Interrelationship and Volatility Transmission between Grain and Oil Prices

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Introduction

The global grain market has experienced a series of severe disturbances in recent years. A number of economists have become interested in studying issues related to the recent high food prices. For example, Timmer (2008) argued that three fundamental factors, all interrelated, combined to drive up food prices: (1) rapid economic growth in China and India has put upward pressure on prices as demand simply outpaced supply; (2) a sustained decline in the US dollar since the mid-2000s added to the pressures on dollar-denominated international market prices; and (3) a combination of high and rising fuel prices coupled with legislative mandates to increase production of biofuels established a firm link between petroleum prices and food prices. Although there are a number of driving forces behind this phenomenon, the sharp increase in the demand for biofuels is considered the key impetus for “ag-flation” (Cha et al., 2011).

The main idea of this study starts from this linkage of high oil prices, biofuels production, and grain prices. The higher crude oil prices turned the spotlight on biofuels as an alternative to expensive fossil fuels. This induces a higher derived demand for corn and soybeans, which results in higher prices for these commodities. While such conditions encourage farmers to expand their planted acreages for corn and soybeans, this expansion results in a decrease in the planted acreage for wheat and rice since the global cropland endowment is limited (Chen et al., 2010). Several studies have empirically investigated the effects of biofuels and oil prices on food prices. Cha et al. (2011) examined the impact of increases in international crude oil prices on ethanol demand for corn, feed demand for corn, average corn prices, and export demand for the US corn by employing a structural vector auto-regression (SVAR) model using the sign restriction approach. Chen et al. (2010) investigated the relationships between crude oil prices and the global grain prices for corn, soybean, and wheat during different periods by applying the autoregressive distributed lag (ARDL) model.

The objective of this study is to investigate the volatility transmission of grain prices with oil prices, under the assumption that the increase in crude oil prices not only affects corn and soybean prices but also other grain commodity prices such as wheat and rice.[1] This study differs from past studies in many respects. First, this study expands the analysis of the impact of oil price uncertainty to four major grain markets such as corn, soybean, wheat and rice. Cha et al. (2011) only considered the corn market in analyzing the impact of high oil prices on the grain market; therefore, they did not expand their discussions to the level that incorporates the ripple effects on major grain markets, or more specifically, the substitution or competitive relationships between alternative grain commodities. Second, this study allows the conditional variance of price to change over time in a systematic fashion to capture the time-varying volatility in grain and oil prices, and to improve the efficiency and accuracy of the estimated coefficients through parameterizations that do not contain a restriction on parameters. Generally, in the well- known BEKK (Baba, Engle, Kraft, and Kroner) model, the diagonal BEKK parameterization is utilized to give a zero restriction on the off-diagonal elements and to simplify the parameter estimations.

The main contents of this study can be summarized as follows. Firstly, this study examines the long-term equilibrium relationship between grain and oil prices. Secondly, impulse response and variance decomposition analysis are used to investigate dynamic interactions of grain and oil prices. These analyses are conducted for two periods: a relatively stabilized period for oil prices and a period with high oil prices. Thirdly, this study analyzes the volatility spillover

[1] As a substitute good for oil, a larger share of corn and soybean production is being used to produce bio-fuel. In this sense, corn and soybean may be called as energy crops, while rice and wheat can be considered as staple food.

effect between oil and grain prices using the bivariate generalized autoregressive conditional heteroskedasticity (GARCH) model to identify the effect of oil price uncertainty on grain prices.

Preliminary Data Analysis

Variables included in the empirical analysis are the prices of oil, rice, wheat, corn, and soybean. West Texas Intermediate was used for the oil price, and the B grade FOB price was used for Thailand long-grain rice. For the other prices, the No. 2 Soft Red product price on wheat, No. 2 Yellow price on corn, and No. 1 Yellow product price on soybean were used. The data for all grain prices were obtained from the US Department of Agriculture, and oil prices were obtained from Thomson-Datastream. The weekly data from one week in 1992 to 53 weeks in 2010 was used for the analysis, for a total number of observations of 1,002. All variables were transformed into natural logs before estimation and testing for unit roots using the augmented Dickey-Fuller (ADF) tests.

As shown in Table 1, variables in level reject the null hypothesis that there is no unit root on all time-series data, whereas differenced variables do not reject the null hypothesis. A series of tests for structural change of oil prices was performed using Chow's (1960) breakpoint test. To find out the optimal breakpoint, this study examined several sequential periods of time and tried to come close to the optimal point by repeatedly performing the breakpoint test. The test indicated that structural change occurred from week 32 in 2006 to week 53 in 2010. Hence, as mentioned above, we conducted our empirical analysis using two time periods: the period of high oil prices (week 32 in 2006 until week 53 in 2010; period II) and the relatively stabilized period (week 31 in 1992 until week 31 in 2006; period I)), in order to check the impact of high oil prices on the grain market.

Table 1 ADF unit root test

Variable	Period I		Period II		Whole Period	
	ADF Statistic	**P-value**	**ADF Statistic**	**P-value**	**ADF Statistic**	**P-value**
Level						
Oil	0.00	0.96	-1.60	0.48	-0.66	0.85
Corn	-2.44	0.13	-2.64	0.09	-1.39	0.59
Soybean	-2.49	0.12	-2.21	0.20	-1.32	0.62
Rice	-2.27	0.18	-1.84	0.36	-1.82	0.37
Wheat	-2.39	0.15	-1.51	0.52	-1.82	0.37
1^{st} Differenced						
Oil	-20.69	0.00	-12.57	0.00	-22.84	0.00
Corn	-21.29	0.00	-12.07	0.00	-24.57	0.00
Soybean	-20.91	0.00	-11.83	0.00	-24.11	0.00
Rice	-21.60	0.00	-6.06	0.00	-14.56	0.00
Wheat	-19.67	0.00	-13.01	0.00	-26.82	0.00

Empirical Results (1): Co-integration Test

The first empirical issue we examined is the possibility of co-integration among variables in the study. Johansen's (1988) co-integration test was applied and leg length was determined by SIC(Schwarz Information Criterion). The test indicated that there were no co-integration relationships among grain and oil prices in both periods, as shown in Table 2. This means that only short-run dynamic interactions exist in grain and oil prices. Accordingly, this study focuses on short-run interrelationship analysis through the VAR (Vector Autoregression) system, instead of the VECM (Vector Error Correction Model) system. For the VAR analysis, each price variable in level needs to be converted into a stationary time series by taking the first difference.

Table 2 Johansen co-integration test

Period	Hypothesized No. of CE(s)	Eigen Value	Trace Statistics	5% Critical value	p-value
Period Ⅰ	rank≤1	0.015463	29.0177	47.85613	0.7675
	rank≤2	0.014738	17.08036	29.79707	0.6341
	rank≤3	0.007412	5.707179	15.49471	0.7298
	rank≤4	1.10E-05	0.008406	3.841466	0.9266
Period Ⅱ	rank=0	0.102752	68.24967	69.81889	0.0663
	rank≤1	0.084755	43.31242	47.85613	0.1251
	rank≤2	0.051805	22.94294	29.79707	0.2489
	rank≤3	0.027359	10.70814	15.49471	0.2301
	rank≤4*	0.018641	4.327899	3.841466	0.0375

Note: Notation * presents that the null hypothesis is rejected at the 5% significance level.

Empirical Results (2):Short-run Dynamic Analysis

Short-run dynamic interactions between grain and oil prices could be visually identified through the impulse response analysis based on VAR models. In this study, Pesaran and Shin's generalized impulse response function (1998) is adopted to avoid the effects of variable ordering within the VAR system and the leg length was determined by SIC. Figure 1 reports the impulse response to oil price shocks; there are some points that claim our attention. First, positively significant responses in wheat, corn, and soybean prices were detected in period II, the high oil prices era, but none in period I, the stable oil prices era. Second, the rice price does not show any significant response to the oil price shocks in both periods. Figure 2 reports the impulse response to grain price shocks. Overall, wheat, corn, and soybean prices show significantly positive interacting responses to each grain price shock, and responses are more sensitive in period II (high oil price period). However, the rice price has no significant response to corn price and soybean price shocks; this illustrates a negative response to the wheat price shock.[3]

Variance decomposition analysis also holds, considering the possibility that a certain error term could move with other error terms within the framework of the impulse response analysis. The estimation results are reported in Table 3. While more than 98% of the change of wheat price is attributed to the variance of wheat price during period I, it decreased to 91% in period II, while the contributions of international oil prices increased up to 8% in period II. In the case of corn price, more than 78% of the change of corn price is attributed to the variance of corn price, and slightly more than 20% can be attributed to the change of wheat price during period I. In period II, the contributions of the change of corn price slightly decreased to 71%, whereas the contribution of the change in international oil prices increased by 9%. In the case of soybean, contribution of the change of soybean price was more than 65%, while the contributions of corn and wheat prices are 25% and 9%, respectively, in period I. Contributions of oil price to variance of soybean price was non-existent in period I but increased up to 13% in period II. While more than 99% of the change of rice price is attributed to the variance of rice price during period I, this decreased to 91% in period II. Oil price has a non-significant contribution to the variance of rice price in both periods. This is quite a contrast to the results of the variance decomposition analysis for the other grains.

[3] This results from the unique characteristic of the international rice market. Rice is mainly produced and consumed in Asia; therefore, it shows a strong characteristic of a self-sufficient commodity. Compared to other grain markets, the supply and demand conditions of the rice market are limited geographically. In addition, the use of rice is not as diverse as other feed grains and wheat; hence there is a shortage of substitute goods. In this respect, rice shows a special characteristic in comparison to other grains.

Figure 1 Impulse response of grain price to oil price shocks

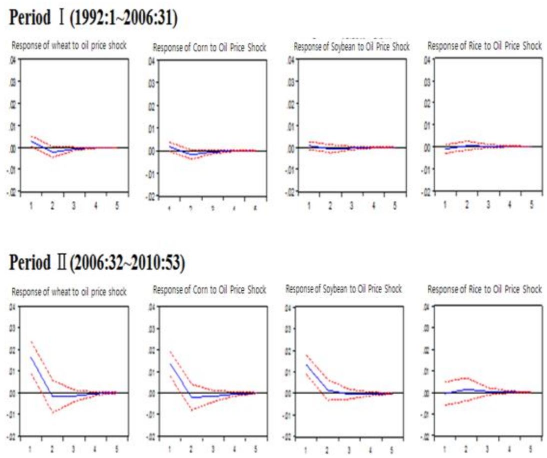


Figure 2 Impulse response to grain price shocks

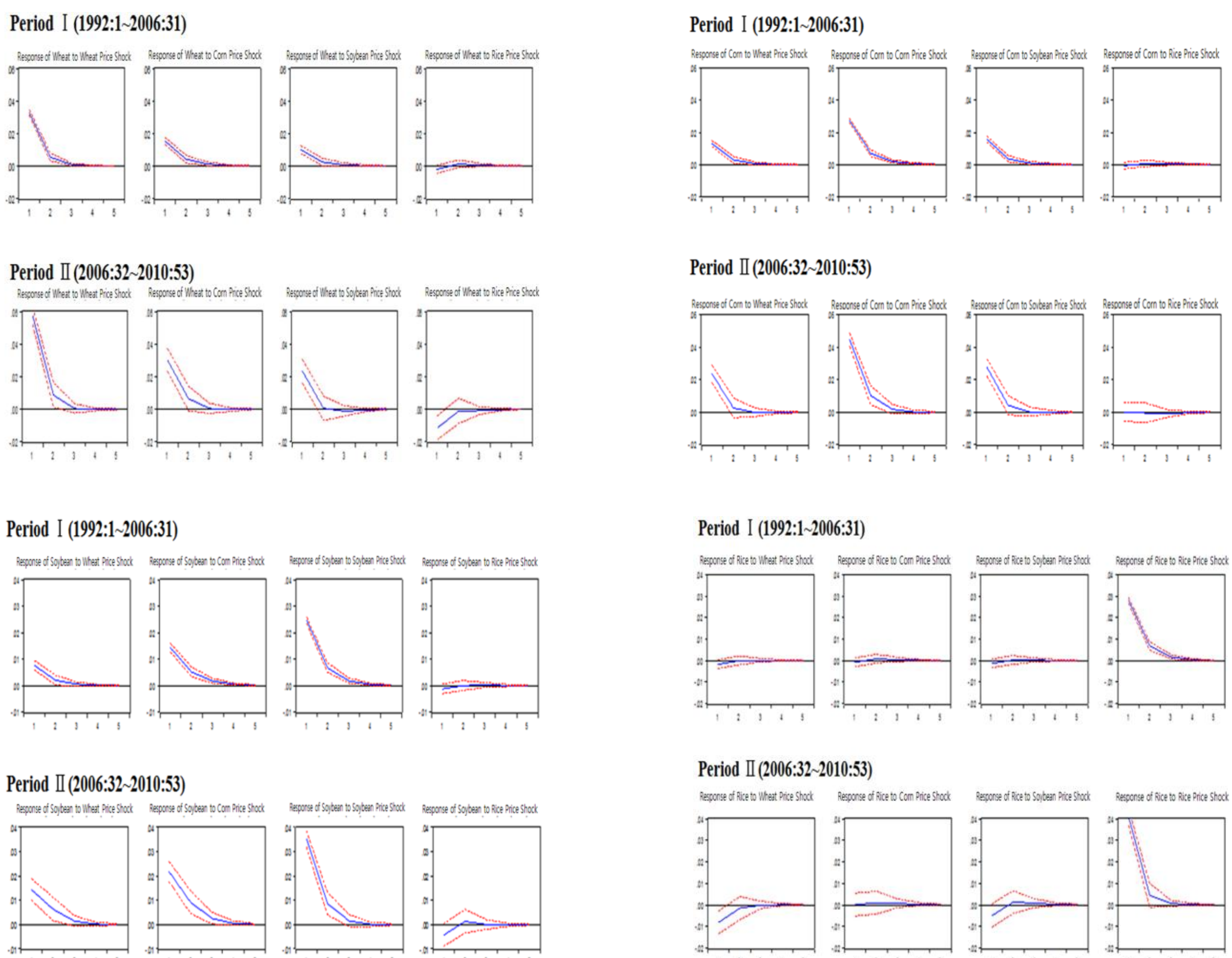


Table 3 Variance decomposition

(Unit: %)

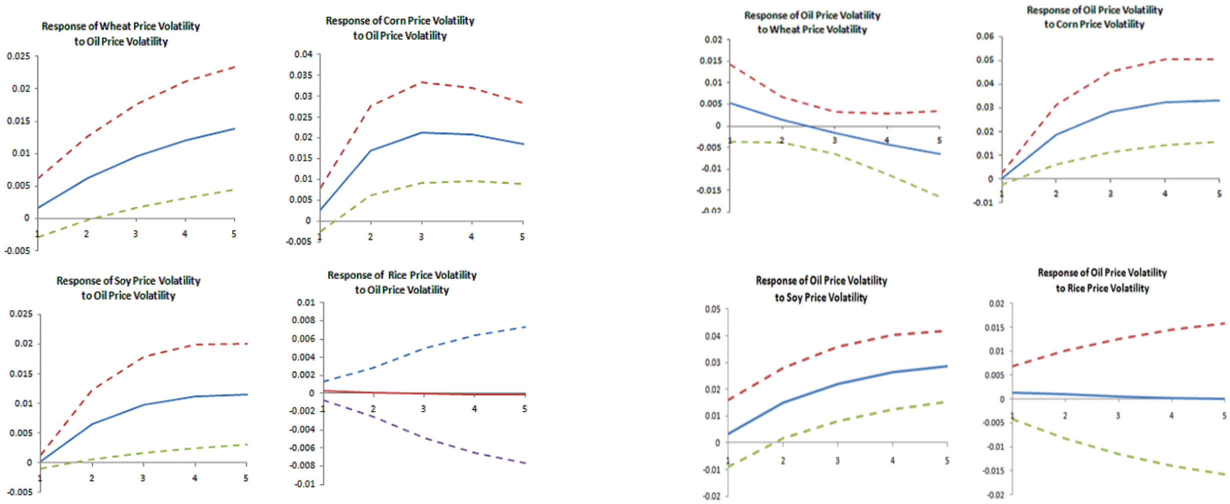
Variable	Time (week)	Period I (1992:1week~2006:31week)					Period Ⅱ (2006:32week~2010:53week)				
		Oil	Wheat	Corn	Soy	Rice	Oil	Wheat	Corn	Soy	Rice
Wheat	1	0.70	99.30	0.00	0.00	0.00	8.13	91.87	0.00	0.00	0.00
	2	1.11	98.42	0.28	0.00	0.20	7.94	91.28	0.28	0.50	0.00
	3	1.15	98.25	0.36	0.00	0.24	7.99	91.12	0.28	0.57	0.04
	4	1.15	98.23	0.37	0.00	0.24	8.00	91.10	0.29	0.57	0.05
	5	1.15	98.23	0.37	0.00	0.24	8.00	91.10	0.29	0.57	0.05
Corn	1	0.33	21.44	78.23	0.00	0.00	9.01	20.79	70.19	0.00	0.00
	2	0.74	21.05	78.12	0.05	0.04	8.61	19.93	71.29	0.07	0.10
	3	0.80	20.98	78.11	0.05	0.06	8.68	19.83	71.22	0.08	0.18
	4	0.80	20.98	78.11	0.06	0.06	8.69	19.83	71.21	0.09	0.20
	5	0.80	20.98	78.11	0.06	0.06	8.69	19.83	71.20	0.09	0.20
Soybean	1	0.09	9.39	23.46	67.06	0.00	13.89	9.65	18.58	57.88	0.00
	2	0.17	9.37	25.09	65.35	0.02	12.90	11.66	20.78	54.23	0.42
	3	0.19	9.36	25.33	65.09	0.03	12.84	11.78	21.06	53.90	0.42
	4	0.20	9.35	25.36	65.06	0.03	12.85	11.78	21.08	53.88	0.43
	5	0.20	9.35	25.36	65.06	0.03	12.85	11.78	21.08	53.87	0.43
Rice	1	0.15	0.36	0.00	0.13	99.36	0.02	4.17	1.42	1.89	92.50
	2	0.16	0.34	0.11	0.13	99.26	0.13	4.33	1.59	1.90	92.04
	3	0.17	0.34	0.13	0.13	99.23	0.14	4.33	1.62	1.91	91.99
	4	0.17	0.34	0.14	0.13	99.23	0.14	4.33	1.63	1.91	91.99
	5	0.17	0.34	0.14	0.13	99.23	0.14	4.33	1.63	1.91	91.99

Volatility Spillover Effect

Another important issue in grain pricing relationships is the degree of price volatility. Volatility of oil prices tends to display similar behavior in grain prices, which suggests the possibility of volatility spillover effects from one grain market to the energy market, and vice versa. In contrast to past studies (e.g., Yang et al., 2003; Apergis et al., 2003), we examine the volatility spillover effect between grain and oil prices using a bivariate GARCH model and maximum likelihood estimation (MLE) is then used for parameter estimation. The results of the multivariate GARCH model with BEKK parameterization for each conditional variance equation are reported in Figure 3 and 4.

The figures also show the results of the form of the impulse response functions to volatility shocks. Our findings indicate that grains that are directly affected by the volatility of oil prices are wheat, corn, and soybean. Significant transmission of volatility from the oil sector to the grain sectors, except for rice, was found only after the first week. Higher levels of conditional volatility in the past are associated with higher conditional volatility in the current period since the coefficients are positive and significant. The behavior of oil price volatility differs a little from that of grains in that volatility of oil only responds to the volatility shock of corn and soybean prices in the direction of increasing volatility. However, both responses of the oil and grain prices volatility reflect no response to the volatility shocks for rice prices. In conclusion, volatility spillover effects between corn and oil price and between soybean and oil price are detected in the direction of increasing volatility with each other.

Figure 3 Impulse response of grain price (left) and oil price (right) volatility



Conclusions

The results presented in this paper suggest several conclusions. Firstly, we find a short-run relationship between the grain market and oil prices, which implies that recent co-movements of oil and grain prices are a temporary phenomenon. The degree of interaction tends to be more sensitive in period II, the high oil prices era, than in period I, the stable oil prices era. The finding that the change in one grain price was significantly influenced by the changes in other grain prices in period II rather than in period I is consistent with the observation that grain commodities are competing with the derived demand for biofuels (i.e., using soybeans or corn to produce ethanol or biodiesel in recent years). Secondly, grain prices, except for rice, are affected to some degree by levels of oil prices. High oil prices have a direct impact on grain production and prices through higher production cost. Therefore, this increases the competitiveness of biofuels production as an alternative to expensive fossil fuels. Thirdly, the prices of corn and soybean, which are sources of bio-fuel, influence the price volatility of oil, and vice versa.

Finally, it is somewhat difficult to find any obvious linkage between rice prices and other grain prices. This may be due to the unique characteristic of the international rice market. Rice is mainly produced and consumed in Asia; hence, the results may reflect the fact that rice is by most accounts a self-sufficient commodity.

Governments of major agricultural producing countries have implemented production subsidies to encourage farmers to plant energy crops primarily because biofuels now have a significant impact on the economy and the environment (Hill et al., 2006). The growth of the ethanol industry has meant that a larger share of corn production is being used to feed the huge mills that produce ethanol. The enormous volume of corn required by the ethanol industry is sending shock waves through the food system (Runge et al., 2007). As indicated by the empirical results of this study, higher oil prices may significantly affect feedstock prices in the short term. The volatility of oil prices could also disturb the stability of grain prices in the short run. These unstable and highly volatile characteristics of oil and grain prices, even if it is a short-term phenomenon, seem to be an undesirable phenomenon, especially for the poor, considering the importance of oil and grain. Therefore, comprehensive energy and food policies should be implemented since oil and grain prices are highly interrelated in the short run.

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