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Interpreting the crude oil price movements: Evidence from the Markov regime switching model

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HIGHLIGHTS

- We investigate the movement regimes of Brent and WTI crude oil prices.
- The Markov regime switching model with dynamic autoregressive coefficients is used.
- There are three regimes in both Brent and WTI crude oil price movements.
- Brent mainly stays in the "sharply upward" regime after the financial crisis.
- WTI tends to stay in the "relatively stable" regime after the financial crisis.

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ABSTRACT

Since 2009, global financial crisis has eased gradually and world economy has begun to recover slowly. Meanwhile, both Brent and WTI (West Texas Intermediate) crude oil prices have entered into a new round of increase and volatility, and the abnormal price spreads between them have been identified. Under this circumstance, this paper employs the Markov regime switching model with dynamic autoregressive coefficients to explore the price regimes of Brent and WTI after the financial crisis. Then it analyzes the causes of the abnormal spreads between the two benchmark crude oil prices based on the statistical observations of their typical regime differences. The results show that there are three main regimes in both Brent and WTI crude oil price returns, i.e., sharply downward, slightly downward and sharply upward regimes for Brent whilst sharply downward, relatively stable and sharply upward regimes for WTI. Meanwhile, the typical price regimes of Brent and WTI are the "sharply upward" and "relatively stable" regimes after the financial crisis, respectively. Besides, their different movement regimes in recent years are mainly attributed to their different market fundamental situations and the dynamics in crude oil markets, which also lead to the occurrence of their abnormal price spreads.

1. Introduction

Crude oil is one of the most important energy sources for the global socio-economic development and an important investment product with significant financial characteristics in recent years. Therefore, the price changes of crude oil have drawn significant attention of academia, policy makers and oil market investors [1]. While world economy has gradually recovered from the severe financial crisis since 2009, the benchmark crude oil (Brent and WTI) prices have meanwhile rebounded quickly from less than $40 per barrel to nearly $100 per barrel by 2013 and remained up-and-down at a relatively high level. Moreover, in the post-financial crisis era, the confluence of uncertain sovereign debt crises in the Eurozone, instable economic prospects in the US and frequent geopolitical events in the Middle East and North African regions has caused intense volatility of crude oil prices, which exaggerates the complexity of crude oil markets and poses great threats to investors and regulators in crude oil market [2,3].

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Table 1
Typical literature about the volatility of Brent and/or WTI crude oil prices.

Typical literature	Models	Main results
Narayan and Narayan [6]	The EGARCH model	The external shocks have permanent and asymmetric effects on volatility and the behavior of crude oil prices tends to change over short time periods during 1991–2006
Agnolucci [7]	The GARCH models and the implied volatility (IV) models	The model combining both GARCH models and IV models has a high power to forecast crude oil futures price volatility.
Wei et al. [8]	Several linear models and GARCH-class models	The GARCH models exhibit greater forecasting accuracy than the linear ones in capturing long-memory and/or asymmetric volatility
Hou and Saurdi [9]	A GARCH model involving nonparametric method and common GARCH models	The nonparametric GARCH model outperforms in forecasting accuracy
Arouri et al. [10]	The GARCH-class models	There are five models with parameter instability out of nine GARCH-based conditional volatility processes for oil prices, and a FIGARCH model seems to better fit the data
Chang et al. [11]	The CCC model, VARMA-GARCH model, VARMA-AGARCH model and DCC model	There is no evidence to support assumptions of constant conditional correlations, and there is little evidence of volatility spillovers between crude oil and financial markets through the VARMA-GARCH and VARMA-AGARCH models
Fan et al. [12]	GED-GARCH	The GED-GARCH-based VaR approach appears more effective than the well-recognized HSAF (i.e. historical simulation with ARMA forecasts). Moreover, this approach is also more realistic and comprehensive than the standard normal distribution-based VaR model that is commonly used
Liu and Wan [13]	The realized volatility (RV) models and GARCH-class models	The RV models are better than GARCH-class models as for the forecast of fuel oil price volatility, when the dynamics of daily volatility of Shanghai fuel oil futures prices based on the 5-minute high frequency data are concerned

In the past decades, due to the relatively better oil quality, [1]the prices of WTI crude oil often outweighed those of Brent by $1–$3 per barrel every trading day. However, this situation has been sturdily reverted in recent years, due to the increase of Brent crude oil demand of emerging economies and the US government legally restraining crude oil exports. Especially after the year of 2011, their abnormal spreads once reached $30 per barrel. Therefore, WTI's reign as the global oil benchmark has been overthrown by the Brent crude oil. Brent essentially draws its oil from more than a dozen oil fields located in the North Sea and represents the Northwest Europe sweet market. Since it started serving as the benchmarks for all West African and Mediterranean crudes, and now for some Southeast Asia crudes, it has directly linked to a larger market. In this way, although most Brent has been destined for European markets, it is also used as a price benchmark for other grades. Overall, since the advent of the post-financial crisis era, many changes may have taken place in crude oil price movements. This paper attempts to reveal the price regimes of Brent and WTI crude oil prices before and after the financial crisis and then explore the fundamental causes for their abnormal spreads based on their typical price regime differences.

The contribution of this paper mainly includes two aspects. One is that we employ the Markov regime switching (MRS) model with dynamic autoregressive coefficients to explore the dynamic characteristics of Brent and WTI crude oil prices before and after the financial crisis. Another one is that we examine the abnormal spreads of Brent and WTI crude oil prices in the post-financial crisis era from the perspective of price regimes.

The rest of the paper is organized as follows. Section 2 reviews the relevant literature. Section 3 introduces the models and data we employ. Section 4 presents the empirical results, followed by the conclusions in Section 5.

2. Related literature review

Due to the vital importance of crude oil in economic sustainable development and financial markets, crude oil price changes have been discussed by a number of studies [4,5]. Here we review the relevant literature from three aspects, i.e., the volatility characteristics of crude oil prices, the crude oil price mechanisms after the recent financial crisis and the application of regime switching models in oil price research.

First, many studies have quantitatively analyzed the volatility characteristics of crude oil prices using nonlinear models. Among the relevant literature, the GARCH-class models have been frequently used to detect oil price volatility, which can be found in Table 1.

Moreover, there are also some other models or approaches used for crude oil price volatility study. For instance, Regnier [14] examines the price volatility for thousands of products by comparing standard deviation of price differences from January 1945 to August 2005. The results show that crude oil, refined petroleum and natural gas prices are more volatile than other products. Ripple and Moosa [15] find that trading volume and open interest are significant determinants of oil price volatility through contract by contract analysis, with significant positive and negative effect, respectively. Larsson and Nossman [16] examine the WTI crude oil prices through affine jump diffusion models with stochastic volatility and find that a stochastic volatility model including jumps in both prices and volatility appears superior to others, and the option values are significantly affected by model choice. Ahmed et al. [17] study the impact of oil price by decomposing oil price volatility into two components, i.e., permanent and transitory, and conclude that there is significant asymmetric effect on the transitory component. These studies provide insightful bases for better understanding of crude oil price movements. However, they seldom explore the state changes of oil price during the sample periods, especially the studies using the GARCH-class models, and cannot well depict the sharp and frequent volatility of oil prices, especially in recent years.

Second, the recent financial crisis has exerted serious impact on global economy in the past years and may have also led to some new changes in crude oil markets. Under this circumstance, some studies have examined the crude oil pricing mechanisms in the post-financial crisis era. For instance, Gallo et al. [18] analyze the characteristics of oil prices, production and consumption for several countries using unit root tests with two endogenous breaks, and the results show that crude oil price volatility should attribute to the oil supply factors, not consumption influences. Afterwards, Mollick and Assefa [19] test the stability of the stock-oil

[1] WTI has an American Petroleum Institute (API) gravity of about 39.6, making it quite light (having an API gravity over 10 means the petroleum is lighter and floats on water). WTI has a sulfur content around 0.24%, making it very sweet. Comparatively, Brent has an API gravity of about 38.06; and Brent contains approximately 0.37% of sulfur, higher sulfur content than that of WTI and not as sweet as WTI, though it is also still considered a sweet crude.