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# The directional volatility connectedness between crude oil and equity markets: New evidence from implied volatility indexes

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ABSTRACT

In this paper, we use a set of newly introduced implied volatility indexes to investigate the directional connectedness between oil and equities in eleven major stock exchanges around the globe from 2008 to 2015. The inference on the oil–equity implied volatility relationships depends on Diebold and Yilmaz (2012, 2014, 2015) who proposed a set of directional measures that enable the dynamic and directional characterization of the relationships among financial variables. We find uniform results across the sample countries indicating that the connectedness between oil and equity is established by the bi-directional information spillovers between the two markets. However, we find that the bulk of association is largely dominated by the transmissions from the oil market to equity markets and not the other way around. The pattern of transmissions is varying over the sample period; however most of the linkages between oil and equities are established from the mid of 2009 to the mid of 2012 which is a period that witnessed the start of global recovery.



## 1. Introduction

The relationship between oil and equity prices has attracted a lot of research. However, there have been a few studies that have focused on the relationship between oil and stock prices' volatility, particularly in the period following the financial global crisis. Moreover, most of research on the oil–equity relationship is based on statistical model volatilities and not on the volatilities used by the market to price options. In this paper, we examine the after crisis connectedness between oil implied volatility and equity implied volatilities in eleven major stock exchanges around the globe.[1] To the best of our knowledge, this has not been done before in the oil–equity volatility relationship literature.

The study was not possible without the recently published crude oil implied volatility index (OVX) by the Chicago Board Options Exchange (CBOE) which has allowed for the investigation of the volatility connectedness between oil and equities that is implied by option market prices and not by historical returns. This type of analysis can provide another perspective on the association between oil and equities for many reasons. First, implied volatilities are more accurate measures of the latent volatility process than either ARCH models or realized volatilities.[2] Second, as volatilities are derived from market option prices, they are forward looking and thus they represent the markets' consensus on the expected future uncertainty. The implied volatility linkages across markets are therefore informative about the relation between market participants' expectations of future uncertainty. This is important as it provides insights into ways of building accurate equity and option valuation models and improves forecasts of cross market volatility. Third, implied volatilities depend on fear and not only on the markets' expectations of future volatility. When fear is high, a risk premium follows and options are priced with higher volatilities than the volatilities used when fear is low. In that sense, the implied volatility analysis tracks the investors' sentiment and, therefore, the inferred volatility connectedness reflects fear connectedness that is expressed by market participants as they trade.[3] Fourth, in the recent years and

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[1] These countries are: USA, Canada, Japan, UK, Germany, Russia, Sweden, Switzerland, India, South Africa and Mexico.

[2] See Blair et al. (2001) for more information about the in sample accuracy of implied volatility compared to other volatility. Furthermore, the studies of Christensen and Prabhala (1998), Fleming (1998), Jorion (1995), Blair et al. (2001) have all found evidence that implied volatilities are more accurate than historical model volatilities in the prediction of the latent volatility process.

[3] The most popular and monitored implied volatility index in the US is the VIX. It is touted as an investor fear gauge. In Whaley (2008), it is argued that the VIX is a barometer of investors' fear in a bear market and investors' excitement in a market rally.

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with the growing activity in the oil paper market, many financial market traders such as speculators, arbitrageurs, and convergence traders have started to invest in oil. These traders are highly leveraged and their trading is occasionally based on sentiment and risk aversion; their presence has hence intensified co-movements of risk across markets. The positive connectedness between oil and equities due to the change and increase in market participants is best captured by focusing on implied volatility linkages that account for cross market sentiments. Therefore, studying short term implied volatility connectedness may provide additional insights on the influence of the change in participants and trading activity on the linkages between oil and equity markets.[4] Furthermore, the different nature of risk transfer between oil and equity markets is useful information for risk management and diversification in derivatives portfolios.

Hence, in this paper, we provide a recent picture about the risk transfer between oil and equities following 2008. We chose to start our estimation sample in 2008 because this year coincides with the beginning of the global financial crisis. Furthermore, during this period, the shale oil industry becomes a consolidated major player in the oil market. The period has also witnessed the collapse of cooperation among OPEC members, the slowdown of the biofuel industry, the Eurozone debt crisis and the slowdown of China which is a major source of incremental oil demand.

In principle, oil volatility can be interrelated with equity volatility through many channels.[5] For instance, the recent plunge in oil prices to $27.62 in January 2016 has dragged down the S&P500 index by 9%. This simultaneous drastic drop in oil and equity prices also reflects an association of volatility between the two markets. These linkages in volatilities are driven by many factors. The volatility in oil prices may cause corresponding variations in the earnings of oil related companies and, hence, uncertainty regarding the equity prices of these companies will increase. Similarly, the volatility of oil prices may cause volatility in the prices of banks and financial institutions that are exposed to oil and oil related companies. Depending on the extent to which volatility in the oil market reflects uncertainty regarding economic growth, it may cause volatilities in other equity markets to rise. The recent increase in the volatility of oil in January 2016 is caused by the heightened worries concerning the future growth of the Chinese economy; it was hence translated to high volatilities across global equity markets.

The bulk of research on the co-movement of oil focuses on oil price connectedness with equities. Little research has dealt with volatility spillovers. Moreover, the analysis in the studies that address risk transmission between oil and equities depends on statistical volatilities that are either model based or computed from historical returns. These volatilities are not accurate measures of the latent volatility such as the volatilities implied from option prices.[6] Therefore, in this paper, we contribute to the literature by giving new insights on implied volatility spillovers following the global financial crisis.

In comparison with the related literature, our methodology is different and depends on a set of connectedness measures that are proposed by Diebold and Yilmaz (2012, 2014, 2015). The biggest advantage of this method is that the proposed measures are dynamic and directional. For instance, according to these measures we may judge the extent of information transmission or volatility connectedness between oil and equities at any particular date. Moreover, as the measures are directional, they become revealing in terms of the origin of the bulk of informational transmission between the oil market and equity markets. Hence, the measures indicate which market is contributing the most to the connectedness of volatilities.

Our results show that the transmission of information between oil implied volatility and equity implied volatilities is bi-directional and asymmetric. In particular, we find that the directional connectedness from the oil market to equity markets is higher than the directional connectedness in the opposite direction. The highest pairwise volatility connectedness measure (26.9%) is from oil to Canadian equities. The second and third highest connectednesses are from oil to the US and UK, where oil contribution amounts to 18.4% and 19.5% respectively. Moreover, oil was a net contributor of volatility to all stock markets under study.[7]

The dynamic analysis of connectedness clearly shows that the information transmissions from the crude oil uncertainty to other equity markets are more pronounced and larger in magnitude than the transmissions in the opposite direction. The nature of risk spillover during the sample period is characterized by a weak transmission at the beginning of the sample period (from Q1-2008 to Q2-2009). The risk transfer from oil to equities has picked up and increased from mid-2009 to mid-2012. As we approached the end of the sample, oil transmission decreases.[8] Over the entire sample period, the volatility transmission is dominated by the oil market.

Results from the Granger causality tests of implied volatilities are consistent with the directional connectedness measures. The direction of causality between implied volatilities of equity and oil markets is dominated by oil. The only exception is the US market where causality is found to be bi-directional. Finally, the dynamic conditional correlations show that correlations are average and varying across countries and time.

Our results are consistent with the bulk of literature that finds significant linkages between the oil volatility and equity volatilities. They conform nicely to the strand of literature that finds that the main information crosses are from the oil market to equity markets (Arouri et al., 2011; Awartani and Maghyereh, 2013; Bouri, 2015a,b; Bouri and Demirer, 2016; Malik and Hammoudeh, 2007; Malik and Ewing, 2009). However, we are different from all in terms of methodology and in that we focus on the linkages of implied volatilities that are used to price oil and equity options.

The rest of the paper is organized as follows: The next section summarizes the literature. Section 3 outlines the directional connectedness measures proposed by Diebold and Yilmaz (2015). Section 4 provides a description of the data set and some preliminary statistics of the implied volatility indices included in the study. In Section 5, we perform a full sample static analysis in which we characterize the connectedness among oil and equity volatilities. Also in this section, we perform a rolling sample analysis to check the dynamics of the connectedness across time. The robustness analysis is included in Section 6. The section presents the results of the Granger Causality tests and the dynamic conditional correlations. Finally Section 7 contains some concluding remarks.

## 2. Literature review

The literature on the oil equity relationship contains numerous studies.[9] The early research of Kling (1985) indicates that oil price is

[4] For more information on this structural change and its impact on markets' linkages, see Kyle and Xiong (2001), Kodres and Pritsker (2002), Broner et al. (2006), Pavlova and Rigobon (2008), Danielsson et al. (2011), and Büyükşahin and Robe (2014)

[5] In terms of returns, there are many reasons why the oil market and equity markets may be interrelated. The higher oil prices can be translated into higher production costs, lower productivity of labor and capital, lower household disposable income, lower demand for energy using durable goods and lower corporate earnings and equity prices. High prices can also mean higher earnings and equity values in the mining, oil, gas and other related industries (Nandha and Faff, 2008; El-Sharif et al., 2005). Or alternatively, it may have no influence whatsoever (Chen, 2010).

[6] For instance, the widely used ARCH models are found to explain less than 10% of the movement in the latent volatility and hence, the information content of these volatilities may be questionable (See Akgiray, 1989; Figlewski, 1997; Franses and Van Dijk, 1996; Brailsford and Faff, 1996).

[7] The net total directional volatility transmission is only positive in the US and in the oil market. This indicates that these
two markets are net spillers of volatility to other equities.

[8] On the contrary, at the start of the sample in 2008, the US dominates the information transmission with the oil market.

[9] See Maghyereh (2004), Maghyereh and Al-Kandari (2007), Kilian (2008), Nandha and Faff (2008), Cong et al. (2008), Chen (2010), Arouri and Rault (2012), El-Sharif et al. (2005), Apergis and Miller (2009), Driesprong et al. (2008), Park and Ratti (2008); Hammoudeh and Aleisa (2004), Bachmeier (2008), Sari et al. (2010), Awartani and Maghyereh (2013), Mollick and Assefa (2013), Bouri (2015a, 2015b), Tsai (2015) and Bouri and Demirer (2016) among many others.