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ScienceDirect

Energy Procedia 104 (2016) 462 – 467

Energy Procedia

CUE2016-Applied Energy Symposium and Forum 2016: Low carbon cities & urban energy systems

Analyzing the risk-return relationship in crude oil futures market using high-frequency data

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Abstract

We comprehensively examine the contemporaneous/intertemporal risk-return relationship in the crude oil futures market. Our empirical results, based on high-frequency transaction data, suggest the contemporaneous relation between risk (volatility risk, downside risk or jump risk) and return in the crude oil futures market is negative and statistically significant, and the contemporaneous negative relation between downside risk and return is stronger than two others. However, the intertemporal volatility/jump risk-return relationship is insignificant, and there is weak negative correlation between downside risk and excepted return in the crude oil futures market.

Peer-review under responsibility of the scientific committee of the Applied Energy Symposium and Forum, CUE2016: Low carbon cities and urban energy systems.

Keywords: Risk-return relationship; Volatility risk; Downside risk; Jump risk; High-frequency data

1. Introduction

The crude oil market is an indispensable part of the economic system [1]. The crude oil is the foundation of a nation's economic development [2][3]. Thus, analyzing the crude oil futures has attracted considerable attention from academics, governments and investors.

Among the various research topics on the crude oil futures, estimating the risk-return relationship in crude oil futures market is of special interest for energy researchers. However, the researchers' empirical evidence is mixed. Some researchers found that the relation between risk and return in crude oil futures market was positive. Considine and Larson [4] applied a stochastic model to test the existence

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Peer-review under responsibility of the scientific committee of the Applied Energy Symposium and Forum, CUE2016: Low carbon cities and urban energy systems.
doi:10.1016/j.egypro.2016.12.078

of risk premia on crude oil and natural gas. Their empirical results provide rather strong support for the existence of risk premia on crude oil market and natural gas. Recently, Cifarelli and Paladino [5] used a univariate GARCH(1,1)-M model to estimate the volatility risk premium. The evidence suggested there were positive feedback trading and positive volatility risk premium in the oil market. However, a number of studies support the contention that the risk premia is negative. Trolle and Schwartz [6] studied variance risk premia in crude oil and natural gas market by using a robust model-independent approach. Their empirical results indicated the average variance risk premia were significant negative for crude oil market. Li et al. [7] found a intertemporal negative relation between return on the price of oil futures and volatility components. Kristoufek [8] also found the correlation between returns and volatility risk of both Brent and WTI crude oils were negative.

The research results from above studies are inconsistent, and accurately estimating the risk-return relationship in crude oil futures market becomes a challenging work. In this paper, we will comprehensively analyze the relationship between contemporaneous/ intertemporal risk and return in the crude oil futures market. Compared with the existing literature, our study has the following advantages. Firstly, our research is more comprehensive. We examine both the contemporaneous risk-return relationship and intertemporal risk-return relationship in the crude oil futures market. Secondly, the existing studies focus mainly on the correlation between volatility risk and return of the crude oil futures. However, we not only estimate the volatility risk-return relationship but also investigate the downside/jump risk-return relationship in the crude oil futures market. Thirdly, we use the high-frequency transaction data to measure the volatility, downside and jump risks of crude oil futures. The high-frequency transaction data contains far more information than the low-frequency transaction data, which is able to more accurately measure the risks. Thus, our empirical results are more reliable.

The remainder of this paper is organized as follows. In the next section, we measure the volatility, downside and jump risks. Section 3 describes the data. In Section 4, we estimate the relationship between contemporaneous risk and return in crude oil futures market using high-frequency transaction data. Section 5 analyzes the relationship between intertemporal risk and return in crude oil futures market through high-frequency data. Section 6 provides the conclusions.

2. Alternative Risk Measures

2.1 Volatility Risk

The volatility risk in financial market cannot be observed, and it needs to use a method to measure. In this paper, we choose the realized volatility ([9], [10] and [11]) to measure the volatility risk of the crude oil futures. The daily realized volatility can be written as

$$RV_{t'}^{d}=\sum_{i=1}^{M} r_{t',i}^{2} \tag{1}$$

where $r_{t',i}$ is the i[th] return (i=1, ・・・, M) in day t'. $P_{t',i}$ is the i[th] closing price in day t'.

In Corsi [12], he used the average realized volatility between day t' and $t'+H$ (where H is the number of days in a month) to measure the monthly realized volatility. Following [12], the monthly volatility risk VR_t is defined as

$$VR_t = RV_t^m = \frac{RV_{t',1}^{d} + RV_{t',2}^{d} + \cdots + RV_{t',H}^{d}}{H} \tag{2}$$

2.2 Downside Risk