



On oil-US exchange rate volatility relationships: An intraday analysis[☆]



Fredj Jawadi^{a,*}, Waël Louhichi^b, Hachmi Ben Ameer^c, Abdoukarim Idi Cheffou^d

^a University of Evry, France

^b ESSCA School of Management, France

^c INSEEC Business School, France

^d EDC Paris Business School, France

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ABSTRACT

The aim of this paper is to investigate the dynamics of oil price volatility by examining interactions between the oil market and the US dollar/euro exchange rate. Unlike previous related studies that focus on low frequency data and GARCH volatility measures, we use recent intraday data to measure realised volatility and to investigate the instantaneous intraday linkages between different types and proxies of oil price and US\$/euro volatilities. We specify the drivers of oil price volatility through a focus on extreme US\$ exchange rate movements (intraday jumps). Accordingly, we find a negative relationship between the US dollar/euro and oil returns, indicating that a US\$ appreciation decreases oil price. Second, we note the presence of a volatility spillover from the US exchange market to the oil market. Interestingly, this spillover effect seems to occur through intraday jumps that take place simultaneously in both markets.

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1. Introduction

Oil is at the centre of various industry activities and is an important production factor. Accordingly, oil price shocks have had a significant impact on the real economy at least since the 1970s (i.e. oil shocks of 1973 and 1979). Hence, oil price fluctuations have been the focus of a number of theoretical and empirical studies. In particular, since the seminal work of Hamilton (1983), several studies have examined the impact of oil price movements on economic activity in general and on financial markets in particular, given the major role played by oil in the real economy. Hamilton (1983) highlighted a significant link between the increase in crude oil prices and US recessions over the period 1948–1972. Focusing on the economies of the USA, UK, Japan, Germany and Canada, Burbidge and Harrison (1984) identified the considerable impact of oil price shocks on domestic economic variables. Based on Hamilton's data, Gisser and Goodwin (1986) found a positive link

between oil prices and unemployment. Uri (1996) confirmed this finding for the agricultural sector. More recently, Lardic and Mignon (2006, 2008) found compelling linkages between oil price and economic growth, while Arouri and Jawadi (2010) pointed to a significant correlation between oil price and exchange rate, with a nonlinear relationship. Several other studies have also explored the linkages between oil price and stock markets (Arouri and Jawadi, 2010; Jawadi et al., 2010; Arouri and Rault, 2012; Ftiti et al., 2015; Pönkä, 2016, etc.).

While the impact of oil price movements on economic indicators has been widely investigated, there has been less interest in the determinants of oil price volatility. Indeed, few studies have looked at this issue to date (De Truchis and Keddad, 2016; Zhang and Yao, 2016).

The present paper aims to fill this gap through the investigation of oil price volatility drivers. Our research question is firstly motivated by significant recent oil price fluctuations. Indeed, at the beginning of 2016, the price per barrel of West Texas Intermediate (WTI) crude oil reached 30 US dollars compared to 140 US dollars in June 2008. Interestingly, the decline in oil price has been accompanied by a historical US dollar appreciation against the euro, which raises the question of the link between these two variables: oil price and the US/€ exchange rate. Secondly, oil price dynamics are of great interest to investors as a clearer understanding can help them to enhance their investment and hedging strategies. It is also an important issue for policymakers who

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* Corresponding author at: University of Evry, 2 rue Facteur Cheval, Evry 91000, France.
E-mail address: fredj.jawadi@univ-evry.fr (F. Jawadi).

can use such information to develop efficient monetary policies. Further, a precise analysis of oil price dynamics can help oil exporting countries to better adjust their oil supply.

In the literature, several papers have examined the impact of dollar exchange rate variations on oil prices.¹ Bénassy-Quéré et al. (2007) found that a 4.3% appreciation in the dollar coincides with a 10% rise in oil price. Using a structural VAR model, Akram (2009) found that a weaker dollar exchange rate leads to a hike in oil price. Reboredo and Rivera-Castro (2013) investigated the link between oil price and US dollar exchange rates using a Wavelet multi-resolution analysis. They identified a negative dependence between the two markets during crisis periods. Turhan et al. (2014) analyzed the co-movements of oil price (in US dollars) and exchange rates (US dollar/local currency) of G20 members from 2000 to 2013, and showed that the link between oil prices and exchange rates has intensified in the last decade as they have become strongly negatively correlated.

Beckmann and Czudaj (2013) focused on the causality pattern between oil price and currencies, concluding that the most significant causality runs from exchange rates to oil price. Tantatape et al. (2014) investigated the relationship between U.S. imported crude oil prices and exchange rates. They showed that, in the short-run, exchange rates Granger-cause the price of crude. Moreover, this study revealed that the impulse response of crude oil price to exchange rate shock is negative and significant. However, oil price shocks apparently have no impact on the exchange rate. Recently, Jammazi et al. (2015) examined the link between US dollar exchange rates against 18 currencies and crude oil prices. The authors highlighted an asymmetrical pass-through from exchange rates to oil prices in both the short and the long run, suggesting that negative exchange rate shocks have more impact on oil prices than positive ones.

While the above studies focus on the first moment (returns), another corpus of research has investigated volatility dependence between the oil market and the foreign exchange market. Zhang et al. (2008) found no volatility spillover from the US dollar exchange rate to the oil market. Salisu and Mobolaji (2013), however, indicated bidirectional returns and volatility between the oil market and the foreign exchange market. Using a GARCH model, Ding and Vo (2012) found no interaction between the two markets in the pre-crisis period (before 2008), while a bidirectional volatility interaction between the two markets during the financial crisis is not rejected. Recently, De Truchis and Keddad (2016) used the framework of copula techniques to test weak dependence between the foreign exchange market and the oil market, especially in the long term. Overall, prior related studies offer heterogeneous findings, and the results appear to be sample and data dependent. Phan et al. (2016), however, argued that understanding the determinants of intraday volatility is useful for investors and portfolio managers involved in high frequency trading to better forecast volatility, while Caporin et al. (2016) highlighted intraday volatility spillover between the S&P500 and leading energy commodities markets.

Accordingly, using available exchange rate and oil price intraday data, this paper extends previous studies while at the same time attempting to investigate whether intraday changes in the US/€ exchange rate might drive oil price. In other words, the aim is to determine whether financial investors' and speculators' behaviour might impact on oil price volatility (Du et al., 2011). This approach is original and interesting in that we not only investigate intraday volatility dependence between oil price and the dollar/euro exchange rate, but we also test the impact of abrupt jumps in the dollar/euro exchange rate on oil prices.

The correlation between oil price and US dollar exchange rate volatility is intuitively supported. Further, economic theory seems to

support both negative and positive relationships. Indeed, a negative relationship between oil and the US\$ exchange rate can be justified by further hedging actions by investors when investing in oil and foreign markets. It can also be justified by the fact that with a highly weak dollar and high oil price, investors can invest in other currencies. The positive relationship is due to the fact that international crude oil trading is quoted in US dollars, and any abrupt change in the US\$/€ exchange rate can positively affect oil transactions and consequently oil price, yielding co-jumps in both markets. We therefore expect to find a causality link between US dollar exchange rate volatility and crude oil prices. More specifically, an appreciation in the US dollar exchange rate will increase oil prices for foreigners in their local currencies, which in turn leads to a decrease in demand and a potential fall in the price of oil. Inversely, a weaker US dollar currency can trigger an increase in oil demand, leading to higher oil prices. We therefore expect a negative relationship between oil price and the US dollar exchange rate as documented by Narayan et al. (2008) and Wu et al. (2012).²

Accordingly, our paper differs from previous related literature and makes at least three contributions. First, we use recent intraday data to investigate instantaneous linkages between oil price and the US\$/€ exchange rate, innovating through the application of a non-parametric approach to search for intraday jumps. Second, to our knowledge, our paper is the first attempt to investigate the spillover effect of extreme US exchange rate movements to oil prices through intraday jumps, while proposing a large number of econometric specifications. Third, we test the co-jump hypothesis between oil and foreign markets.

Our intraday analysis offers several findings. First, we highlight a negative relationship between the dollar/euro exchange rate and oil returns, which means that a US dollar appreciation leads to a drop in the price of oil. This result confirms our preliminary suggestion and is in line with portfolio choice expectations (Krugman, 1983; Golub, 1983). Second, we identify significant volatility spillover from the foreign exchange market to the oil market. Indeed, intraday jumps that occur in the foreign market have a real impact on oil market conditional volatility. Finally, we show that intraday jumps occur simultaneously in the dollar/euro currency market and the oil market.

The remainder of the paper is organised as follows. Section 2 presents the data and the methodology. We discuss the main empirical results in Section 3. Section 4 concludes.

2. Data and methodology

2.1. Data and preliminary analysis

Intraday data is obtained from the Bloomberg database. The sample under consideration covers a six-month period from August 2014 to January 2016. We computed 5-minute returns for WTI and for the US dollar/euro exchange rate during this period of study according to the logarithm formula. Table 1 presents the resulting descriptive statistics on returns for both the US/€ exchange rate and oil price.

From Table 1, we note that oil returns exhibit higher standard deviation than dollar/euro returns, suggesting that oil price is more volatile than the US\$/€ exchange rate. Further, the skewness coefficient positivity for both series indicates that both distributions are skewed right, while the positive excess of kurtosis — which is higher for the exchange rate — means that distribution has fatter tails than a normal distribution. Consequently, the Jarque–Bera test significantly rejects the normality hypothesis for both series.

¹ Another corpus of studies has focused on oil prices as an explanatory variable of exchange rate movements (Krugman, 1983; Golub, 1983; Chen and Chen, 2007; Coudert et al., 2008; Narayan et al., 2008, among others).

² It is however important to note that some other studies including Dibooglu (1996); Amano and van Norden (1998); Bénassy-Quéré et al. (2007); Chen and Chen (2007) found a positive relationship between oil prices and the exchange rate.

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