Overview

The recent changes in crude oil price behaviour between 2007 and 2009 revived the question about the underlying dynamics governing crude oil prices. Even more importantly, the outstanding question over whether we can forecast crude oil price and returns or not needs to be readdressed. The goal of this paper is to present an analysis of crude oil spot daily price/returns. The aim is to find if the structural changes in the crude oil market have had an effect on the ability to forecast daily returns. Also, we argue that there is still a gap between computational methods and traditional statistical methods for time series forecasting, hence, in this paper we make an effort to give due consideration to the statistical properties of the time series in the building process of soft-computing models.

Methods

Econometric and Soft Computing methods:

1. Testing for non-linearity and chaos:
   - The BDS test (Brock, Scheinkman et al. 1996),
   - the Fuzzy Classifier System for non-linearity (FCS) proposed by Kaboudan (1999),
   - a time-domain test for non-linearity introduced by Barnett and Wolff (2005), and
   - Lyapunov exponents.

2. Forecasting

ARIMA, GARCH/EGARCH and Artificial Neural Networks (ANN).

Results

Our tests show consistently over time that the dynamical forces driving crude oil price and returns are non-linear, of possibly low dimension. Moreover, the FCS test shows evidence of high level of noise which means that smoothing or noise reduction is necessary to achieve any level of forecast accuracy. To forecast crude oil spot returns in the short-term, we compared the performance of ARIMA(p,d,q), EGARCH(p,q) and ANN models. We conclude that it is possible to forecast crude oil price using non-linear models, providing noise control measures were used. Our results also show some evidence of successful multi-step forecasting (up 26 steps) for the smoothed daily returns.
Conclusions

In this paper we aimed to discover what types of dynamics govern crude oil price/returns and whether these dynamics have changed over time. Our analyses included several tests for non-linearity and chaos, as well as fitting several forecasting models. The BDS test rejected the null hypotheses of iid for all crude oil price and return sub-series included in this study. On the other hand the Kaboudan FCS test highlighted the presence of noise in the data. In addition to this, according to the FCS test, the noise in data increased over the last few years. This noise is a serious issue in hindering our ability to forecast crude oil returns, even for one day ahead, regardless to the model being used. It was also evident that the noise in the data was much greater in the last ten years. This is consistent with the major changes in the market, ranging from OPEC policies, to increasing Asian demand for oil, to the global financial crisis. The Lyapunov exponent analysis showed some evidence of chaos which could explain the random walk-like behaviour of the crude oil return. Nevertheless, we are not able to confirm (or reject) that crude oil follows chaotic dynamics. What is evident, though, is that the noise in the series plays a hindering role in any forecasting or analysis. However, since crude oil dynamics are mostly non-linear we concentrated our effort on modelling with ANN. Hence, we tested several data transformations and smoothing with the hope that we could reduce the noise and highlight certain dynamics, such as mean reversion. Indeed our empirical results showed that some of these measures are effective in improving the forecast accuracy. Moreover, in our ANN forecasting model, we discovered a non-linear pattern in the smoothed crude oil return data. We showed that, for smoothed data, multi-step forecasting is possible (for 19 to 25 steps ahead) with reasonable accuracy. Finally, we expect that the analysis presented in this paper is useful for researchers and energy economists interested in predicting crude oil price and return.

References


