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# How does oil price volatility affect non-energy commodity markets?

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ABSTRACT

The influence of price volatility in the crude oil market is expanding to non-energy commodity markets. With the substitution of fossil fuels by biofuel and hedge strategies against inflation induced by high oil prices, the link between crude oil market and agriculture markets and metal markets has increased. This study measures the influence of the crude oil market on non-energy commodity markets before and after the 2008 financial crisis. By introducing the US dollar index as exogenous shocks, we investigate price and volatility spillover between commodity markets by constructing a bivariate EGARCH model with time-varying correlation construction. The results reveal that the crude oil market has significant volatility spillover effects on non-energy commodity markets, which demonstrates its core position among commodity markets. The overall level of correlation strengthened after the crisis, which indicates that the consistency of market price trends was enhanced affected by economic recession. In addition, the influence of the US dollar index on commodity markets has weakened since the crisis.



## 1. Introduction

With the acceleration of global market integration and rapid development of information carriers, traders tend to adopt global investment portfolio strategies to reduce market risk. Moreover, the liberalization of capital flows facilitated by development in market trading technologies and rapidly improved information transmission have prompted increased integration between commodity markets so that commodity prices tend to rise and fall together over time in response to the same shock. Pindyck and Rotemberg [25] selected seven "unrelated" (none of them are substitutes or complements, none are co-produced, and none is used as a major input for the production of another) largely raw commodities and found that comovement of prices is evident.

Recently, owing to increased use of biofuels, including bioethanol and biodiesel, the relationship between the oil market and the agriculture market has become closer (Chang and Su [9]). Through the refining process and supply and demand chains, crude oil affects price changes for other commodities (Baffes [2]). Therefore, changes in commodity prices represented by crude oil tend to be more consistent. In particular, during the 2008 global financial crisis triggered by the US subprime crisis, major commodity prices fell sharply at the same time because of the effect of the economic downturn. In the second half of 2008, the West Texas Intermediate (WTI) crude oil price fell from a record high of $147.27 per barrel to $30 per barrel and the extent of the reduction exceeded 70% over a period of 6 months. The London Metal Exchange (LME) copper futures price fell from $8600 per ton to $2800 per ton; the Chicago Mercantile Exchange (CME) soybean futures price fell from 1650 cents per bushel to 950 cents per bushel and the corn futures price fell from 750 cents per bushel to 400 cent per bushel, all of which represent price decreases of more than 40%. Thus, contagion among financial derivatives spread to the commodity markets. Against the background of global economic instability, information spillover effects among commodity markets were magnified and a shock in one market had significant volatility effects on other commodity markets. Therefore, an analysis of volatility behavior between commodity markets, especially changes before and after the 2008 crisis, is important for exploring price volatility characteristics of commodities and making worldwide across-market hedging decisions.

The volatility spillover researches had been a key concept for portfolio diversification strategies and widely analyzed among financial markets. Billio and Pelizzon [3] investigated the effect of deregulation, recent financial crises and the introduction of the euro on the volatility spillover from the world market index to European stock markets. They found that both the world index and the German market have increased after EMU for most European stock markets. Savva et al. [28] also investigated the impact of the introduction of the euro on the interactions across the New York, London, Frankfurt and Paris stock markets. Cappiello et al. [8] used an asymmetric version of the dynamic conditional correlation model to analyze asymmetries in conditional variances, correlations in international equity and bond returns. It is found

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that national equity index return show strong asymmetries in conditional volatility, while little evidence was seen on bond index returns. And Savva and Aslanidis [27] measured the degree in stock market integration between five Eastern European countries and the Euro-zone.

The volatility spillover research for oil markets has been focused on three aspects: interactions between the crude oil market and other energy markets, equity markets and exchange rate markets. Ewing et al. [13] investigated how volatility changes between oil and natural gas sectors and observed volatility spillover effects. Chen et al. [10] used the threshold error correction model to analyze asymmetric price transmission between crude oil and US retail gasoline prices. They found that asymmetric transmission occurs not only in spot markets, but also in futures markets. Narayan and Narayan [20] modeled the impact of oil prices on Vietnam's stock prices. It is found that the impact of factors for increasing foreign portfolio investment inflows and preferences of holding local market stocks were more dominant than the oil price rise on the Vietnamese stock market. Malik and Hammoudeh [19] used a multivariate GARCH model to analyze the volatility and shock transmission mechanism among global crude oil markets, US equity markets and Gulf equity markets. The results indicated that Gulf equity markets are affected by volatility in the oil market, but only Saudi Arabia had a significant volatility spillover from the oil market. Soytas and Oran [32] examined the volatility spillover from world oil spot markets to aggregate and electricity stock index returns in Turkey. The results revealed that world oil prices Granger cause electricity index and adjusted electricity index returns in variance, but not the aggregate market index returns. Papapetrou [24] used a multivariate VAR model to research the dynamic correlation among oil prices, real stock prices, interest rates and real economic activity for Greece. The results revealed that oil price changes affected real economic activity in Greece and were important in explaining stock price movements. Ghosh [14] used GARCH and EGARCH models to examine the volatility spillover effect for crude oil price shocks on Indian exchange rate. The results revealed that an increased oil return leads to the depreciation of Indian currency vis-à-vis US dollar. Zhang [33] used VAR and GARCH models to explore mean spillover, volatility spillover and risk spillover between the US dollar exchange rate and crude oil prices. A significant long-term equilibrium co-integrating relationship could be identified between the two markets, but the effects of volatility spillover and risk spillover from the US dollar exchange rate to crude oil prices were not significant.

The interaction between the crude oil market and other commodity markets is increasingly clear, and many researchers have begun to focus on these relationships, and also confirmed the existence of long-term relationships. However, the literature on volatility spillover effects between the crude oil price and other commodity markets is still limited. Chen et al. [11] investigate the relationships between the crude oil price and the global grain prices for corn, soybean and wheat and found the significant impact of crude oil price on global grain prices. Kanamura [17] investigated interaction between energy and agriculture futures prices shedding light on the recent upsurge of biofuels using a correlation model. The results revealed that correlations between petroleum, soybean and soybean oil increased sharply after 2004, which may correspond to the recent increase in biofuels. Harri et al. [15] examined the influence of crude oil prices on agriculture prices and found that commodity prices are linked to the oil price for corn, cotton and soybeans, but not for wheat. Campiche et al. [6] examined the covariability between crude oil prices and corn, sorghum, sugar and soybean during 2003–2007. The results revealed no cointegrating relationships during 2003–2005, but corn and soybean prices were cointegrated with crude oil prices during 2006–2007. Nazlioglu and Soytas [22] examined the short- and long-run interdependence between world oil prices and individual agricultural commodity prices in Turkey. The impulse-response analysis suggests that Turkish agricultural prices do not significantly react to oil prices in the short run. Hammoudeh and Yuan [16] used GARCH family models to examine the volatility behavior of gold, silver and copper in the presence of crude oil shocks. The results revealed that previous oil shocks did not impact all three metals similarly, with calming effects on the precious metals but not on copper. Soytas et al. [31] examined the long- and short-run transmission of information between world oil prices and Turkish spot gold and silver prices. They found that the world oil price had no predictive power for precious metal prices and Turkish spot precious metal prices did not provide information to improve forecasting of world oil prices in the long run. Narayan et al. [21] examined cointegration and synchronization relationships between gold and oil spot and futures markets. The results revealed that the oil market can be used to predict gold market prices and vice versa; thus, these two markets are jointly inefficient. Sari et al. [30] used forecast error variance decomposition and an impulse response function to analyze the comovement and information transmission among the spot prices of four precious metals, oil prices and exchange rates. The results revealed that metal returns had a positive influence on oil price and oil could explain 1.7% of gold price returns.

This paper examines the volatility spillover effects between the crude oil market and metal market, agriculture market and aggregate non-energy commodity market, and estimates dynamic conditional correlations. Considering that most international commodities are priced in dollars and commodity prices are generally affected by the US dollar exchange rate (Akram [1]), the US dollar index is introduced as an exogenous shock. The main contributions of the paper are as follows. (1) We use an authoritative CRB subindex that reflects price changes for commodity markets as the representative indicator of each commodity market and introduce the US dollar index as an exogenous shock for crude oil and each commodity market in a bivariate EGARCH model. (2) The different characteristics of volatility spillover effects between crude oil and each commodity market before and after the 2008 financial crisis are analyzed comprehensively, and the influence of crude oil price volatility on various commodity markets is compared. (3) Finally, we estimate the dynamic conditional correlation between the crude oil market and each commodity market and analyze the time-varying characteristics of correlations before and after the 2008 crisis.

## 2. Volatility spillover between crude oil and commodity markets: bivariate EGARCH model[1]

Asymmetry effects of price volatility in capital markets had been confirmed (Booth et al. [5], Reyes [26], Canarella et al. [7]), whereas potential asymmetry effects between commodity markets need to be further verified. We use the exponential generalized autoregressive conditional heteroskedasticity (EGARCH) model proposed by Nelson [23] and expand it to a multivariate model.

### 2.1. Mean equation

We consider the dollar index as an exogenous shock, assuming that commodity returns are impacted not only by its own lagged term but also by the lagged term of other commodity returns and the dollar index return. Thus, the mean equations for the crude oil market and each commodity market are formulated as follows:

[1] For estimating the asymmetric effect between markets, EGARCH model is preferred to the multivariate GARCH model. Confined by complex coefficient estimation, it is difficult to expand EGARCH model to a multivariate version. Therefore, bivariate EGARCH model is selected in our research.