Energy Economics 46 (2014) 318–327

Contents lists available at ScienceDirect

Energy Economics

journal homepage: www.elsevier.com/locate/eneco

Time-varying long range dependence in energy futures markets☆

Ahmet Sensoy *, Erk Hacihasanoglu

Borsa Istanbul, Research & Business Development Department, Emirgan, 34467 Istanbul, Turkey

ARTICLE INFO

Article history:
Received 17 December 2013
Received in revised form 26 September 2014
Accepted 26 September 2014
Available online 22 October 2014

JEL classification:
C65
G14
Q40

Keywords:
Energy markets
Futures markets
Market efficiency
Generalized Hurst exponent

ABSTRACT

This study aims to investigate the presence of long-range dependence in energy futures markets. Using a daily dataset covering from 1990 to 2013 (which includes crucial events for energy markets such as invasion of Iraq and global financial crisis of 2008), we estimate time-varying generalized Hurst exponents of several energy futures contracts with different times to maturity using a rolling window approach. Results reveal that efficiency of energy futures markets is clearly time-varying and changes drastically over the sample period. For futures contracts with 1–4 months to maturities, crude oil and gasoline are found to be more efficient compared to others. On the other hand, for contracts with 5–9 months to maturities, crude oil and natural gas futures are more efficient. For almost every different month to maturity, heating oil and gas oil futures are found to be the least efficient markets. Moreover in general, the efficiency of energy futures markets is found to be decreasing dramatically when time to maturity is increasing. Several implications are discussed.

1. Introduction

The investigation of long-range dependence in asset returns has been an intriguing subject for both academicians and market professionals for a long time. According to the weak form[1] of the Efficient Market Hypothesis (EMH) (Fama, 1970), all past prices are fully reflected in present prices thus the security returns cannot be predicted on the basis of past price changes. On the other hand, according to Mandelbrot (1971) and then many others (Fama, 1988; Lo and Mackinley, 1988; Poterba and Summers, 1988; Brock et al., 1992), long memory exists in asset returns.

The presence of long-range dependence brings out several other problems: The investors' preferred investment horizon becomes a risk factor (Mandelbrot, 1997); the methods used to price financial derivatives (such as the Black and Scholes, 1973 model) may not be useful anymore[2]; the usual tests based on the Capital Asset Pricing Model and Arbitrage Pricing Theory (Black et al., 1972) cannot be applied to series with long-range dependence.

The main goal of this paper is to investigate the existence/non-existence of long-range dependence (thus naturally weak-form efficiency characteristics) in energy markets. While efficient market literature heavily focuses on stock markets, relatively less attention has been paid to energy markets. Energy markets are of extreme importance since they are the largest and the most strategic commodity markets in the global economy and energy price movements substantially affect the performance of most economic sectors at different levels and through various channels (Lescaroux and Mignon, 2008).

Table 1
Analyzed commodities in energy sector and the corresponding Bloomberg tickers.

Energy	
Commodity	Ticker
WTI crude oil	CL*x*
Brent crude oil	CO*x*
Natural gas	NG*x*
Gasoline	XBW*x*
Heating oil	HO*x*
Gas oil	QS*x*

Note: For each ticker, lower case letter *x* refers to the number of months to maturity. In our study, *x* runs through 1 to 9.

☆ The views expressed in this work are those of the authors and do not necessarily reflect those of the Borsa Istanbul or its members.

* Corresponding author. Tel.: +90 212 298 27 39; fax: +90 212 298 25 00.
E-mail address: ahmet.sensoy@borsaistanbul.com (A. Sensoy).

[1] Other forms are semi-strong efficiency, where the information set is publicly known and reflected in the prices, and the strong efficiency, where prices reflect all kinds of information (public and private).

[2] For example, Black–Scholes' (B–S) Geometric Brownian Motion (GBM) assumes Fickian neutral independence of the return innovations whereas late empirical researchers observe non-Fickian degrees of persistence in the financial markets. Jamdee and Los (2007) demonstrate how such long memory phenomena change European option values compared to the B–S' GBM assumption.

http://dx.doi.org/10.1016/j.eneco.2014.09.023
0140-9883/

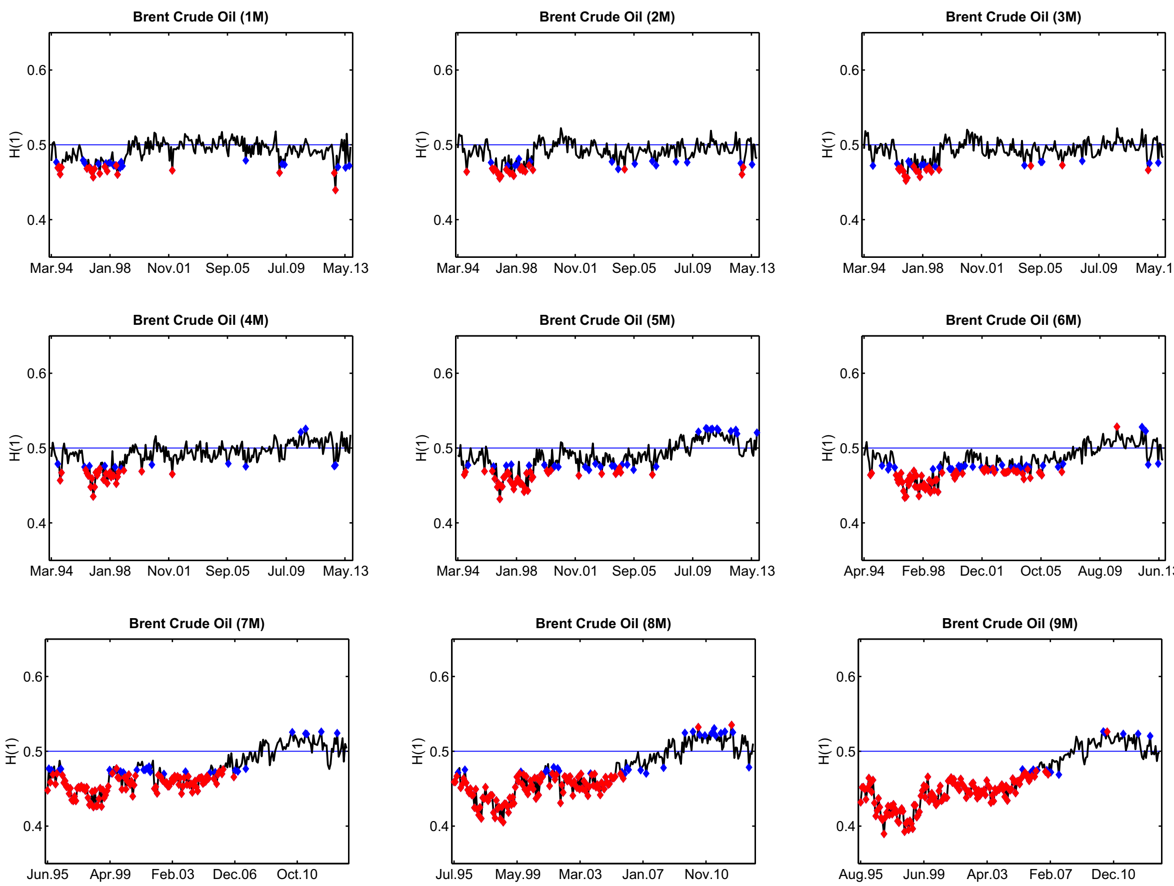

Fig. 1. Time-varying $H(1)$ for Brent crude oil futures with different maturities. Blue and red markers denote the rejection of weak form efficiency at 5% and 1% significance levels respectively.

Moreover, instead of spot market, this paper focuses on weak form efficiency of energy futures markets. The reason of our special interest on futures actually lies in the following arguments:

Since future markets are zero sum games (i.e. every long position corresponds to a short position), a profit creating price movement for one market participant will result with an equal loss to another. And in contrast to the spot energy market, futures market is the preferred trading arena for hedgers and speculators placing their bets on that market's future destination. Also producers and policymakers refer to these markets for predicting future spot prices and minimizing their risk. Accordingly, when informed traders actively participate on both long and short sides, the prices of futures contracts carry information about expectations of the spot prices at the maturity date. Hence, in theory, these markets are expected to serve as a well price discovery mechanism based on publicly available market fundamentals and supposed to be highly efficient. Combining these facts implies that speculators cannot earn consistent abnormal profits in future markets (except through luck).

Therefore, analyzing the energy prices from an EMH's point of view matters because efficiency enables us to know if it is actually possible to earn abnormal returns by speculative trading in the world's largest and most important commodity markets.

Many previous weak-form EMH studies assume a fixed level of market efficiency throughout the entire estimation period. It is incorrect to assume that the market is perpetually in an equilibrium state (Lo, 2004, 2005) and recent studies revealed that market efficiency evolves over time.[3] Hence, instead of regular static approaches, we use a time-varying approach to see the dynamics of the efficiency. Moreover, instead of the popular R/S (Hurst, 1951) and modified R/S (Lo, 1991) statistics, we use the generalized Hurst exponent (GHE) introduced by Barabasi and Vicsek (1991). It combines sensitivity to any type of dependence in the data and simplicity. Furthermore, since it does not deal with maxima and minima, it is less sensitive to outliers than the popular R/S statistics (Barabasi and Vicsek, 1991; Di Matteo et al., 2005). Besides, it is a stylized fact that the stock returns are not normally distributed and are heavy-tailed. Barunik and Kristoufek (2010) study how the sampling properties of the Hurst exponent estimate change with fat tails by comparing the R/S analysis, multifractal detrended fluctuation analysis, detrending moving average and the generalized Hurst exponent approach. They show that GHE is robust to heavy tails in the underlying process and provides the lowest variance.

Another contribution to the literature is that the sample we analyze covers more than 23 years from Apr-90 to Nov-13. Such an interval covers major events for energy markets such as Gulf War in 1990–1991, The North American Free Trade Agreement (NAFTA) in 1994, US' invasion of Iraq in 2003 and global financial crisis of 2008.

Our results reveal that efficiency of energy futures markets is clearly time-varying and changes drastically over the sample period. For futures contracts with 1–4 months to maturities, crude oil and gasoline are found to be more efficient compared to others. However, for contracts with 5–9 months to maturities, crude oil and natural gas futures are more efficient. For almost every different month to maturity, heating oil and gas oil futures are found to be the least efficient markets. Moreover in general, the efficiency of energy futures markets is found to be decreasing while time to maturity is increasing.

The rest of the paper is organized as follows: Section 2 gives a brief literature review on the efficiency of energy futures markets. Section 3 explains the methodology used in this study. Section 4 presents the

[3] There is an expanding literature tracking the evolution of market efficiency over time by means of a time-varying parameter model or a rolling estimation window. For details, see the survey paper by Lim and Brooks (2011).