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Oil and the short-term predictability of stock return volatility[☆]

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ABSTRACT

The goal of this paper is to show that crude oil volatility is predictive of stock volatility in the short-term from both in-sample and out-of-sample perspectives. The revealed predictability is also of economic significance, as shown by examining the performance of portfolios constructed on the oil-based forecasts of stock volatility. Results from robustness tests suggest that oil volatility provides different information from traditional macro variables. Further analysis shows that simple linear regression is sufficient for capturing predictive relationships between oil and stock volatility. Oil volatility is found to predict return volatilities of a significant number of industry portfolios during recent periods.

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1. Introduction

Since the seminal work of Schwert (1989a), economic sources of financial volatility have been investigated extensively (e.g., Asgharian et al. (2013); Choudhry et al. (2016); Christiansen et al. (2012); Diebold and Yilmaz (2008); Engle and Rangel (2008); Engle et al. (2013); Nonejad (2017); Paye (2012)). This interest stems from the fact that financial volatility is a crucial input in risk management, portfolio allocation and asset pricing. Financial volatility is also found to successfully predict business cycles, providing early signals of upcoming recessions (Chauvet et al., 2015). However, a recent paper by Paye (2012) shows that although some variables such as treasury spread and default returns can theoretically affect stock volatility, it is difficult to find an individual variable that can predict stock volatility. In detail, adding any macro variables to the benchmark autoregressive model cannot significantly improve out-of-sample forecasting performance. The failure of individual fundamental variables in forecasting stock volatility is further confirmed by more comprehensive analyses conducted by Christiansen et al. (2012), unless some modeling issues such as parameter instability and model uncertainty are addressed (Nonejad, 2017).

In this paper, we show that a new variable, crude oil volatility, can be strongly predictive of stock volatility. We demonstrate that oil volatility improves the short-horizon predictability of stock volatility over the autoregressive benchmark model. This predictability is significant during various sample periods. Our investigation complements studies of modeling and forecasting volatility by providing a new fundamental determinant of stock volatility. Our findings are helpful for understanding the economic sources of changes in stock volatility.

Various studies have investigated the relationship between oil and stock volatility (see, e.g., Degiannakis et al. (2014); Arouri et al. (2011, 2012); Creti et al. (2013)). Most papers take an in-sample perspective using multivariate GARCH models. However, it

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is commonly understood that good *in-sample* performance does not imply that the predictive model displays superior *out-of-sample* performance. We contribute to the literature by paying attention to the ability of oil to predict stock volatility from an *out-of-sample* perspective. We employ a parsimonious predictive regression based on realized volatility to provide forecasts, the superiority of which over the GARCH has been well documented in the literature.

Our paper is closely related to Driesprong et al. (2008), who find that changes in oil prices predict stock returns *in-sample*. We complement their work by showing that oil volatility can also predict stock volatility both *in-sample* and *out-of-sample*. This paper is also linked to Chen et al. (2010), who show that commodity prices cannot predict asset prices such as exchange rate. We provide a novel example whereby the volatility of a special commodity, crude oil, is shown to have predictive power over stock return volatility. We extend the idea of Chen et al. (2010) to a volatility case and obtain different results.

We use daily data spanning January 1990 to December 2015 for the S&P 500 index and prices of West Texas Intermediate (WTI) and Brent oils. We use simple predictive regressions for realized volatility of stock index and take past oil volatility as a predictor in addition to lagged stock volatility. The squared daily returns in each month are summed to construct monthly realized volatility. Our in-sample results indicate significant Granger causality from oil volatility to stock volatility. An increase in current month's oil volatility can result in a significant increase in next month's stock volatility. WTI oil volatility provides greater in-sample predictive power than Brent oil volatility; possibly and plausibly because WTI oil is more closely related to the U.S. economy.

We use both recursive and rolling estimation window to generate one-step-ahead out-of-sample forecasts of stock volatility for January 1996 through December 2015. We compare the out-of-sample forecasting performance of oil models for stock volatility with the benchmark autoregressive model to detect the information content of oil. In addition to the standard regression, we impose an economic constraint on the coefficient of oil volatility in the forecasting procedure. In detail, according to standard economic theory, oil price uncertainty should have positive effects on stock uncertainty. If the sign of the oil volatility coefficient is not consistent with economic theory (i.e., negative), we abandon the oil model forecasts and instead use the benchmark alternatives. The similar parameter restriction method has hitherto been applied in stock return forecasting studies (Campbell and Thompson, 2008; Pettenuzzo et al., 2014). The rationale is that the "abnormal" coefficient sign implies that the variable of interest is not a determinant of the dependent variable. The incorporation of irrelevant variables in the predictive regression is likely to cause overfitting, manifesting itself as improved in-sample performance but inferior out-of-sample performance.

Following the literature (Paye, 2012; Goyal and Welch, 2008), we use the out-of-sample R^2 (ΔR^2_{OOS}) to evaluate out-of-sample performance. This criterion measures the percentage decrease in the mean squared predictive error (MSPE) of the model of interest relative to the MSPE of the benchmark model. A positive ΔR^2_{OOS} implies that the model of interest produces more accurate forecasts. The Clark and West (2007) statistic is used to test the equivalence of MSPEs between two nested models. We find significant predictability from WTI oil to stock volatility over each of a variety of sample periods. Imposing economic constraints on coefficients improves predictive ability moderately when a rolling window is used.

We also explore the economic significance of the volatility predictability. We consider an investor with mean–variance utility who allocates his/her wealth between the stock index and risk-free Treasury bill, where the volatility forecast is a key input in computing optimal *ex-ante* stock index weights. The usefulness of volatility forecasts is evaluated by observing portfolio performance. We compare the utility of a portfolio constructed on volatility forecasts of oil models with the utility of an alternative constructed on benchmark forecasts. Our results indicate that accounting for oil volatility information improves portfolio performance. Notably, the percent increase in portfolio utility of oil model relative to that of the benchmark model is as high as 79% during the 2001–2005 period.

To explore whether oil volatility information has been covered by macro variables considered in the literature, we use 12 fundamental variables reflecting stock market activity to carry out the robustness analysis. These fundamental variables are regularly used in studies of return and volatility forecasting (Rapach et al., 2010; Neely et al., 2014; Christiansen et al., 2012; Zhu and Zhu, 2013). We put these variables in the benchmark of autoregressive model and investigate whether oil volatility information still improves the predictive ability of these amended models. Our empirical results indicate that the reduction of MSPE is significant after taking advantage of oil information for different benchmark models. Furthermore, we also consider the uncertainty variables developed by Ludvigson et al. (2015) and Jurado et al. (2015). The out-of-sample predictability from oil to stock volatility becomes weaker after using economic uncertainty as a control variable. Nevertheless, significant predictability still exists during more recent periods. Therefore, the revealed out-of-sample predictability is generally robust to alternative benchmarks. Oil information does not substantively overlap with traditional macro information.

Our empirical analysis is further extended to nonlinear models. We consider two types of nonlinear relationships including asymmetric oil models and regime switching models. In summary, we find little evidence supporting the superiority of nonlinear models over linear specifications in forecasting stock volatility. Our forecasting exercise is also conducted for longer horizons. We find significant predictability for horizons of 3 and 6 months. However, the predictability disappears for longer horizons. A plausible explanation for this is that the response of stock prices to oil information completes within a short period of time (Wang et al., 2013). Oil volatility is further found to predict the return volatilities of a significant number of portfolios during more recent periods.

The predictability of stock volatility revealed by oil volatility can be explained by information transmissions from oil to stock markets. Crude oil is a core input in modern industry. Oil price shocks can certainly lead to changes in stock prices by affecting real economic activities (Hamilton, 1983; Kilian, 2009), current and future cash flows (Jones and Kaul, 1996) and monetary policy (Bernanke et al., 1996). In addition to transmissions of price information, there are three channels for transmitting oil volatility information to stock volatility. The first is the business cycle channel. It has been well documented in the literature that stock volatility is always higher when the economy undergone a recession (Schwert, 1989b; Hamilton and Lin, 1996). Because of the great importance of crude oil for the real economy, the large increase in oil price (i.e., high volatility) is an important factor driving

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