China’s crude oil futures: Introduction and some stylized facts

Qiang Ji, Dayong Zhang

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ABSTRACT

The launching of China’s first crude oil futures contract has marked the start of a new era in the international energy market. Using high frequency transaction data in the first two trading months since its inception in March 2018, this paper seeks to present some fresh and interesting stylized facts about this new comer. Evidence shows that, first, significant jumps exist in the realized volatility; Second, trading volumes have shown clear multiple u-shape patterns, which is consistent with the literature on intraday seasonality. Finally, we document a statistically significant return-volume relationship in the market.

1. Introduction

On 26 March, 2018, China launched its first ever crude oil futures in the Shanghai International Energy Exchange (INE). After years of preparation, planning and discussion, the RMB (Yuan) denominated oil futures contract is now available to both domestic and international investors.

The new crude oil futures contract is based on a basket of medium and heavy crudes extracted from the Middle East and China with a higher sulfur content, whereas the other two well-known benchmark prices, WTI and Brent, are based on all light low-sulfur oil. The new crude oil futures contract has some distinctive features when compared to, for example, the seven grades of deliverable crude oil, namely, Dubai crude oil, Upper Zakum crude oil, Omen crude oil, Qatar marine crude oil, Masila crude oil, Basrah light and Shengli crude oil. First, trading hours are different. There are three segmented trading hours for the new futures contract, which are day trading hours between 9:00 and 11:30, 13:30 and 15:00 local time and night trading hours between 21:00 and 2:30 (t + 1). Second, there is a 4% daily price change limit. Third, the transaction fee is noticeably higher than other main oil futures contracts.

The introduction of this new Yuan-dominated crude oil contract is critically meaningful to China’s companies. Being the largest oil importer in the world and the seventh largest producer, China has had long-standing and increasing needs of hedging oil price risks. This Yuan-dominated crude oil contract allows local companies to hedge more effectively in domestic currency. From a broader

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Communicating author.
E-mail address: dzhang@swufe.edu.cn (D. Zhang).

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perspective, there have been a lack of effective benchmark prices in Asia, which is often considered the cause of the well-known “Asian Premium” (see for example, AlKathiri et al., 2017; Zhang et al., 2018) in both oil and natural gas markets. While some other Asian countries, such as Japan and Singapore, have been trying to form oil pricing benchmarks, none of them has succeeded yet. Skeptical views have also been cast on whether China can outpace other countries and become the first price benchmark in Asia. Another major argument about the meaning of China’s crude oil futures is its important role in pushing the internationalization of RMB. The success of China’s crude oil futures is expected to further reinforce the importance of RMB in international trades and create a new petrocurrency. Clearly, China has had all the necessary elements contributing to the success of its first crude oil futures. It has the long-standing demand for oil futures to meet its hedging need, supply of speculative traders to provide liquidity, and also the experience and ability to regulate the market. All these preconditions, together with the strong incentives of the China’s central government, may increase the possibility that the Shanghai crude oil futures will join Brent and WTI to be an international benchmark price.

The question is whether the market will accept this change. Two months now since its first launch, it is interesting to see how the Shanghai crude oil futures has worked. The first glance of the data is that average daily trading volume in Shanghai for the September delivery contract has exceeded the Omen contract traded in Dubai Mercantile Exchange, though it is still much smaller than that of WTI or Brent. Although it is too early to gather long enough time series data for a proper econometric analysis, high frequency intraday data in the first 40 trading days already allows us to gather some preliminary information, which is crucially important for both investors and regulators to see the progress.

The main purpose of this paper is therefore to use the currently available information to conduct a first ever analysis on various issues, such as volatility characteristics, intraday seasonality and volatility-volume relationships. Specifically, we explore one-minute trading data and use some recently developed empirical methods to formally analyze the issues of interest and summarize a set of stylized facts. The results, although yet to be improved with more data, hope to provide investors, regulators and academia with fresh and valuable information to understand China’s new crude oil futures.

The remaining part of this paper starts from a simple introduction of methods used for measuring realized volatility and testing for jump components. Section 3 reports the source of data and the empirical results. The last section concludes.

2. Realized volatility and jump detection

Volatility modeling is one of the most important aspects for the futures market. High frequency data have been widely used to model and forecast volatility in futures market (for example, Chevallier and Sévi, 2012; Gao et al., 2018; Sévi, 2014). The methodology used in this paper mainly follows Busch et al. (2011). We use one-minute frequency trading data to calculate realized volatility and then test whether there are significant jump components.

Realized volatility, defined by Andersen and Bollerslev (1998), is the sum of intraday squared returns:

$$RV_{t,m} = \sum_{j=1}^{m} r_{t,j}^2, \text{ for } t = 1, \ldots, T$$

(1)

where \( r_{t,j} \) is one-minute return and \( m \) is the number of intraday trading periods. It is known that the realized volatility may have \( N \) discontinuous jump components with size denoted as \( \kappa_{t,j} \), then we can write:

$$RV_{t,m} \rightarrow \int_{t-1}^{t} \sigma^2(s)ds + \sum_{j=1}^{N} \kappa_{t,j}$$

(2)

Barndorff-Nielsen and Shephard (2004, 2006) propose the bi-power variation (BPV) measure to disentangle jumps from the continuous components such as:

$$BPV_{t,m} = \mu_1^{-2} \frac{m}{m - (k + 1)} \sum_{j=k+2}^{m} \kappa_{t,j} \| r_{t,j-k-1} \|$$

(3)

where \( \mu_1 = \sqrt{1/\pi}, k = 0 \) for non-staggered BPV estimation such as Chevallier and Sévi (2012). The jump components are therefore \( \max[RV - BPV, 0] \). Following Andersen et al. (2007) and Huang and Tauchen (2005), a ratio statistic can be constructed as:

$$Z_t = \sqrt{m} \frac{(RV_t - BPV_t)RV_t^{-1}}{\sqrt{\mu_1^{-1} + 2\mu_1^{-2} - 5}\max[1, TQ_tBPV_t^{-2}]}$$

(4)

where \( TQ_t \) is the staggered tripower quarticity:

$$TQ_t = \mu_2^{-3} \frac{m^2}{m - 2(k + 1)} \sum_{j=2k+3}^{m} \| r_{t,j} \|^{4/3} \| r_{t,j-k-1} \|^{1/3} \| r_{t,j-2k-2} \|^{4/3}$$

(5)

$$\mu_2 = 2^{2/3} \Gamma(7/6) / \Gamma(1/2),$$

and the ratio statistic follows a standard normal distribution.
3. Data and results

3.1. Data description

Intraday data with one-minute frequency is collected from the Shanghai International Energy Exchange between the first launching day and 25 May 2018 for the main contract SC1809. This gives us totally 40 days and 22,200 observations. A simple time series plot in daily frequency is given in Fig. 1, which shows both closing price (panel a) and trading volume (panel b).

A clear fall of prices in the early couple of weeks can be seen but after that price quickly went up in an upward trend to around 485 Yuan/barrel (equivalent to 75.66 US dollar per barrel), whereas the prices on the same day (25 May 2018) for Brent September contract was 76.14 US dollar per barrel and WTI crude oil futures price was 67.45 US dollar per barrel. Trading volumes increased modestly in the first month with high volatility but experienced a clear boom after 27 days to around 100,000 contracts.

3.2. Realized volatility and jump components

Daily realized volatility, the BPV jump robust volatility (panel a) and statistically significant (at 1%) jumps (panel b) are plotted in Fig. 2. Not surprisingly, the realized volatilities were high in the early few trading days and then fell slowly. According to the statistical tests, quite a few jump components existed and the biggest one was on 8 May, which was the day when US president Trump announced that the US would exit the Iran nuclear agreements.

3.3. Intraday seasonality

Another important stylized fact in China’s crude oil futures is its intraday seasonality. A U-shaped trading pattern has frequently been documented in the literature demonstrating a relatively high volume/volatility when market opens and closes (see for example, Iwatsubo et al., 2018, for the discussion of relevant literature). Whether similar patterns exist in China’s new crude oil futures is worth further exploration as it has three segmented trading periods. Fig. 3 provides a simple graphic plots for returns and trading volumes (averagely across 40 trading days).

It is clearly seen that both series demonstrate clear seasonal patterns. It can be summarized as having had a multi-U-shape pattern. Significantly higher level of trading volume can be observed in the morning starting period, afternoon closing time and the starting...
period of night trading sessions. These periods are also featured with clear higher return volatility. A very interesting observation from the graph is the sharp increase in trading volume and return volatility at 22:31 China local time, corresponding to 10:31 New York time and 9:31 Chicago time. Although it is too early to form a conclusion, this interesting pattern certainly implies a possible influence from international investors, especially US investors.

Table 1 provides additional information on the 40-day average of intraday return and volume patterns for different trading periods. The numbers reported in Table 1 can also convey some interesting information. First of all, morning sessions tend to have highest average returns, whereas night trading period has the highest return volatility. Clearly, trading volume during the night session is much higher than those during the other two sessions. Given the fact that trades during night trading sessions are mainly performed by international investors, it further confirms our projection that international market participants tend to have high impacts on China’s crude oil futures.

3.4. Return-volume relationship

Return-volume relationship is also a crucial point for investors in the futures market. Using 40-days average one-minutes data, we setup a simple bi-variate vector autoregressive (VAR) model to investigate how these two factors link with one another. Using Akaike information criteria (AIC) to choose the optimal lag, five lags are used for the model. The pairwise Granger causality test indicates a significant causal relationship from return to trading volume (F-statistic = 3.61), whereas the opposite causality does not exist. The generalized impulse response function is shown in Fig. 4 and a negative and statistically significant response of volume to return can be seen. The largest response is found in three lags.

4. Conclusion

The launching of crude oil futures by the Shanghai International Futures Exchanges has attracted intensive attention from both practitioners and academia. Its strategic importance to the Chinese government and the unique features of its host country has made it an important asset since the very beginning. This paper seeks to provide a first-hand empirical investigation of what happened in the last two months and summarize some stylized facts using standard techniques in futures studies. Although not perfect/robust given the sample size, our results show some interesting characteristics and hope to serve as a foundation for further analysis.

Starting with volatilities, it is not surprising to see that China’s first crude oil futures contract had high level of volatility in the first few trading days. It fell significantly after the first couple of weeks. There is however, clear evidence that jump components

### Table 1
Summary statistics for intraday patterns.

<table>
<thead>
<tr>
<th></th>
<th>Full day</th>
<th>Morning</th>
<th>Afternoon</th>
<th>Night</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Return</td>
<td>Volume</td>
<td>Return</td>
<td>Volume</td>
</tr>
<tr>
<td>Mean</td>
<td>0.0002</td>
<td>197.2287</td>
<td>0.0015</td>
<td>128.7030</td>
</tr>
<tr>
<td>Std. dev.</td>
<td>0.0091</td>
<td>148.5468</td>
<td>0.0069</td>
<td>111.8344</td>
</tr>
<tr>
<td>Skewness</td>
<td>−0.4174</td>
<td>3.1046</td>
<td>0.5448</td>
<td>6.8995</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>4.2463</td>
<td>22.6554</td>
<td>4.9863</td>
<td>63.7529</td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>52.0347</td>
<td>9285.5620^a</td>
<td>28.8692</td>
<td>21832.4600^a</td>
</tr>
<tr>
<td>Observations</td>
<td>555</td>
<td>555</td>
<td>135</td>
<td>135</td>
</tr>
</tbody>
</table>

^a Denotes 1% level of significance for the Jarque-Bera test.
existed throughout the whole trading period. The size of jumps was higher in both the first few days and the largest corresponds to a major exogenous shock in the international markets.

Consistent with the existing literature on asset intraday seasonality, we also demonstrate clear evidence of the U-shaped patterns in both volume and returns. Due to the special features of trading hours, the intraday seasonal patterns are multiple-U-shape, applicable to each trading period. In other words, higher trading volume/return volatility were observed in all starting periods and closing periods. Our results also show an interesting within period U-shape corresponding to 22:31 Beijing time, which can be interpreted as potential US market participation.

Finally, a simple VAR model with Granger causality test shows that a one-directional causality from return to volume exists, and the relationship is significant and negative. In other words, higher returns in the market tend to reduce trading volume.

In general, this paper provides a set of fresh information on the stylized facts in China’s new crude oil futures market. Given the number of trading days and limited information, our results should be taken with caution. Notwithstanding, to the best of our knowledge it is the first empirical summary of a potentially influential oil futures and provides interesting information to both investors and regulators. With further development of this new futures and more information available, we hope this area of research will be more intensively studied based on the foundation laid by our analysis.

References


