International Review of Economics and Finance 25 (2013) 113–121

Contents lists available at SciVerse ScienceDirect

International Review of Economics and Finance

journal homepage: www.elsevier.com/locate/iref

Volatility transmission between gold and oil futures under structural breaks

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ARTICLE INFO

Article history:
Received 28 November 2011
Received in revised form 13 June 2012
Accepted 13 June 2012
Available online 20 June 2012

JEL classifications:
G1

Keywords:
Volatility transmission
Oil volatility
Gold volatility
Structural breaks
GARCH

ABSTRACT

This paper employs univariate and bivariate GARCH models to examine the volatility of gold and oil futures incorporating structural breaks using daily returns from July 1, 1993 to June 30, 2010. We find strong evidence of significant transmission of volatility between gold and oil returns when structural breaks in variance are accounted for in the model. We compute optimal portfolio weights and dynamic risk minimizing hedge ratios to highlight the significance of our empirical results. Our findings support the idea of cross-market hedging and sharing of common information by financial market participants.

1. Introduction

Historically, economies have relied on oil for use in production, transportation and other energy related activities. Not surprisingly, oil related information such as production, prices, and futures is among the most widely watched of economic variables and indicators. Economic theories abound as to the role that oil plays in the performance of the overall economy and associated business cycles. Particular attention is often paid to the ways in which oil markets are tied to changes in consumer and producer prices. Interestingly, the role of gold prices is also often linked to output and prices. For example, gold is used in a number of productive capacities and has traditionally served as a hedge against inflation. It is therefore natural to expect that in asset pricing models the prices and/or volatilities of these two commodities could be linked. Moreover, while such a linkage or channel might exist, it is quite possible that the dynamics have changed over time particularly due to structural changes in the underlying economy or fundamentals that drive these two markets. Consequently, it is important to take into account the possible existence of sudden changes, or breaks, in the time series behaviors of these prices or their respective volatilities. This paper specifically examines the linkage that may exist between the volatilities in these assets prices allowing for sudden changes or regime shifts in variances. Knowledge about the accurate time series relationships between gold and oil markets will benefit financial market participants and policy makers alike.

A number of channels exist through which gold and oil markets could be linked together, the most obvious being inflation. Traditional macroeconomic models suggest higher oil prices place upward pressure on the overall price level particularly through greater production and transportation costs. A number of studies have confirmed the oil price—inflation link (e.g., Hooker, 2002;

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doi:10.1016/j.iref.2012.06.008

Hunt, 2006). Moreover, inflationary expectations may lead investors to purchase gold, a commodity, either to hedge against the expected decline in the value of money (see Jaffe, 1989) or to speculate on the associated increase in the price of gold.[2]

An alternative channel for establishing a relationship between gold and oil markets is provided by Melvin and Sultan (1990) who conclude that political unrest and oil price changes are significant determinants of volatility in gold prices. They reason that higher oil prices result in greater revenue streams for oil exporting countries. Consequently, since gold constitutes a significant share of their respective portfolios, this pushes up the demand for gold and leads to higher gold prices.

Additionally, Ross (1989) shows that volatility in asset returns depends upon the rate of information flow, suggesting that information from one market can be incorporated into the volatility generating process of the another market. Since the flow of information and the time used in processing that information vary across markets, one may expect different volatility patterns across markets. Similarly, Fleming, Kirby, and Ostdiek (1998) show that cross-market hedging and sharing of common information can transmit volatility across markets over time. Based on the above mentioned reasons, we would expect to find evidence of volatility transmission between the gold and oil markets.

The present paper studies the volatility dynamics of gold and crude oil futures using daily data from July 1, 1993 to June 30, 2010. We find significant structural breaks in volatility (i.e. volatility shifts) in both the gold and oil return series using modified iterated cumulative sums of squares (ICSS) algorithm. This is consistent with widespread evidence that variance in asset prices contains structural breaks (see Starica & Granger, 2005). We then introduce these structural breaks into univariate GARCH models to capture the true impact of news on volatility in each market and then into bivariate GARCH models to accurately estimate the volatility spillover dynamics across markets. We find strong evidence of significant transmission of volatility between gold and oil markets after structural breaks are incorporated into the model. We further show that some of these important dynamics would be overlooked if structural breaks are ignored in the model. Perhaps just as importantly, our results also indicate that volatility shifts have been more frequent over the recent global financial crisis and the great recession. Thus, recent economic and geo-political events have likely led to greater economic uncertainty, substantially affecting both gold and oil, and increasing the risk of investing in these markets.

Volatility in gold and oil prices is not only an important factor in derivative valuation and hedging decisions but also has significant consequences for broader financial markets as well as the overall economy. Volatility in oil prices directly impacts both consumer behavior and financial markets and thus affects the performance of the overall economy. Traditionally, gold is used as a hedge, and is often considered a useful indicator of future inflation, while gold also constitutes an important asset in a standard portfolio. Changes in the volatility of gold and oil prices can also affect the risk exposure of their producers and consumers potentially altering their respective investments in gold and oil. Asset volatility also determines the value of commodity-based contingent claims. If changes in volatility in gold or oil are expected to be very persistent following some unexpected news (i.e., shocks), then that news may have a major impact on prices of options and other derivatives that are tied to the price of gold or oil. Alternatively, if changes in volatility are highly temporary, then they should have little or no impact on market variables or option values. Poterba and Summers (1986) argue this point with their asset pricing model which explicitly shows that the amount of persistence in volatility directly affects the price of an asset. Lamoureux and Lastrapes (1990) similarly contend that pricing of contingent claims depends on the perception of how permanent the shocks are and show that shocks perceived to be temporary will have a smaller impact on the pricing of derivatives. Thus, correctly estimating volatility dynamics in gold and oil prices is important for building accurate pricing models, forecasting future price volatility and has implications for understanding broader financial markets and the overall economy.

2. Literature review

Oil price volatility is an important input in modern macroeconometric models, financial market risk assessment calculations such as value at risk (VaR), and option pricing formulas for futures contracts. Haigh and Holt (2002) analyze the crude oil contracts for their effectiveness in reducing price volatility for an energy trader. They find that modeling the time-variation in hedge ratios via multivariate GARCH methodology, which takes into account volatility spillovers between markets, results in significant reductions in uncertainty. Guo and Kliesen (2005) show that a volatility measure constructed using daily crude oil futures prices has a significant negative effect on future gross domestic product (GDP) growth. Malik and Hammoudeh (2007) use a multivariate GARCH model to find significant volatility and shock transmission among US equity, Gulf equity and global crude oil markets.

In a recent study, Driesprong, Jacobsen, and Maat (2008) examine data from both developed and emerging markets to show statistically and economically significant predictability of stock returns when incorporating oil price changes in their model. Geman and Kharoubi (2008) examine the diversification effect from including crude oil futures into a portfolio of stocks and find that the desirable negative correlation effect is more pronounced in the distant maturity oil futures. Ewing and Malik (2010) using univariate GARCH models report that, contrary to previous findings, oil shocks have a strong initial impact on volatility but dissipate very quickly. They argue that understanding this behavior of volatility in oil prices is important for derivative valuation and hedging decisions. Wu, Guan, and Myers (2011) using a volatility spillover model find evidence of significant spillovers from crude oil prices to corn futures prices and show that these spillover effects are time-varying. Based on this strong volatility link, they propose a new cross-hedging strategy for managing corn price risk using oil futures.

The literature examining gold market prices has also covered a number of different research areas. Cai, Cheung, and Wong (2001) find that prices of gold futures have time varying volatility and that US announcements concerning GDP and inflation have

[2] Alan Greenspan has argued that gold is a "store of value measure which has shown a fairly consistent lead on inflation expectations and has been over the years a reasonably good indicator." (Wall Street Journal, Feb 28, 1994)