Energy Economics 48 (2015) 336–349

Contents lists available at ScienceDirect

Energy Economics

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

Inventory announcements, jump dynamics, volatility and trading volume in U.S. energy futures markets

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ARTICLE INFO

Article history:
Received 23 March 2013
Received in revised form 5 November 2014
Accepted 10 November 2014
Available online 31 December 2014

JEL classification:
C32
G13

Keywords:
Realized variation
Bipower variation
Intraday jump statistics
Energy futures price
Trading volume behavior and inventory news events

ABSTRACT

This paper applies nonparametric methods to identify jumps in daily futures prices and intraday jumps surrounding inventory announcements of crude oil, heating oil and natural gas contracts traded on the New York Mercantile Exchange. The sample period of our intraday data covers January 1990 to January 2008. We have obtained several interesting empirical results. (1) Large volatility days are often associated with large jump components, and large jump components are often associated with the Energy Information Administration's inventory announcement dates. (2) The volatility jump component is less persistent than the continuous sample path component. (3) Volatility and trading volume are higher on days with a jump at the inventory announcement than on days without a jump at the announcement. Furthermore, the intraday volatility returns to normal faster following inventory announcements with jumps than after announcements without jumps.

1. Introduction

Observers of energy futures markets have long noted that energy futures prices are very volatile and often exhibit jumps (price spikes) at news releases. Thus, the assumption of a continuous diffusion process for asset price behavior is often violated in practice. Volatility behavior is the central topic for option pricing (Merton, 1976a,b), risk measurement and risk management (Duffie and Pan, 2001) and asset allocation strategies (Jarrow and Rosenfeld, 1984). Therefore, market participants, regulators and academics have a strong interest in the identification of jumps over time and measuring the relative importance of the jump component versus the smooth sample path component as contributors to total volatility.[1] Motivated by the increase in the availability of high-frequency data (tick by tick data) Barndorff-Nielsen and Shephard (2004, 2006) and Jiang and Oomen (2008) have developed nonparametric procedures for detecting the presence of jumps in high-frequency intraday financial time series. Jiang and Oomen (2008) show that these two nonparametric methods can be combined to produce a test that remains powerful but more robust to noise in the price series. Lee and Mykland (2008) developed an alternative nonparametric test that yields both the direction and size of detected jumps at the intraday level. Most importantly, the test allows for identification of exact timing of the jump. Despite this, there has been no empirical work using this newly developed procedure to investigate the presence of jumps over time, jumps associated with inventory announcements and the relative contribution of jumps to the volatility of energy futures prices and trading volume behavior surrounding inventory announcements with and without jumps. This paper seeks to fill this gap in the literature.

Literature using nonparametric methods to identify jumps includes Huang and Tauchen (2005), who apply a procedure by Barndorff-Nielsen and Shephard (2004, 2006), and provide evidence that jumps account for 7% of the realized variance in the S&P 500 index. Tauchen and Zhou (2006) use bipower variation to identify realized jumps on financial markets and to estimate parametrically the jump intensity, mean and variance. Using the same nonparametric approach, Andersen et al. (2007) provide empirical evidence that the volatility jump component is both highly significant and less persistent than the continuous

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[1] Andersen et al. (2007) have examined the effects of accounting for jumps in realized volatility model for forecasting US T-Bonds, DM/$ and S&P 500 markets. They use the HAR-RV-J model to demonstrate the impacts of jump components on daily, weekly and monthly ahead forecasts (see pp. 705–709). They find that the coefficients of jumps are negative and significant, and the magnitude of negative coefficients decreases as the forecasting horizon moves from daily to monthly. In short, jump components have a reversal effect on daily, weekly and monthly forecasting.

http://dx.doi.org/10.1016/j.eneco.2014.11.006
0140-9883/

sample path component in the foreign exchange rate spot (DM/$) market, U.S. S&P 500 index futures and thirty-year U.S. Treasury bond futures.[2]

Previous literature documents that jumps in asset prices are often associated with major news releases. Barndorff-Nielsen and Shephard (2006), for example, document that days with a jump in the DM/$ foreign exchange market can be linked with macroeconomic news. This is consistent with findings by Andersen et al. (2007), who report that macroeconomic announcements lead to large intraday price moves in a dataset from the foreign exchange markets. Lee and Mykland (2008) introduce a new nonparametric jump statistic and find a strong association between jumps and news events in the U.S. equity markets. Johannes (2004) uses a parametric approach and shows that jumps in daily Treasury bill rates are associated with specific news. Jiang et al. (2008) find that about 70% of the jumps in the U.S. Treasury markets occur at prescheduled macroeconomic announcements.

Volatility behavior of energy futures prices has been investigated by Pindyck (2004), Linn and Zhu (2004), Chan et al. (2010), Mu (2007), Wang et al. (2008) and others. Pindyck (2004) documents a significant positive trend in natural gas futures during the sample period from May 2, 1990 to February 2, 2003. Chan et al. (2010) study the common jump dynamics in natural gas futures and spot markets within a bivariate autoregressive jump intensity GARCH framework. They particularly examine the role of weather as a short-run demand factor and inventory as a short-run supply factor in explaining price spikes and time varying volatility in spot and futures returns. Mu (2007) finds that extreme weather conditions and low inventories are important factors affecting natural gas futures volatility within a single equation model with a GARCH error process. Wang et al. (2008) examine the realized volatility and correlation of crude oil and natural gas futures. They provide evidence that realized crude oil futures volatility increases in the weeks immediately before OPEC recommends price increases.

Previous papers that examine price behavior and volatility surrounding inventory announcements of energy stocks include Linn and Zhu (2004), Gay et al. (2009), Halova et al. (2014) and others. Linn and Zhu (2004) report an increase in volatility before and after the release of inventory reports by the Energy Information Administration. Gay et al. (2009) demonstrate that 1% unexpected increase in natural gas inventory results in an approximately 1% drop in the natural gas price. Furthermore, they provide evidence that prices react strongest to forecasts of analysts with better prior forecast accuracy. Halova et al. (2014) provide evidence that previous estimates of the impact of oil and gas inventory surprises' effect on oil and gas price behavior suffer bias due to measurement error in inventory surprises. After correcting the measurement error in the inventory surprise, they show that energy prices are more strongly influenced by unexpected changes in inventory than shown in previous research. However, none of these papers have identified jumps over time and examined the association of jumps with inventory announcements and the behavior of trading volume surrounding inventory announcements with and without jumps.

This paper makes several contributions to the literature on detecting jump components and in analyzing the time series properties of jumps in energy futures prices. First, we examine the realized volatility behavior of natural gas, heating oil and crude oil futures contracts traded on the New York Mercantile Exchange (NYMEX) using high-frequency intraday data from January 1990 to January 2008. Second, using nonparametric test statistics proposed by Barndorff-Nielsen and Shephard (2006) and Jiang and Oomen (2008), we identify significant jump components in energy futures prices and estimate the relative contribution of jumps to the realized variance in these three futures contracts. Third, we identify whether significant jumps often occur during the Energy Information Administration's (EIA) inventory announcement time periods with and without announcement surprises. Fourth, we investigate the behavior of volatility and trading volume during the announcement periods with jumps, announcements without jumps and on days with no announcements and no jumps. Finally, we demonstrate that there is a positive relationship between trading volume and jump components.

The remainder of the paper is organized as follows. Section 2 provides the background of the statistical methodology used in this paper. Section 3 describes the data, the contract specifications of the three energy futures and the timing of EIA's inventory announcements. Empirical results are reported in Section 4, and Section 5 presents a summary and conclusions.

2. Background of statistical methodology

2.1. Asset price dynamics and jumps statistics

Let $X_t = \log S_t$ denote the logarithmic price where S_t is the observed price at time t. Assume that the logarithmic price process follows a continuous-time diffusion process X_t coupled with a discrete process defined as,

$$dX_t = \mu_t\,dt + \sigma_t\,dW_t + \kappa_t dq_t, \tag{1}$$

where μ_t is the instantaneous drift process and σ_t is the diffusion process; W_t is the standard Wiener process; dq_t is a Poisson jump process with intensity λ_t, that is $P(dq_t = 1) = \lambda_t dt$; and κ_t is the logarithmic size of the price jump at time t if a jump occurred. If X_t denotes the price immediately prior to the jump at time t, then $\kappa = X_t - X_{t-}$.

2.2. Bipower variation

Barndorff-Nielsen and Shephard (2004, 2006) propose a number of nonparametric statistics based on realized power variations to test for jumps and to estimate the contribution of jumps to the total variation. Specifically, the statistics are based on the difference between two estimators of the integrated daily cumulative variation. The realized (quadratic) variance is defined as the sum of squared intraday returns,

$$\mathrm{RV}_t = \sum_{j=1}^{m_t} r_{t_j}^2, \tag{2}$$

where m_t is the number of intraday Δ-returns during the tth trading day and is assumed to be an integer; and r_{t_j} is the intraday logarithmic return. Jacod and Shiryaev (1987) show that the realized variation converges to the integrated daily variation under the assumption that the underlying process follows Eq. (1) without jumps. Furthermore, in the presence of jumps ($\lambda > 0$), the realized variance converges in probability to the total variation as $\Delta \rightarrow 0$,

$$\mathrm{RV}_t \xrightarrow{p} \int_{t-1}^{t} \sigma_s^2\,ds + \sum_{t-1<s<t} \kappa^2(s). \tag{3}$$

Hence, the realized variance captures the variance of both the continuous and the discrete processes. A second estimator of the integrated daily variance is the *realized bipower variation*, which is defined as,

$$\mathrm{BV}_t = \frac{\pi}{2}\frac{m_t}{m_t - 1}\sum_{j=2}^{m_t} |r_{t_j}||r_{t_{j-1}}|. \tag{4}$$

[2] Recent literature based on parametric approaches to identify and model jumps in stock returns includes Chan and Maheu (2002), Maheu and McCurdy (2004) and others. Chan and Maheu (2002) propose an autoregressive conditional jump intensity within a GARCH model approach to detect and model jumps in seventy-two years of daily stock returns. They find a significant time variation in the conditional jump intensity and in the jump size in stock returns during the sample period. Maheu and McCurdy (2004) model conditional variance of returns as a combination of jumps and smoothly changing components.