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IS THERE A CAUSAL RELATIONSHIP BETWEEN GRAINS FUTURES AND AGRICULTURAL EQUITIES?

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ABSTRACT

This study focuses on the causal relationship between grains futures and agricultural companies quotations over the period of January of 1971 to December of 2015. The grains futures index has been created with corn, wheat and soybean future contracts using world-production weighted methodology of daily prices. The daily equity prices of the dominant agricultural companies that are directly or indirectly related to the grains sector with each representing varied focus areas, like oil seeds processing, fertilizers, biotechnology products and packaged foods, have been used for the analysis. To check the relationship between grains futures index and agricultural companies, Toda and Yamamoto (1995) procedure has been applied. The empirical analysis has shown that some agricultural equities showed no or only partial interaction with the grains futures index, while others showed strong interaction with such index. The agricultural companies that are highly focused on the grains, food processing, fertilizers and packaged foods without diversifying themselves to distinct sectors like financial or insurance services showed stronger causality with the grains futures index. The results suggest that individual investors can get diversification benefits of investing in the grains sector-related agricultural companies by grouping them with identification of their like-wise major services and products in narrow based approach and not

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grouping the complete agricultural sector from a broader perspective using standard industrial classification (SIC) codes.

Keywords: grains futures, agricultural equities, futures prices, stock prices, world-production weighted index, causal relationship, Toda and Yamamoto procedure, grains futures index

JEL Classification: C43, G13, G15

1. INTRODUCTION

Historically, commodity trading started with the agricultural futures. Farmers initially used these contracts to hedge any losses that could occur during the crop yields. As per UNCTAD (2009), there was an increased interest to invest in the agricultural sector of lower and middle-income countries. This trend reflects underlying structural factors which include the growth of population, increase in the rate of urbanization (this refers to the increase in the global population share that depends on food purchases) and the change of dietary habits (such as the increased consumption of meat and fast food in industrial countries). All of these factors are increasing the global demand for food (Godfray et al. 2010). On the other hand, there is an apparent supply constraint in different parts of the world that includes decreased production and productivity (for example in Gulf), which is severely contributing to the upward pressure on food prices in the long term. The global demand for energy and agricultural commodities along with increased technological capacity for higher yields and returns also suggests that agriculture is the best investment option in the long run. Investments in grain sectors also benefit also from policy changes. Several food importing nations promote agricultural investments in foreign countries as part of their national food security strategy. Economic liberalization which includes lifting foreign investment restrictions is also helping to enter these markets. A key driving force is also the policy incentives to investing in biofuels.

In the past, institutional asset managers and private investors assigned a smaller role to the commodities in their investment decisions. The estimation report provided by the Goldman Sachs (2006) shows that in 2005 fund managers allocated only 2 to 4 percent of their portfolio weight to the commodities segment. This has been changing in the recent years as the commodities possess financially important characteristics. Many investors consider passive investments in indexes as the most suitable. As reported by the Reuters (2014), global commodities assets under management rose to $325 billion in June 2014. According to the report of G20 study group on commodities (2011), "[*c*]*ommodity-related investments have risen since the mid-2000s. Since 2005, there is a significant increase in the estimated market value of the commodity-based assets under management. They reached more than 410 billion USD in the first quarter of 2011 when we compared it to the 270 billion USD in mid-2008. The commodity-related investments attracted more inflows since 2009 at the* *rate of about 15 billion USD per quarter*". According to the Acworth (2013), the Global Futures and Options Volume Rose 2.1% to 21.64 Billion in 2013.

Tang and Xiong (2012) observed a growing interest of investors in commodities over the last few years. The benefits of having commodities as an asset class in the portfolio are empirically evident. With time, commodities showed a positive correlation with the inflation rate and low or negative correlation with stocks and bonds. These characteristics show that overall portfolio risk can be reduced by including the commodities in the traditional portfolio of stocks and bonds. In other words, an inclusion of commodities improves the risk-adjusted performance of the complete portfolio. Furthermore, over the past 45 years, the risk premium of a diversified commodity futures portfolio has been similar to the Standard & Poor's 500. However, the sources of these returns should be analyzed carefully.

Food grains represent the major portion of the agricultural sector. Investing in grains sector comprises using individual futures contracts of mainly corn, soybean, wheat, rice, barley and oats. An alternative way of investing is to use the equities of companies that focus on grains sector directly or indirectly, which may also include fertilizer, equipment, seeds & genetics, crop protection or food processor companies. The third way of investing is through Exchange Traded Funds (ETFs) that focus on the grain sector, like Corn Fund (CORN), DJ-UBS Grains Total Return Sub-Index ETN (JJG) and MLCX Grains Index TR ETN (GRU).

Drawing from earlier studies (see literature review), our paper focuses on the empirical investigation of the causation between equity prices of the major grains-based commodity companies and the grains futures index. The world-production weighted index of commodity futures composed of corn, wheat and soybean future contracts is created, based on the spot-month continuous contract calculated from Chicago Board of Trade (CBOT) over the period between January 1971 and December 2015. The source of data is a database maintained by the Quandl[1]. The daily equity prices of agricultural companies that are directly or indirectly related to the grains sector with multiple products and services like oil seeds processing, fertilizers, biotechnology products and packaged foods are taken for the analysis. The start date for the agricultural equities is the initial available date of the company's incorporation into the stock market and the end date is December 2015. S&P 500 index with daily values from January 1971 till December 2015 is taken to represent the overall business climate in the regression analysis. Time series data based on daily prices are analyzed. The unique and more advanced technique called Toda and Yamamoto (1995) procedure is used for this analysis. Most of the previous research has been done from broader perspective by analyzing the agricultural sector as a whole based on the standard information classification (SIC) codes. There is no significant research done by analyzing the causality between grains futures index and agricultural equities. So we have clearly targeted more accurate data by narrowing our research to the grains sector and their related agricultural equities.

[1] www.quandl.com/.

The remaining part of the paper is organized as follows. The next section presents and evaluates the existing evidence in the literature. Section 3 shows the selection of agricultural equities and grains futures for the analysis, along with the creation of Grains futures index. Section 3 further looks at the approach to derive potential relationship along with its impact on the above-said relationships using Toda and Yamamoto procedure. Finally, section 4 infers results and is followed by conclusion in section 5.

2. LITERATURE REVIEW

Gorton and Rouwenhorst (2006) analyzed the correlation between stocks of companies that produce commodities and commodities futures from broader perspective using four-digit SIC codes for matching the companies and found that commodity companies' equities behaved similarly to other stocks rather than their equivalents in the commodity futures market. Creti, Joëts, and Mignon (2013) examined the correlation between 25 individual commodities and S&P 500 index. They found high volatility and correlations during the 2007–2008 financial crises. This finding shows the link between commodity and stock markets along with the financialization of the commodity markets. Commodity futures may produce investment benefits when treated as an addition to the diversified portfolio. But commodity futures can also underperform their equities counterparts in absolute terms and on a risk-adjusted basis determined by the Sharpe Ratio. Erb and Harvey (2006) found that average commodity futures contract did not have equity-like return. Gorton and Rouwenhorst (2006) paper "Facts and Fantasies about Commodity Futures" was re-examined by Bharadwaj, Goton and Rouwenhorst (2015), who corroborated main results from the original study. Chong and Miffre (2010) also analyzed the conditional return correlations between the traditional asset classes like stocks and bonds with various commodity futures. They found that in times of increased volatility of interest rates the correlation between returns on treasury bonds and futures was negative. Gao and Liu (2014) found that commodity futures' volatility differed from that of U.S. stocks. They also found that correlations between U.S stock returns and commodity returns were much lower than the correlation between U.S stock and world stock returns. Mensi, Beljid, Boubaker and Managi (2013) showed that there was a significant transmission of volatility and correlations between the equity and commodity markets.

Nevertheless, Heidorn and Demodova-Menzel (2007) proved commodities might produce investment benefits when considered as an addition to a diversified portfolio. The decision to add an investment product to an existing portfolio depends on the means and the variances of the existing portfolio and the investment vehicle, as well as the correlation between the portfolio and the investment vehicle. Egelkraut, Woodard, Garcia and Pennings (2005) concluded that adding a small proportion of commodities to the portfolio results in improved performance, i.e. increasing returns and a decreasing standard deviation. When constructing a commodity futures portfolio, an investor can potentially rely on the lack of correlation between many markets to reduce portfolio volatility. But if the investor is relying on diversification, then he must be careful on commodity correlation properties. Correlations amongst commodity markets can vary seasonally. At times, this leads to a temporary high correlation between the unrelated markets. This situation becomes problematic for portfolio diversification because two commodities that become unexpectedly correlated can increase (and even double) the risk.

Jansen (2009) tested the relationship between oil equities and oil futures with high-frequency data. He confirmed the connection between oil futures and oil equities but the volatility did not have a common root due to the varied types and motivations of traders. Zapata, Detre and Hanabuchi (2012) analyzed the historical performance of commodity and stock markets, and found negative correlation between stock and commodity markets. They also found that investors preferred to invest in agricultural commodity indexes and agribusinesses. Schnitkey and Kramer (2011) analyzed the performance of publicly traded agricultural firms and concluded that agricultural index had exceeded the S&P 500 index over the period of 2007–2011. Bannister and Forward (2002) mentioned that there was an increasing trend in the upcoming decade for the commodities market, and this result was based on descriptive analysis of the relationship between stock and commodity prices.

Malliaris and Urrutia (1996) used the error correction model (ECM) of Engle and Granger (1987) to show the existence of long term relationships between corn, wheat, oats, soybean, soybean meal and soybean oil. All of the above studies are done by finding the correlation between stocks and commodity futures from a broader perspective, ordinary Granger Causality between grains futures or finding the benefits of adding commodities to the traditional portfolios. But none of these studies have focused on analyzing the causation between grains futures and agricultural equities with a narrowed approach, especially using a more advanced technique like Toda and Yamamoto (1995) procedure. Our study aims to fill this gap by examining whether agricultural equities that are directly or indirectly related to the grains sector have a causal relationship to the grains futures and thus can provide significant investment opportunities to the individual investor.

3. METHODOLOGY

3.1. SELECTION OF AGRICULTURAL EQUITIES AND GRAINS FUTURES

We have considered the dominant global traders of grains and fertilizers producing companies (c.f. Annex Table 1) such as Archer Daniels Midland (ADM), Bunge, Mosaic, Monsanto, Agrium, Potash Corporation, ConAgra and CF industries stocks. According to Murphy, David and Jennifer (2012), ADM, Bunge, Cargill and Dreyfus companies control 73 percent of the total grain trade in the

Table 1. Top 20 Agricultural Futures & Options Contracts

Rank	Contract	Contract Size	Jan–Dec 2012	Jan–Dec 2013	% Change	Country
1	SoyMeal Futures, DCE	10 tonnes	325,876,653	265,357,592	–18.6	China
2	RapeseedMeal Futures, ZCE *	10 tonnes	421,207	160,100,378	N/A	China
3	SoyOil Futures, DCE	10 tonnes	68,858,554	96,334,673	39.9	China
4	Palm Oil Futures, DCE	10 tonnes	43,310,013	82,495,230	90.5	China
5	Rubber Futures, SHFE	5 tonnes	75,176,266	72,438,058	–3.6	China
6	White Sugar Futures, ZCE	10 tonnes	148,290,190	69,794,046	–52.9	China
7	Corn Futures, CBOT	5,000 bushels	73,184,337	64,322,600	–12.1	USA
8	Soybean Futures, CBOT	5,000 bushels	52,041,615	46,721,081	–10.2	USA
9	Sugar #11 Futures, ICE Futures U.S.	112,000 pounds	27,126,728	29,813,680	9.9	USA
10	Wheat Futures, CBOT	5,000 bushels	27,379,403	24,993,158	–8.7	USA
11	SoybeanOil Futures, CBOT	60,000 pounds	27,627,590	23,805,912	–13.8	USA
12	Corn Options, CBOT	5,000 bushels	26,599,756	23,534,308	–11.5	USA
13	SoybeanMeal Futures, CBOT	100 shorttons	18,187,433	20,237,181	11.3	USA
14	Soybean Options, CBOT	5,000 bushels	18,402,208	14,760,704	–19.8	USA
15	Corn Futures, DCE	5,000 bushels	37,824,356	13,313,633	–64.8	China
16	Live Cattle Futures, CME	40,000 pounds	13,985,374	12,463,043	–10.9	USA
17	RapeseedOil Futures, ZCE*	5 tonnes	2,021	11,853,858	N/A	China
18	Lean Hog Futures, CME	40,000 pounds	11,461,892	11,277,038	–1.6	USA
19	No. 1 Soybean Futures, DCE	10 tonnes	45,475,425	10,993,500	–75.8	China
20	Crude Palm Oil (FCPO) Futures, MDEX	25 tonnes	7,443,143	7,966,096	7.0	Malaysia

* Began trading in December 2012.
Source: FIA Volume Report 2013.

world. Of these four companies only ADM and Bunge are publicly traded, so we have chosen them for our analysis. We are also analyzing Agrium, Potash Corporation, CF Industries and Mosaic which represent fertilizers, whereas Monsanto represent seeds and crop protection using biotechnology. ConAgra represents the commercial foods industry. In general, commodity companies can have a product range of grains to precious metals; we have selected the closest matches possible to represent the grains sector.

Agricultural based commodities futures market consists of different types of products. In this paper, the main focus is on the investments in the grains segment, which include corn, soybeans and wheat.

Table 1 shows that majority of the grains futures are either traded on the Chicago Board of Trade (CBOT) or Dalian Commodity Exchange (DCE). The CBOT is the world's oldest futures and options exchange established in 1848. The agricultural products in Grains and Oilseeds section are traded as follows: corn, mini-sized corn, Chicago Soft Red Winter (SRW) Wheat, Chicago Soft Red Winter (SRW) mini-sized wheat, KC Hard Red Winter (HRW) wheat, soybeans, mini-sized soybean, soybean meal, soybean oil, oats, rough rice, black sea wheat and crude palm oil. The DCE is a futures exchange based in China, and it was established in 1993. The agricultural products traded are soybean, soybean oil, corn, palm oil, soybean meal. We have selected CBOT Futures Exchange for the data collection, as it has the futures contracts dating back to many years in the past compared to the DCE Futures Exchange.

Table 2. Average daily volume of Grains Futures during November 2015

Exchange	CBOT(ADV)	($ Millions)
Corn	437,393	8,133
Soybean	166,343	7,306
Wheat	157,539	3,739
KC HRW Wheat	45,506	1,076
SoybeanMeal	107,198	3,058
SoybeanOil	133,369	2,354
Oats	1,249	15
Rough Rice	955	23

Sources: CBOT and ICE.

Table 2 shows that corn, wheat and soybean are the primary drivers of the grains futures market, which also include soybean meal, soybean oil, KC HRW wheat, oats and rough rice. We have chosen only corn, wheat and soybean to avoid any possible incorrect weighting or duplication of grains futures. Oats and rough rice future contracts traded on the CBOT exchange are very low, so we excluded them from our selection. We also excluded KC HRW wheat, soybean meal or soybean oil to avoid any possible incorrect weighting or duplication effects. Moreover, the effect of substitutability is visible between soybean, soybean meal and soybean oil, as the increase in soybean oil prices leads to increased crushing activity of soybean to produce more oil.

3.2. GRAINS FUTURES INDEX

Financial indexes are constructed in three different ways: price-weighted index, capitalization-weighted index and equal-weighted index. Price-weighted index assigns a weight proportional to the each individual stock. Stocks with higher price will have a greater influence on the overall index value by ignoring the relative size of the company.

$$I_P = \frac{\sum P_i}{n} \tag{1}$$

where: I_p – price-weighted index value, P_i – stock prices, n – number of stocks after splits.

Capitalization-weighted index assigns a weight proportional to the market capitalization of each individual stock. This index ends up tilting the control towards the few big companies.

$$I_v = \frac{\sum P_t \cdot n}{\sum P_b \cdot n} \cdot I_b \tag{2}$$

where: I_v – value-weighted index value, P_t – stock prices today, P_b – stock prices in base year, n – number of stocks, I_b – index value in base year.

Equally-weighted index simply assigns an equal weight to all constituent stocks. Arithmetic averages or geometric averages can be used to calculate the index value.

Gorton and Rouwenhorst (2006) constructed equally-weighted index of commodity futures monthly returns over the period between July of 1959 and December of 2004. They studied simple properties of commodity futures as an asset class. Greer (2000) studied the available commercial indexes like Chase Physical Commodity Index between 1970 and 1999 and found that returns of commodity index are positively correlated with the rate of inflation and negatively correlated with stocks and bonds. Fama and French (1987) observed average monthly excess returns for 21 commodities by creating an equally-weighted portfolio. Bodie and Rosansky (1980) constructed an equally-weighted index using quarterly data between 1950 and 1976 to analyze the returns on commodity futures with returns on common stocks.

S&P GSCI index acts as a benchmark for the investments in the commodity markets. This index uses world-production weighted methodology. DJAIG index uses a mixture of liquid factors like open interest in futures contracts and production weighting as a methodology. After analyzing price-weighted, capitalization-weighted, equally-weighted and production-weighted methodologies that are used for the creation of financial indexes, we have assumed that world-production weighted index suits our needs well. Production weighting is considered to be a more realistic approach to weighing commodities. It clearly reflects the amount we use and its prominence to the economy.

There is no commercial index readily available with wide time range and representing only high valued grains futures. So we have created our own grains futures index with corn, wheat and soybean using world-production weighted methodology. Our grains futures index is calculated as follows:

$$I_w = \frac{\left(C_f \cdot C_w\right) + \left(W_f \cdot W_w\right) + \left(S_f \cdot S_w\right)}{\left(C_w + W_w + S_w\right)} \cdot 100 \tag{3}$$

where: I_w – world-production weighted index value, C_f, W_f, S_f – corn, wheat and soybean futures contract today price, C_w, W_w, S_w – corn, wheat and soybean previous year's world production weight value.

Our index might possess a selection bias. First, our index is composed of only three commodities – corn, wheat and soybean in the grains sector. Second, to avoid double counting, we have selected futures contracts from a single exchange. In reality, commodity might be traded on multiple exchanges. Finally, every commodity has multiple contracts listed according to their corresponding maturity date. For each month, we take the price of each commodity future using the spot-month contract that has the shortest time to expiry. The price difference between two successive contracts is smoothed by using a weighted-average process. The continuous contract gradually changes from 100% front and 0% back weighting, to 0% front and 100% back weighting in duration of 5 days. This price adjustment represents a automatic roll strategy wherein the trader rolls 20% of the position each day for the next 4 days before the roll date.

The grains based agricultural commodity index was computed by taking January 1971 as the base point and its value as 100. The adjustments were made accordingly to the entire index.

3.3. RETURNS CALCULATION

The returns of the stock prices or grains futures index values are calculated as given in equation (4) and (5):

$$AR_t = \frac{A_t}{A_{t-1}} \tag{4}$$

$$GR_t = \frac{G_t}{G_{t-1}} \tag{5}$$

where: AR – agricultural equities return, GR – grains futures index return, A_t – natural logarithm of closing price of equities, G_t – natural logarithm grains futures index, t – time subscript.

3.4. TODA AND YAMAMOTO PROCEDURE

This section of the paper deals with the econometric technique applied to analyze the causal relationship between the grains futures index and of the individual agricultural equities prices. Generally the technique proposed by Granger (1969), known as Granger causality is used to study the cause and effect relationship between the time series variables. This test uses the following Vector Autoregression (VAR) model.

$$G_i = \alpha_0 + \sum_{i=1}^{n} \alpha_i A_{t-i} + \sum_{j=1}^{n} \beta_j G_{t-j} + \sum_{k=1}^{n} \theta_k S_{t-k} + \mu_{1t}, \tag{6}$$

$$A_i = \delta_0 + \sum_{i=1}^{n} \delta_i G_{t-i} + \sum_{j=1}^{n} \gamma_j A_{t-j} + \sum_{k=1}^{n} \lambda_k S_{t-k} + \mu_{2t}, \tag{7}$$

In Equation (6) and (7), G_t is the log normal daily grains futures index price series, A_t is the log normal daily agricultural equity closing price and S_{t-k} is the lagged log normal daily SP500 index closing price. α_i, β_j, δ_i, γ_j, θ_k, λ_k are the coefficients of the given variables, and μ_{1t}, μ_{2t} are the error terms. Causality from equity closing prices to the grains futures index or grains futures index to the equity closing prices is determined if the estimated coefficient of the lagged variables G_i, A_i are found statistically different from zero.

As mentioned by Gujarati (1995), a causality test is highly dependent on model specification and the number of lags. As we are doing a two-variable Granger Causality test, there might be a third relevant variable which might produce different result as it is not currently included in the model. This leads to specification bias. Gujarati (1995) also mentioned that integration of variables leads to invalid F-test procedure, as the test statistic does not follow standard distribution. In this case t-statistic is still valid to test the significance of individual coefficients, but using F-statistic to jointly test the Granger causality is not possible. The above outlined pitfalls let the present study to use the substitute model for the estimation of an unrestricted VAR known as Toda and Yamamoto (1995) procedure, as it ensures the asymptotic distribution of the Wald statistic.

Toda and Yamamoto procedure is performed as follows:

Step 1: Identify the maximal order of integration ($\rho_{\max}$) for the variables used in the model using Augmented Dickey Fuller (ADF) test or Phillips-Perron (PP) tests. If the test result found that one variable has *I(N)* and the other variable has *I(N–1)* as order of integration, then $\rho_{\max} = N$.

Step 2: Automatically determine the appropriate maximum lag length for the variables of the VAR using usual information criterions like AIC and FPE Criterion. Choosing the appropriate lag length needs to remove serial correlation. Check the selected lag length using Lagrange Multiplier (LM) test on the residuals for serial independence. Increase or decrease the lag length chosen by AIC and FPE criterions till the serial correlation issues are resolved and by cross checking using LM test on residuals. After the selection of preferred VAR model with optimal lag (k) and the maximal order of integration selected in the step 1, i.e. (ρ_{max}) is further added to each of the VAR equations. The final bivariate VAR ($k + \rho_{max}$) model is shown below

$$G_i = \varnothing + \sum_{i=1}^{k} \alpha_i G_{t-i} + \sum_{i=k+1}^{k+\rho_{\max}} \alpha_i G_{t-i} + \sum_{i=1}^{k} \beta_i A_{t-i} + \sum_{i=k+1}^{k+\rho_{\max}} \beta_i A_{t-i} + \\ + \sum_{i=1}^{k} \theta_i S_{t-i} + \sum_{i=k+1}^{k+\rho_{\max}} \theta_i S_{t-i} + \mu_{1t} \qquad (8)$$

$$A_i = \varnothing + \sum_{i=1}^{k} \delta_i A_{t-i} + \sum_{i=k+1}^{k+\rho_{\max}} \delta_i A_{t-i} + \sum_{i=1}^{k} \gamma_i G_{t-i} + \sum_{i=k+1}^{k+\rho_{\max}} \gamma_i G_{t-i} + \\ + \sum_{i=1}^{k} \lambda_i S_{t-i} + \sum_{i=k+1}^{k+\rho_{\max}} \lambda_i S_{t-i} + \mu_{2t} \qquad (9)$$

Where: G_i is the log normal daily grains futures index price, A_i is the log normal daily agricultural equity closing price and S_{t-i} is the lagged log normal daily SP500 index closing price, α_i, β_j, δ_i, γ_j, θ_i, λ_i are the model parameters and μ_{1t}, μ_{2t} are residuals of the model, ρ_{max} is the maximum order of integration.

Step 3: The null hypothesis (H_0) for the VAR model is formulated as follows

For equation (8), we set:

H_0: $\beta_i = \theta_i = 0, \forall\, i = 1, 2, 3,\dots k$, or agricultural equities do not cause grains futures

H_1: $\beta_i \neq \theta_i \neq 0, \forall\, i = 1, 2, 3,\dots k$, or agricultural equities cause grains futures

For equation (9), we set:

H_0: $\gamma_i = \lambda_i = 0, \forall\, i = 1, 2, 3,\dots k$, or grains futures do not cause agricultural equities

H_1: $\gamma_i \neq \lambda_i \neq 0, \forall\, i = 1, 2, 3,\dots k$, or grains futures cause agricultural equities

Step 4: Modified Wald test (MWALD) is used to test the null hypothesis.

4. EMPIRICAL RESULTS

4.1. DESCRIPTIVE STATISTICS

Basic characteristics of the data are outlined in Table 3. All of the analyzed companies and their corresponding time period grains futures index returns have clearly shown positive returns with reasonable variation. Around 87.5 percent of the companies' returns are skewed towards left, whereas the remaining companies' returns and 87.5 percent of the index returns (corresponding to the companies' time period) are skewed towards right. This shows that the returns series are asymmetric and abnormal. The p-values of Jarque-Bera test show that every series in the data set features non-normal distribution due to the rejection of null hypothesis of normal distribution. The shape of the frequency distribution of the return series is leptokurtic as the kurtosis values are above 3.

Table 3. Descriptive Statistics of the Agricultural Companies Returns

Company		Mean	Std. Dev	Skewness	Kurtosis	Jarque-Bera	Probability
ADM	ADM Return	0.000172	0.008563	–0.285917	11.84699	26974.88	0.000000
	GrainsFutures Index Return	1.43E–05	0.005826	0.015059	5.757701	2610.382	0.000000
Bunge	Bunge Return	0.000199	0.009600	–0.746992	14.35104	19716.33	0.000000
	GrainsFutures Index Return	6.75E–05	0.006902	0.004540	4.987613	594.2494	0.000000
Mosaic	Mosaic Return	7.88E–05	0.011631	–1.446021	30.52158	224028.8	0.000000
	GrainsFutures Index Return	2.82E–05	0.006038	0.013067	5.615616	2001.608	0.000000
Monsanto	Monsanto Return	0.000279	0.009582	–0.163598	10.40912	8727.012	0.000000
	GrainsFutures Index Return	6.92E–05	0.006819	0.010325	5.025502	651.0228	0.000000
Agrium	Agrium Return	0.000203	0.010394	–0.494967	12.80581	20984.96	0.000000
	GrainsFutures Index Return	3.08E–05	0.006472	0.015881	5.136722	986.5736	0.000000
PotashCorporation	Potash Return	0.000250	0.009584	–0.617925	18.57756	66378.38	0.000000
	GrainsFutures Index Return	2.08E–05	0.006073	0.014810	5.508865	1711.267	0.000000
ConAgra	ConAgra Returns	0.000221	0.007320	0.965181	59.24086	1039093	0.000000
	GrainsFutures Index Return	1.67E–05	0.005875	0.008106	5.760202	2499.977	0.000000
CF Industries	CF Return	0.000445	0.013401	–1.285481	20.78077	34966.28	0.000000
	GrainsFutures Index Return	6.61E–05	0.007286	–0.056759	4.868176	379.4884	0.000000

Source: Author's calculation.

4.2. UNIT ROOT TEST

Our study deals with the time series data of grains futures index, agricultural equities prices and SP500 index values. Non-stationarity property is mostly observed in the time series data, which makes the application of many statistical models and the hypothesis test results incorrect. The time series analysis starts with checking the stationarity of the variables used to construct the VAR model. In this paper Augmented Dickey-Fuller (ADF) test is used to check the existence of unit root. ADF test helps to check the stability in the data set and also determines the maximum order of integration ($\rho_{\max}$) to be added in the Vector Autoregressive (VAR) model for Toda and Yamamoto test. Absence of stationarity will leads to spurious results. The results of the ADF test are shown in Table 4. It is clear that the closing prices of both grains futures index and agricultural equities are integrated at order one. Therefore, for all of the companies analyzed, VAR model will add only one extra lag ($\rho_{\max}$) to perform the causality test.

Table 4. Results of the Unit Root Test

Company Stock/Market Index (Log Daily)		Stock/Index priceshas a unitroot			($\rho_{\max}$)
		With Intercept (P-Values)	With Trend and Intercept (P-Values)	None (P-Values)	
GrainsFutures Index	I[0]	0.1170	0.2332	0.8460	1
	I[1]	0.0001	0.0001	0.0001	
SP500 Index	I[0]	0.5356	0.6411	0.9978	1
	I[1]	0.0001	0.0000	0.0001	
ADM	I[0]	0.5434	0.1910	0.9523	1
	I[1]	0.0001	0.0000	0.0001	
Bunge	I[0]	0.0980	0.3284	0.9028	1
	I[1]	0.0001	0.0000	0.0001	
Mosaic	I[0]	0.2680	0.5357	0.7244	1
	I[1]	0.0001	0.0001	0.0001	
Monsanto	I[0]	0.5563	0.8297	0.9606	1
	I[1]	0.0001	0.0000	0.0001	
Agrium	I[0]	0.8459	0.3282	0.9328	1
	I[1]	0.0001	0.0000	0.0001	
Potash	I[0]	0.4869	0.9252	0.8077	1
	I[1]	0.0001	0.0001	0.0001	
ConAgra	I[0]	0.0560	0.0090	0.9720	1
	I[1]	0.0001	0.0000	0.0001	
CF Industries	I[0]	0.3769	0.6871	0.9251	1
	I[1]	0.0001	0.0000	0.0001	

Source: Author's calculation.

4.3. TODA AND YAMAMOTO GRANGER CAUSALITY RESULTS

As described earlier in the methodology section, appropriate maximum lagged length (k) for the variables is chosen using AIC and FPE criterion. It is not possible to find the best fitted model with our daily data set with just these information criterions. Lagrange multiplier (LM) test is used to remove any possible error by testing the null hypothesis "no residual serial correlation". Depending on the results of the LM test, pre-selected lag length based on AIC and FPE criterion is changed to create the best fitted VAR model for the Toda and Yamamoto procedure.

Table 5 shows the results of Wald statistics along with their appropriate lag lengths. ADM Company showed no causality between their equities and grains futures index. As outlined in the Annex Figure 1, ADM is a global company with diversified business interests that include investor services and insurance services. ADM has also become a major investor in the corn-based ethanol production, which leads to the new interlinks between agricultural and non-agricultural markets. All these diversified activities of the ADM enmesh into a complex scenario where the company's equities exposure to the grains prices cannot be identified anymore. Bunge and ConAgra showed unilateral causality from grains futures index price to the stock price of the company. This result can be supported by the fact that both of these companies diversified their business interests within the agricultural sector ranging from grains trading, food processing, fertilizers and sale of packaged foods. Mosaic, Potash Corporation and CF industries show the bilateral causality between companies equities and grains futures index. These results are in line with our initial assumptions, as they are purely based on fertilizers. Agrium also showed bidirectional causality between company equities

Table 5. Wald Statistics (Toda and Yamamoto Granger Causality Test)

Company (Log Daily)	Lags	Stock Prices do not cause Grains Futures Index Price		Grains Futures Index price does not cause Stock Price	
		Wald Statistics	P-Value	Wald Statistics	P-Value
ADM	6	14.31000	0.2814	17.98596	0.1161
Bunge	7	20.92108	0.1037	53.65239	0.0000
Mosaic	11	53.95419	0.0002	85.17287	0.0000
Monsanto	7	26.18288	0.0245	16.95673	0.2585
Agrium	6	24.80848	0.0158	47.19904	0.0000
Potash	7	27.47428	0.0167	60.08609	0.0000
ConAgra	6	17.70538	0.1249	19.31246	0.0813
CF Industries	3	27.39704	0.0001	11.84938	0.0654

Source: Author's Calculation.

and grains futures index as the company has strong focus on fertilizers, apart from being agricultural products retail supplier. Monsanto, whose business includes herbicides and biotechnology products, showed unilateral causality from equities to the grains futures index.

In previous research, Gorton and Rouwenhorst (2006) found that commodities companies' share price changes displayed higher correlations with their stock counterparts than with underlying commodity prices. Schneeweis and Spurgin (1997) found that indirect commodity investment in energy companies did not provide direct exposure to commodity price changes. Most of the research discussed earlier has been done from broader perspective by analyzing the commodities sector as a whole. There is no significant research done by analyzing the causality between grains futures index and agricultural equities. So we have produced more accurate results by narrowing our research to the grains sector and their related agricultural equities. The results we have obtained are consistent with initial assumption that the more company has diversified, the harder it is to directly reflect the changes of the commodity prices in the stock price.

5. CONCLUSIONS

This paper focused on studying causal relationship between grains futures and agricultural companies. The empirical analysis using grains futures index based on world-production weighted methodology and Toda and Yamamoto (1995) procedure shows varied levels of interaction (either unilateral/bilateral) between agricultural equities and the grains futures index. Some companies show independent movement or partial causality between their equities and the grains futures index, and others showed complete causality.

Individual investors can get diversification benefits of investing in the grains sector related agricultural companies by grouping them by their major products and services and not treating the complete agricultural sector from broader perspective using standard industrial classification (SIC) codes. However, individual investors should perform careful analyses identifying the product diversification of the corresponding companies.

Our study has brought new evidence, suggesting the legitimacy of carrying out further narrow analyses on other agricultural sub-sectors like Livestock, Dairy, Lumber and Softs with their related companies' equities.

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CZY ISTNIEJE ZWIĄZEK PRZYCZYNOWY MIĘDZY KONTRAKTAMI TERMINOWYMI NA ZBOŻA A AKCJAMI AGROROLNICZYMI (FIRM AGROROLNICZYCH)?

STRESZCZENIE

W artykule skupiono uwagę na związku przyczynowym między kontraktami terminowymi na zboża a notowaniami przedsiębiorstw agrorolniczych w okresie od stycznia 1971 r. do grudnia 2015 roku. Korzystając z metodologii dziennych cen ważonej produkcji światowej, opracowano indeks kontraktów terminowych na zboża obejmujący kontrakty terminowe na kukurydzę, pszenicę i soję. Do analizy wykorzystano dzienne ceny akcji dominujących przedsiębiorstw agrorolniczych, które są bezpośrednio lub pośrednio związane z sektorem zbóż, przy czym każde reprezentowało różne (inne) główne obszary, jak np. przetwórstwo nasion oleistych, nawozy, produkty biotechnologiczne i pakowaną żywność. W celu zbadania związku między indeksem kontraktów na zboża oraz przedsiębiorstwami agrorolniczymi zastosowano procedurę Toda i Yamamoto (1995). Analiza empiryczna pokazała, że niektóre akcje agrorolnicze nie wykazały żadnych powiązań lub tylko częściowe powiązania z indeksem kontraktów terminowych na zboża, podczas gdy inne wykazały silne powiązania z tym indeksem. Przedsiębiorstwa agrorolnicze, które są w wysokim stopniu skupione na zbożach, produkcji żywności, nawozach i pakowanej żywności bez dywersyfikacji do innych sektorów, jak usługi finansowe lub ubezpieczeniowe, wykazywały silniejszą zależność od indeksu kontraktów terminowych na zboża. Wyniki sugerują, że indywidualni inwestorzy mogą uzyskać korzyści z dywersyfikacji inwestowania w przedsiębiorstwa agrorolnicze związane z sektorem zbóż poprzez grupowanie ich na podstawie identyfikacji podobieństwa ich głównych usług i produktów w krótkim okresie (in *narrow based approach*) a nie grupowania całego sektora agrorolniczego z szerszej perspektywy na podstawie kodów standardowej klasyfikacji przemysłowej (SIC).

Słowa kluczowe: Kontrakty terminowe na zboża, akcje agrorolnicze, ceny kontraktów terminowych, ceny akcji, produkcja światowa, indeks ważony, związek przyczynowy, procedura Toda i Yamamoto, indeks kontraktów terminowych na zboża.

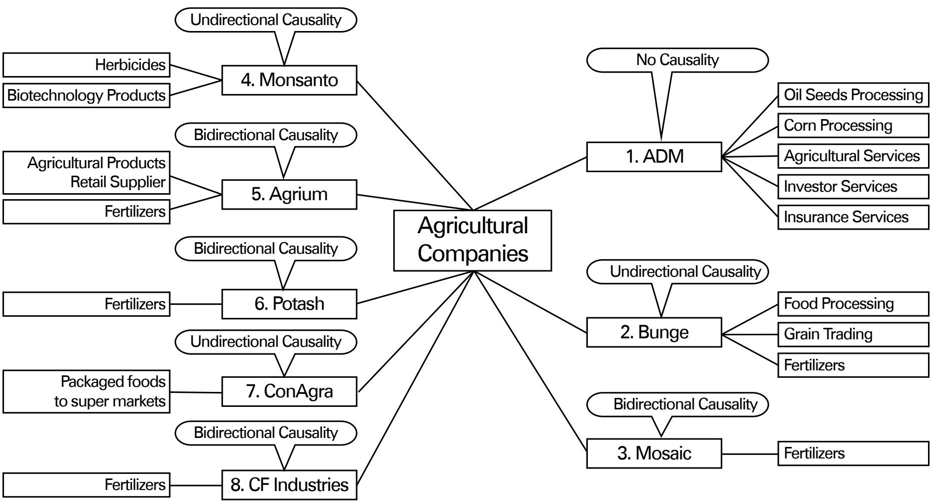
Klasyfikacja JEL: C43, G13, G15

ANNEX

Table 1. Description of the stock data time frame taken for different companies

Company Name	Begin Date	End Date
Archer Daniels Midland(ADM)	April 1983	December 2015
Bunge Ltd	August 2001	December 2015
Mosaic	January 1988	December 2015
Monsanto	October 2000	December 2015
Agrium	May 1995	December 2015
Potash Corporation	January 1990	December 2015
ConAgra	September 1984	December 2015
CF Industries	August 2005	December 2015

Figure 1. Product map of different agricultural company's products



Source: Author's diagram.