



## Full length article

## Evolving efficiency of spot and futures energy markets: A rolling sample approach

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## ARTICLE INFO

## Article history:

Received 8 November 2014

Received in revised form 14 March 2015

Accepted 23 March 2015

Available online 23 April 2015

## Keywords:

Market efficiency

Energy market

Rolling approach

Variance Ratio

Run test

Modified R/S and DFA

## ABSTRACT

In this paper, we examine the weak-form efficient market hypothesis of energy markets by testing the random walk behavior of spot and futures prices. We contribute to the financial market efficiency literature by investigating the time varying markets efficiency using a “rolling sample” approach instead of an analysis of different time periods. For this end, we use the wild bootstrap Variance Ratio (VR) tests and the Detrended Fluctuation Analysis (DFA) technique. Empirical results show strong evidence of time varying markets efficiency with rapid mean reversion towards markets efficiency. The evolving efficiency of spot and futures markets depends on the prevailing economic and political conditions. Among the energy markets examined in this study, the spot and futures crude oil and the RBOB regular gasoline markets show the highest degree of market efficiency, while spot and future propane market is at the end of the ranking.

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## 1. Introduction

The Efficient Market Hypothesis (EMH) is one of the most important concepts in the modern finance literature. Formulated by Fama (1970), the EMH suggests that at any given time, prices fully reflect all available information. Since markets are efficient and current prices reflect all information then it is impossible to outperform the market. According to the EMH, no investor has an advantage in predicting a return on a stock price because no one has access to information not already available to everyone else. The EMH exists in various degrees: weak, semi-strong and strong, which addresses the inclusion of non-public information in market prices. The weak form

efficiency indicates that the information of all past prices is reflected in today's prices. The semi-strong efficiency implies that all public information is calculated into current prices. The strong form efficiency indicates that all information in a market, whether public or private, is accounted for in prices. This study empirically analyzes the weak form efficiency for the energy spot and futures markets. Hereafter, “the efficiency” refers to the weak form efficiency in this study.

The EMH has important implications for both monetary authorities and investors regarding market regulation, asset pricing, and portfolio allocation issues. The informational efficiency matters in two main ways. First, if a particular market is inefficient, investors may build up various trading strategies that lead to earn abnormal returns. Second, if all relevant information is incorporated in financial securities' prices as soon as they appear, new capital will go to the most productive investments. These features thus highlight the necessity of research on the efficiency of markets.

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<http://dx.doi.org/10.1016/j.jbef.2015.03.006>

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Understanding the efficiency of energy markets is of great importance for policy makers because energy plays an essential role in the world economy. Energy price movements have an impact on the performance of most economic sectors in both oil-importing and oil-exporting countries (Lescaroux and Mignon, 2008). The level of market efficiency will determine the trading and other strategies of market participants, and profitable opportunities may be available in an inefficient market. Moreover, energy markets have been considered as important markets for international portfolio diversification because of their different volatile returns and low correlations with stocks markets (Arouri and Nguyen, 2010; Daskalaki and Skiadopoulos, 2011; among others). In addition, the futures markets have two important functions. The first one is the hedging of risks. The other is the mechanism of price discovery, enabling to forecast spot prices at specified future dates. These two functions are based on the theory that the futures prices can reflect the expectation of investors which is one of the important determinants of price mechanism.

In weak-form efficiency, future prices cannot be predicted based on the analysis of their past performance. This is consistent with the random walk model which assumes that the price changes are homogeneously distributed random variables. The examination of weak-form efficiency can be performed by empirically testing the random walk model. The existence of long-range dependence in return series can reject the random walk model, thereby indicating that the market is not efficient in weak-form.

The specificity of the energy market in comparison to other markets is it slightly nonlinear serial dependence in the return series (Alvarez-Ramirez et al., 2008, 2010; Tabak and Cajueiro, 2007; Serletis and Andreadis, 2004; Charfeddine, 2014). Thus, testing for market efficiency remains a challenging and interesting task especially in spot and futures energy markets.

Although many studies to date have addressed the issue of energy markets efficiency, only a few researches have focused on the time-varying of market efficiency. Therefore, unlike traditional methods for testing market efficiency, this paper examines the time-varying efficiency of the spot and futures energy markets using the rolling sample approach. As tests of markets efficiency, we employ two variants of the VR tests statistics (Lo and MacKinlay, 1988; Chow and Denning, 1993), the wild bootstrapping technique of Kim (2006), and the Detrended Fluctuation Analysis (DFA) technique of Peng et al. (1994). Further, we provide a ranking of markets efficiency based on the percentage of time window that market departs from efficiency.

In this paper, we further extend the works in existing literatures on the weak form of the EMH in the energy markets in four ways. First, in this study we pay more attention to energy market dynamics than to the average behavior of spot and futures energy prices. The classical test of market efficiency of Fama (1970) leads to a rejection or not of the null hypothesis of random walk for the sample period, which is highly unrealistic. However, according to the adaptive markets hypothesis of Lo (2004, 2005), the

market efficiency is not an all-or-none condition but is a characteristic that varies continuously over time, with periods of inefficiency alternate with those of efficiency. The evolving market efficiency over time is due by and large to changing market condition (cycles, bubbles, crashes, crises,...) and institutional factors. Hence, Instead of relying on a single measure of market efficiency for the whole sample period, we employ time-varying or rolling sample approach rather than focusing on time-invariant regressions or some different sub-periods. Therefore, there is no need to identify an event date, which is often subject to criticism. Moreover, the application of a rolling window essentially captures the persistence of energy prices departures from a random walk benchmark over time and so allows us to propose some relevant policy recommendations according to the degree of market efficiency. Second, in addition to the VR tests, we use the DFA method. Comparing with classical statistics, the DFA permits the detection of long term memory embedded in seemingly non-stationary time series, and also avoids the spurious detection of apparent long term memory that is an artifact of non-stationarity. In addition, the advantages of DFA in computation of  $H$  are that inherent trends are avoided at all timescales and local correlations can be easily probed. Third, this study is based on a more extensive sample. We use daily prices of spot and futures energy from the New Mercantile Exchange (NYMEX) with the one month maturity contracts over the period spanning from 1983 to 2014. Such period covers major events such as the Gulf war, the North American Free Trade Agreement (NAFTA), the US' invasion of Iraq, the Asian and Russian crises, the subprime crisis and the Spring Arab. Fourth, we provide a ranking of the spot and futures markets efficiency of the crude oil (Light-Sweet, Cushing, Oklahoma), rBOB Regular Gasoline (New York Harbor), No. 2 Heating Oil (New York Harbor), and Propane (Mont Belvieu, Texas) based on different ranking criteria. In fact, ranking the efficiency of energy markets has evolved as an important information tool for policy makers and regulators to improve the efficiency channeling effective resource allocation to reduce distortions in the economy. To the best of our knowledge, this is the first work that ranks the efficiency of spot and futures energy markets.

The main finding of the paper is that all four energy spot and futures markets show weak-form efficiency changing over time, depending on the prevailing economic and political conditions, which is in line with the predictions of the adaptive markets hypothesis. Moreover, it is found that the crude oil market is the most efficient, while the propane market is at the end of the ranking.

The remaining of the paper is organized as follows. Section 2 presents a literature review. Section 3 presents the data and methodology. Section 4 discusses the empirical results. Finally, Section 5 concludes the paper.

## 2. Literature review

There is a plethora of researches on the efficiency of energy markets. Previous studies have focused on different countries and markets (spot and/or futures markets), and have adopted various estimators, methodologies, sample periods and time frequencies. Overall, empirical evidences

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