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Trading on mean-reversion in energy futures markets

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ABSTRACT

We study whether simple technical trading strategies enjoying large popularity among practitioners can be employed profitably in the context of hedge portfolios for Crude Oil, Natural Gas, Gasoline and Heating Oil futures. The strategies tested are based on mean-reverting calendar spread portfolios established with dynamic hedge ratios. Entry and exit signals are generated by so-called Bollinger Bands. The trading system is applied to twenty-two years of historical data from 1992 to 2013 for various specifications, taking transaction costs into account. The significance of the results is evaluated with a bootstrap test in which randomly generated orders are compared to orders placed by the trading system. Whereas we find most combinations involving the front-month and second-month futures to be significantly profitable for all commodities tested, the best results for the risk-adjusted Sharpe Ratio are obtained for WTI Crude Oil and Natural Gas, with Sharpe Ratios in excess of 2 for most combinations and a rather smooth performance for all calendar spreads. Based on our results, there is a serious doubt whether energy futures markets can be considered weakly efficient in the short-term.
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1. Introduction

Over the past decade, energy commodity prices have exhibited dramatic rises and falls to an extent not observed since the energy crisis of the 1970s (Koch, 2014). At the same time, energy futures have experienced an impressive increase in financial investor demand after the US futures markets have been transformed radically due to the US Commodity Futures Modernization Act in 2000 which introduced more flexibility, allowing financial agents such as commodity index funds to enter them. On the one hand, energy commodities are regarded as low-cost diversification instruments that widen the opportunity set for portfolio optimization (Engelen and Kaiser, 2008). Furthermore, markets with a high liquidity attract short-term investors who intend to go long or short the asset for only a few days or even on an intraday basis. These developments have triggered a controversial discussion in literature aiming to establish whether supply and demand fundamentals or speculative trading effects prevail in the price building process of energy futures contracts (e.g. Chevallier, 2013; Sanders et al., 2004). Given the ever increasing interest in these markets, a question of tremendous relevance for academic research and practitioners related to the price building processes in energy futures markets is whether historical price patterns can be exploited by savvy investors. This study examines whether there could be profitable trading opportunities in four very popular energy futures markets by using simple trading rules.

Due to the increased investment interest in commodity markets and related products and the wide availability of investment instruments (e.g. futures, CFDs, various certificates), the efficiency of energy markets and especially the crude oil market has already been addressed in academic literature. Shambora and Rossiter (2007) use an artificial neural network model with moving average crossover inputs to predict crude oil futures prices and document significant profitability which is at odds with the expectation of an efficient oil futures market. Tabak and Cajueiro (2007) analyze the efficiency of Brent and West Texas Intermediate (WTI) Crude Oil using rescaled range Hurst analysis and find evidence that the oil market has become more efficient over time. Alvarez-Ramirez et al. (2008) analyze the autocorrelations of the international crude oil price process by the means of detrended fluctuation analysis and document that over long horizons the crude oil market is consistent with the efficient market hypothesis by Fama (1970) but cannot exclude the possibility of market inefficiencies at short time horizons. Alvarez-Ramirez et al. (2010) continue this analysis using lagged detrended fluctuation analysis and confirm that deviations from efficiency are dependent of the forecasting horizon. Wang and Liu (2010) test for the efficiency of the WTI Crude Oil market by studying the dynamics of local Hurst exponents and show that crude oil prices are becoming more efficient over time for all considered time horizons. Lean et al. (2010) study WTI Crude Oil spot and futures prices using mean-variance and stochastic dominance approaches and find that there are

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no arbitrage opportunities between spot and futures prices. Focusing on the high-frequency dynamics of futures price data of Crude Oil, Heating Oil, Gasoline, and Natural Gas, Wang and Yang (2010) identify market inefficiencies, especially for Heating Oil and Natural Gas mostly during periods of bullish markets.

Our work is primarily motivated by the divergent findings in the literature regarding market efficiency and technical trading in commodity markets as well as the lack of studies on the performance of the so called Bollinger Bands, a well-known tool to technical analysts which has been regarded in academic literature to only rather limited extent. The discussion among academics and practitioners about the merits of technical analysis has been ongoing for decades. Technical trading systems are discussed in a number of research studies like Bessembinder and Chan (1998), Brock et al. (1992), Levich and Thomas (1993) or Kwon and Kish (2002). The comprehensive survey by Park and Irwin (2007) shows that the main focus of attention of academic research is on equity and foreign exchange markets, not on commodities. The profitability of technical trading rules for commodity markets has been addressed by a few studies, mainly related to momentum and simple moving average rules. Miffre and Rallis (2007) apply contrarian and momentum strategies to US commodity futures contracts. While contrarian strategies are found to perform poorly, momentum strategies appear to be profitable over time periods of up to 12 months. Shen et al. (2007) compare the performance of momentum strategies for commodity and equity markets and document highly significant momentum profits for holding periods up to 9 months with magnitudes comparable to those realized with equity trading. Contrary to the studies claiming that technical strategies in commodity futures earn profits that cannot be considerably weakened by the relatively low transactions costs prevailing in these markets, Marshall et al. (2008) apply a large set of technical trading rules to 15 major commodity futures series, and find that the resulting profits cannot consistently exceed those expected to emerge due to random variation. More recently, Fuertes et al. (2010) examine combinations of momentum and term structure trading signals in commodity futures markets and find momentum and term structure strategies to be profitable when implemented individually while Szakmary et al. (2010) document pure trend-following strategies generally to outperform momentum strategies.[1]

Apart from the controversy about the profitability of technical trading rules in commodity markets, none of these studies apply Bollinger Bands which are an easy to implement tool for technical analysis. Despite the fact that these trading rules enjoy extensive popularity among practitioners, the academic literature investigating their performance is rather limited. Moreover, these studies cast doubts on the profitability of the Bollinger Bands. Using data of equity indices and the forex market, Lento et al. (2007) establish that the Bollinger Bands are consistently unable to earn profits in excess of the buy-and-hold trading strategy. Leung and Chong (2003) compare the profitability of Moving Average Envelopes and Bollinger Bands for a broad sample of equity market indices and find that Bollinger Bands underperform the Moving Average Envelopes. Studies related to this paper are Girma and Paulson (1998) and Girma and Paulson (1999) who, even though not explicitly acknowledging that their trading rules are similar to the Bollinger Bands, investigate whether the mean-reverting property of petroleum futures crack spreads can be economically exploited for generating excess returns. Unlike our approach, these authors use predetermined portfolio weights. Their simulations indicate that spread seasonalities may be used for generating profitable trading strategies but do not lead to consistently significant results.

Given the recent empirical evidence that Bollinger Bands are not as effective as other technical indicators, this paper extends the existing literature on technical trading by implementing these rather simple trading rules for trading hedge portfolios consisting of futures on the same underlying asset but of different maturities for major energy futures markets. The study focuses on four NYMEX contracts (WTI Crude Oil, Heating Oil, Gasoline and Natural Gas).[2] The individual futures are selected as they are primary instruments used for hedging and are among the most heavily traded commodity derivatives contracts. Moreover, the course of the NYMEX Crude Oil futures prices is closely monitored by regulators and policy makers. For example, the European Central Bank employs oil futures prices in constructing the inflation and output-gap forecasts that guide monetary policy Alquist and Kilian (2010). The considered four futures are important constituents of leading commodity futures indexes, adding up to 38.5% of the S&P GSCI and 25.27% of the DJ-UBSCI.[3]

The tested mean-reversion strategies involve calendar spreads constructed with these futures and complement existing literature on spread trading in energy markets (e.g. Girma and Paulson, 1998, 1999; Dunis et al., 2006, 2008). Butterworth and Holmes (2002) state that "an analysis of spread trading is important since it contributes to the economics of arbitrage and serves as an alternative to cash-futures arbitrage for testing for futures market efficiency". Moreover, spreads are particularly interesting because they are less likely to suffer from information shocks, as the movements of the two legs often offset each other (Dunis et al., 2006). More specifically, similarly to Cummins and Bucca (2012) and Barett and Kolb (1995), we consider futures contracts on the same asset but of different maturities and extend extant literature by establishing dynamic hedge ratios with Kalman filter techniques. Using daily data from 1992 to 2013, we find most combinations involving the front-month and second-month futures to be significantly profitable for all futures under consideration. The best risk-adjusted results are documented for WTI Crude Oil and Natural Gas, with Sharpe Ratios in excess of 2 for most combinations and a rather even performance for all tested combinations. Our results support extant studies (Alvarez-Ramirez et al., 2008, 2010; Shambora and Rossiter, 2007) which cannot rule out the possibility of short-term market inefficiencies.

The remainder of the paper is organized as follows. Section 2 gives an overview of the data used in the testing of the trading strategies. The methodology of the utilized trading strategies and significance tests is presented in Section 3. The results of the back tests are presented in Section 4 and the final Section concludes.

2. Data

Data used in this article are obtained from Datastream. Our sample includes settlement prices for the futures of the nearest five months for WTI Crude Oil, Natural Gas, Heating Oil and Gasoline (*RBOB, Reformulated gasoline Blendstock for Oxygenate Blending*). All futures in our sample are traded on the New York Mercantile Exchange. According to the data provider, the futures price series are constructed by rolling over on the first trading day of the month. The daily settlement prices for the considered energy futures are also available for Trading at Settlement (orders for trade at settlement products are executed at the current day's settlement price). The futures contracts are traded almost around the clock at the CME (at both Globex and ClearPort electronic platforms) so that the trading strategies are viable in real-life terms. Table 1 contains further detailed information on the employed futures contracts. Summary statistics for the daily futures prices from January 1991 to December 2013 are reported in Table 2. Data for Gasoline is only available since October 2005. The choice of 1991 as the beginning of our sample period is based on the attempt to use sample periods of unified length for all assets under consideration (which is not possible for Gasoline futures only).

[1] Trading commodities is treated in numerous introductory books on technical analysis as well, for example Stridsman (2001) and Chan (2013).

[2] Earlier versions of this paper included additionally futures contracts on Brent Crude Oil traded on the ICE. The trading strategies utilizing Brent futures were found to perform very similarly to WTI. The corresponding results are omitted for the sake of brevity.

[3] Target index weights for 2014. Sources: press.djindexes.com and spindices.com.

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