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Dynamic spillover effects across petroleum spot and futures volatilities, trading volume and open interest

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ABSTRACT

This paper examines the existence of dynamic spillover effects across petroleum based commodities and among spot-futures volatilities, trading volume and open interest. Realized volatilities of spot-futures markets are used as inputs to estimate a VAR model following Diebold and Yilmaz (2014, 2015) and distinguish dynamic spillovers in total and net effects. Results reveal the existence of large and time-varying spillovers among the spot-futures volatilities and across petroleum-based commodities when examined pairwise. In addition, speculative pressures, as reflected by futures trading volume, and hedging pressures, as reflected by open interest, are shown to transmit large and persistent spillovers to the spot and futures volatilities of crude oil and heating oil-gasoline markets, respectively.

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1. Introduction

The interest on cross-asset interdependencies in general and within the energy commodities market in particular has been stimulated during and after the period of the global financial crisis (Alizadeh & Tamvakis, 2016; Baruník, Kočenda, & Vácha, 2015; Mensi, Hammoudeh, Nguyen & Yoon, 2014; Sadorsky, 2012). Apart from the historically remarkable and growing dependence of global industrial production on energy commodities, the interest on this specific asset class has been pronounced after 2000s also because of the substantial increase of their price volatility.[1,2] This excess volatility has been linked with tight oil production from shale formations and the financialization of commodities markets (Baumeister & Kilian, 2012; Büyükşahin &

Robe, 2014; Hamilton & Wu, 2015; Singleton, 2013).[3] For example, the increasing trend in commodity prices, which is often linked to the upward trend in crude oil, was followed by a sharp decline when the global financial crisis hit during 2007–2009 (Cevik & Sedik, 2011); a repeating pattern of large fluctuations also during the Eurozone debt crisis (2010−2013).[4] Such notable price movements are often attributed to transaction costs, information asymmetries, supply-demand imbalances and other market microstructure issues which create information spillover relationships among commodities markets. The aforementioned reasons highlight the importance of modelling spillovers of information across energy commodities and among volatilities and trading characteristics for several market participants.

This paper provides novel empirical evidence on two distinct but interrelated research questions, stemming from two underlying research hypotheses. The first issue examined is the evolution, severity and direction of volatility spillovers between the spot and futures markets examined across petroleum-based commodities. This is motivated by recent empirical evidence (see, for instance, Antonakakis, Floros, & Kizys, 2015) documenting large co-movements across asset classes

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[1] According to British Petroleum's (BP) statistical review of world energy published in June 2015 referring to 2014 year-end, the global energy consumption experienced a growth of 0.9%, the smallest growth since 2009. However, world's dependence on energy commodities remains emphatic as the percentages of global energy consumption among all sources of energy is the following: crude oil and oil products (32.6%), coal (30%), natural gas (23.7%), hydroelectric energy (6.8%), nuclear energy (4.4%) and renewables (2.5%).

[2] The importance of petroleum-based commodities for the global economy and economic development has been highlighted as early as in Hamilton (1983). Furthermore, oil price shocks have been shown to affect the U.S. stock market (Kilian & Park, 2009).

[3] The term "financialization" refers to the inclusion of commodities in investment portfolios for diversification purposes.

[4] More recently, based on data from the U.S. Department of Energy, oil prices tumbled from 106.2 $/barrel in June 2014 to 26.55 $/barrel in January 2016.

which have led investors to rebalance their portfolios towards safer investments, increase their diversification through investing in different asset classes and hedge their positions in the spot market with opposite positions in the futures market. The related to the issue futures literature examines the relation between spot and futures markets and is dominated by the price discovery hypothesis (Chan, 1992; Ghosh, 1993) and the volatility spillover hypothesis (Tao & Green, 2012).

The second issue examined in this paper is the evolution, severity and direction of spillovers among spot and futures price volatility, trading volume and open interest for each individual petroleum-based commodity. This research question stems from the Mixture of Distributions Hypothesis (MDH) suggested in Clark (1973) and the Sequential Information Flow (SIF) developed in Copeland (1976). The MDH approach assumes that price changes and trading volume follow a joint probability distribution. Specifically, trading volume has been widely used as a measure for the rate of informational arrival. In contrast, the SIF approach assumes that information is released sequentially in the market, i.e. informed traders acquire the information first with the rest of the market following to eventually restore equilibria. Open interest is considered as a proxy for the dispersion of investors' beliefs (Bessembinder, Chan, & Seguin, 1996) and as a proxy for the demand of futures contracts as hedging instruments (Aguenaou, Gwilym, & Rhodes, 2011). Open interest has been shown to contain information about future economic activity which is different than the one contained in futures prices (Hong & Yogo, 2012).

Prior empirical studies have focused on the aforementioned hypotheses across futures markets but do not examine their validity over time for the important class of energy futures markets. Specifically, prior studies on the issue do not investigate the existence, severity and direction of dynamic spillovers across petroleum-based commodities and across spot-futures volatility, trading volume and open interest (Alizadeh & Tamvakis, 2016; Chevallier & Sévi, 2012; Foster, 1995; Moosa & Silvapulle, 2000). To the best of our knowledge, this paper is the first to investigate this issue by providing novel evidence regarding the existence of dynamic (time-varying) spillovers among spot-futures volatilities when petroleum-based commodities are examined pairwise; and among spot-futures volatilities, futures trading volume and open interest when petroleum-based commodities are examined individually. The examined futures contracts are traded on the New York Mercantile Exchange (NYMEX) and include: West Texas Intermediate (WTI) crude oil (CL), New York harbor heating oil (HO) and Reformulated Blendstock for Oxygen Blending (RBOB) gasoline (XB). These futures contracts are included in the empirical analysis of this paper as they exhibit the highest trading volume and account for the vast majority of trades among all energy futures contracts traded in NYMEX (Alizadeh & Tamvakis, 2016).

Prior relevant studies on the research question of this paper include Baruník et al. (2015) who investigate dynamic volatility spillovers across futures markets of petroleum-based commodities. The authors reveal that after 2008 volatility spillovers increased substantially across petroleum-based commodities and exhibit asymmetric effects (positive or negative). However, the authors do not examine both spot-futures volatilities and trading activity measures, such as trading volume and open interest. Furthermore, Barunik and Krehlik (2016) extend the Diebold and Yilmaz (DY) (2009, 2012, 2014) estimation framework and provide empirical evidence highlighting the importance of the proper measurement of dynamics across time and frequencies by emphasizing the important role of cross-sectional correlation in the connectedness origins. In another study, Alizadeh and Tamvakis (2016) investigate spillovers between returns and volatilities of energy futures contracts of different maturities and their corresponding trading volumes. The authors show that the state of the market (contango or backwardation) has an effect on the relationship between futures price volatility and changes of trading volume; making the relationship stronger when the market is in backwardation.[5] However, one

limitation of the previous empirical studies on the issue, with the exception of Baruník et al. (2015), is that they examine static spillover effects without capturing time-variation in spillovers and with no inference regarding "directional" spillovers which can reveal "from/to" receiving/transmitting patterns. This is an important aspect as computing the average spillover effect over a long and turbulent period might mask potential cyclical movements in spillover effects.

The identification of dynamic spillover effects across petroleum based commodities and among spot and futures volatilities, trading volume and open interest has a number of important implications for several market participants.[6] This is because volatility comprises a risk measure and therefore the existence of volatility spillovers across markets can induce a major impact on risk-averse investors (Doran & Ronn, 2008). In this way, the identification of spillovers between spot-futures volatilities and trading characteristics has important implications regarding trading strategies, hedging activities, asset allocation (portfolio construction/rebalancing) and forecasting prices of petroleum based commodities. Moreover, volatility spillovers measure market co-movements which are shown to be more intense during financial crises periods, i.e. volatility increases notably in one market and spills over to other markets (Reinhart & Rogoff, 2008).

This paper contributes to the existing literature in the following ways: First, it investigates for the first time the dynamic spillover effects across petroleum based commodities and among spot-futures volatilities, trading volume and open interest. Trading volume reflects speculative demand for futures, whereas open interest represents hedging activity (Bessembinder & Seguin, 1993). Second, the use of the DY approach enables the estimation of dynamic total and net spillovers; an important feature which has not been applied by the relevant literature on the issue with the exception of Baruník et al. (2015). However, Baruník et al. (2015) concentrate on futures markets volatilities only and not trading characteristics, such as the trading volume and open interest. Third, this paper evaluates whether futures trading volume and open interest carry relevant information for the future variation of spot and futures volatilities (forecast error variance – FEV) and vice versa.

The main empirical findings of this study can be summarized as follows. First, regarding the dynamic volatility spillovers between the spot-futures markets and across petroleum-based commodities when examined pairwise, results suggest that crude oil's futures volatility transmits considerable spillovers to futures volatilities of heating oil (25.8%) and gasoline (24.4%), but much lower shocks to the underlying market of spot crude oil volatility (around 11%). By contrast, heating oil's futures volatility transmits larger spillovers to heating oil's spot volatility (19.6%) rather than to crude oil's future volatility (15.2%), while gasoline's futures volatility transmits larger spillovers to crude oil's futures volatility (18.8%) rather than to gasoline's spot volatility (7.8%). Moreover, the total spillovers are increased during the period 2008 to 2009 and especially after the Lehman Brothers collapse in September 2008 for all pairs of commodities examined (crude oil – heating oil, crude oil – gasoline and heating oil – gasoline).

Second, regarding the dynamic spillovers among spot-futures volatilities, futures trading volume and futures open interest for each petroleum-based commodity individually, results suggest that in the crude oil market trading volume and futures volatility are transmitting large and persistent shocks to the open interest and the spot volatility. This result suggests that speculative pressures as reflected in futures trading volume contain a significant information regarding the future error variance of spot volatility and open interest. However, for heating oil and gasoline commodities, open interest and futures volatility are mainly

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[5] Backwardation is the state of the market when the futures price is below the expected future spot price, i.e. in favour of traders being "net long" in their positions.

[6] This paper focuses on the existence of economic spillovers in the volatilities rather than in the returns of the spot-futures markets of petroleum-based commodities. This is due to the fact that volatilities appear to be more useful in assessing interdependencies since they are well-approximated as Gaussian rather than returns (for details on this, see, Diebold & Yilmaz, 2015).