one, is useful to explain the presence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

APPENDIX III: AUTOCORRELATION FUNCTIONS (RAW SERIES - 1st DIFERRENCE)

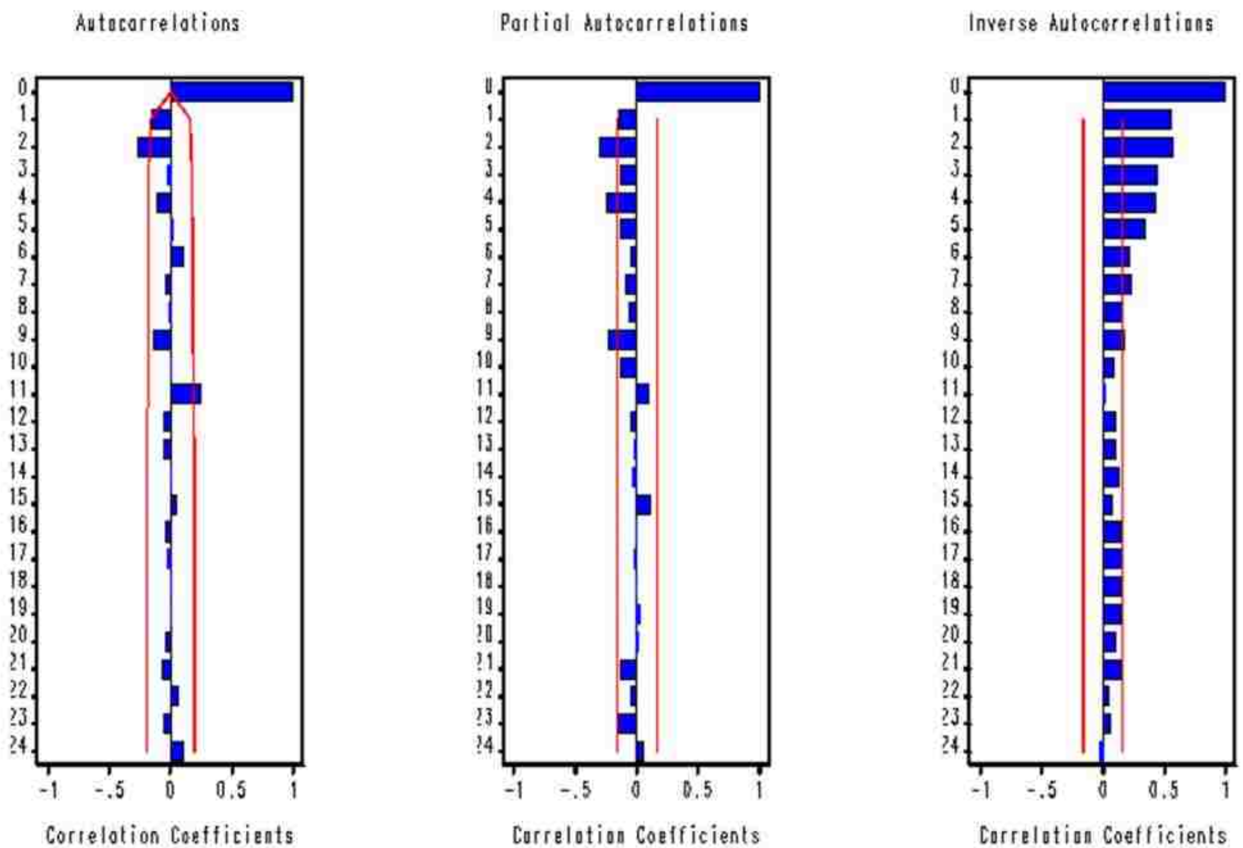

Figure 22. Soybeans Futures Price Volatility Autocorrelation Function (1st Difference).

Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, less than one, is useful to explain the absence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

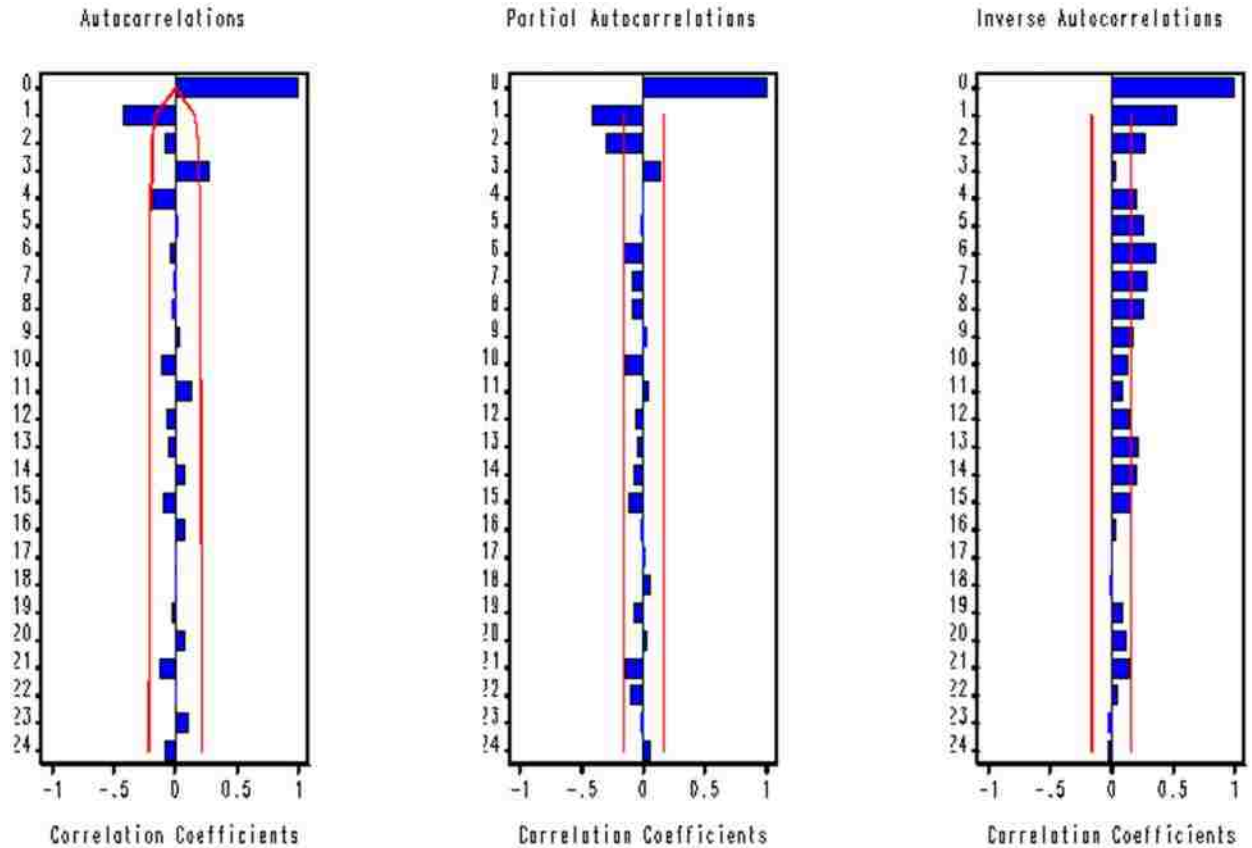

Figure 23. Oil Spot Prices Autocorrelation Functions (1st Difference).

Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, less than one, is useful to explain the absence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

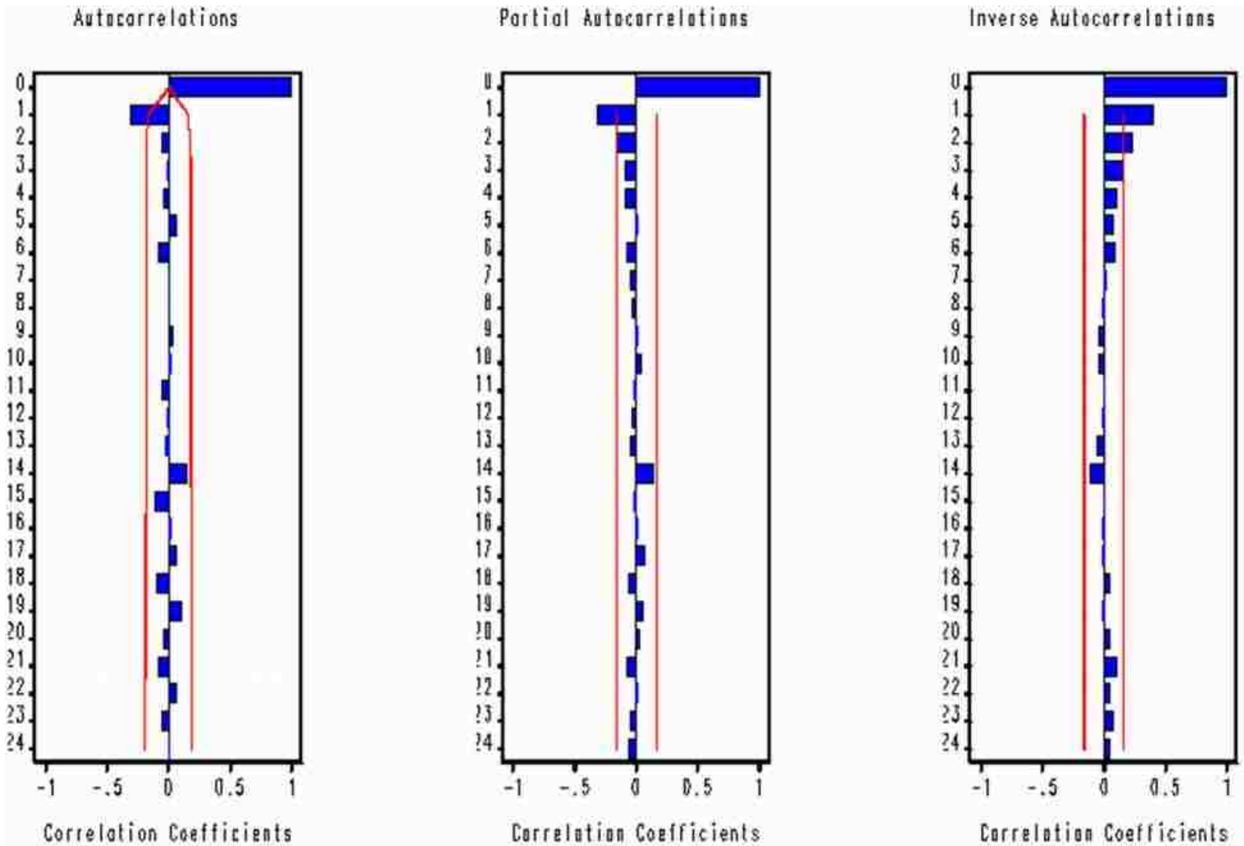

Figure 24. U.S Dollar Index Autocorrelation Functions (1st Difference).

Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, less than one, is useful to explain the absence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

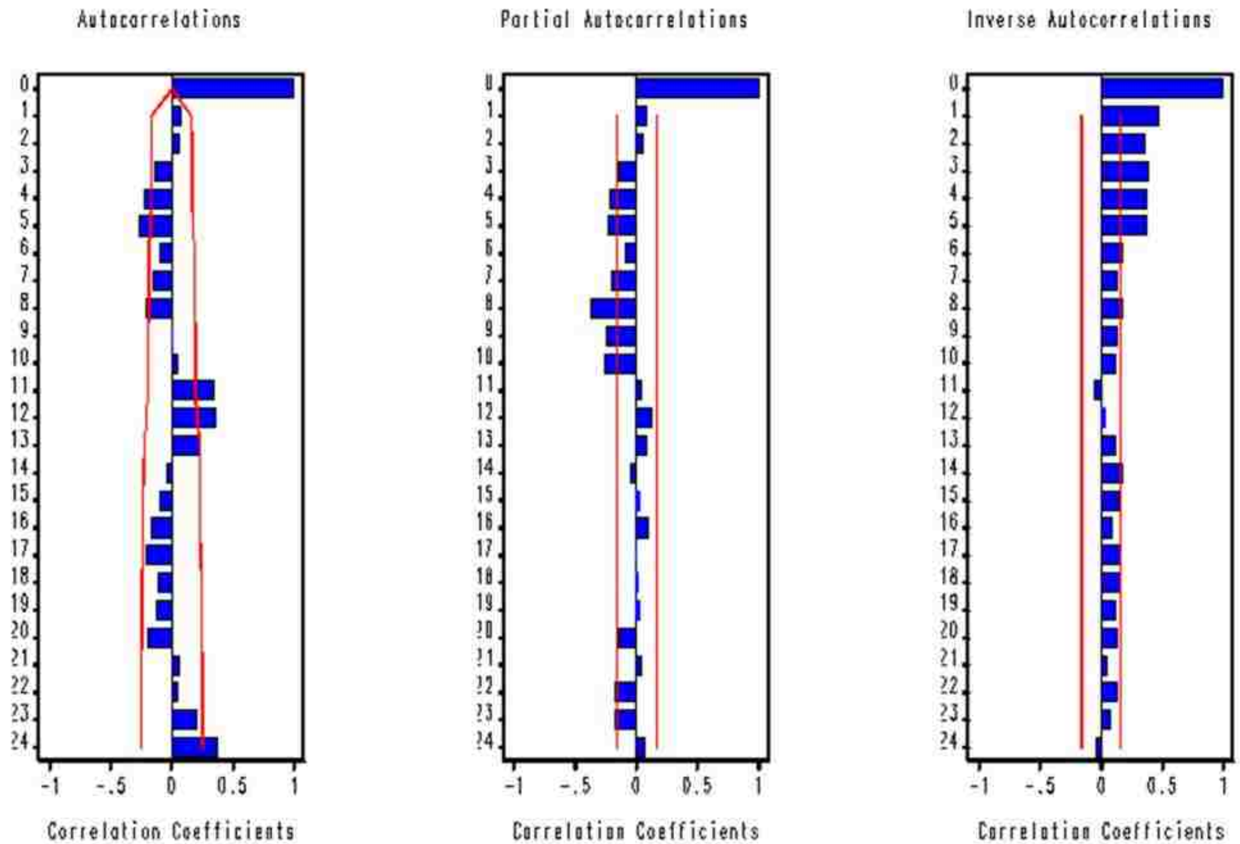

Figure 25. China Soybeans Imports Autocorrelation Functions (1st Difference).
Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, less than one, is useful to explain the absence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

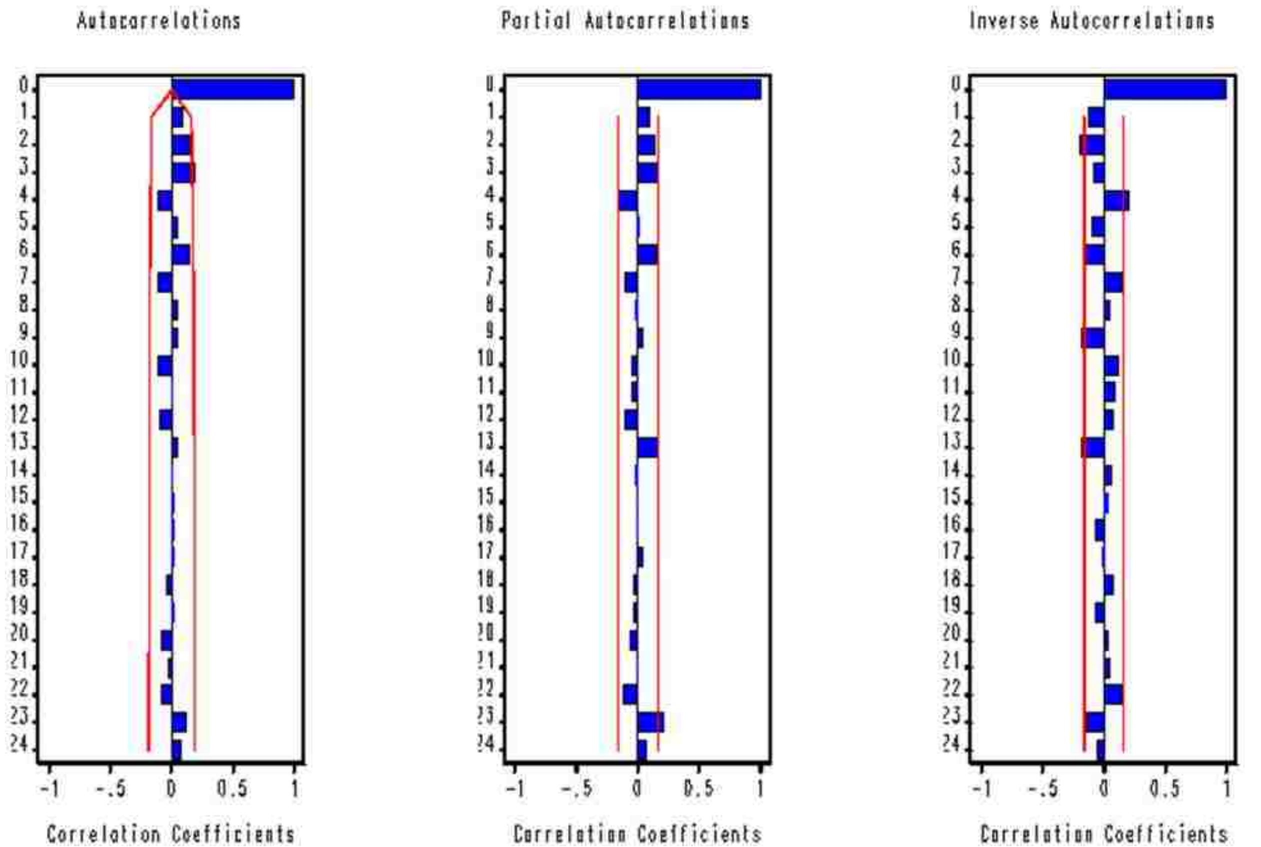

Figure 26. Number of Mutual Funds Autocorrelation Functions (1st Difference).

Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, less than one, is useful to explain the absence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

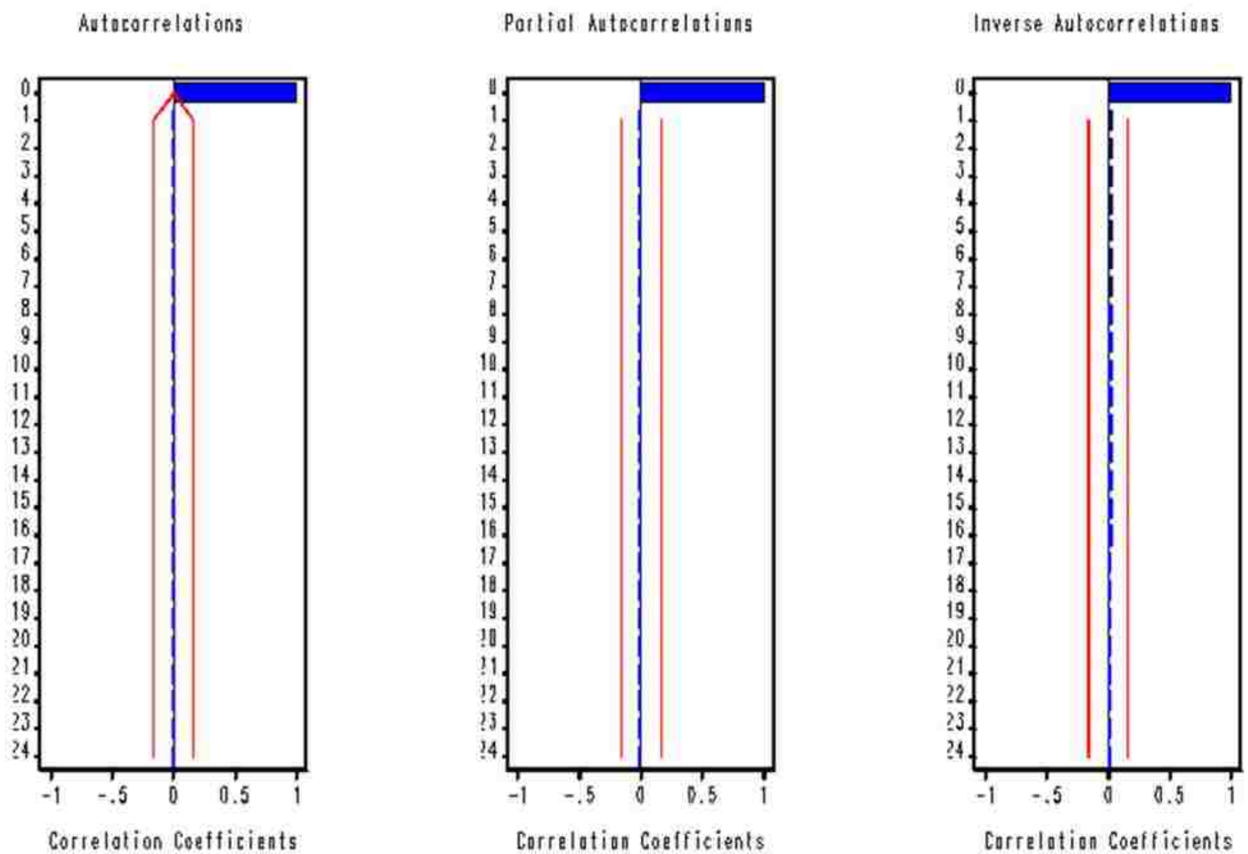

Figure 27. Number of Index Funds Autocorrelation Functions (1st Difference).

Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, less than one, is useful to explain the absence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality.

APPENDIX IV: AUTOCORRELATION FUNCTIONS (ADJUSTED SERIES - 1st DIFERRENCE)

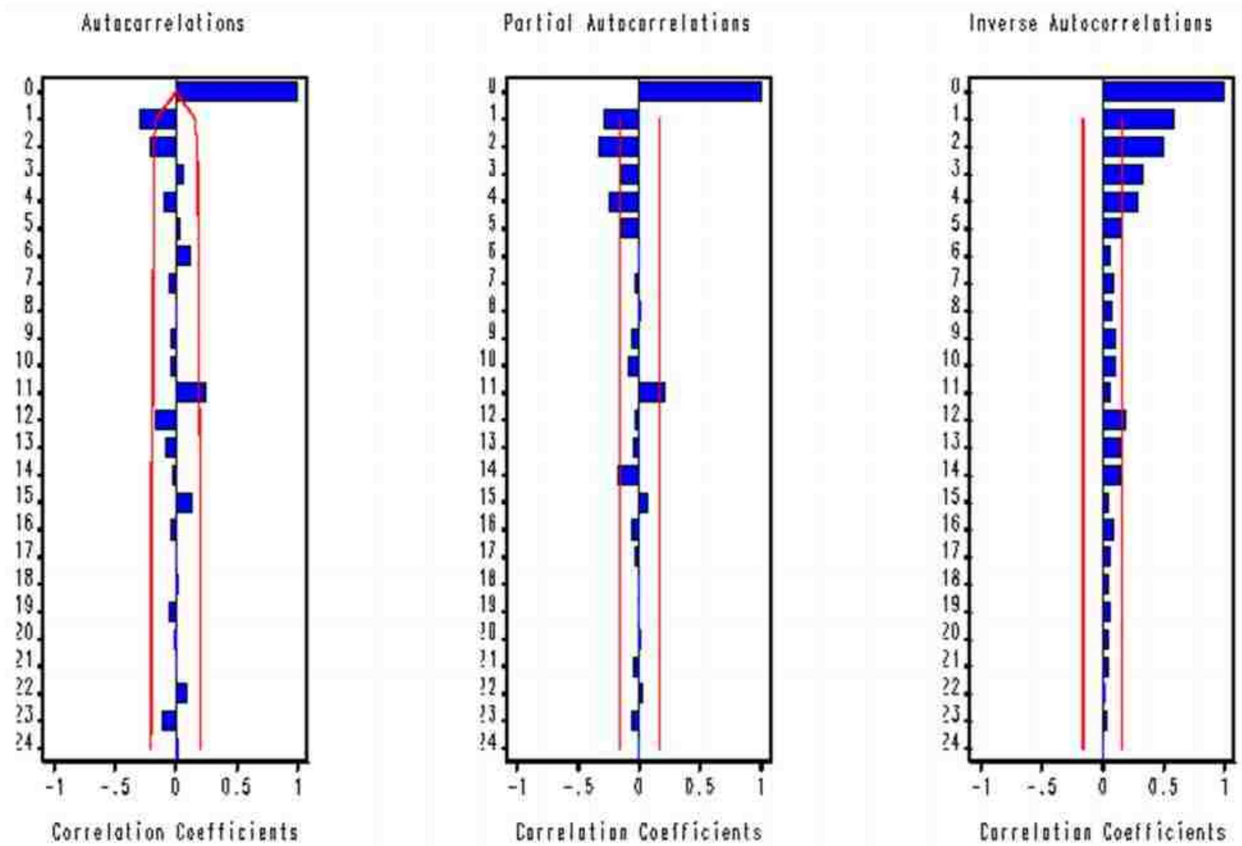

Figure 28. Soybeans Future Price Volatility Autocorrelation Functions (Adjusted Series – 1st Difference).

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Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, less than one, is useful to explain the absence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality. The adjusted series contains data seasonally adjusted by the X-11 method

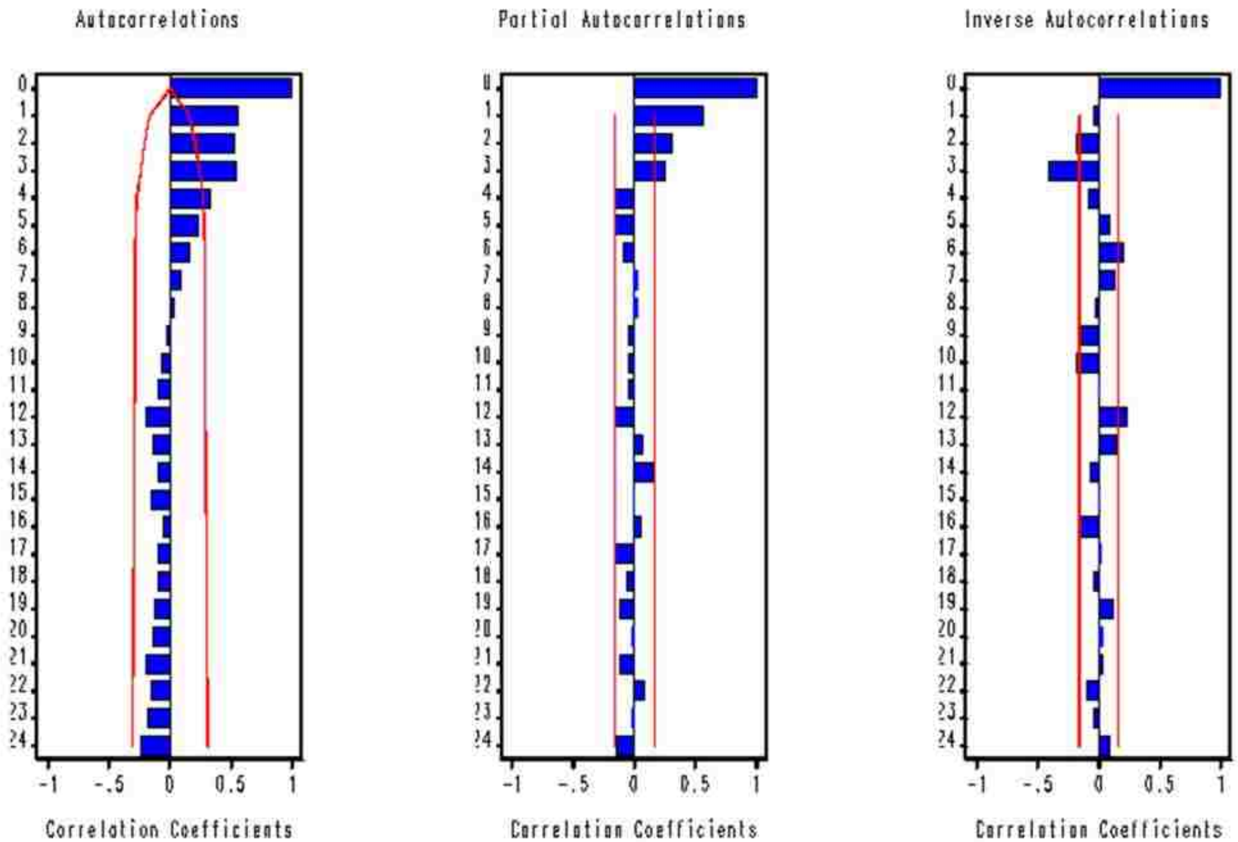

Figure 29. Oil Spot Prices Autocorrelation Functions (Adjusted Series -1st Difference).
Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, less than one, is useful to explain the absence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality. The adjusted series contains data seasonally adjusted by the X-11 method

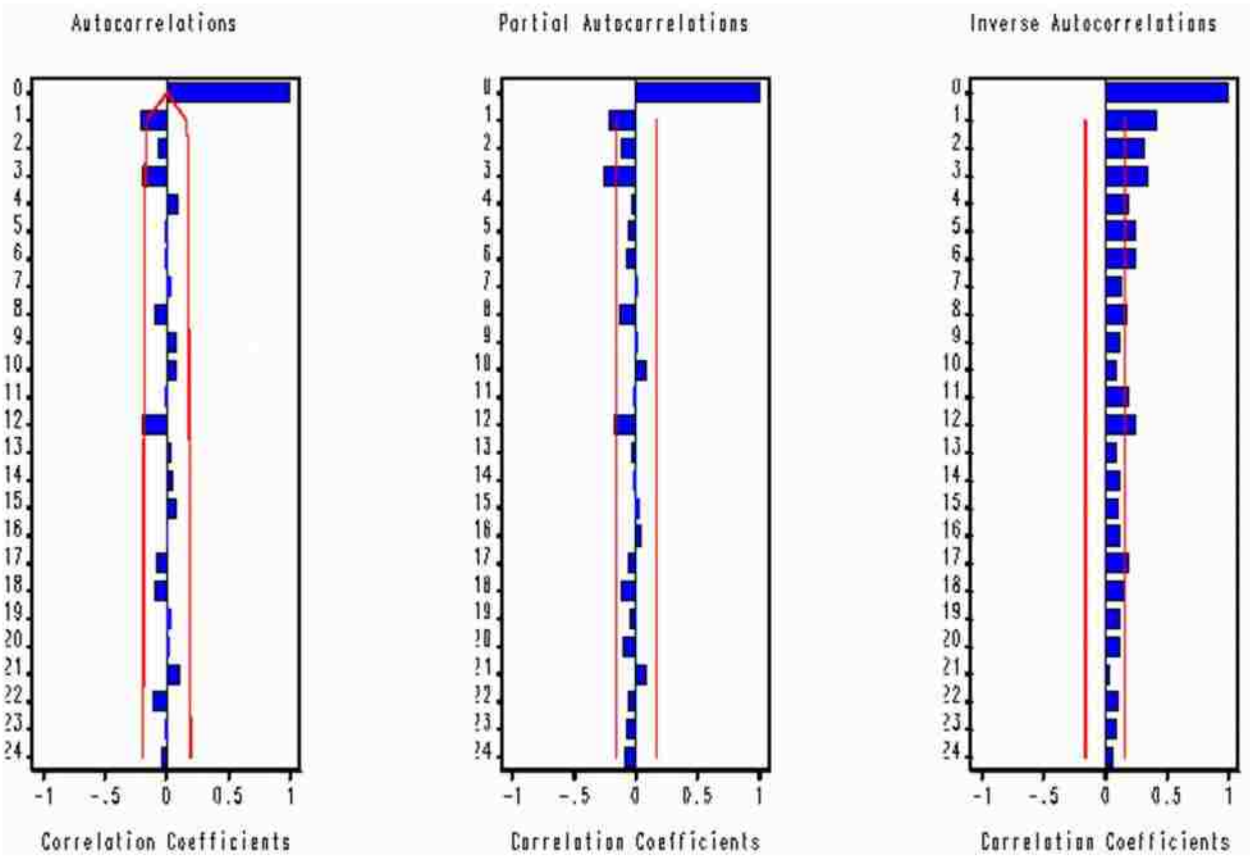

Figure 30. China Soybeans Imports Autocorrelation Functions (Adjusted Series – 1st Difference).
Note: In general, a slow decay of the autocorrelation function denotes an Autoregressive (AR) process, with a lag length provided by the number of spikes in the partial autocorrelation function. The first spike (lag one) of the partial and autocorrelation function, less than one, is useful to explain the absence of a unit-root. The inverse autocorrelation function is utilized to analyze seasonality, and if the spikes are beyond the 95 percent confidence interval, it suggests seasonality. The adjusted series contains data seasonally adjusted by the X-11 method

APPENDIX V: MEANS BY SEASON

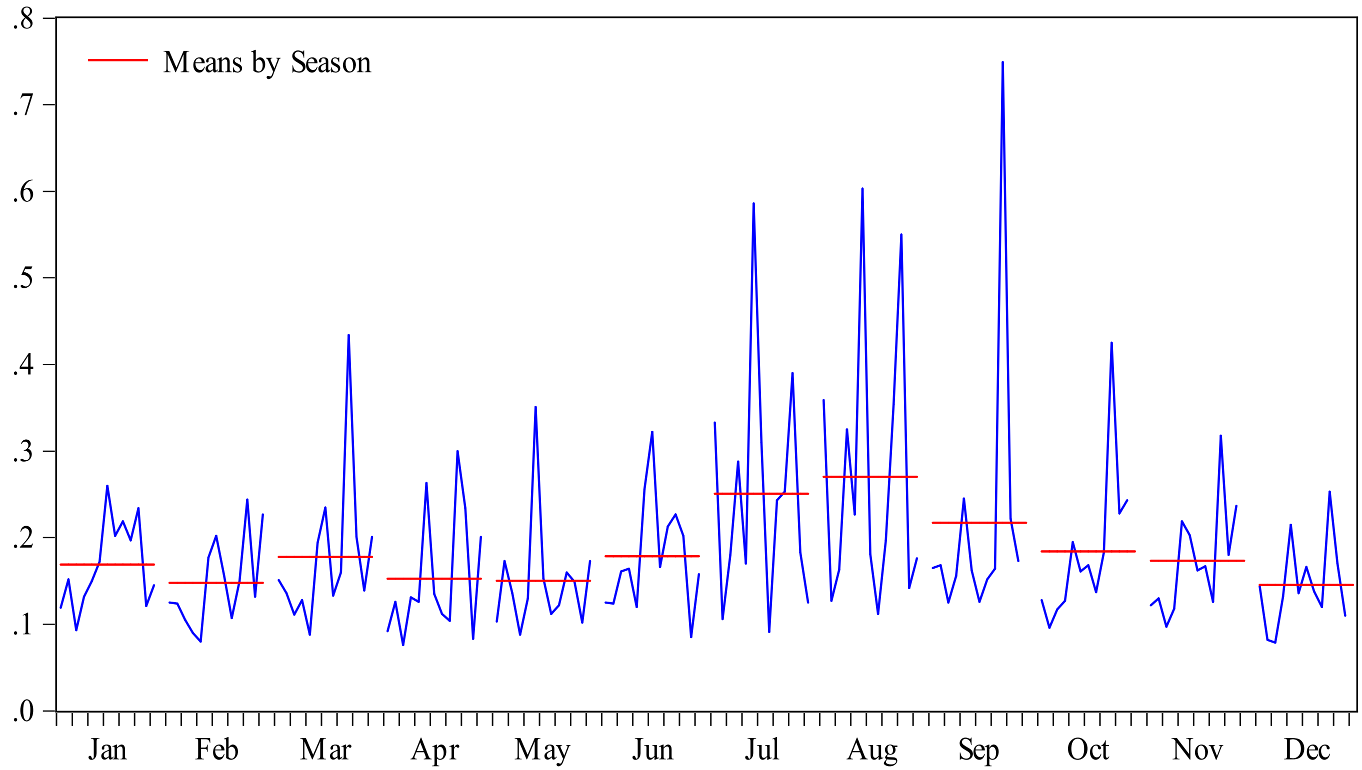

Figure 31. Monthly Soybeans Futures Price Volatility by Season.

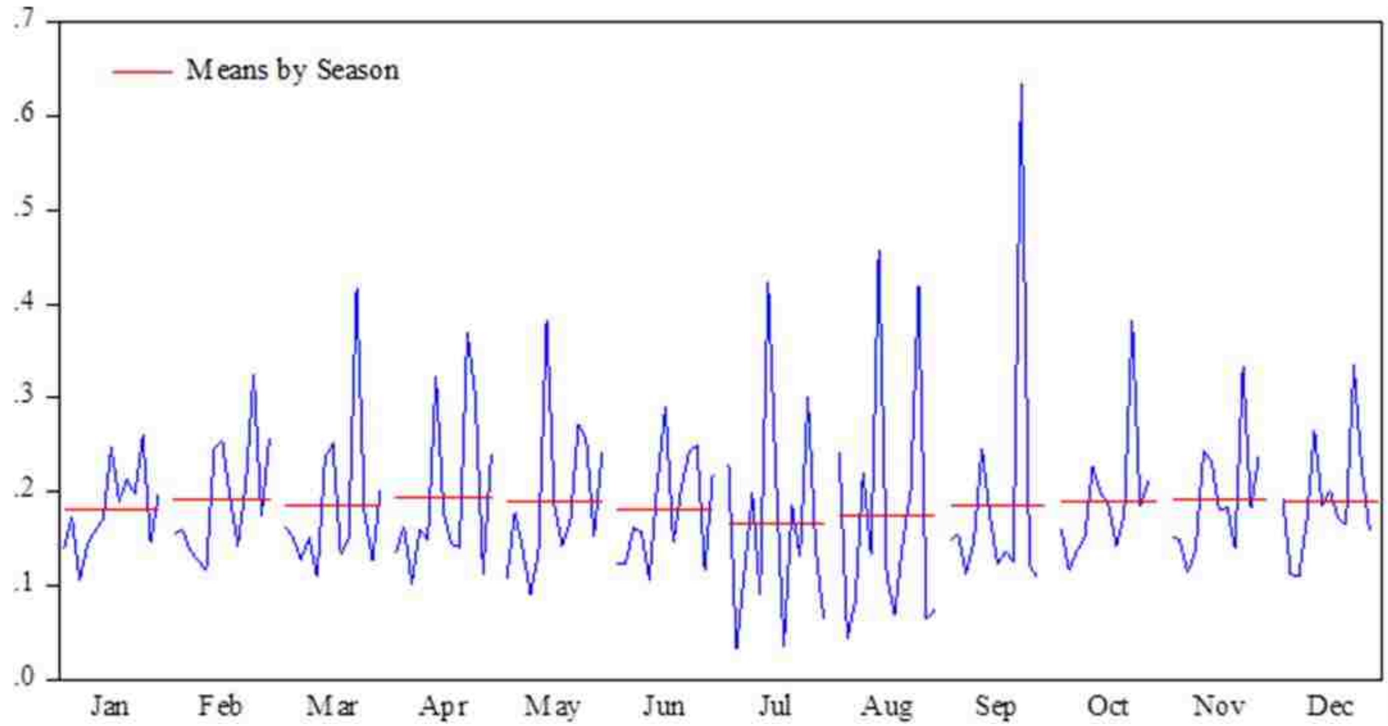

Figure 32. Monthly Soybeans Futures Price Volatility Seasonal Adjustment.
Note: The adjusted series contains data seasonally adjusted by the X-11 method

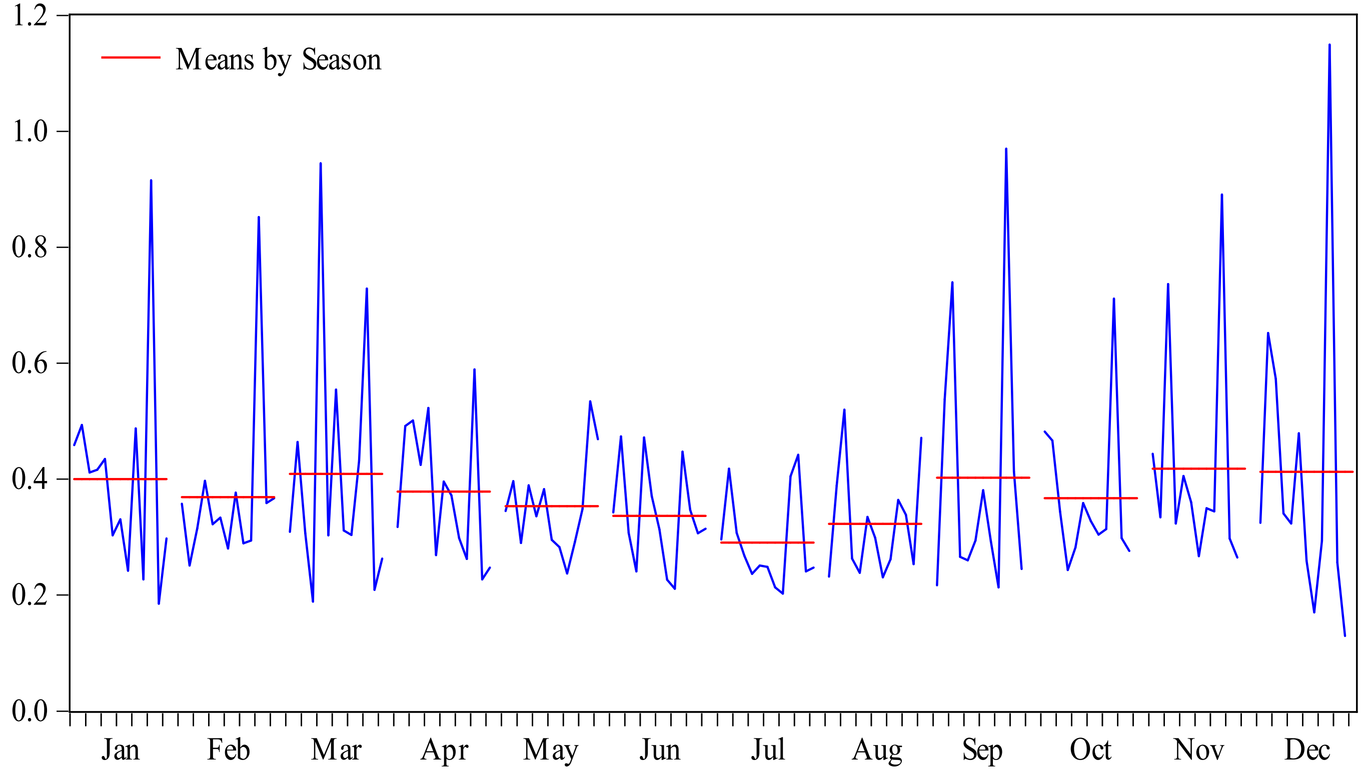

Figure 33. Monthly Oil Spot Price Volatility by Season.

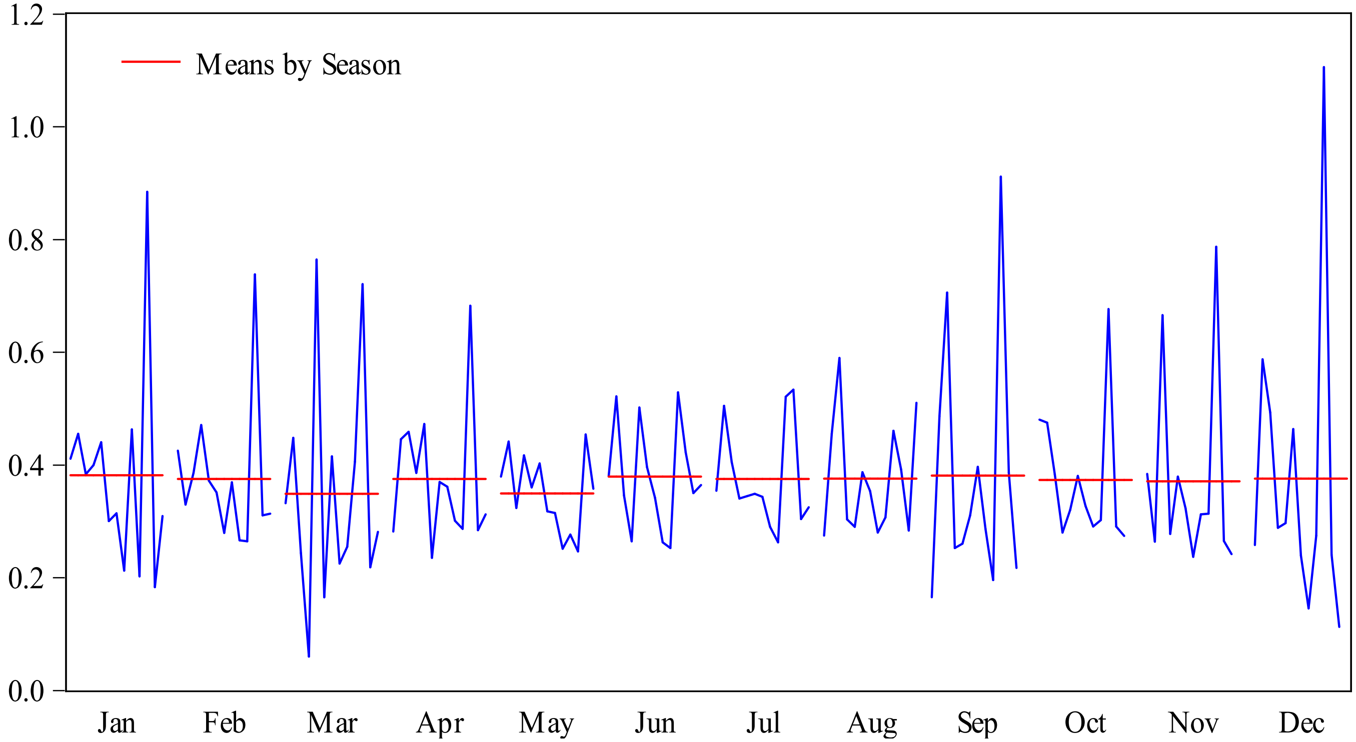

Figure 34. Monthly Oil Spot Price Volatility Seasonal Adjustment.

Note: The adjusted series contains data seasonally adjusted by the X-11 method

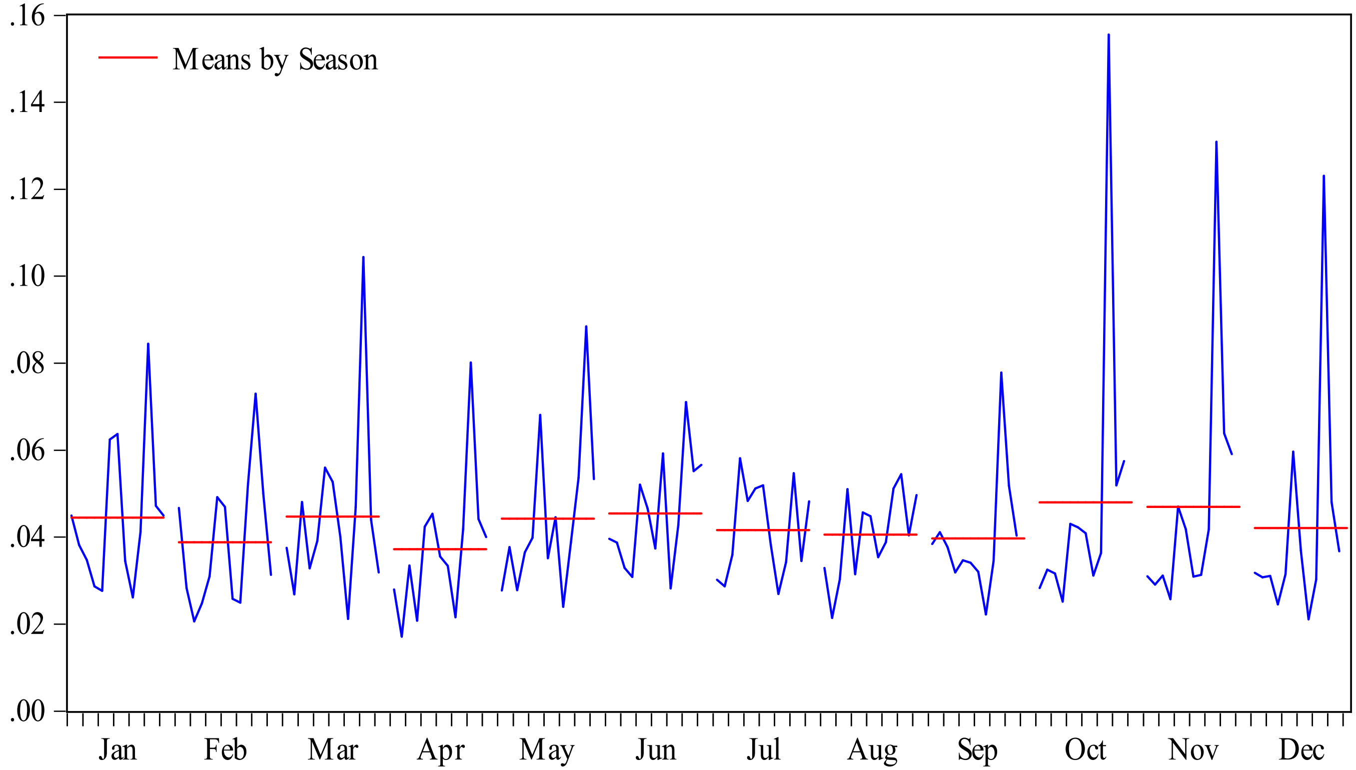

Figure 35. Monthly U.S Dollar Index Volatility by Season.
Note: The adjusted series contains data seasonally adjusted by the X-11 method

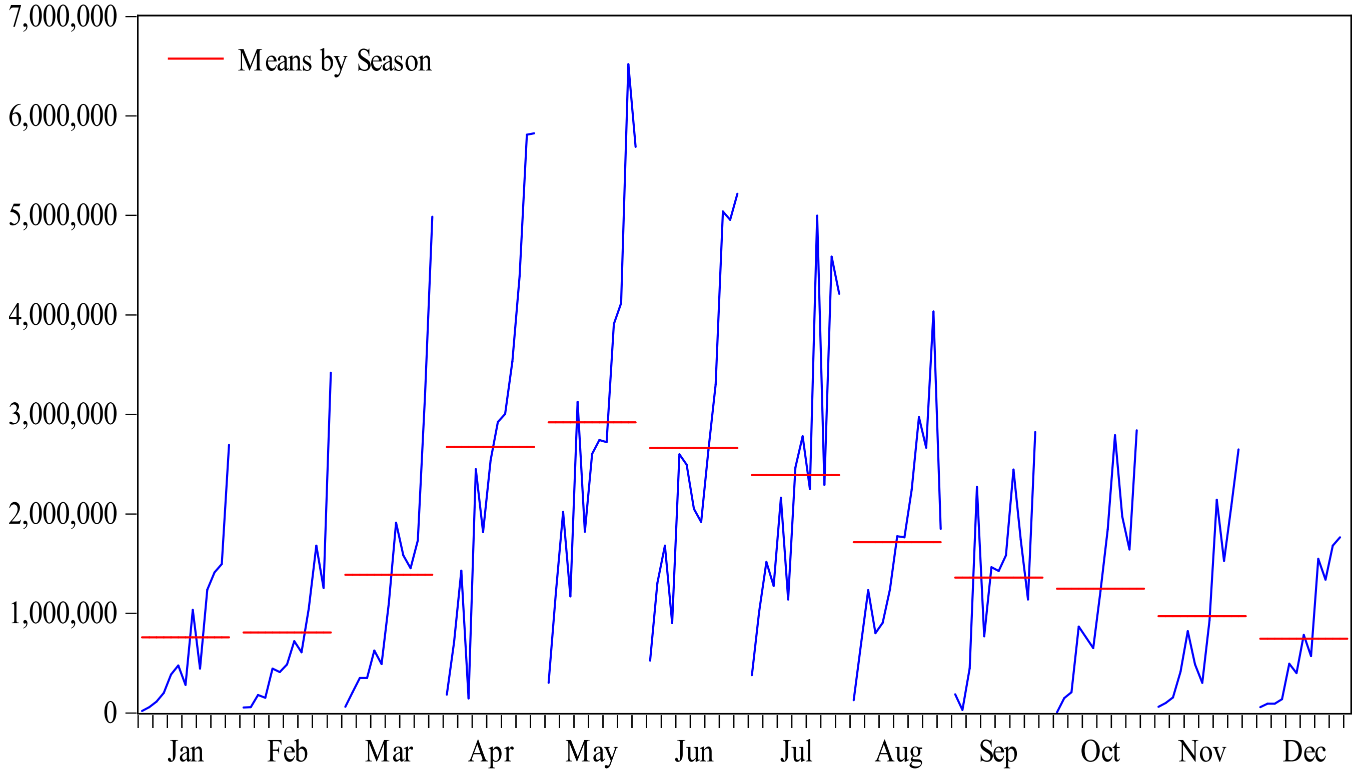

Figure 36. Monthly China Soybeans Imports by Season (ton).

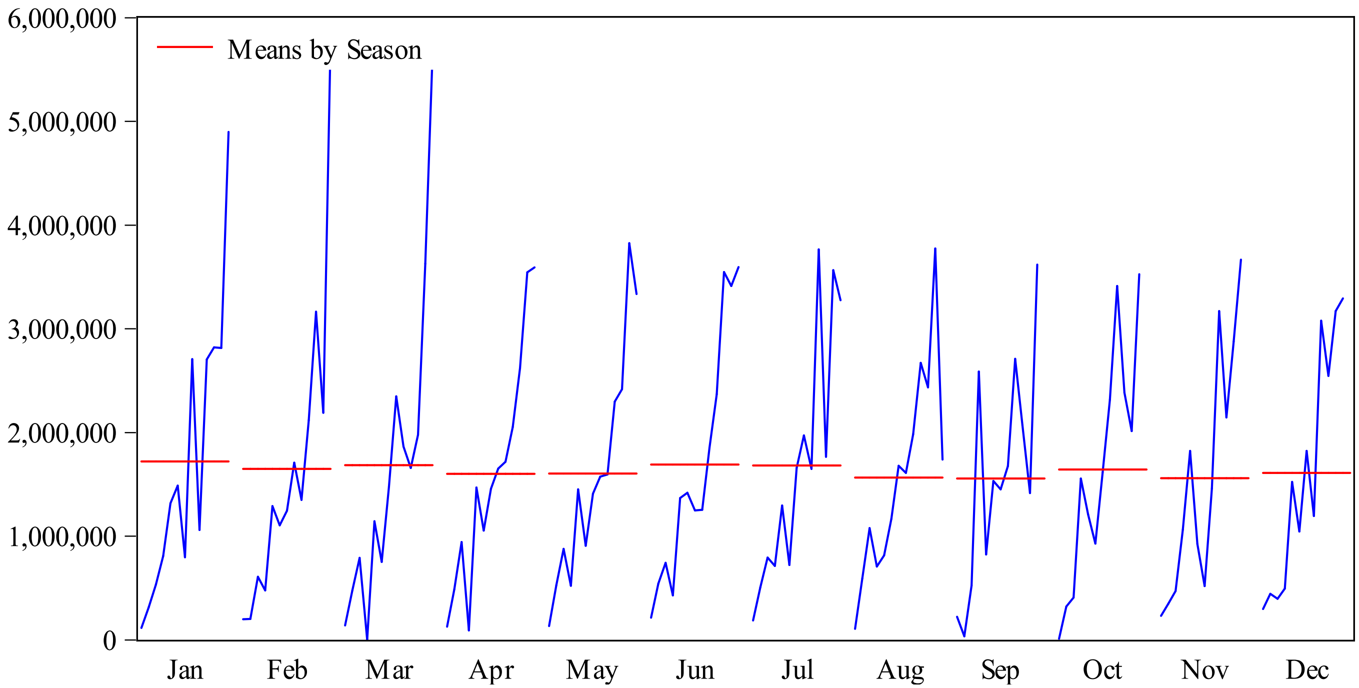

Figure 37. Monthly China Soybeans Imports Seasonal Adjustment.
Note: The adjusted series contains data seasonally adjusted by the X-11 method

APPENDIX VI: CROSS-CORRELATION FUNCTIONS (ADJUSTED SERIES – 1st DIFFERENCE)

Table 29. Soybeans Future Price Volatility and Oil Spot Prices Cross-Correlation Function (Adjusted Series – 1st Difference).

```
Lag   Covariance    Correlation   -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
-24   -0.0001675    -.01484       |                  .  |  .                  |
-23   -0.0005128    -.04544       |                  . *|  .                  |
-22   -0.0004964    -.04399       |                  . *|  .                  |
-21   0.00067273    0.05962       |                  .  |* .                  |
-20   0.00068076    0.06033       |                  .  |* .                  |
-19   -0.0008530    -.07560       |                  .**|  .                  |
-18   0.00023858    0.02114       |                  .  |  .                  |
-17   0.00039566    0.03507       |                  .  |* .                  |
-16   -0.0011545    -.10232       |                  .**|  .                  |
-15   0.00071129    0.06304       |                  .  |* .                  |
-14   -0.0006537    -.05794       |                  . *|  .                  |
-13   -0.0005303    -.04700       |                  . *|  .                  |
-12   0.00017088    0.01514       |                  .  |  .                  |
-11   -0.0001606    -.01424       |                  .  |  .                  |
-10   0.00069383    0.06149       |                  .  |* .                  |
 -9   0.00056259    0.04986       |                  .  |* .                  |
 -8   -0.0009296    -.08239       |                  .**|  .                  |
 -7    0.0010719    0.09500       |                  .  |**.                  |
 -6   -0.0000679    -.00602       |                  .  |  .                  |
 -5   -0.0008479    -.07515       |                  .**|  .                  |
 -4   -0.0000811    -.00718       |                  .  |  .                  |
 -3    0.0018651    0.16530       |                  .  |***                  |
 -2   -0.0002483    -.02201       |                  .  |  .                  |
 -1   -0.0011738    -.10403       |                  .**|  .                  |
  0    0.0015328    0.13584       |                  .  |***                  |
  1   -0.0010854    -.09619       |                  .**|  .                  |
  2   0.00019617    0.01739       |                  .  |  .                  |
  3   0.00043442    0.03850       |                  .  |* .                  |
  4   -0.0013825    -.12252       |                  .**|  .                  |
  5   0.00041424    0.03671       |                  .  |* .                  |
  6   0.00042194    0.03740       |                  .  |* .                  |
  7   0.00004351    0.00386       |                  .  |  .                  |
  8   0.00057098    0.05060       |                  .  |* .                  |
  9   -0.0001130    -.01001       |                  .  |  .                  |
 10   -0.0012034    -.10665       |                  .**|  .                  |
 11    0.0022679    0.20100       |                  .  |****                 |
 12   -0.0023014    -.20396       |                 ****|  .                  |
 13   0.00066953    0.05934       |                  .  |* .                  |
 14    0.0011262    0.09981       |                  .  |**.                  |
 15   -0.0017217    -.15259       |                  ***|  .                  |
 16   0.00041838    0.03708       |                  .  |* .                  |
 17    0.0015607    0.13832       |                  .  |***                  |
 18   -0.0022464    -.19909       |                 ****|  .                  |
 19   -0.0002599    -.02303       |                  .  |  .                  |
 20    0.0018269    0.16191       |                  .  |***                  |
 21   -0.0021247    -.18831       |                 ****|  .                  |
 22    0.0011306    0.10020       |                  .  |**.                  |
 23   -0.0008292    -.07349       |                  . *|  .                  |
 24    0.0011597    0.10278       |                  .  |**.                  |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval. The adjusted series contains data seasonally adjusted by the X-11 method.

Table 30. Oil Spot Prices and Soybeans Futures Price Volatility Cross-correlation Function (Adjusted Series - 1st Difference).

<table>
<tr><th>Lag</th><th>Covariance</th><th>Correlation</th><th>-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1</th></tr>
<tr><td>-24</td><td>0.0011597</td><td>0.10278</td><td>| . |**. |</td></tr>
<tr><td>-23</td><td>-0.0008292</td><td>-.07349</td><td>| . *| . |</td></tr>
<tr><td>-22</td><td>0.0011306</td><td>0.10020</td><td>| . |**. |</td></tr>
<tr><td>-21</td><td>-0.0021247</td><td>-.18831</td><td>| ****| . |</td></tr>
<tr><td>-20</td><td>0.0018269</td><td>0.16191</td><td>| . |*** |</td></tr>
<tr><td>-19</td><td>-0.0002599</td><td>-.02303</td><td>| . | . |</td></tr>
<tr><td>-18</td><td>-0.0022464</td><td>-.19909</td><td>| ****| . |</td></tr>
<tr><td>-17</td><td>0.0015607</td><td>0.13832</td><td>| . |*** |</td></tr>
<tr><td>-16</td><td>0.00041838</td><td>0.03708</td><td>| . |* . |</td></tr>
<tr><td>-15</td><td>-0.0017217</td><td>-.15259</td><td>| ***| . |</td></tr>
<tr><td>-14</td><td>0.0011262</td><td>0.09981</td><td>| . |**. |</td></tr>
<tr><td>-13</td><td>0.00066953</td><td>0.05934</td><td>| . |* . |</td></tr>
<tr><td>-12</td><td>-0.0023014</td><td>-.20396</td><td>| ****| . |</td></tr>
<tr><td>-11</td><td>0.0022679</td><td>0.20100</td><td>| . |**** |</td></tr>
<tr><td>-10</td><td>-0.0012034</td><td>-.10665</td><td>| .**| . |</td></tr>
<tr><td>-9</td><td>-0.0001130</td><td>-.01001</td><td>| . | . |</td></tr>
<tr><td>-8</td><td>0.00057098</td><td>0.05060</td><td>| . |* . |</td></tr>
<tr><td>-7</td><td>0.00004351</td><td>0.00386</td><td>| . | . |</td></tr>
<tr><td>-6</td><td>0.00042194</td><td>0.03740</td><td>| . |* . |</td></tr>
<tr><td>-5</td><td>0.00041424</td><td>0.03671</td><td>| . |* . |</td></tr>
<tr><td>-4</td><td>-0.0013825</td><td>-.12252</td><td>| .**| . |</td></tr>
<tr><td>-3</td><td>0.00043442</td><td>0.03850</td><td>| . |* . |</td></tr>
<tr><td>-2</td><td>0.00019617</td><td>0.01739</td><td>| . | . |</td></tr>
<tr><td>-1</td><td>-0.0010854</td><td>-.09619</td><td>| .**| . |</td></tr>
<tr><td>0</td><td>0.0015328</td><td>0.13584</td><td>| . |*** |</td></tr>
<tr><td>1</td><td>-0.0011738</td><td>-.10403</td><td>| .**| . |</td></tr>
<tr><td>2</td><td>-0.0002483</td><td>-.02201</td><td>| . | . |</td></tr>
<tr><td>3</td><td>0.0018651</td><td>0.16530</td><td>| . |*** |</td></tr>
<tr><td>4</td><td>-0.0000811</td><td>-.00718</td><td>| . | . |</td></tr>
<tr><td>5</td><td>-0.0008479</td><td>-.07515</td><td>| .**| . |</td></tr>
<tr><td>6</td><td>-0.0000679</td><td>-.00602</td><td>| . | . |</td></tr>
<tr><td>7</td><td>0.0010719</td><td>0.09500</td><td>| . |**. |</td></tr>
<tr><td>8</td><td>-0.0009296</td><td>-.08239</td><td>| .**| . |</td></tr>
<tr><td>9</td><td>0.00056259</td><td>0.04986</td><td>| . |* . |</td></tr>
<tr><td>10</td><td>0.00069383</td><td>0.06149</td><td>| . |* . |</td></tr>
<tr><td>11</td><td>-0.0001606</td><td>-.01424</td><td>| . | . |</td></tr>
<tr><td>12</td><td>0.00017088</td><td>0.01514</td><td>| . | . |</td></tr>
<tr><td>13</td><td>-0.0005303</td><td>-.04700</td><td>| . *| . |</td></tr>
<tr><td>14</td><td>-0.0006537</td><td>-.05794</td><td>| . *| . |</td></tr>
<tr><td>15</td><td>0.00071129</td><td>0.06304</td><td>| . |* . |</td></tr>
<tr><td>16</td><td>-0.0011545</td><td>-.10232</td><td>| .**| . |</td></tr>
<tr><td>17</td><td>0.00039566</td><td>0.03507</td><td>| . |* . |</td></tr>
<tr><td>18</td><td>0.00023858</td><td>0.02114</td><td>| . | . |</td></tr>
<tr><td>19</td><td>-0.0008530</td><td>-.07560</td><td>| .**| . |</td></tr>
<tr><td>20</td><td>0.00068076</td><td>0.06033</td><td>| . |* . |</td></tr>
<tr><td>21</td><td>0.00067273</td><td>0.05962</td><td>| . |* . |</td></tr>
<tr><td>22</td><td>-0.0004964</td><td>-.04399</td><td>| . *| . |</td></tr>
<tr><td>23</td><td>-0.0005128</td><td>-.04544</td><td>| . *| . |</td></tr>
<tr><td>24</td><td>-0.0001675</td><td>-.01484</td><td>| . | . |</td></tr>
</table>

Note: The vertical symbols (...) denote a 95 percent confidence interval. The adjusted series contains data seasonally adjusted by the X-11 method.

Table 31. Soybeans Futures Price Volatility and Renewable Fuel Policy Cross Correlation Function (Adjusted Series – 1st Difference).

```
     Lag    Covariance    Correlation    -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
     -24    -0.0009203        -.02337    |                 .  |  .                 |
     -23    6.03755E-6        0.00015    |                 .  |  .                 |
     -22    -0.0001662        -.00422    |                 .  |  .                 |
     -21    -0.0003629        -.00921    |                 .  |  .                 |
     -20    0.00010018        0.00254    |                 .  |  .                 |
     -19    -0.0006821        -.01732    |                 .  |  .                 |
     -18    -0.0007729        -.01963    |                 .  |  .                 |
     -17    -0.0007804        -.01982    |                 .  |  .                 |
     -16    -0.0003412        -.00866    |                 .  |  .                 |
     -15    -0.0002009        -.00510    |                 .  |  .                 |
     -14    -0.0012289        -.03121    |                 . *|  .                 |
     -13    -0.0004468        -.01134    |                 .  |  .                 |
     -12    -0.0001800        -.00457    |                 .  |  .                 |
     -11    0.00007912        0.00201    |                 .  |  .                 |
     -10    -0.0001173        -.00298    |                 .  |  .                 |
      -9    0.00018886        0.00480    |                 .  |  .                 |
      -8    -0.0004285        -.01088    |                 .  |  .                 |
      -7    -0.0001559        -.00396    |                 .  |  .                 |
      -6    0.00004705        0.00119    |                 .  |  .                 |
      -5    0.00028807        0.00731    |                 .  |  .                 |
      -4    0.00036559        0.00928    |                 .  |  .                 |
      -3    0.00040320        0.01024    |                 .  |  .                 |
      -2    0.00014736        0.00374    |                 .  |  .                 |
      -1    0.00029663        0.00753    |                 .  |  .                 |
       0    0.00032757        0.00832    |                 .  |  .                 |
       1    -3.1813E-6        -.00008    |                 .  |  .                 |
       2    0.00016293        0.00414    |                 .  |  .                 |
       3    -0.0001974        -.00501    |                 .  |  .                 |
       4    -0.0001806        -.00459    |                 .  |  .                 |
       5    -0.0003829        -.00972    |                 .  |  .                 |
       6    0.00033677        0.00855    |                 .  |  .                 |
       7    0.00019228        0.00488    |                 .  |  .                 |
       8    0.00023278        0.00591    |                 .  |  .                 |
       9    -0.0000378        -.00096    |                 .  |  .                 |
      10    -0.0003457        -.00878    |                 .  |  .                 |
      11    0.00011903        0.00302    |                 .  |  .                 |
      12    -0.0001012        -.00257    |                 .  |  .                 |
      13    -0.0000168        -.00043    |                 .  |  .                 |
      14    -0.0000557        -.00141    |                 .  |  .                 |
      15    0.00020683        0.00525    |                 .  |  .                 |
      16    0.00014506        0.00368    |                 .  |  .                 |
      17    -0.0002958        -.00751    |                 .  |  .                 |
      18    -0.0003459        -.00878    |                 .  |  .                 |
      19    -0.0021178        -.05378    |                 . *|  .                 |
      20    -0.0013424        -.03409    |                 . *|  .                 |
      21    -0.0005474        -.01390    |                 .  |  .                 |
      22    -0.0005157        -.01309    |                 .  |  .                 |
      23    -0.0001699        -.00431    |                 .  |  .                 |
      24    -0.0012195        -.03097    |                 . *|  .                 |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval. The adjusted series contains data seasonally adjusted by the X-11 method.

Table 32. Renewable Fuel Policy and Soybeans Futures Price Volatility Cross-correlation Function (Adjusted Series - 1st Difference).

```
  Lag    Covariance   Correlation    -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  -24     0.0033354       0.48264    |                 .  |**********          |
  -23    0.00087551       0.12669    |                 .  |***                 |
  -22    -0.0001607       -.02326    |                 .  |  .                 |
  -21    0.00030438       0.04404    |                 .  |* .                 |
  -20    0.00024131       0.03492    |                 .  |* .                 |
  -19     0.0011759       0.17016    |                 .  |***                 |
  -18     0.0017497       0.25318    |                 .  |*****               |
  -17    -0.0000729       -.01056    |                 .  |  .                 |
  -16    0.00001604       0.00232    |                 .  |  .                 |
  -15    -0.0002880       -.04167    |                 . *|  .                 |
  -14    -0.0003731       -.05398    |                 . *|  .                 |
  -13    -0.0001593       -.02305    |                 .  |  .                 |
  -12    -0.0001712       -.02477    |                 .  |  .                 |
  -11    -0.0000446       -.00646    |                 .  |  .                 |
  -10    -0.0002104       -.03045    |                 . *|  .                 |
   -9    0.00012920       0.01870    |                 .  |  .                 |
   -8    -0.0001541       -.02230    |                 .  |  .                 |
   -7    -0.0003850       -.05572    |                 . *|  .                 |
   -6    -0.0001296       -.01875    |                 .  |  .                 |
   -5    -0.0003888       -.05626    |                 . *|  .                 |
   -4    0.00010418       0.01508    |                 .  |  .                 |
   -3    -0.0001373       -.01986    |                 .  |  .                 |
   -2    -0.0000683       -.00988    |                 .  |  .                 |
   -1    -0.0003385       -.04899    |                 . *|  .                 |
    0    -0.0001847       -.02673    |                 . *|  .                 |
    1    -0.0005567       -.08055    |                 .**|  .                 |
    2    -0.0008460       -.12242    |                 .**|  .                 |
    3    -0.0002095       -.03031    |                 . *|  .                 |
    4    -0.0003197       -.04626    |                 . *|  .                 |
    5    -0.0003043       -.04403    |                 . *|  .                 |
    6    -0.0002897       -.04191    |                 . *|  .                 |
    7    0.00005727       0.00829    |                 .  |  .                 |
    8    -0.0000161       -.00232    |                 .  |  .                 |
    9    0.00009429       0.01364    |                 .  |  .                 |
   10    -0.0000819       -.01185    |                 .  |  .                 |
   11    -0.0000358       -.00518    |                 .  |  .                 |
   12    -0.0003419       -.04947    |                 . *|  .                 |
   13    -0.0001855       -.02684    |                 . *|  .                 |
   14    0.00005006       0.00724    |                 .  |  .                 |
   15    0.00076841       0.11119    |                 .  |**.                 |
   16    -0.0001143       -.01653    |                 .  |  .                 |
   17    -0.0001579       -.02284    |                 .  |  .                 |
   18    0.00048291       0.06988    |                 .  |* .                 |
   19    0.00046130       0.06675    |                 .  |* .                 |
   20    0.00034003       0.04920    |                 .  |* .                 |
   21    -0.0001623       -.02348    |                 .  |  .                 |
   22    0.00020860       0.03018    |                 .  |* .                 |
   23    -0.0000370       -.00535    |                 .  |  .                 |
   24    -0.0001092       -.01581    |                 .  |  .                 |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval. The adjusted series contains data seasonally adjusted by the X-11 method.

Table 33. Soybeans Futures Price Volatility and U.S Dollar Index Cross Correlation Function (Adjusted Series – 1st Difference).

<table>
<tr><th>Lag</th><th>Covariance</th><th>Correlation</th><th>-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1</th></tr>
<tr><td>-24</td><td>-0.0002369</td><td>-.10439</td><td>| .**| . |</td></tr>
<tr><td>-23</td><td>0.00010825</td><td>0.04771</td><td>| . |* . |</td></tr>
<tr><td>-22</td><td>-0.0000859</td><td>-.03786</td><td>| . *| . |</td></tr>
<tr><td>-21</td><td>0.00021031</td><td>0.09269</td><td>| . |**. |</td></tr>
<tr><td>-20</td><td>-0.0001140</td><td>-.05025</td><td>| . *| . |</td></tr>
<tr><td>-19</td><td>-0.0000254</td><td>-.01118</td><td>| . | . |</td></tr>
<tr><td>-18</td><td>0.00002783</td><td>0.01226</td><td>| . | . |</td></tr>
<tr><td>-17</td><td>-0.0000552</td><td>-.02434</td><td>| . | . |</td></tr>
<tr><td>-16</td><td>0.00005172</td><td>0.02279</td><td>| . | . |</td></tr>
<tr><td>-15</td><td>0.00002466</td><td>0.01087</td><td>| . | . |</td></tr>
<tr><td>-14</td><td>0.00006676</td><td>0.02942</td><td>| . |* . |</td></tr>
<tr><td>-13</td><td>-0.0000943</td><td>-.04157</td><td>| . *| . |</td></tr>
<tr><td>-12</td><td>-0.0000225</td><td>-.00991</td><td>| . | . |</td></tr>
<tr><td>-11</td><td>-0.0001235</td><td>-.05444</td><td>| . *| . |</td></tr>
<tr><td>-10</td><td>-0.0001041</td><td>-.04588</td><td>| . *| . |</td></tr>
<tr><td>-9</td><td>0.00034073</td><td>0.15017</td><td>| . |*** |</td></tr>
<tr><td>-8</td><td>-0.0003647</td><td>-.16072</td><td>| ***| . |</td></tr>
<tr><td>-7</td><td>0.00030986</td><td>0.13656</td><td>| . |*** |</td></tr>
<tr><td>-6</td><td>0.00017830</td><td>0.07858</td><td>| . |**. |</td></tr>
<tr><td>-5</td><td>-0.0000974</td><td>-.04292</td><td>| . *| . |</td></tr>
<tr><td>-4</td><td>-0.0002085</td><td>-.09190</td><td>| .**| . |</td></tr>
<tr><td>-3</td><td>-0.0001613</td><td>-.07108</td><td>| . *| . |</td></tr>
<tr><td>-2</td><td>-0.0000192</td><td>-.00848</td><td>| . | . |</td></tr>
<tr><td>-1</td><td>0.00040910</td><td>0.18030</td><td>| . |**** |</td></tr>
<tr><td>0</td><td>0.00018539</td><td>0.08170</td><td>| . |**. |</td></tr>
<tr><td>1</td><td>-0.0001557</td><td>-.06861</td><td>| . *| . |</td></tr>
<tr><td>2</td><td>-0.0002586</td><td>-.11396</td><td>| .**| . |</td></tr>
<tr><td>3</td><td>0.00004415</td><td>0.01946</td><td>| . | . |</td></tr>
<tr><td>4</td><td>0.00013215</td><td>0.05824</td><td>| . |* . |</td></tr>
<tr><td>5</td><td>-0.0001185</td><td>-.05222</td><td>| . *| . |</td></tr>
<tr><td>6</td><td>-0.0000612</td><td>-.02698</td><td>| . *| . |</td></tr>
<tr><td>7</td><td>-0.0000396</td><td>-.01747</td><td>| . | . |</td></tr>
<tr><td>8</td><td>0.00008376</td><td>0.03692</td><td>| . |* . |</td></tr>
<tr><td>9</td><td>-0.0000773</td><td>-.03407</td><td>| . *| . |</td></tr>
<tr><td>10</td><td>0.00043541</td><td>0.19190</td><td>| . |**** |</td></tr>
<tr><td>11</td><td>-0.0003252</td><td>-.14332</td><td>| ***| . |</td></tr>
<tr><td>12</td><td>-0.0001488</td><td>-.06560</td><td>| . *| . |</td></tr>
<tr><td>13</td><td>0.00037414</td><td>0.16489</td><td>| . |*** |</td></tr>
<tr><td>14</td><td>-0.0002795</td><td>-.12317</td><td>| .**| . |</td></tr>
<tr><td>15</td><td>0.00023595</td><td>0.10399</td><td>| . |**. |</td></tr>
<tr><td>16</td><td>-0.0001817</td><td>-.08007</td><td>| .**| . |</td></tr>
<tr><td>17</td><td>-0.0000355</td><td>-.01563</td><td>| . | . |</td></tr>
<tr><td>18</td><td>0.00011590</td><td>0.05108</td><td>| . |* . |</td></tr>
<tr><td>19</td><td>-0.0000358</td><td>-.01578</td><td>| . | . |</td></tr>
<tr><td>20</td><td>-0.0001386</td><td>-.06110</td><td>| . *| . |</td></tr>
<tr><td>21</td><td>0.00008734</td><td>0.03849</td><td>| . |* . |</td></tr>
<tr><td>22</td><td>0.00005929</td><td>0.02613</td><td>| . |* . |</td></tr>
<tr><td>23</td><td>-0.0001891</td><td>-.08336</td><td>| .**| . |</td></tr>
<tr><td>24</td><td>0.00016662</td><td>0.07343</td><td>| . |* . |</td></tr>
</table>

Note: The vertical symbols (...) denote a 95 percent confidence interval. The adjusted series contains data seasonally adjusted by the X-11 method.

Table 34. U.S Dollar Index and Soybeans Futures Price Volatility Cross-correlation Function (Adjusted Series - 1st Difference).

<table>
<tr><th>Lag</th><th>Covariance</th><th>Correlation</th><th>-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1</th></tr>
<tr><td>-24</td><td>0.00016662</td><td>0.07343</td><td>| . |* . |</td></tr>
<tr><td>-23</td><td>-0.0001891</td><td>-.08336</td><td>| .**| . |</td></tr>
<tr><td>-22</td><td>0.00005929</td><td>0.02613</td><td>| . |* . |</td></tr>
<tr><td>-21</td><td>0.00008734</td><td>0.03849</td><td>| . |* . |</td></tr>
<tr><td>-20</td><td>-0.0001386</td><td>-.06110</td><td>| . *| . |</td></tr>
<tr><td>-19</td><td>-0.0000358</td><td>-.01578</td><td>| . | . |</td></tr>
<tr><td>-18</td><td>0.00011590</td><td>0.05108</td><td>| . |* . |</td></tr>
<tr><td>-17</td><td>-0.0000355</td><td>-.01563</td><td>| . | . |</td></tr>
<tr><td>-16</td><td>-0.0001817</td><td>-.08007</td><td>| .**| . |</td></tr>
<tr><td>-15</td><td>0.00023595</td><td>0.10399</td><td>| . |**. |</td></tr>
<tr><td>-14</td><td>-0.0002795</td><td>-.12317</td><td>| .**| . |</td></tr>
<tr><td>-13</td><td>0.00037414</td><td>0.16489</td><td>| . |*** |</td></tr>
<tr><td>-12</td><td>-0.0001488</td><td>-.06560</td><td>| . *| . |</td></tr>
<tr><td>-11</td><td>-0.0003252</td><td>-.14332</td><td>| ***| . |</td></tr>
<tr><td>-10</td><td>0.00043541</td><td>0.19190</td><td>| . |**** |</td></tr>
<tr><td>-9</td><td>-0.0000773</td><td>-.03407</td><td>| . *| . |</td></tr>
<tr><td>-8</td><td>0.00008376</td><td>0.03692</td><td>| . |* . |</td></tr>
<tr><td>-7</td><td>-0.0000396</td><td>-.01747</td><td>| . | . |</td></tr>
<tr><td>-6</td><td>-0.0000612</td><td>-.02698</td><td>| . *| . |</td></tr>
<tr><td>-5</td><td>-0.0001185</td><td>-.05222</td><td>| . *| . |</td></tr>
<tr><td>-4</td><td>0.00013215</td><td>0.05824</td><td>| . |* . |</td></tr>
<tr><td>-3</td><td>0.00004415</td><td>0.01946</td><td>| . | . |</td></tr>
<tr><td>-2</td><td>-0.0002586</td><td>-.11396</td><td>| .**| . |</td></tr>
<tr><td>-1</td><td>-0.0001557</td><td>-.06861</td><td>| . *| . |</td></tr>
<tr><td>0</td><td>0.00018539</td><td>0.08170</td><td>| . |**. |</td></tr>
<tr><td>1</td><td>0.00040910</td><td>0.18030</td><td>| . |**** |</td></tr>
<tr><td>2</td><td>-0.0000192</td><td>-.00848</td><td>| . | . |</td></tr>
<tr><td>3</td><td>-0.0001613</td><td>-.07108</td><td>| . *| . |</td></tr>
<tr><td>4</td><td>-0.0002085</td><td>-.09190</td><td>| .**| . |</td></tr>
<tr><td>5</td><td>-0.0000974</td><td>-.04292</td><td>| . *| . |</td></tr>
<tr><td>6</td><td>0.00017830</td><td>0.07858</td><td>| . |**. |</td></tr>
<tr><td>7</td><td>0.00030986</td><td>0.13656</td><td>| . |*** |</td></tr>
<tr><td>8</td><td>-0.0003647</td><td>-.16072</td><td>| ***| . |</td></tr>
<tr><td>9</td><td>0.00034073</td><td>0.15017</td><td>| . |*** |</td></tr>
<tr><td>10</td><td>-0.0001041</td><td>-.04588</td><td>| . *| . |</td></tr>
<tr><td>11</td><td>-0.0001235</td><td>-.05444</td><td>| . *| . |</td></tr>
<tr><td>12</td><td>-0.0000225</td><td>-.00991</td><td>| . | . |</td></tr>
<tr><td>13</td><td>-0.0000943</td><td>-.04157</td><td>| . *| . |</td></tr>
<tr><td>14</td><td>0.00006676</td><td>0.02942</td><td>| . |* . |</td></tr>
<tr><td>15</td><td>0.00002466</td><td>0.01087</td><td>| . | . |</td></tr>
<tr><td>16</td><td>0.00005172</td><td>0.02279</td><td>| . | . |</td></tr>
<tr><td>17</td><td>-0.0000552</td><td>-.02434</td><td>| . | . |</td></tr>
<tr><td>18</td><td>0.00002783</td><td>0.01226</td><td>| . | . |</td></tr>
<tr><td>19</td><td>-0.0000254</td><td>-.01118</td><td>| . | . |</td></tr>
<tr><td>20</td><td>-0.0001140</td><td>-.05025</td><td>| . *| . |</td></tr>
<tr><td>21</td><td>0.00021031</td><td>0.09269</td><td>| . |**. |</td></tr>
<tr><td>22</td><td>-0.0000859</td><td>-.03786</td><td>| . *| . |</td></tr>
<tr><td>23</td><td>0.00010825</td><td>0.04771</td><td>| . |* . |</td></tr>
<tr><td>24</td><td>-0.0002369</td><td>-.10439</td><td>| .**| . |</td></tr>
</table>

Note: The vertical symbols (...) denote a 95 percent confidence interval. The adjusted series contains data seasonally adjusted by the X-11 method.

Table 35. Soybeans Futures Price Volatility and China Soybeans Imports Cross-correlation Function (Adjusted Series – 1st Difference)

```
  Lag    Covariance   Correlation    -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  -24     -1224.576       -.02703    |                 . *|  .                 |
  -23      2043.162       0.04510    |                 .  |* .                 |
  -22      -131.425       -.00290    |                 .  |  .                 |
  -21     -3383.599       -.07469    |                 . *|  .                 |
  -20      4712.914       0.10404    |                 .  |**.                 |
  -19      4946.339       0.10919    |                 .  |**.                 |
  -18     -1153.867       -.02547    |                 . *|  .                 |
  -17     -4.351564       -.00010    |                 .  |  .                 |
  -16     -4704.283       -.10385    |                 .**|  .                 |
  -15      1558.055       0.03439    |                 .  |* .                 |
  -14      3401.018       0.07508    |                 .  |**.                 |
  -13     -2102.252       -.04641    |                 . *|  .                 |
  -12     -4108.249       -.09069    |                 .**|  .                 |
  -11      4293.967       0.09479    |                 .  |**.                 |
  -10     -6678.433       -.14743    |                 ***|  .                 |
   -9      8430.054       0.18609    |                 .  |****                |
   -8     -5032.034       -.11108    |                 .**|  .                 |
   -7      4259.876       0.09404    |                 .  |**.                 |
   -6     -8227.721       -.18163    |                ****|  .                 |
   -5     -1914.391       -.04226    |                 . *|  .                 |
   -4      9004.583       0.19877    |                 .  |****                |
   -3      -839.634       -.01853    |                 .  |  .                 |
   -2     -1703.155       -.03760    |                 . *|  .                 |
   -1      3447.466       0.07610    |                 .  |**.                 |
    0     -5417.668       -.11959    |                 .**|  .                 |
    1     -7707.615       -.17014    |                 ***|  .                 |
    2     13665.107       0.30166    |                 .  |******              |
    3     -2831.772       -.06251    |                 . *|  .                 |
    4      1063.717       0.02348    |                 .  |  .                 |
    5     -4720.006       -.10419    |                 .**|  .                 |
    6      2782.887       0.06143    |                 .  |* .                 |
    7      -267.686       -.00591    |                 .  |  .                 |
    8     -1200.577       -.02650    |                 . *|  .                 |
    9       232.286       0.00513    |                 .  |  .                 |
   10       115.869       0.00256    |                 .  |  .                 |
   11      1014.994       0.02241    |                 .  |  .                 |
   12      2016.056       0.04450    |                 .  |* .                 |
   13      3506.587       0.07741    |                 .  |**.                 |
   14     -5617.473       -.12400    |                 .**|  .                 |
   15      4215.120       0.09305    |                 .  |**.                 |
   16     -6843.437       -.15107    |                 ***|  .                 |
   17      3644.251       0.08045    |                 .  |**.                 |
   18       230.498       0.00509    |                 .  |  .                 |
   19      -465.668       -.01028    |                 .  |  .                 |
   20     80.033797       0.00177    |                 .  |  .                 |
   21     -3890.009       -.08587    |                 .**|  .                 |
   22      3386.682       0.07476    |                 .  |* .                 |
   23      2909.056       0.06422    |                 .  |* .                 |
   24     -1669.836       -.03686    |                 . *|  .                 |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval. The adjusted series contains data seasonally adjusted by the X-11 method.

Table 36. China Soybeans Imports and Soybeans Futures Price Volatility Cross-correlation Function (Adjusted Series - 1st Difference).

<table>
<tr><th>Lag</th><th>Covariance</th><th>Correlation</th><th>-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1</th></tr>
<tr><td>-24</td><td>-1669.836</td><td>-.03686</td><td>| . *| . |</td></tr>
<tr><td>-23</td><td>2909.056</td><td>0.06422</td><td>| . |* . |</td></tr>
<tr><td>-22</td><td>3386.682</td><td>0.07476</td><td>| . |* . |</td></tr>
<tr><td>-21</td><td>-3890.009</td><td>-.08587</td><td>| .**| . |</td></tr>
<tr><td>-20</td><td>80.033797</td><td>0.00177</td><td>| . | . |</td></tr>
<tr><td>-19</td><td>-465.668</td><td>-.01028</td><td>| . | . |</td></tr>
<tr><td>-18</td><td>230.498</td><td>0.00509</td><td>| . | . |</td></tr>
<tr><td>-17</td><td>3644.251</td><td>0.08045</td><td>| . |**. |</td></tr>
<tr><td>-16</td><td>-6843.437</td><td>-.15107</td><td>| ***| . |</td></tr>
<tr><td>-15</td><td>4215.120</td><td>0.09305</td><td>| . |**. |</td></tr>
<tr><td>-14</td><td>-5617.473</td><td>-.12400</td><td>| .**| . |</td></tr>
<tr><td>-13</td><td>3506.587</td><td>0.07741</td><td>| . |**. |</td></tr>
<tr><td>-12</td><td>2016.056</td><td>0.04450</td><td>| . |* . |</td></tr>
<tr><td>-11</td><td>1014.994</td><td>0.02241</td><td>| . | . |</td></tr>
<tr><td>-10</td><td>115.869</td><td>0.00256</td><td>| . | . |</td></tr>
<tr><td>-9</td><td>232.286</td><td>0.00513</td><td>| . | . |</td></tr>
<tr><td>-8</td><td>-1200.577</td><td>-.02650</td><td>| . *| . |</td></tr>
<tr><td>-7</td><td>-267.686</td><td>-.00591</td><td>| . | . |</td></tr>
<tr><td>-6</td><td>2782.887</td><td>0.06143</td><td>| . |* . |</td></tr>
<tr><td>-5</td><td>-4720.006</td><td>-.10419</td><td>| .**| . |</td></tr>
<tr><td>-4</td><td>1063.717</td><td>0.02348</td><td>| . | . |</td></tr>
<tr><td>-3</td><td>-2831.772</td><td>-.06251</td><td>| . *| . |</td></tr>
<tr><td>-2</td><td>13665.107</td><td>0.30166</td><td>| . |****** |</td></tr>
<tr><td>-1</td><td>-7707.615</td><td>-.17014</td><td>| ***| . |</td></tr>
<tr><td>0</td><td>-5417.668</td><td>-.11959</td><td>| .**| . |</td></tr>
<tr><td>1</td><td>3447.466</td><td>0.07610</td><td>| . |**. |</td></tr>
<tr><td>2</td><td>-1703.155</td><td>-.03760</td><td>| . *| . |</td></tr>
<tr><td>3</td><td>-839.634</td><td>-.01853</td><td>| . | . |</td></tr>
<tr><td>4</td><td>9004.583</td><td>0.19877</td><td>| . |**** |</td></tr>
<tr><td>5</td><td>-1914.391</td><td>-.04226</td><td>| . *| . |</td></tr>
<tr><td>6</td><td>-8227.721</td><td>-.18163</td><td>| ****| . |</td></tr>
<tr><td>7</td><td>4259.876</td><td>0.09404</td><td>| . |**. |</td></tr>
<tr><td>8</td><td>-5032.034</td><td>-.11108</td><td>| .**| . |</td></tr>
<tr><td>9</td><td>8430.054</td><td>0.18609</td><td>| . |**** |</td></tr>
<tr><td>10</td><td>-6678.433</td><td>-.14743</td><td>| ***| . |</td></tr>
<tr><td>11</td><td>4293.967</td><td>0.09479</td><td>| . |**. |</td></tr>
<tr><td>12</td><td>-4108.249</td><td>-.09069</td><td>| .**| . |</td></tr>
<tr><td>13</td><td>-2102.252</td><td>-.04641</td><td>| . *| . |</td></tr>
<tr><td>14</td><td>3401.018</td><td>0.07508</td><td>| . |**. |</td></tr>
<tr><td>15</td><td>1558.055</td><td>0.03439</td><td>| . |* . |</td></tr>
<tr><td>16</td><td>-4704.283</td><td>-.10385</td><td>| .**| . |</td></tr>
<tr><td>17</td><td>-4.351564</td><td>-.00010</td><td>| . | . |</td></tr>
<tr><td>18</td><td>-1153.867</td><td>-.02547</td><td>| . *| . |</td></tr>
<tr><td>19</td><td>4946.339</td><td>0.10919</td><td>| . |**. |</td></tr>
<tr><td>20</td><td>4712.914</td><td>0.10404</td><td>| . |**. |</td></tr>
<tr><td>21</td><td>-3383.599</td><td>-.07469</td><td>| . *| . |</td></tr>
<tr><td>22</td><td>-131.425</td><td>-.00290</td><td>| . | . |</td></tr>
<tr><td>23</td><td>2043.162</td><td>0.04510</td><td>| . |* . |</td></tr>
<tr><td>24</td><td>-1224.576</td><td>-.02703</td><td>| . *| . |</td></tr>
</table>

Note: The vertical symbols (...) denote a 95 percent confidence interval. The adjusted series contains data seasonally adjusted by the X-11 method.

Table 37. Soybeans Futures Price Volatility and Number of Mutual Funds Cross-correlation Functions (Adjusted Series 1st Difference)

```
Lag    Covariance    Correlation    -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
-24    0.00044710        0.01532    |                 .  |  .                 |
-23    -0.0038200        -.13090    |                 ***|  .                 |
-22     0.0066700        0.22857    |                 .  |*****               |
-21     0.0025746        0.08822    |                 .  |**.                 |
-20    -0.0064037        -.21944    |                ****|  .                 |
-19     0.0020556        0.07044    |                 .  |* .                 |
-18    -0.0032875        -.11266    |                 .**|  .                 |
-17     0.0030546        0.10467    |                 .  |**.                 |
-16     0.0031811        0.10901    |                 .  |**.                 |
-15    -0.0038146        -.13072    |                 ***|  .                 |
-14    0.00007570        0.00259    |                 .  |  .                 |
-13    -0.0006910        -.02368    |                 .  |  .                 |
-12    -0.0021004        -.07197    |                 . *|  .                 |
-11     0.0019463        0.06669    |                 .  |* .                 |
-10    0.00021646        0.00742    |                 .  |  .                 |
 -9    -0.0014904        -.05107    |                 . *|  .                 |
 -8    -0.0017809        -.06103    |                 . *|  .                 |
 -7    -0.0012494        -.04281    |                 . *|  .                 |
 -6     0.0023055        0.07900    |                 .  |**.                 |
 -5    -0.0005348        -.01833    |                 .  |  .                 |
 -4    -0.0002294        -.00786    |                 .  |  .                 |
 -3    -0.0001280        -.00439    |                 .  |  .                 |
 -2    -0.0008346        -.02860    |                 . *|  .                 |
 -1    0.00071217        0.02440    |                 .  |  .                 |
  0    -0.0010388        -.03560    |                 . *|  .                 |
  1    0.00054244        0.01859    |                 .  |  .                 |
  2     0.0056853        0.19482    |                 .  |****                |
  3    -0.0025469        -.08728    |                 .**|  .                 |
  4    -0.0008866        -.03038    |                 . *|  .                 |
  5     0.0029538        0.10122    |                 .  |**.                 |
  6    -0.0052482        -.17984    |                ****|  .                 |
  7    -0.0002673        -.00916    |                 .  |  .                 |
  8     0.0010710        0.03670    |                 .  |* .                 |
  9    -0.0011253        -.03856    |                 . *|  .                 |
 10     0.0032979        0.11301    |                 .  |**.                 |
 11    -0.0018895        -.06475    |                 . *|  .                 |
 12     0.0021809        0.07474    |                 .  |* .                 |
 13    -0.0004676        -.01602    |                 .  |  .                 |
 14    -0.0015739        -.05393    |                 . *|  .                 |
 15    -0.0005900        -.02022    |                 .  |  .                 |
 16     0.0028077        0.09621    |                 .  |**.                 |
 17    -0.0020745        -.07109    |                 . *|  .                 |
 18     0.0028843        0.09884    |                 .  |**.                 |
 19    -0.0041787        -.14320    |                 ***|  .                 |
 20    0.00051291        0.01758    |                 .  |  .                 |
 21    -0.0009728        -.03333    |                 . *|  .                 |
 22    -0.0006987        -.02394    |                 .  |  .                 |
 23     0.0015174        0.05200    |                 .  |* .                 |
 24    -0.0031416        -.10765    |                 .**|  .                 |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval. The adjusted series contains data seasonally adjusted by the X-11 method.

Table 38. Number of Mutual Funds and Soybeans Futures Price Volatility Cross-correlation Function (Adjusted Series - 1st Difference).

```
  Lag    Covariance   Correlation   -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  -24    -0.0031416       -.10765    |                 .**|  .                 |
  -23     0.0015174       0.05200    |                 .  |* .                 |
  -22    -0.0006987       -.02394    |                 .  |  .                 |
  -21    -0.0009728       -.03333    |                 . *|  .                 |
  -20    0.00051291       0.01758    |                 .  |  .                 |
  -19    -0.0041787       -.14320    |                 ***|  .                 |
  -18     0.0028843       0.09884    |                 .  |**.                 |
  -17    -0.0020745       -.07109    |                 . *|  .                 |
  -16     0.0028077       0.09621    |                 .  |**.                 |
  -15    -0.0005900       -.02022    |                 .  |  .                 |
  -14    -0.0015739       -.05393    |                 . *|  .                 |
  -13    -0.0004676       -.01602    |                 .  |  .                 |
  -12     0.0021809       0.07474    |                 .  |* .                 |
  -11    -0.0018895       -.06475    |                 . *|  .                 |
  -10     0.0032979       0.11301    |                 .  |**.                 |
   -9    -0.0011253       -.03856    |                 . *|  .                 |
   -8     0.0010710       0.03670    |                 .  |* .                 |
   -7    -0.0002673       -.00916    |                 .  |  .                 |
   -6    -0.0052482       -.17984    |                ****|  .                 |
   -5     0.0029538       0.10122    |                 .  |**.                 |
   -4    -0.0008866       -.03038    |                 . *|  .                 |
   -3    -0.0025469       -.08728    |                 .**|  .                 |
   -2     0.0056853       0.19482    |                 .  |****                |
   -1    0.00054244       0.01859    |                 .  |  .                 |
    0    -0.0010388       -.03560    |                 . *|  .                 |
    1    0.00071217       0.02440    |                 .  |  .                 |
    2    -0.0008346       -.02860    |                 . *|  .                 |
    3    -0.0001280       -.00439    |                 .  |  .                 |
    4    -0.0002294       -.00786    |                 .  |  .                 |
    5    -0.0005348       -.01833    |                 .  |  .                 |
    6     0.0023055       0.07900    |                 .  |**.                 |
    7    -0.0012494       -.04281    |                 . *|  .                 |
    8    -0.0017809       -.06103    |                 . *|  .                 |
    9    -0.0014904       -.05107    |                 . *|  .                 |
   10    0.00021646       0.00742    |                 .  |  .                 |
   11     0.0019463       0.06669    |                 .  |* .                 |
   12    -0.0021004       -.07197    |                 . *|  .                 |
   13    -0.0006910       -.02368    |                 .  |  .                 |
   14    0.00007570       0.00259    |                 .  |  .                 |
   15    -0.0038146       -.13072    |                 ***|  .                 |
   16     0.0031811       0.10901    |                 .  |**.                 |
   17     0.0030546       0.10467    |                 .  |**.                 |
   18    -0.0032875       -.11266    |                 .**|  .                 |
   19     0.0020556       0.07044    |                 .  |* .                 |
   20    -0.0064037       -.21944    |                ****|  .                 |
   21     0.0025746       0.08822    |                 .  |**.                 |
   22     0.0066700       0.22857    |                 .  |*****               |
   23    -0.0038200       -.13090    |                 ***|  .                 |
   24    0.00044710       0.01532    |                 .  |  .                 |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval. The adjusted series contains data seasonally adjusted by the X-11 method.

Table 39. Soybeans Futures Price Volatility and Number of Index Funds Cross-correlation Function (Adjusted Series – 1st Difference).

```
Lag    Covariance    Correlation    -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
-24    0.00024615       0.02675     |                    .  |* .                   |
-23    0.00013994       0.01521     |                    .  |  .                   |
-22     0.0017382       0.18892     |                    .  |****                  |
-21    -0.0007794       -.08472     |                    .**|  .                   |
-20    -0.0006887       -.07486     |                    . *|  .                   |
-19    0.00023797       0.02587     |                    .  |* .                   |
-18    -0.0007361       -.08001     |                    .**|  .                   |
-17     0.0010384       0.11287     |                    .  |**.                   |
-16     0.0025198       0.27387     |                    .  |*****                 |
-15    -0.0022193       -.24121     |                 *****|  .                   |
-14    -0.0002822       -.03068     |                    . *|  .                   |
-13    -0.0002372       -.02578     |                    . *|  .                   |
-12    -0.0001186       -.01289     |                    .  |  .                   |
-11    0.00008454       0.00919     |                    .  |  .                   |
-10    -0.0002688       -.02922     |                    . *|  .                   |
 -9    0.00048047       0.05222     |                    .  |* .                   |
 -8    -0.0009271       -.10077     |                    .**|  .                   |
 -7    0.00064558       0.07017     |                    .  |* .                   |
 -6    0.00032166       0.03496     |                    .  |* .                   |
 -5     0.0019332       0.21012     |                    .  |****                  |
 -4    -0.0025185       -.27374     |                 *****|  .                   |
 -3    -0.0002409       -.02618     |                    . *|  .                   |
 -2    -0.0000324       -.00352     |                    .  |  .                   |
 -1    0.00038229       0.04155     |                    .  |* .                   |
  0    -0.0005385       -.05853     |                    . *|  .                   |
  1    -0.0002723       -.02960     |                    . *|  .                   |
  2    -3.7874E-7       -.00004     |                    .  |  .                   |
  3    -0.0000431       -.00469     |                    .  |  .                   |
  4    0.00014064       0.01529     |                    .  |  .                   |
  5    -0.0003149       -.03423     |                    . *|  .                   |
  6    0.00005031       0.00547     |                    .  |  .                   |
  7    0.00050440       0.05482     |                    .  |* .                   |
  8    0.00068916       0.07490     |                    .  |* .                   |
  9    -9.1491E-7       -.00010     |                    .  |  .                   |
 10    0.00050159       0.05452     |                    .  |* .                   |
 11    -0.0005538       -.06019     |                    . *|  .                   |
 12    -0.0003901       -.04240     |                    . *|  .                   |
 13    0.00088000       0.09565     |                    .  |**.                   |
 14    -0.0002269       -.02466     |                    .  |  .                   |
 15    0.00072844       0.07917     |                    .  |**.                   |
 16    0.00033187       0.03607     |                    .  |* .                   |
 17    -0.0010237       -.11127     |                    .**|  .                   |
 18    0.00001808       0.00197     |                    .  |  .                   |
 19     0.0013378       0.14541     |                    .  |***                   |
 20    -0.0021179       -.23020     |                 *****|  .                   |
 21    0.00006948       0.00755     |                    .  |  .                   |
 22    0.00024490       0.02662     |                    .  |* .                   |
 23    -0.0003750       -.04075     |                    . *|  .                   |
 24    0.00049885       0.05422     |                    .  |* .                   |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval. The adjusted series contains data seasonally adjusted by the X-11 method.

Table 40. Number of Index Funds and Soybeans Futures Price Volatility Cross-correlation Function (Adjusted Series - 1st Difference).

```
 Lag    Covariance    Correlation    -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
 -24    0.00049885        0.05422    |                 .  |* .                |
 -23    -0.0003750        -.04075    |                 . *|  .                |
 -22    0.00024490        0.02662    |                 .  |* .                |
 -21    0.00006948        0.00755    |                 .  |  .                |
 -20    -0.0021179        -.23020    |               *****|  .                |
 -19     0.0013378        0.14541    |                 .  |***                |
 -18    0.00001808        0.00197    |                 .  |  .                |
 -17    -0.0010237        -.11127    |                 .**|  .                |
 -16    0.00033187        0.03607    |                 .  |* .                |
 -15    0.00072844        0.07917    |                 .  |**.                |
 -14    -0.0002269        -.02466    |                 .  |  .                |
 -13    0.00088000        0.09565    |                 .  |**.                |
 -12    -0.0003901        -.04240    |                 . *|  .                |
 -11    -0.0005538        -.06019    |                 . *|  .                |
 -10    0.00050159        0.05452    |                 .  |* .                |
  -9    -9.1491E-7        -.00010    |                 .  |  .                |
  -8    0.00068916        0.07490    |                 .  |* .                |
  -7    0.00050440        0.05482    |                 .  |* .                |
  -6    0.00005031        0.00547    |                 .  |  .                |
  -5    -0.0003149        -.03423    |                 . *|  .                |
  -4    0.00014064        0.01529    |                 .  |  .                |
  -3    -0.0000431        -.00469    |                 .  |  .                |
  -2    -3.7874E-7        -.00004    |                 .  |  .                |
  -1    -0.0002723        -.02960    |                 . *|  .                |
   0    -0.0005385        -.05853    |                 . *|  .                |
   1    0.00038229        0.04155    |                 .  |* .                |
   2    -0.0000324        -.00352    |                 .  |  .                |
   3    -0.0002409        -.02618    |                 . *|  .                |
   4    -0.0025185        -.27374    |               *****|  .                |
   5     0.0019332        0.21012    |                 .  |****               |
   6    0.00032166        0.03496    |                 .  |* .                |
   7    0.00064558        0.07017    |                 .  |* .                |
   8    -0.0009271        -.10077    |                 .**|  .                |
   9    0.00048047        0.05222    |                 .  |* .                |
  10    -0.0002688        -.02922    |                 . *|  .                |
  11    0.00008454        0.00919    |                 .  |  .                |
  12    -0.0001186        -.01289    |                 .  |  .                |
  13    -0.0002372        -.02578    |                 . *|  .                |
  14    -0.0002822        -.03068    |                 . *|  .                |
  15    -0.0022193        -.24121    |               *****|  .                |
  16     0.0025198        0.27387    |                 .  |*****              |
  17     0.0010384        0.11287    |                 .  |**.                |
  18    -0.0007361        -.08001    |                 .**|  .                |
  19    0.00023797        0.02587    |                 .  |* .                |
  20    -0.0006887        -.07486    |                 . *|  .                |
  21    -0.0007794        -.08472    |                 .**|  .                |
  22     0.0017382        0.18892    |                 .  |****               |
  23    0.00013994        0.01521    |                 .  |  .                |
  24    0.00024615        0.02675    |                 .  |* .                |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval. The adjusted series contains data seasonally adjusted by the X-11 method.

APPENDIX VII: CROSS-CORRELATION FUNCTIONS (RAW SERIES – 1st DIFFERENCE)

Table 41. Soybeans Futures Price Volatility and Oil Spot Prices Cross Correlation Functions (Raw Series – 1st Difference).

```
   Lag   Covariance  Correlation    -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
   -24   -0.0008271     -.05796    |                . *|  .                 |
   -23   -0.0011598     -.08127    |                .**|  .                 |
   -22   -0.0002433     -.01705    |                .  |  .                 |
   -21   0.00019022     0.01333    |                .  |  .                 |
   -20    0.0016567     0.11610    |                .  |**.                 |
   -19   -0.0012101     -.08480    |                .**|  .                 |
   -18   0.00053515     0.03750    |                .  |* .                 |
   -17   0.00025158     0.01763    |                .  |  .                 |
   -16   -0.0011089     -.07771    |                .**|  .                 |
   -15   0.00058384     0.04091    |                .  |* .                 |
   -14   0.00025898     0.01815    |                .  |  .                 |
   -13   -0.0006651     -.04661    |                . *|  .                 |
   -12   -0.0005139     -.03601    |                . *|  .                 |
   -11   -0.0003461     -.02425    |                .  |  .                 |
   -10   0.00054561     0.03823    |                .  |* .                 |
    -9   -0.0002361     -.01655    |                .  |  .                 |
    -8   0.00069557     0.04874    |                .  |* .                 |
    -7   0.00044942     0.03149    |                .  |* .                 |
    -6   -0.0005320     -.03728    |                . *|  .                 |
    -5   -0.0001838     -.01288    |                .  |  .                 |
    -4   -0.0006383     -.04473    |                . *|  .                 |
    -3    0.0028228     0.19781    |                .  |****                |
    -2   0.00014280     0.01001    |                .  |  .                 |
    -1   -0.0018121     -.12698    |                ***|  .                 |
     0    0.0021120     0.14800    |                .  |***                 |
     1   -0.0020727     -.14525    |                ***|  .                 |
     2   0.00029694     0.02081    |                .  |  .                 |
     3   -0.0002501     -.01752    |                .  |  .                 |
     4   -0.0006452     -.04521    |                . *|  .                 |
     5   -0.0001080     -.00757    |                .  |  .                 |
     6   0.00041264     0.02892    |                .  |* .                 |
     7   0.00021739     0.01523    |                .  |  .                 |
     8    0.0012301     0.08620    |                .  |**.                 |
     9   -0.0000438     -.00307    |                .  |  .                 |
    10   -0.0006284     -.04404    |                . *|  .                 |
    11    0.0020067     0.14062    |                .  |***                 |
    12   -0.0026035     -.18244    |               ****|  .                 |
    13   0.00017682     0.01239    |                .  |  .                 |
    14    0.0010344     0.07249    |                .  |* .                 |
    15   -0.0027284     -.19119    |               ****|  .                 |
    16    0.0021406     0.15001    |                .  |***                 |
    17    0.0011792     0.08263    |                .  |**.                 |
    18   -0.0027914     -.19561    |               ****|  .                 |
    19   0.00035007     0.02453    |                .  |  .                 |
    20    0.0017098     0.11982    |                .  |**.                 |
    21   -0.0018279     -.12809    |                ***|  .                 |
    22    0.0014150     0.09916    |                .  |**.                 |
    23   -0.0010708     -.07504    |                .**|  .                 |
    24    0.0013969     0.09789    |                .  |**.                 |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval.

Table 42. Oil Spot Prices and Soybeans Futures Price Volatility Cross-correlation Function (Raw Series - 1st Difference).

<table>
<tr><th>Lag</th><th>Covariance</th><th>Correlation</th><th>-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1</th></tr>
<tr><td>-24</td><td>0.0013969</td><td>0.09789</td><td>| . |**. |</td></tr>
<tr><td>-23</td><td>-0.0010708</td><td>-.07504</td><td>| .**| . |</td></tr>
<tr><td>-22</td><td>0.0014150</td><td>0.09916</td><td>| . |**. |</td></tr>
<tr><td>-21</td><td>-0.0018279</td><td>-.12809</td><td>| ***| . |</td></tr>
<tr><td>-20</td><td>0.0017098</td><td>0.11982</td><td>| . |**. |</td></tr>
<tr><td>-19</td><td>0.00035007</td><td>0.02453</td><td>| . | . |</td></tr>
<tr><td>-18</td><td>-0.0027914</td><td>-.19561</td><td>| ****| . |</td></tr>
<tr><td>-17</td><td>0.0011792</td><td>0.08263</td><td>| . |**. |</td></tr>
<tr><td>-16</td><td>0.0021406</td><td>0.15001</td><td>| . |*** |</td></tr>
<tr><td>-15</td><td>-0.0027284</td><td>-.19119</td><td>| ****| . |</td></tr>
<tr><td>-14</td><td>0.0010344</td><td>0.07249</td><td>| . |* . |</td></tr>
<tr><td>-13</td><td>0.00017682</td><td>0.01239</td><td>| . | . |</td></tr>
<tr><td>-12</td><td>-0.0026035</td><td>-.18244</td><td>| ****| . |</td></tr>
<tr><td>-11</td><td>0.0020067</td><td>0.14062</td><td>| . |*** |</td></tr>
<tr><td>-10</td><td>-0.0006284</td><td>-.04404</td><td>| . *| . |</td></tr>
<tr><td>-9</td><td>-0.0000438</td><td>-.00307</td><td>| . | . |</td></tr>
<tr><td>-8</td><td>0.0012301</td><td>0.08620</td><td>| . |**. |</td></tr>
<tr><td>-7</td><td>0.00021739</td><td>0.01523</td><td>| . | . |</td></tr>
<tr><td>-6</td><td>0.00041264</td><td>0.02892</td><td>| . |* . |</td></tr>
<tr><td>-5</td><td>-0.0001080</td><td>-.00757</td><td>| . | . |</td></tr>
<tr><td>-4</td><td>-0.0006452</td><td>-.04521</td><td>| . *| . |</td></tr>
<tr><td>-3</td><td>-0.0002501</td><td>-.01752</td><td>| . | . |</td></tr>
<tr><td>-2</td><td>0.00029694</td><td>0.02081</td><td>| . | . |</td></tr>
<tr><td>-1</td><td>-0.0020727</td><td>-.14525</td><td>| ***| . |</td></tr>
<tr><td>0</td><td>0.0021120</td><td>0.14800</td><td>| . |*** |</td></tr>
<tr><td>1</td><td>-0.0018121</td><td>-.12698</td><td>| ***| . |</td></tr>
<tr><td>2</td><td>0.00014280</td><td>0.01001</td><td>| . | . |</td></tr>
<tr><td>3</td><td>0.0028228</td><td>0.19781</td><td>| . |**** |</td></tr>
<tr><td>4</td><td>-0.0006383</td><td>-.04473</td><td>| . *| . |</td></tr>
<tr><td>5</td><td>-0.0001838</td><td>-.01288</td><td>| . | . |</td></tr>
<tr><td>6</td><td>-0.0005320</td><td>-.03728</td><td>| . *| . |</td></tr>
<tr><td>7</td><td>0.00044942</td><td>0.03149</td><td>| . |* . |</td></tr>
<tr><td>8</td><td>0.00069557</td><td>0.04874</td><td>| . |* . |</td></tr>
<tr><td>9</td><td>-0.0002361</td><td>-.01655</td><td>| . | . |</td></tr>
<tr><td>10</td><td>0.00054561</td><td>0.03823</td><td>| . |* . |</td></tr>
<tr><td>11</td><td>-0.0003461</td><td>-.02425</td><td>| . | . |</td></tr>
<tr><td>12</td><td>-0.0005139</td><td>-.03601</td><td>| . *| . |</td></tr>
<tr><td>13</td><td>-0.0006651</td><td>-.04661</td><td>| . *| . |</td></tr>
<tr><td>14</td><td>0.00025898</td><td>0.01815</td><td>| . | . |</td></tr>
<tr><td>15</td><td>0.00058384</td><td>0.04091</td><td>| . |* . |</td></tr>
<tr><td>16</td><td>-0.0011089</td><td>-.07771</td><td>| .**| . |</td></tr>
<tr><td>17</td><td>0.00025158</td><td>0.01763</td><td>| . | . |</td></tr>
<tr><td>18</td><td>0.00053515</td><td>0.03750</td><td>| . |* . |</td></tr>
<tr><td>19</td><td>-0.0012101</td><td>-.08480</td><td>| .**| . |</td></tr>
<tr><td>20</td><td>0.0016567</td><td>0.11610</td><td>| . |**. |</td></tr>
<tr><td>21</td><td>0.00019022</td><td>0.01333</td><td>| . | . |</td></tr>
<tr><td>22</td><td>-0.0002433</td><td>-.01705</td><td>| . | . |</td></tr>
<tr><td>23</td><td>-0.0011598</td><td>-.08127</td><td>| .**| . |</td></tr>
<tr><td>24</td><td>-0.0008271</td><td>-.05796</td><td>| . *| . |</td></tr>
</table>

Note: The vertical symbols (...) denote a 95 percent confidence interval.

Table 43. Soybeans Futures Price Volatility and Renewable Fuel Policy Cross-Correlation Function (Raw Series – 1st Difference).

Lag	Covariance	Correlation	-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
-24	-0.0015061	-.03294	| . *| . |
-23	0.00010779	0.00236	| . | . |
-22	0.00013401	0.00293	| . | . |
-21	-0.0003349	-.00732	| . | . |
-20	0.00006892	0.00151	| . | . |
-19	-0.0009413	-.02058	| . | . |
-18	-0.0005169	-.01130	| . | . |
-17	-0.0007061	-.01544	| . | . |
-16	-0.0002646	-.00579	| . | . |
-15	-0.0003101	-.00678	| . | . |
-14	-0.0014915	-.03262	| . *| . |
-13	-0.0010196	-.02230	| . | . |
-12	-0.0003333	-.00729	| . | . |
-11	0.00015679	0.00343	| . | . |
-10	0.00016266	0.00356	| . | . |
-9	0.00017691	0.00387	| . | . |
-8	-0.0003540	-.00774	| . | . |
-7	-0.0004511	-.00986	| . | . |
-6	0.00017484	0.00382	| . | . |
-5	0.00023242	0.00508	| . | . |
-4	0.00036935	0.00808	| . | . |
-3	0.00026067	0.00570	| . | . |
-2	-0.0001541	-.00337	| . | . |
-1	0.00020658	0.00452	| . | . |
0	0.00027324	0.00598	| . | . |
1	0.00002729	0.00060	| . | . |
2	0.00019973	0.00437	| . | . |
3	-0.0001595	-.00349	| . | . |
4	0.00006549	0.00143	| . | . |
5	-0.0004117	-.00900	| . | . |
6	0.00088341	0.01932	| . | . |
7	0.00059970	0.01311	| . | . |
8	0.00046555	0.01018	| . | . |
9	0.00024708	0.00540	| . | . |
10	-0.0003675	-.00804	| . | . |
11	-0.0005074	-.01110	| . | . |
12	-0.0001789	-.00391	| . | . |
13	-0.0000378	-.00083	| . | . |
14	-0.0001308	-.00286	| . | . |
15	0.00022267	0.00487	| . | . |
16	0.00038522	0.00842	| . | . |
17	-0.0002478	-.00542	| . | . |
18	0.00001384	0.00030	| . | . |
19	-0.0018107	-.03960	| . *| . |
20	-0.0008127	-.01777	| . | . |
21	-0.0000746	-.00163	| . | . |
22	-0.0004281	-.00936	| . | . |
23	-0.0007180	-.01570	| . | . |
24	-0.0013621	-.02979	| . *| . |

Note: The vertical symbols (...) denote a 95 percent confidence interval.

Table 44. Renewable Fuel Policy and Soybeans Futures Price Volatility Cross-correlation Function (Raw Series - 1st Difference).

```
   Lag   Covariance  Correlation   -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
   -24    0.0036943      0.44846   |                 .  |*********           |
   -23    0.0010807      0.13119   |                 .  |***                 |
   -22   0.00041159      0.04996   |                 .  |* .                 |
   -21   0.00024765      0.03006   |                 .  |* .                 |
   -20   -0.0001915      -.02325   |                 .  |  .                 |
   -19   0.00073425      0.08913   |                 .  |**.                 |
   -18    0.0016253      0.19729   |                 .  |****                |
   -17   -0.0002509      -.03046   |                 . *|  .                 |
   -16   0.00005818      0.00706   |                 .  |  .                 |
   -15   -0.0004470      -.05426   |                 . *|  .                 |
   -14   -0.0004076      -.04948   |                 . *|  .                 |
   -13   -0.0000261      -.00316   |                 .  |  .                 |
   -12   -0.0001507      -.01829   |                 .  |  .                 |
   -11   0.00006626      0.00804   |                 .  |  .                 |
   -10   0.00037338      0.04532   |                 .  |* .                 |
    -9   0.00017689      0.02147   |                 .  |  .                 |
    -8   -0.0004214      -.05115   |                 . *|  .                 |
    -7   -0.0005418      -.06577   |                 . *|  .                 |
    -6   -0.0001759      -.02135   |                 .  |  .                 |
    -5   -0.0005360      -.06506   |                 . *|  .                 |
    -4   0.00021367      0.02594   |                 .  |* .                 |
    -3   -0.0003187      -.03869   |                 . *|  .                 |
    -2   -0.0001226      -.01488   |                 .  |  .                 |
    -1   -0.0003256      -.03952   |                 . *|  .                 |
     0   -0.0002209      -.02682   |                 . *|  .                 |
     1   -0.0004830      -.05863   |                 . *|  .                 |
     2   -0.0006261      -.07601   |                 .**|  .                 |
     3   -0.0001349      -.01638   |                 .  |  .                 |
     4   -0.0004917      -.05969   |                 . *|  .                 |
     5   -0.0004864      -.05905   |                 . *|  .                 |
     6   -0.0003514      -.04266   |                 . *|  .                 |
     7   -0.0001897      -.02303   |                 .  |  .                 |
     8   0.00010589      0.01285   |                 .  |  .                 |
     9   -0.0001363      -.01654   |                 .  |  .                 |
    10   -0.0001555      -.01888   |                 .  |  .                 |
    11   -0.0001183      -.01436   |                 .  |  .                 |
    12   -0.0003935      -.04777   |                 . *|  .                 |
    13   -0.0000304      -.00369   |                 .  |  .                 |
    14   0.00082073      0.09963   |                 .  |**.                 |
    15   0.00089371      0.10849   |                 .  |**.                 |
    16   -0.0002241      -.02720   |                 . *|  .                 |
    17   -0.0003500      -.04249   |                 . *|  .                 |
    18   0.00031031      0.03767   |                 .  |* .                 |
    19   0.00009021      0.01095   |                 .  |  .                 |
    20   0.00046761      0.05676   |                 .  |* .                 |
    21   -0.0003480      -.04225   |                 . *|  .                 |
    22   0.00009225      0.01120   |                 .  |  .                 |
    23   -0.0001817      -.02206   |                 .  |  .                 |
    24   -0.0001778      -.02158   |                 .  |  .                 |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval.

Table 45. Soybeans Futures Price Volatility and U.S Dollar Index Cross-correlation Function (Raw Series – 1st Difference).

<table>
<tr><th>Lag</th><th>Covariance</th><th>Correlation</th><th>-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1</th></tr>
<tr><td>-24</td><td>-0.0001937</td><td>-.07354</td><td>| . *| . |</td></tr>
<tr><td>-23</td><td>-1.631E-6</td><td>-.00062</td><td>| . | . |</td></tr>
<tr><td>-22</td><td>0.00009717</td><td>0.03688</td><td>| . |* . |</td></tr>
<tr><td>-21</td><td>0.00018057</td><td>0.06854</td><td>| . |* . |</td></tr>
<tr><td>-20</td><td>-0.0001352</td><td>-.05131</td><td>| . *| . |</td></tr>
<tr><td>-19</td><td>0.00005319</td><td>0.02019</td><td>| . | . |</td></tr>
<tr><td>-18</td><td>-0.0001005</td><td>-.03814</td><td>| . *| . |</td></tr>
<tr><td>-17</td><td>-0.0000895</td><td>-.03397</td><td>| . *| . |</td></tr>
<tr><td>-16</td><td>0.00007888</td><td>0.02994</td><td>| . |* . |</td></tr>
<tr><td>-15</td><td>0.00008978</td><td>0.03408</td><td>| . |* . |</td></tr>
<tr><td>-14</td><td>0.00006276</td><td>0.02382</td><td>| . | . |</td></tr>
<tr><td>-13</td><td>-0.0001645</td><td>-.06243</td><td>| . *| . |</td></tr>
<tr><td>-12</td><td>0.00003390</td><td>0.01287</td><td>| . | . |</td></tr>
<tr><td>-11</td><td>-0.0002003</td><td>-.07602</td><td>| .**| . |</td></tr>
<tr><td>-10</td><td>6.63957E-6</td><td>0.00252</td><td>| . | . |</td></tr>
<tr><td>-9</td><td>0.00031099</td><td>0.11804</td><td>| . |**. |</td></tr>
<tr><td>-8</td><td>-0.0003367</td><td>-.12778</td><td>| ***| . |</td></tr>
<tr><td>-7</td><td>0.00037728</td><td>0.14320</td><td>| . |*** |</td></tr>
<tr><td>-6</td><td>0.00002813</td><td>0.01068</td><td>| . | . |</td></tr>
<tr><td>-5</td><td>-0.0001381</td><td>-.05242</td><td>| . *| . |</td></tr>
<tr><td>-4</td><td>-0.0002321</td><td>-.08809</td><td>| .**| . |</td></tr>
<tr><td>-3</td><td>-0.0000801</td><td>-.03041</td><td>| . *| . |</td></tr>
<tr><td>-2</td><td>-0.0000289</td><td>-.01097</td><td>| . | . |</td></tr>
<tr><td>-1</td><td>0.00041815</td><td>0.15872</td><td>| . |*** |</td></tr>
<tr><td>0</td><td>0.00033696</td><td>0.12790</td><td>| . |*** |</td></tr>
<tr><td>1</td><td>-0.0002944</td><td>-.11176</td><td>| .**| . |</td></tr>
<tr><td>2</td><td>-0.0002307</td><td>-.08755</td><td>| .**| . |</td></tr>
<tr><td>3</td><td>-0.0000566</td><td>-.02147</td><td>| . | . |</td></tr>
<tr><td>4</td><td>0.00018353</td><td>0.06966</td><td>| . |* . |</td></tr>
<tr><td>5</td><td>-0.0000404</td><td>-.01535</td><td>| . | . |</td></tr>
<tr><td>6</td><td>-0.0002128</td><td>-.08077</td><td>| .**| . |</td></tr>
<tr><td>7</td><td>3.56085E-6</td><td>0.00135</td><td>| . | . |</td></tr>
<tr><td>8</td><td>0.00005018</td><td>0.01904</td><td>| . | . |</td></tr>
<tr><td>9</td><td>-0.0000304</td><td>-.01155</td><td>| . | . |</td></tr>
<tr><td>10</td><td>0.00055297</td><td>0.20989</td><td>| . |**** |</td></tr>
<tr><td>11</td><td>-0.0003962</td><td>-.15038</td><td>| ***| . |</td></tr>
<tr><td>12</td><td>-0.0000869</td><td>-.03300</td><td>| . *| . |</td></tr>
<tr><td>13</td><td>0.00024049</td><td>0.09128</td><td>| . |**. |</td></tr>
<tr><td>14</td><td>-0.0000895</td><td>-.03396</td><td>| . *| . |</td></tr>
<tr><td>15</td><td>0.00006171</td><td>0.02342</td><td>| . | . |</td></tr>
<tr><td>16</td><td>-0.0001353</td><td>-.05136</td><td>| . *| . |</td></tr>
<tr><td>17</td><td>0.00001073</td><td>0.00407</td><td>| . | . |</td></tr>
<tr><td>18</td><td>0.00005011</td><td>0.01902</td><td>| . | . |</td></tr>
<tr><td>19</td><td>-0.0000612</td><td>-.02321</td><td>| . | . |</td></tr>
<tr><td>20</td><td>-0.0001124</td><td>-.04267</td><td>| . *| . |</td></tr>
<tr><td>21</td><td>0.00005174</td><td>0.01964</td><td>| . | . |</td></tr>
<tr><td>22</td><td>0.00006621</td><td>0.02513</td><td>| . |* . |</td></tr>
<tr><td>23</td><td>-0.0001683</td><td>-.06387</td><td>| . *| . |</td></tr>
<tr><td>24</td><td>0.00030907</td><td>0.11731</td><td>| . |**. |</td></tr>
</table>

Note: The vertical symbols (...) denote a 95 percent confidence interval.

Table 46. U.S Dollar Index and Soybeans Futures Price Volatility Cross-correlation Function (Raw Series - 1st Difference).

```
 Lag    Covariance  Correlation    -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
 -24    0.00030907      0.11731    |                 .  |**.                 |
 -23    -0.0001683      -.06387    |                 . *|  .                 |
 -22    0.00006621      0.02513    |                 .  |* .                 |
 -21    0.00005174      0.01964    |                 .  |  .                 |
 -20    -0.0001124      -.04267    |                 . *|  .                 |
 -19    -0.0000612      -.02321    |                 .  |  .                 |
 -18    0.00005011      0.01902    |                 .  |  .                 |
 -17    0.00001073      0.00407    |                 .  |  .                 |
 -16    -0.0001353      -.05136    |                 . *|  .                 |
 -15    0.00006171      0.02342    |                 .  |  .                 |
 -14    -0.0000895      -.03396    |                 . *|  .                 |
 -13    0.00024049      0.09128    |                 .  |**.                 |
 -12    -0.0000869      -.03300    |                 . *|  .                 |
 -11    -0.0003962      -.15038    |                 ***|  .                 |
 -10    0.00055297      0.20989    |                 .  |****                |
  -9    -0.0000304      -.01155    |                 .  |  .                 |
  -8    0.00005018      0.01904    |                 .  |  .                 |
  -7    3.56085E-6      0.00135    |                 .  |  .                 |
  -6    -0.0002128      -.08077    |                 .**|  .                 |
  -5    -0.0000404      -.01535    |                 .  |  .                 |
  -4    0.00018353      0.06966    |                 .  |* .                 |
  -3    -0.0000566      -.02147    |                 .  |  .                 |
  -2    -0.0002307      -.08755    |                 .**|  .                 |
  -1    -0.0002944      -.11176    |                 .**|  .                 |
   0    0.00033696      0.12790    |                 .  |***                 |
   1    0.00041815      0.15872    |                 .  |***                 |
   2    -0.0000289      -.01097    |                 .  |  .                 |
   3    -0.0000801      -.03041    |                 . *|  .                 |
   4    -0.0002321      -.08809    |                 .**|  .                 |
   5    -0.0001381      -.05242    |                 . *|  .                 |
   6    0.00002813      0.01068    |                 .  |  .                 |
   7    0.00037728      0.14320    |                 .  |***                 |
   8    -0.0003367      -.12778    |                 ***|  .                 |
   9    0.00031099      0.11804    |                 .  |**.                 |
  10    6.63957E-6      0.00252    |                 .  |  .                 |
  11    -0.0002003      -.07602    |                 .**|  .                 |
  12    0.00003390      0.01287    |                 .  |  .                 |
  13    -0.0001645      -.06243    |                 . *|  .                 |
  14    0.00006276      0.02382    |                 .  |  .                 |
  15    0.00008978      0.03408    |                 .  |* .                 |
  16    0.00007888      0.02994    |                 .  |* .                 |
  17    -0.0000895      -.03397    |                 . *|  .                 |
  18    -0.0001005      -.03814    |                 . *|  .                 |
  19    0.00005319      0.02019    |                 .  |  .                 |
  20    -0.0001352      -.05131    |                 . *|  .                 |
  21    0.00018057      0.06854    |                 .  |* .                 |
  22    0.00009717      0.03688    |                 .  |* .                 |
  23     -1.631E-6      -.00062    |                 .  |  .                 |
  24    -0.0001937      -.07354    |                 . *|  .                 |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval.

Table 47. Soybeans Futures Price Volatility and China Soybeans Imports Cross-Correlation Function (Raw Series – 1st Difference).

```
     Lag   Covariance   Correlation    -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
     -24    -7363.401      -.09881     |                 .**|  .                 |
     -23     2610.240      0.03503     |                 .  |* .                 |
     -22     6879.482      0.09232     |                 .  |**.                 |
     -21     9548.326      0.12813     |                 .  |***                 |
     -20    17544.699      0.23543     |                 .  |*****               |
     -19     1095.870      0.01471     |                 .  |  .                 |
     -18   -10159.748      -.13633     |                 ***|  .                 |
     -17    -9324.167      -.12512     |                 ***|  .                 |
     -16    -8726.421      -.11710     |                 .**|  .                 |
     -15     2457.242      0.03297     |                 .  |* .                 |
     -14    -1191.233      -.01599     |                 .  |  .                 |
     -13    -1941.628      -.02605     |                 . *|  .                 |
     -12    -4164.640      -.05589     |                 . *|  .                 |
     -11   -57.323899      -.00077     |                 .  |  .                 |
     -10    -2870.396      -.03852     |                 . *|  .                 |
      -9    29047.722      0.38979     |                 .  |********            |
      -8     4339.258      0.05823     |                 .  |* .                 |
      -7    -3092.649      -.04150     |                 . *|  .                 |
      -6   -11459.132      -.15377     |                 ***|  .                 |
      -5    -9991.202      -.13407     |                 ***|  .                 |
      -4     4565.638      0.06127     |                 .  |* .                 |
      -3    -3937.558      -.05284     |                 . *|  .                 |
      -2    -3210.620      -.04308     |                 . *|  .                 |
      -1     7790.653      0.10454     |                 .  |**.                 |
       0   -13050.501      -.17512     |                ****|  .                 |
       1    -7814.240      -.10486     |                 .**|  .                 |
       2    23915.351      0.32092     |                 .  |******              |
       3     3483.526      0.04675     |                 .  |* .                 |
       4     6758.117      0.09069     |                 .  |**.                 |
       5    -5569.638      -.07474     |                 . *|  .                 |
       6      651.166      0.00874     |                 .  |  .                 |
       7    -7626.159      -.10234     |                 .**|  .                 |
       8    -8407.998      -.11283     |                 .**|  .                 |
       9     1540.964      0.02068     |                 .  |  .                 |
      10    -3706.469      -.04974     |                 . *|  .                 |
      11     1097.901      0.01473     |                 .  |  .                 |
      12     2048.982      0.02750     |                 .  |* .                 |
      13     5125.809      0.06878     |                 .  |* .                 |
      14    -1858.753      -.02494     |                 .  |  .                 |
      15    16178.998      0.21711     |                 .  |****                |
      16    -1839.341      -.02468     |                 .  |  .                 |
      17    -2754.142      -.03696     |                 . *|  .                 |
      18    -1134.410      -.01522     |                 .  |  .                 |
      19   -10025.622      -.13453     |                 ***|  .                 |
      20     -995.129      -.01335     |                 .  |  .                 |
      21    -4230.263      -.05677     |                 . *|  .                 |
      22     2724.789      0.03656     |                 .  |* .                 |
      23     3171.396      0.04256     |                 .  |* .                 |
      24      221.198      0.00297     |                 .  |  .                 |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval.

Table 48. China Soybeans Imports and Soybeans Futures Price Volatility Cross-correlation Function (RawSeries - 1st Difference).

<table>
<tr><th>Lag</th><th>Covariance</th><th>Correlation</th><th>-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1</th></tr>
<tr><td>-24</td><td>221.198</td><td>0.00297</td><td>| . | . |</td></tr>
<tr><td>-23</td><td>3171.396</td><td>0.04256</td><td>| . |* . |</td></tr>
<tr><td>-22</td><td>2724.789</td><td>0.03656</td><td>| . |* . |</td></tr>
<tr><td>-21</td><td>-4230.263</td><td>-.05677</td><td>| . *| . |</td></tr>
<tr><td>-20</td><td>-995.129</td><td>-.01335</td><td>| . | . |</td></tr>
<tr><td>-19</td><td>-10025.622</td><td>-.13453</td><td>| ***| . |</td></tr>
<tr><td>-18</td><td>-1134.410</td><td>-.01522</td><td>| . | . |</td></tr>
<tr><td>-17</td><td>-2754.142</td><td>-.03696</td><td>| . *| . |</td></tr>
<tr><td>-16</td><td>-1839.341</td><td>-.02468</td><td>| . | . |</td></tr>
<tr><td>-15</td><td>16178.998</td><td>0.21711</td><td>| . |**** |</td></tr>
<tr><td>-14</td><td>-1858.753</td><td>-.02494</td><td>| . | . |</td></tr>
<tr><td>-13</td><td>5125.809</td><td>0.06878</td><td>| . |* . |</td></tr>
<tr><td>-12</td><td>2048.982</td><td>0.02750</td><td>| . |* . |</td></tr>
<tr><td>-11</td><td>1097.901</td><td>0.01473</td><td>| . | . |</td></tr>
<tr><td>-10</td><td>-3706.469</td><td>-.04974</td><td>| . *| . |</td></tr>
<tr><td>-9</td><td>1540.964</td><td>0.02068</td><td>| . | . |</td></tr>
<tr><td>-8</td><td>-8407.998</td><td>-.11283</td><td>| .**| . |</td></tr>
<tr><td>-7</td><td>-7626.159</td><td>-.10234</td><td>| .**| . |</td></tr>
<tr><td>-6</td><td>651.166</td><td>0.00874</td><td>| . | . |</td></tr>
<tr><td>-5</td><td>-5569.638</td><td>-.07474</td><td>| . *| . |</td></tr>
<tr><td>-4</td><td>6758.117</td><td>0.09069</td><td>| . |**. |</td></tr>
<tr><td>-3</td><td>3483.526</td><td>0.04675</td><td>| . |* . |</td></tr>
<tr><td>-2</td><td>23915.351</td><td>0.32092</td><td>| . |****** |</td></tr>
<tr><td>-1</td><td>-7814.240</td><td>-.10486</td><td>| .**| . |</td></tr>
<tr><td>0</td><td>-13050.501</td><td>-.17512</td><td>| ****| . |</td></tr>
<tr><td>1</td><td>7790.653</td><td>0.10454</td><td>| . |**. |</td></tr>
<tr><td>2</td><td>-3210.620</td><td>-.04308</td><td>| . *| . |</td></tr>
<tr><td>3</td><td>-3937.558</td><td>-.05284</td><td>| . *| . |</td></tr>
<tr><td>4</td><td>4565.638</td><td>0.06127</td><td>| . |* . |</td></tr>
<tr><td>5</td><td>-9991.202</td><td>-.13407</td><td>| ***| . |</td></tr>
<tr><td>6</td><td>-11459.132</td><td>-.15377</td><td>| ***| . |</td></tr>
<tr><td>7</td><td>-3092.649</td><td>-.04150</td><td>| . *| . |</td></tr>
<tr><td>8</td><td>4339.258</td><td>0.05823</td><td>| . |* . |</td></tr>
<tr><td>9</td><td>29047.722</td><td>0.38979</td><td>| . |******** |</td></tr>
<tr><td>10</td><td>-2870.396</td><td>-.03852</td><td>| . *| . |</td></tr>
<tr><td>11</td><td>-57.323899</td><td>-.00077</td><td>| . | . |</td></tr>
<tr><td>12</td><td>-4164.640</td><td>-.05589</td><td>| . *| . |</td></tr>
<tr><td>13</td><td>-1941.628</td><td>-.02605</td><td>| . *| . |</td></tr>
<tr><td>14</td><td>-1191.233</td><td>-.01599</td><td>| . | . |</td></tr>
<tr><td>15</td><td>2457.242</td><td>0.03297</td><td>| . |* . |</td></tr>
<tr><td>16</td><td>-8726.421</td><td>-.11710</td><td>| .**| . |</td></tr>
<tr><td>17</td><td>-9324.167</td><td>-.12512</td><td>| ***| . |</td></tr>
<tr><td>18</td><td>-10159.748</td><td>-.13633</td><td>| ***| . |</td></tr>
<tr><td>19</td><td>1095.870</td><td>0.01471</td><td>| . | . |</td></tr>
<tr><td>20</td><td>17544.699</td><td>0.23543</td><td>| . |***** |</td></tr>
<tr><td>21</td><td>9548.326</td><td>0.12813</td><td>| . |*** |</td></tr>
<tr><td>22</td><td>6879.482</td><td>0.09232</td><td>| . |**. |</td></tr>
<tr><td>23</td><td>2610.240</td><td>0.03503</td><td>| . |* . |</td></tr>
<tr><td>24</td><td>-7363.401</td><td>-.09881</td><td>| .**| . |</td></tr>
</table>

Note: The vertical symbols (...) denote a 95 percent confidence interval.

Table 49. Soybeans Futures Price Volatility and Number of Mutual Funds Cross-correlation Function (Raw Series - 1st Difference).

```
   Lag   Covariance  Correlation   -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
   -24    0.0026653      0.07866   |                 .  |**.                 |
   -23   -0.0023615      -.06969   |                 . *|  .                 |
   -22    0.0058153      0.17162   |                 .  |***                 |
   -21    0.0034262      0.10112   |                 .  |**.                 |
   -20   -0.0050337      -.14855   |                 ***|  .                 |
   -19   -0.0012814      -.03782   |                 . *|  .                 |
   -18   -0.0029261      -.08636   |                 .**|  .                 |
   -17    0.0038316      0.11308   |                 .  |**.                 |
   -16    0.0014663      0.04327   |                 .  |* .                 |
   -15   -0.0023374      -.06898   |                 . *|  .                 |
   -14   -0.0004966      -.01466   |                 .  |  .                 |
   -13   -0.0028169      -.08313   |                 .**|  .                 |
   -12   0.00007328      0.00216   |                 .  |  .                 |
   -11    0.0041491      0.12245   |                 .  |**.                 |
   -10   -0.0015940      -.04704   |                 . *|  .                 |
    -9   0.00044639      0.01317   |                 .  |  .                 |
    -8   -0.0024916      -.07353   |                 . *|  .                 |
    -7   -0.0021942      -.06476   |                 . *|  .                 |
    -6    0.0036813      0.10864   |                 .  |**.                 |
    -5   -0.0014732      -.04348   |                 . *|  .                 |
    -4   -0.0022855      -.06745   |                 . *|  .                 |
    -3   0.00059766      0.01764   |                 .  |  .                 |
    -2   -0.0016849      -.04972   |                 . *|  .                 |
    -1   -0.0002314      -.00683   |                 .  |  .                 |
     0   0.00034640      0.01022   |                 .  |  .                 |
     1    0.0022733      0.06709   |                 .  |* .                 |
     2    0.0051118      0.15086   |                 .  |***                 |
     3   -0.0006438      -.01900   |                 .  |  .                 |
     4   -0.0011383      -.03359   |                 . *|  .                 |
     5    0.0010768      0.03178   |                 .  |* .                 |
     6   -0.0051664      -.15247   |                 ***|  .                 |
     7   -0.0010286      -.03036   |                 . *|  .                 |
     8   0.00019463      0.00574   |                 .  |  .                 |
     9   -0.0005449      -.01608   |                 .  |  .                 |
    10    0.0022167      0.06542   |                 .  |* .                 |
    11   -0.0026160      -.07720   |                 .**|  .                 |
    12    0.0040850      0.12056   |                 .  |**.                 |
    13   0.00089378      0.02638   |                 .  |* .                 |
    14   -0.0017075      -.05039   |                 . *|  .                 |
    15   0.00066467      0.01962   |                 .  |  .                 |
    16    0.0029649      0.08750   |                 .  |**.                 |
    17   -0.0028536      -.08422   |                 .**|  .                 |
    18    0.0030540      0.09013   |                 .  |**.                 |
    19   -0.0045455      -.13415   |                 ***|  .                 |
    20   -0.0008931      -.02636   |                 . *|  .                 |
    21   -0.0005336      -.01575   |                 .  |  .                 |
    22   -0.0013233      -.03905   |                 . *|  .                 |
    23    0.0014128      0.04170   |                 .  |* .                 |
    24   -0.0021031      -.06207   |                 . *|  .                 |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval.

Table 50. Number of Mutual Funds and Soybeans Futures Price Volatility Cross-correlation Function (Raw Series - 1st Difference).

<table>
<tr><th>Lag</th><th>Covariance</th><th>Correlation</th><th>-1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1</th></tr>
<tr><td>-24</td><td>-0.0021031</td><td>-.06207</td><td>| . *| . |</td></tr>
<tr><td>-23</td><td>0.0014128</td><td>0.04170</td><td>| . |* . |</td></tr>
<tr><td>-22</td><td>-0.0013233</td><td>-.03905</td><td>| . *| . |</td></tr>
<tr><td>-21</td><td>-0.0005336</td><td>-.01575</td><td>| . | . |</td></tr>
<tr><td>-20</td><td>-0.0008931</td><td>-.02636</td><td>| . *| . |</td></tr>
<tr><td>-19</td><td>-0.0045455</td><td>-.13415</td><td>| ***| . |</td></tr>
<tr><td>-18</td><td>0.0030540</td><td>0.09013</td><td>| . |**. |</td></tr>
<tr><td>-17</td><td>-0.0028536</td><td>-.08422</td><td>| .**| . |</td></tr>
<tr><td>-16</td><td>0.0029649</td><td>0.08750</td><td>| . |**. |</td></tr>
<tr><td>-15</td><td>0.00066467</td><td>0.01962</td><td>| . | . |</td></tr>
<tr><td>-14</td><td>-0.0017075</td><td>-.05039</td><td>| . *| . |</td></tr>
<tr><td>-13</td><td>0.00089378</td><td>0.02638</td><td>| . |* . |</td></tr>
<tr><td>-12</td><td>0.0040850</td><td>0.12056</td><td>| . |**. |</td></tr>
<tr><td>-11</td><td>-0.0026160</td><td>-.07720</td><td>| .**| . |</td></tr>
<tr><td>-10</td><td>0.0022167</td><td>0.06542</td><td>| . |* . |</td></tr>
<tr><td>-9</td><td>-0.0005449</td><td>-.01608</td><td>| . | . |</td></tr>
<tr><td>-8</td><td>0.00019463</td><td>0.00574</td><td>| . | . |</td></tr>
<tr><td>-7</td><td>-0.0010286</td><td>-.03036</td><td>| . *| . |</td></tr>
<tr><td>-6</td><td>-0.0051664</td><td>-.15247</td><td>| ***| . |</td></tr>
<tr><td>-5</td><td>0.0010768</td><td>0.03178</td><td>| . |* . |</td></tr>
<tr><td>-4</td><td>-0.0011383</td><td>-.03359</td><td>| . *| . |</td></tr>
<tr><td>-3</td><td>-0.0006438</td><td>-.01900</td><td>| . | . |</td></tr>
<tr><td>-2</td><td>0.0051118</td><td>0.15086</td><td>| . |*** |</td></tr>
<tr><td>-1</td><td>0.0022733</td><td>0.06709</td><td>| . |* . |</td></tr>
<tr><td>0</td><td>0.00034640</td><td>0.01022</td><td>| . | . |</td></tr>
<tr><td>1</td><td>-0.0002314</td><td>-.00683</td><td>| . | . |</td></tr>
<tr><td>2</td><td>-0.0016849</td><td>-.04972</td><td>| . *| . |</td></tr>
<tr><td>3</td><td>0.00059766</td><td>0.01764</td><td>| . | . |</td></tr>
<tr><td>4</td><td>-0.0022855</td><td>-.06745</td><td>| . *| . |</td></tr>
<tr><td>5</td><td>-0.0014732</td><td>-.04348</td><td>| . *| . |</td></tr>
<tr><td>6</td><td>0.0036813</td><td>0.10864</td><td>| . |**. |</td></tr>
<tr><td>7</td><td>-0.0021942</td><td>-.06476</td><td>| . *| . |</td></tr>
<tr><td>8</td><td>-0.0024916</td><td>-.07353</td><td>| . *| . |</td></tr>
<tr><td>9</td><td>0.00044639</td><td>0.01317</td><td>| . | . |</td></tr>
<tr><td>10</td><td>-0.0015940</td><td>-.04704</td><td>| . *| . |</td></tr>
<tr><td>11</td><td>0.0041491</td><td>0.12245</td><td>| . |**. |</td></tr>
<tr><td>12</td><td>0.00007328</td><td>0.00216</td><td>| . | . |</td></tr>
<tr><td>13</td><td>-0.0028169</td><td>-.08313</td><td>| .**| . |</td></tr>
<tr><td>14</td><td>-0.0004966</td><td>-.01466</td><td>| . | . |</td></tr>
<tr><td>15</td><td>-0.0023374</td><td>-.06898</td><td>| . *| . |</td></tr>
<tr><td>16</td><td>0.0014663</td><td>0.04327</td><td>| . |* . |</td></tr>
<tr><td>17</td><td>0.0038316</td><td>0.11308</td><td>| . |**. |</td></tr>
<tr><td>18</td><td>-0.0029261</td><td>-.08636</td><td>| .**| . |</td></tr>
<tr><td>19</td><td>-0.0012814</td><td>-.03782</td><td>| . *| . |</td></tr>
<tr><td>20</td><td>-0.0050337</td><td>-.14855</td><td>| ***| . |</td></tr>
<tr><td>21</td><td>0.0034262</td><td>0.10112</td><td>| . |**. |</td></tr>
<tr><td>22</td><td>0.0058153</td><td>0.17162</td><td>| . |*** |</td></tr>
<tr><td>23</td><td>-0.0023615</td><td>-.06969</td><td>| . *| . |</td></tr>
<tr><td>24</td><td>0.0026653</td><td>0.07866</td><td>| . |**. |</td></tr>
</table>

Note: The vertical symbols (...) denote a 95 percent confidence interval.

Table 51. Soybeans Futures Price Volatility and Number of Index Funds Cross-correlation Function (Raw Series - 1st Difference).

```
 Lag    Covariance  Correlation  -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
 -24    0.00053749      0.05031  |                 .  |* .                 |
 -23    -0.0002368      -.02216  |                 .  |  .                 |
 -22     0.0019131      0.17907  |                 .  |****                |
 -21    -0.0011310      -.10587  |                 .**|  .                 |
 -20    -0.0005291      -.04952  |                 . *|  .                 |
 -19    0.00060617      0.05674  |                 .  |* .                 |
 -18    0.00029308      0.02743  |                 .  |* .                 |
 -17    0.00055732      0.05217  |                 .  |* .                 |
 -16     0.0023699      0.22183  |                 .  |****                |
 -15    -0.0021996      -.20590  |                ****|  .                 |
 -14    -0.0008422      -.07883  |                 .**|  .                 |
 -13    -0.0005512      -.05159  |                 . *|  .                 |
 -12    0.00021528      0.02015  |                 .  |  .                 |
 -11    -0.0002177      -.02038  |                 .  |  .                 |
 -10    -0.0000379      -.00355  |                 .  |  .                 |
  -9    0.00022943      0.02148  |                 .  |  .                 |
  -8    -0.0008511      -.07967  |                 .**|  .                 |
  -7    0.00085456      0.07999  |                 .  |**.                 |
  -6     0.0020525      0.19213  |                 .  |****                |
  -5     0.0013016      0.12184  |                 .  |**.                 |
  -4    -0.0032977      -.30869  |              ******|  .                 |
  -3    -0.0001619      -.01516  |                 .  |  .                 |
  -2    -0.0003822      -.03578  |                 . *|  .                 |
  -1    0.00002696      0.00252  |                 .  |  .                 |
   0    -0.0002081      -.01948  |                 .  |  .                 |
   1    -0.0003975      -.03721  |                 . *|  .                 |
   2    0.00009800      0.00917  |                 .  |  .                 |
   3    -0.0001238      -.01159  |                 .  |  .                 |
   4    0.00014234      0.01332  |                 .  |  .                 |
   5    -0.0001871      -.01752  |                 .  |  .                 |
   6     0.0010001      0.09362  |                 .  |**.                 |
   7    0.00011902      0.01114  |                 .  |  .                 |
   8    0.00032331      0.03026  |                 .  |* .                 |
   9    0.00013152      0.01231  |                 .  |  .                 |
  10    0.00011641      0.01090  |                 .  |  .                 |
  11    -0.0008764      -.08204  |                 .**|  .                 |
  12    -0.0000555      -.00520  |                 .  |  .                 |
  13    0.00057141      0.05349  |                 .  |* .                 |
  14    -0.0000654      -.00613  |                 .  |  .                 |
  15    0.00045871      0.04294  |                 .  |* .                 |
  16    0.00039366      0.03685  |                 .  |* .                 |
  17    -0.0007365      -.06894  |                 . *|  .                 |
  18     0.0019595      0.18343  |                 .  |****                |
  19    0.00044951      0.04208  |                 .  |* .                 |
  20    -0.0029212      -.27344  |               *****|  .                 |
  21    -7.5651E-6      -.00071  |                 .  |  .                 |
  22    0.00027352      0.02560  |                 .  |* .                 |
  23    -0.0004471      -.04185  |                 . *|  .                 |
  24    0.00080936      0.07576  |                 .  |**.                 |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval.

Table 52. Number of Index Funds and Soybeans Futures Price Volatility Cross-correlation Function (Adjusted Series - 1st Difference).

```
  Lag    Covariance    Correlation    -1 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 1
  -24    0.00080936        0.07576    |                 .  |**.                 |
  -23    -0.0004471        -.04185    |                 . *|  .                 |
  -22    0.00027352        0.02560    |                 .  |* .                 |
  -21    -7.5651E-6        -.00071    |                 .  |  .                 |
  -20    -0.0029212        -.27344    |               *****|  .                 |
  -19    0.00044951        0.04208    |                 .  |* .                 |
  -18     0.0019595        0.18343    |                 .  |****                |
  -17    -0.0007365        -.06894    |                 . *|  .                 |
  -16    0.00039366        0.03685    |                 .  |* .                 |
  -15    0.00045871        0.04294    |                 .  |* .                 |
  -14    -0.0000654        -.00613    |                 .  |  .                 |
  -13    0.00057141        0.05349    |                 .  |* .                 |
  -12    -0.0000555        -.00520    |                 .  |  .                 |
  -11    -0.0008764        -.08204    |                 .**|  .                 |
  -10    0.00011641        0.01090    |                 .  |  .                 |
   -9    0.00013152        0.01231    |                 .  |  .                 |
   -8    0.00032331        0.03026    |                 .  |* .                 |
   -7    0.00011902        0.01114    |                 .  |  .                 |
   -6     0.0010001        0.09362    |                 .  |**.                 |
   -5    -0.0001871        -.01752    |                 .  |  .                 |
   -4    0.00014234        0.01332    |                 .  |  .                 |
   -3    -0.0001238        -.01159    |                 .  |  .                 |
   -2    0.00009800        0.00917    |                 .  |  .                 |
   -1    -0.0003975        -.03721    |                 . *|  .                 |
    0    -0.0002081        -.01948    |                 .  |  .                 |
    1    0.00002696        0.00252    |                 .  |  .                 |
    2    -0.0003822        -.03578    |                 . *|  .                 |
    3    -0.0001619        -.01516    |                 .  |  .                 |
    4    -0.0032977        -.30869    |              ******|  .                 |
    5     0.0013016        0.12184    |                 .  |**.                 |
    6     0.0020525        0.19213    |                 .  |****                |
    7    0.00085456        0.07999    |                 .  |**.                 |
    8    -0.0008511        -.07967    |                 .**|  .                 |
    9    0.00022943        0.02148    |                 .  |  .                 |
   10    -0.0000379        -.00355    |                 .  |  .                 |
   11    -0.0002177        -.02038    |                 .  |  .                 |
   12    0.00021528        0.02015    |                 .  |  .                 |
   13    -0.0005512        -.05159    |                 . *|  .                 |
   14    -0.0008422        -.07883    |                 .**|  .                 |
   15    -0.0021996        -.20590    |                ****|  .                 |
   16     0.0023699        0.22183    |                 .  |****                |
   17    0.00055732        0.05217    |                 .  |* .                 |
   18    0.00029308        0.02743    |                 .  |* .                 |
   19    0.00060617        0.05674    |                 .  |* .                 |
   20    -0.0005291        -.04952    |                 . *|  .                 |
   21    -0.0011310        -.10587    |                 .**|  .                 |
   22     0.0019131        0.17907    |                 .  |****                |
   23    -0.0002368        -.02216    |                 .  |  .                 |
   24    0.00053749        0.05031    |                 .  |* .                 |
```

Note: The vertical symbols (...) denote a 95 percent confidence interval.

VITA

Diego J. Gavilanez Hernandez was born in Riobamba, Ecuador. He graduated from high school in 2001 at the Colegio Salesianos Santo Tomas Apostol Riobamba (STAR). Then, he enrolled in the Panamericam School of Agriculture "El Zamorano" in 2002, from where he obtained a Bachelor of Science in Agribusiness Management in 2005. From 2007 to 2009, he acquired valuable experience in the agribusiness industry, particularly of grains and fertilizers, while working in Sao Paulo, Brazil, and Buenos Aires, Argentina, at a prestigious multinational company. In 2010, he came to Baton Rouge, Louisiana, to enroll in a master program at Louisiana State University (LSU). After a successful career as Graduated Research Assistant, he obtained a Master of Science in agricultural economics with concentration in agribusiness in 2012. He is fluent in Portuguese, Spanish and English. Some of his skills are oriented to develop and manage relationships with suppliers and customers of agricultural commodities, as well as to offer support in a form of managerial strategies to producers, merchandisers, and processors of agricultural commodities. Now, he will go back to the private industry of grains and fertilizers, where he expects to develop his professional career.