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Volatility Spillover from Oil to Food and Agricultural Raw Material Markets

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Abstract

The upward movement in oil and food prices in the 2000s has attracted interest in the information transmission mechanism between the two markets. This paper investigates the volatility spillover between oil, food consumption item, and agricultural raw material price indexes for the period January 1980 to April 2008. The results of the Cheung-Ng procedure show that variation in oil prices does not Granger cause the variance in food and agricultural raw material prices. Since there is no volatility spillover from oil markets to food and agricultural raw material markets, investors can benefit from risk diversification. However, there is bi-directional spillover between agricultural raw material and food markets.

Keywords: Oil Prices, Food Prices, Agricultural Raw Material Prices, Volatility Spillover

1. Introduction

The simultaneous upward trend in world food prices and oil prices in the 2000s has triggered an increased interest on information transmission dynamics between the two markets. As commodity markets are increasingly viewed as alternative investment areas, existence and direction of spillovers must be carefully evaluated by investors. The existence and nature of the link between alternative investments will determine the extent to which investors will be involved in each market for risk management purposes.

One conjecture about the recent rise in food prices is that rising energy prices drive the food prices up [1]. This argument is due to the fact that energy is an important input in agricultural activities. The link between food and energy markets, however, may be more complicated than that (Abbott *et al*. 2008) [2]. There might be feedback mechanisms that result in food prices leading the energy prices. One such mechanism may exist due to the use of some food items in energy generation. Increased demand for energy may be driving the oil prices as well as food prices. Hence, in order to fully understand the link between the two markets a me- thod that allows such dynamic feedbacks is required.

In Agricultural Trade Policy Analysis [3] it is stated that from 2005 to 2007 biodiesel production increased by 5.5 million tones. Additionally, Collins [4] put forth that 60% of the increase in maize prices from 2006 to 2008 may be caused from the increase in maize used in ethanol. One can conjecture that the increased demand for bio-energy results in an increase in food prices and there might be a switch to the traditional fossil fuel alternatives. If this conjecture holds, then one expects to see world food prices leading the oil prices. However, the increase in food prices is not limited to food items that are also used in bio-fuel production.

Food consumption item prices are also showing an upward trend. However, to the extent of our knowledge, there are no studies that examine the dynamic link between world oil and food consumption item prices. This paper is probably the first to examine the volatility spillover between world oil, food, and agricultural raw material prices. Applying a relatively new methodology that allows us to test causality both ways, we find that there is no volatility spillover from oil prices to food consumption item price index or to agricultural raw materials price index. Furthermore, there is no feedback to the oil market as well. We discover bi-directional Granger causality in variance between the food and agricultural raw material markets. The results of this study may have important implications for both policy makers and global investors who need to follow the price shocks and transmission mechanisms between alternative investment areas closely.

The remaining of the paper evolves as follows. Next section discusses the relevant literature. Third section introduces the data and discusses methodological issues. Fourth section presents the empirical findings and the last section concludes.

2. Price Transmissions

There is a large literature on information transmission between various commodity markets. For the sake of brevity, we concentrate on the studies related to the food prices and oil prices. Coyle *et al*. [5] examine the structural changes in the food market and argue that the changes in the food market can also be associated to the production process where food is an input to the system. They find that increased demand for maize used in ethanol production and the increased demand for rapeseed used in biodiesel production are responsible for rising prices (Soaring Food Prices: Facts, Perspectives, Impacts and Actions Required) [6]. Also the USDA's chief Economist asserts that much of the increase in farm prices of maize and soybeans is due to bio-fuel production [7].

There are a group of studies that focus on transmission between various food markets. Rezitis [8] underlines that both farm and retail prices in Greece have significant effects on each other. Volatility spillover effects are also present between producer and consumer prices. In another study that deals solely with food prices, Christian and Rashad [9] examine the increased food prices between 1950 and 2005 and report a decrease in farm value of retail prices. Vavra and Goodwin [10] examine the relation between retail prices and consumer prices of food and discover presence of asymmetric affects of price changes in U.S. They find that with decreasing retail prices, consumer prices decline as well. Furthermore, the links between retail and farm prices is not contemporaneous but with a time lag. In an earlier study, Minten and Kyle [11] emphasize that the increase in the wholesale prices is significantly transmitted to the retail prices within the same week of the price change in wholesale level. Aksoy and Isik-Dikmelik [12] document that a change in the commodity prices is more significant in countries in which people consume more staples rather than various kinds of foods to extend that consumption of staple food crops affects the household income. They infer that the increase in the staple food crop prices has a significant influence on the household welfare.

Since there is no study that addresses the relationship between world consumption food items, agricultural raw materials, and oil prices, we next consider studies on volatility spillover in various commodity markets. In the literature, the return and volatility spillover effects are examined by a variety of methods. Worthington *et al*. [13] apply MGARCH method to analyze transmission prices and price volatility in Australian electricity spot markets. Fan *et al*. [14] look for the spillover effect between two markets, WTI (West Texas Intermediate crude oil) and Brent crude oil spot markets. GED-GARCH method is used to estimate the conditional heteroscedasticity. The results point out two-way Granger causality.

Spillover effects in energy futures markets have been the subject of many studies as well. Lin and Tamvakis [15], for example, examine the information transmission between two oil markets (NYMEX and IPE). They find that closing prices in NYMEX lead prices in IPE the next morning. However, there is bidirectional spillover when both exchanges are trading simultaneously. Baffes [16] examines the price transmission between crude oil prices and 35 other commodity prices between 1960 and 2005. He states that there is information transmission from crude oil to agricultural commodities. He mentions that as long as the crude oil prices continue to remain high for a certain amount of time the price booms will be higher than the booms experienced before, especially for food commodities, fertilizers and precious metals. This suggests a volatility spillover from oil to agricultural markets. Ewing and Thompson [17] argue that a possible explanation for the increase in consumer prices is the increase in crude oil prices. But they also point out that with the in- crease in the industrial production; there is an avowed rise in oil prices.

As Askari and Krichene [18] state even if the oil prices rise tremendously, change in the demand for commodities or for oil will be relatively small if the elasticity is low. That is, increasing oil price will not have a significant influence on demand for food commodities.

As world food markets are open to investors and speculators, just like the oil markets, the prices in both commodity markets may be governed by similar dynamics. Food, oil and other commodity prices have been studied extensively in the literature. However, to the extent of our knowledge there aren't any studies that explicitly examine the volatility link between world food, agricultural raw material, and oil prices. This paper is concerned with the spillover effects between agricultural raw material, food consumption items, and oil prices. In the next section we introduce the data and data sources.

3. Data Characteristics

We use monthly data on agricultural raw material spot prices (ARMI), food spot prices (FPI) and oil spot prices (OPI) for the period January-1980 to April-2008. ARMI measures the price changes for timber, cotton, wool, rubber and hides price indices. FPI measures the price changes for fruits, vegetables, meat, poultry, fish, grocery food and non-alcoholic beverages. We have chosen the FPI to understand whether variation in world oil prices are transferred to food consumption items. The FPI clearly represents food items that are not alternatively used in biodiesel production. ARMI is chosen to understand whether other agricultural raw materials also oil prices. OPI measures the price changes for crude oil. The three price indexes are sourced from International Monetary Fund (IMF). All price indexes are converted to log returns.

DLARMI: differenced natural log of agricultural raw material spot prices

DLFPI: differenced natural log of food spot prices

DLOPI: differenced natural log of oil spot prices

The descriptive statistics are given in **Table 1**. We see that standard deviation of OPI is far more than FPI and ARMI. In addition, OPI has the highest coefficient of variation while FPI has the lowest of all. That is the most volatile variable is the oil prices followed by agricultural raw material prices and food prices respectively. According to **Table 1**, kurtosis exceeds 3 pointing out the presence of fat tails which can also be seen in OPI and FPI. Additionally, negative skewness and significant Jarque-Bera test statistics imply deviations from normality. The three price indexes seem to have similar characteristics with most financial series. Therefore, the methods used in the examination must account for these properties. The next section discusses the stationarity properties of the series in concern. The stationarity of the series are essential for GARCH modeling of the conditional variances.

4. Unit Root Tests

In order to have robust estimation results, the stationarity of the data is very important. To investigate the stationarity properties of the series six different unit root tests are conducted: augmented Dickey-Fuller (ADF) [19], Elliot-Rothenberg-Stock [20] Dickey-Fuller GLS detrended (DF-GLS) [19], Phillips-Perron (PP) [21], Kwiatkowski-Phillips-Schmidt-Shin (KPSS) [22], Point Optimal (ERS-PO), and Ng and Perron's MZ_α (NP) [23]. The results of the unit root tests are presented in **Table 2** for levels and first differences, respectively.

Table 1. Descriptive statistics.

	ARMI	OPI	FPI
Mean	93.15299	52.89554	101.7999
Median	97.28017	46.18479	100.3424
Maximum	132.3509	204.3880	172.5399
Minimum	56.92235	18.51047	75.39381
Std. Dev.	18.14362	30.91256	14.49051
Skewness	–0.416911	2.104470	1.261623
Kurtosis	2.275578	7.933221	7.063554
Jarque-Bera	17.28401	595.7344	324.1227
Probability	0.000177	0.000000	0.000000

Table 2. Unit root test results[a].

		ADF	DF-GLS	PP	KPSS	ERS-PO	NG(Mz_α)
Levels							
Intercept	LOPI	–0.867 (1)	–1.06 (1)	–0.265 (8)	0.678^b (15)	6.75^a (1)	–3.72 (1)
	LARMI	–1.49 (1)	–0.961 (1)	–1.32 (3)	1.33^a (15)	8.66^a (1)	–2.79 (1)
	LFPI	–0.818 (1)	–0.992 (1)	0.436 (0)	0.374^c (15)	7.15^a (1)	–3.40 (1)
Trend and intercept	LOPI	–1.51 (1)	–1.08 (1)	–0.879 (10)	0.463^a (15)	20.9^a (1)	–4.07 (1)
	LARMI	–2.37 (1)	–2.21 (1)	–2.28 (4)	0.348^a (15)	9.38^a (1)	–9.86 (1)
	LFPI	–0.263 (1)	–0.768 (1)	0.269 (5)	0.214^b (14)	20.8^a (1)	–3.33 (1)
First differences							
Intercept	LOPI	$–14.0^a$ (0)	$–13.6^a$ (0)	$–13.5^a$ (12)	0.437^c (8)	0.185 (0)	$–158^a$ (0)
	LARMI	$–15.0^a$ (0)	$–2.66^a$ (4)	$–15.0^a$ (0)	0.065 (3)	0.506 (0)	$–9.80^b$ (4)
	LFPI	$–13.5^a$ (0)	$–11.0^a$ (0)	$–13.4^a$ (7)	0.553^b (1)	0.231 (1)	$–162^a$ (0)
Trend and intercept	LOPI	$–14.1^a$ (0)	$–14.1^a$ (0)	$–13.6^a$ (14)	0.034 (11)	0.586 (0)	$–162^a$ (0)
	LARMI	$–15.0^a$ (0)	$–4.63^a$ (4)	$–15.0^a$ (0)	0.069 (3)	0.793 (0)	$–20.9^a$ (4)
	LFPI	$–13.7^a$ (0)	$–12.3^a$ (0)	$–13.4^a$ (10)	0.138^c (2)	0.692 (0)	$–161^a$ (0)

[a]Superscripts a, b, and c represent significance at the 1%, 5%, and 10% respectively.

According to **Table 2** results, although there are slight differences in test results, we can safely conclude that all the variables are integrated of order 1. That is price indexes are I(1) in levels. Taking the natural logs and the first differences converts them into compounded returns and makes them stationary.

5. Volatility Spillover

Volatility spillover can be viewed as risk spillover. High volatility means high risk. Financial asset returns (and commodity returns that follow them closely) generally exhibit volatility clusters through time. We observe high volatility periods, and then low volatility periods as clusters. When return fluctuations in one market lead fluctuations in the returns of another market, then there is volatility spillover.

In order to test whether there is volatility spillover between the three price indexes used in this study, we utilize the Granger causality in variance approach developed by Cheung and Ng (1996) (CN hereafter) [24]. Following this procedure we first examine the mean equations of the three series. The series in concern must be stationary, therefore the first differences of natural logs are employed in the mean equations, as suggested by the unit root tests. For the food and oil returns Akaike information criteria selects a mean equation with a constant only; whereas, for the agricultural raw material returns ARMA(2, 2) are selected. We find that there are ARCH effects that need to be modeled explicitly. Hence, we construct the univariate GARCH models. For agricultural raw material and food returns GARCH(1,1), for oil returns EGARCH(1,1) model were appropriate (results are available upon request).

The CN procedure takes the squared standardized residuals $\hat{\varepsilon}_{it}^2 = (z_{it} - \hat{\mu}_{it})^2 / \hat{h}_{it}^2$ from the univariate models and examines the cross-correlations, where z_{it} are the stationary variables and $\hat{h}_{it}$ are the time varying variances. Then the sample residual cross-correlation functions between the two standardized residuals ($\hat{\rho}_{u_1u_2}(k)$) are derived. The sample residual cross-correlation functions between the squares of the two standardized residuals ($\hat{\rho}_{v_1v_2}(k)$) are derived and the test statistic $\sqrt{T}\hat{\rho}_{v_1v_2}(k)$ is computed (where T is the sample size v_i are the squared standardized error terms estimated via $\hat{\varepsilon}_{it}^2$). The test statistic asymptotically follows the normal distribution. The CN procedure enables us to see the time lag through which the volatility spillover occurs. **Table 3** summarizes the CN Granger causality in variance tests.

Table 3 indicates that volatility spillover in food returns leads fluctuations in agricultural raw material returns

Table 3. Granger causality in variance test statistics[a].

	$\sqrt{T}\hat{\rho}_{v_1v_2}(k)$					
	DLARMI and DLFPI		DLARMI and DLOPI		DLOPI and DLFPI	
i	lag	lead	lag	lead	lag	lead
0	0.73981	0.73981	1.806384[b]	1.80638[b]	0.07917	0.07917
1	–0.7123	–1.2942[c]	–0.1395	–0.7527	–0.0644	–1.3404[c]
2	0.58194	–0.6444	–0.8059	–0.3047	–0.6684	–0.2338
3	–0.6444	1.07759	–1.0152	0.63701	–0.1123	–1.0863
4	–0.2607	0.27353	0.70677	0.3286	0.37008	0.3977
5	1.672374[b]	1.36397[c]	–0.8004	0.16338	0.80829	–0.4548
6	–1.1786	0.27353	–1.2575	0.74715	–0.8433	–0.8396
7	0.87382	–0.8573	–0.4681	0.64802	0.69229	–0.5468
8	–1.1051	0.23681	1.92938[b]	0.2056	0.55604	–0.0939
9	–0.0991	–0.2056	–0.8702	0.05874	–0.3903	0.67756
10	–0.6554	0.22396	–0.9509	–0.279	–0.3406	0.32221
11	–0.4443	–0.7765	–0.8812	–0.8885	–0.5671	–0.4861
12	–0.6756	0.14135	0.1799	1.04271	–0.0442	–1.1158

[a]Superscripts a, b, and c denote significance at 1%, 5%, and 10% respectively. The second variable Granger causes the first variable in variance if the test statistic is significant for some lags; vice versa if the test statistic is significant for some leads.

at lag 5 at the 5% significance level. There is also weak evidence of Granger causality in variance from raw materials to food returns at lags 1 and 5. The results also show that there is a contemporaneous link between oil and agricultural raw material returns. This is not surprising since both are used as inputs in further production. At the 5% significance level oil volatility leads agricultural raw material volatility at lag 8. The CN procedure provides some evidence of a volatility spillover from oil to food returns at lag 1. However, the result is weak since the test statistic is very close to the 10% critical value of 1.28.

Although the CN procedure seems to have uncovered links between the volatilities of the three indexes, the evidence is not too strong and the fact that the spillover occurs in 5 to 8 months indicate that the markets respond with a lag to changes in the volatility in the other market. The only link that can be easily interpreted is the contemporaneous adjustment of the agricultural raw material and oil returns since they are closely linked to the production processes. The neutrality between agricultural raw material, food and oil returns is confirmed by the volatility spillover test results.

6. Conclusions

The commodity markets are viewed as attractive investment areas as alternatives to financial markets. If they are seen as alternative investment areas, then commodity prices must respond to the same factors as financial asset prices. One such factor is oil price shocks. The responsiveness of financial returns to oil price shocks has been studied a lot in the literature. However, the commodity market and energy market links are only recently attracting attention. In the commodity price-energy price, food and agricultural raw material prices is probably the least studied.

Countries that rely on commodity trade are more vulnerable to risk and uncertainty in commodity prices. Price instability affects producers, investors, financial intermediaries and policy makers in addition to its negative impact on growth and income distribution. Volatility has been a major source of price instability and its importance has not diminished due to more liberalization, reduction of barriers to trade, and globalization. There is a developed commodity derivatives market available for hedging against the commodity price risk, but problems still remain due to low accessibility of such markets, spread between local and international prices, low liquidity, lack of local reference prices, lack of derivative instruments for certain commodities [25]. The transfer of volatility between commodity markets makes decisions even harder for producers, traders and policy makers. If there is no volatility spillover between alternative commodity markets, then market based approaches can be used to diversify risk. However, if there is evidence of risk transmission, traditional methods like regulations, buffer stocks, buffer funds, and international agreements [25] can be sought.

This paper investigates the volatility spillover between world oil, food, and agricultural raw material price indexes. We find that there is no volatility spillover from the oil returns to the food returns. Overall our results indicate only a contemporaneous link between oil and agricultural raw materials. Since there is no relationship between the three market returns studied, there are risk reduction benefits from employing the three price indexes in portfolio formation. Furthermore, policy makers cannot use developments in the world oil market to improve their forecasts of the food and agricultural raw material prices and volatilities. Our results do not support the claim that oil price hikes are causing the inflation in food prices.

Further research examining the information transmission mechanisms between oil prices and individual prices of different food items or different agricultural indexes (*i.e.*, wheat, corn, soybean etc.) may prove to be fruitful. The price and volatility spillover from international markets to local markets is also an area where further research is needed. Since commodity markets are increasingly viewed as assets, the dynamic relationship between commodity prices and financial markets is also of interest to producers, traders, policy makers and scholars.

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