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# Efficiency of Thai stock markets: Detrended fluctuation analysis

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## HIGHLIGHTS

- The results obtained support notions that emerging markets are becoming more efficient.
- The first time of using econophysics to analyse market efficiency of MAI.
- The research outcomes take side with that market capitalization plays an important role in market efficiency.

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## ABSTRACT

The evolution of Hurst exponent of SET index over time, as a measure of market efficiency, is examined by DFA method. It is found that, during the study period, Hurst exponent tends to decrease to the ideal value 0.5, i.e., the market becomes more efficient. This finding readily conforms to the assertion that emerging markets are becoming more efficient. Additionally, the development of Hurst exponent during November 2006 to March 2015 of SET index compared to MAI index is investigated. The result shows that the deviation of the Hurst exponent from 0.5 for the MAI index is larger than that of the SET index. This implies that SET is more efficient than MAI and thus supports the assumption that market capitalization has significant influence on market efficiency.



## 1. Introduction

The studies of market efficiency (in Fama sense [1,2]), i.e., finding the evidence of long-range correlations, have been undertaken by many econophysicists. Cajueiro and Tabak [3,4] employed a rolling sample approach to estimate median Hurst exponents and ranked efficiency for emerging markets. Di Matteo et al. [5], using the generalized Hurst exponent approach to stock market indices, foreign exchange rates and fixed income instruments, showed that the scaling exponents can be used to differentiate markets by their stage of development. Tabak and Cajueiro [6] employed the detrended fluctuation analysis (DFA) method to provide the evidence of the market becoming weakly efficient over time by examining the time-varying long-range correlations in prices of crude oil markets. Alvarez-Ramirez et al. [7] found that crude oil markets exhibit a time-varying short-term inefficient behavior that became efficient in long term. Czarnecki et al. [8] applied time-varying Hurst exponent to Polish Stock Exchange and found that there is connection between local Hurst exponent pattern and crashes of the market. Kristoufek [9] studied the evolution of Prague Stock Exchange and confirmed that analyzing the time-dependent Hurst exponent, based on DFA, can predict crashes in the stable market with well defined and long lasting trends. Recently, Domino [10] analyzed the local Hurst exponent of Warsaw Stock Exchange to predict changing of trend. Matos et al. [11] used local Hurst exponent with scale dependence to establish stock market classes displaying

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similar behavior. Alvarez-Ramirez et al. [12] suggested, by using time-varying Hurst exponent, that the efficiency of US stock markets is higher and higher after the end of the Bretton Woods system. Cajueiro and Tabak [13] also used time-varying Hurst exponent to verify that financial market liberalization could increase the degree of market efficiency of the Athens Stock Exchange. Furthermore, Cajueiro and Tabak [14] applied Rescaled Range Analysis (R/S) method to analyze emerging markets and found that all emerging markets seem to have higher and higher efficiency for the period of 1992–2002 except for Brazil, Taiwan, the Philippines and Thailand. They also examined Chinese stock markets and claimed that liquidity influences the evolution of the Hurst exponent [15]. Moreover, they also noted the positive relationship between market efficiency and liquidity [3]. Sensoy [16] determined market efficiency of 19 members of the Federation of Euro–Asian Stock Exchanges (FEAS) and found strong positive relationship between efficiency and market liquidity. However, Bariviera [17] indicates that correlation between the efficiency and liquidity in case of the Stock Exchange of Thailand (SET) is weak.

The Stock Exchange of Thailand or SET is one of the most interesting and important stock markets in Southeast Asian region and in the near future, together with the forming ASEAN Economic Community (AEC), would have become the world spectacle. Even though Thai stock markets are not world's major markets but they have been through crisis after crisis and, in particular, the 1997 Asian crisis, which began with the devaluation of Thai baht. Over 40 years since its existence, SET has undergone stages of developments such as the introduction of new price ceiling and floor limits, the reduction of the par value of common stocks to inject liquidity and online trading. Apart from SET, which is the biggest and well-known market, there are other secondary markets such as Market for Alternative Investment (MAI) for small and medium enterprise, Bond Electronic Exchange (BEX), Thailand Future Exchange (TFEX) and Agricultural Futures Exchange of Thailand (AFET). So far most of the literature dealing with Thai stock markets just included them as one of the many stock markets in the studies [3–5,14,18–22], and only a few investigated the markets on them solely. Bariviera [17], using R/S and DFA, investigated the evolution of $H$ of SET and indicated that there is a weak relationship between market capitalization and the efficiency of the market and that the latter is not significantly affected by the presence of foreign investors. Islam et al. [23] used run-test and autocorrelation function test on SET. They concluded that SET is inefficiency especially after 1997 Asian crisis. Nevertheless, in all these work, the only market that has been paid attention to is SET.

In this work, our main interest concerns with two topics. Firstly, time-varying Hurst exponent calculation is performed to test the efficiency of The Stock Exchange of Thailand (SET), one of the Thai stock markets. For this purpose, the most recent data until 31 March 2015, which has not been covered by previous studies on the SET, are employed. The results obtained are extension of those showed in the research of Cajueiro and Tabak [14] for SET. Regarding to their works, the Thai market which is considered as emerging market, seem to be an exceptional case of the notification that the emerging markets are becoming more efficient over time. Secondly, time-varying and global Hurst exponent of Market for Alternative Investment (MAI), another Thai stock exchange which has never been studied in any work before, is investigated by comparing with SET. As SET and MAI are in the same environment and under the same regulations, market capitalization and trading volume are the main difference between them and this should make the study of the role of liquidity on market efficiency more conclusive. In this study, additionally, $H$ is calculated from DFA method.

## 2. Methodology

### 2.1. Detrended fluctuation analysis

In 1951, Hurst [24] proposed the Rescaled Range Analysis (R/S), which is the best known scaling method for estimation of power-law correlation exponents from random signals. Nevertheless the R/S statistic is highly affected by outliers and shows a biased evaluation of the Hurst exponent ($H$). Peng et al. [25] introduced the Detrended Fluctuation Analysis (DFA) in their study on the correlation of molecular chains in deoxyribonucleic acid (DNA). The main advantage of DFA is its ability to distinguish intrinsic auto-correlation related to memory effects in the underlying dynamical system from those imposed by external non-stationary trends. For completeness, let us briefly restate the main steps of DFA method. Consider the log return time series

$$x(t) = \ln\left[\frac{P(t)}{P(t-1)}\right], \tag{1}$$

where $P(t)$ stands for the stock price at time $t$ with $t = 1, \ldots, N$. The first step of the DFA technique is creating the following profile

$$y(k) = \sum_{t=1}^{k} \left[x(t) - \langle x \rangle\right], \tag{2}$$

where $\langle x \rangle$ is the average value of the series $x(t)$ and $k = 1, \ldots, N$.

DFA of the integrated signal $y(k)$ allows us to analyze long-range correlations in $x(t)$ readily by getting rid of trends. Particularly, the series $y(k)$ is divided into $M \equiv \text{int}(N/n)$ non-overlapping boxes of equal length $n$. The boxes are indexed by $m = 1, \ldots, M$ and their starting times are written as $k_{nm}$. For each $m$th box of size $n$, the least squares line $y_{nm}(k)$