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Multifractal Detrended Flucutation Approach for the ETF in Chinese Market

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Abstract

This paper presents a empirical research based on multifractal detrended flucutation on ETF fund in China. Our analysis exhibits multifractal characteristics for ETF in china, The results show more comprehensive picture of ETF performance appraisal and hence a complement to traditional risk approach.

Key words: Multifractal Detrended Fluctuation Approach; Singularity Exponent; Singularity Spectrum; Etf Fund

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INTRODUCTION

In the 1960s, E. Fama developed the efficient market hypothesis (EMH). The Efficient-Market Hypothesis asserts that efficient markets are informational efficient and no one could earn excess profit by using any kind of information in efficient market. Based on the assumption of EMH, the distribution of return series follow Gaussian normal distribution. However, in recent years, many practitioners and academics found there are some anomaly phenomenon existed in the stock market which caused strong debate with EMH. The stock market is a complexity system; it follows the fat-tailed probability distributions and non-linear temporal correlation. So new way to analysis the market is needed. Yudong Wang, *et al*. analyse and investigate the efficiency and multifractality of gold markets based on multifractal detrended fluctuation analysis[1]. Zhou Yu, Leung Yee, *et al.* show relationships of exponents in multifractal detrended fluctuation analysis and conventional multifractal analysis[2]. Rongbao Gu, *et al.* present a paper on multifractal analysis on international crude oil markets based on the multifractal detrended fluctuation analysis, the multifractal nature of WTI and Brent crude oil markets is studied employing the multifractal detrended fluctuation analysis[3]. Jingliang Sun, *et al.* give multifractal detrended cross-correlation analyse of Chinese stocks, and use multifractal detrended cross-correlation analysis method to investigate the cross-correlation of Chinese stocks [4-8]. Jian Yang, *et al.* examine daily return predictability for eighteen international stock index ETFs, based on linear and various popular nonlinear models and both statistical and economic criteria for model comparison.[9] Jing Wang, Zongfang Zhou, *et al.* analyse the tracking error between SSE-50 ETF and SSE-180 ETF[10]. In this paper we use multifractal detrended fluctuation approach to do analysis on ETF fund in china and also find the multifractal character of ETF fund in Chinese market (GEM).

METHOD

The multifractal detrended fluctuation analysis (MDFA) has been used extensively for many years (work by Stanley, Havlin, Bunde, …). Therefore, we would like to provide a brief summary here. Use of the logarithmic unit for the price pt of stock share or index fund at time t is standard in such analysis. The price change from the previous close at a time step u is given by

$$x(u) = \ln(p_t) - \ln(p_{t-1}) = \ln(p_t / p_{t-1})$$
$$(u = 1,2,3,....N) \quad (1)$$

The running deviation in price change from a mean $\bar{x}$ over an interval u is

$$y(u) = \sum_{i}^{u} (x(u) - \bar{x}) \quad (u = 1,2,3,...N) \quad (2)$$

The length N of the time series is partitioned into n segments, each of length s, $N = ns$. A least square method can be used to identify trends in running deviation over each segment k by a polynomial g(u). The average fluctuation Fk(s) in each subregion k is

$$[F_k(s)]^2 = \frac{1}{s}\sum_{u=(k-1)s+1}^{ks} [y_k(u) - g(u)]^2 \quad (3)$$

The average moment of the fluctuation of order q over n segments of the time series is

$$F_q(s) = \{\frac{1}{n}\sum_{k=1}^{n} [F_k(s)]^q\}^{\frac{1}{q}} \quad (4)$$

$$as \quad q \to 0 \quad \ln F_0(s) = \frac{1}{n}\sum_{k=1}^{n} F_k(s)\ln F_k(s) \quad (5)$$

The power-law dependence of the q-th order moment of the fluctuation Fq(s) in interval s of the time series provides an estimate of the Hurst exponent h(q), i.e.,

$$F_q(s) \propto s^{h(q)} \quad (6)$$

Thus, the Hurst exponent h(q) of the q-th order fluctuation moment can be evaluated from the slope of the ln Fq(s) versus ln s plot. The rate of change of the Hurst index with the order of the moment q defines the singularity exponent α, (using the Legendre transformation), i.e.,

$$\alpha = \frac{dh}{dq} \quad (7)$$

and the singularity spectrum $f(a)$

$$f(\alpha) = q\alpha - \alpha \quad (8)$$

The width of fractal $\Delta\alpha = \alpha_{max} - \alpha_{min}$ spectrum, the difference between maximum and minimum values of the $\Delta f = f(\alpha_{min}) - f(\alpha_{max})$ singularity exponents provide an estimate of the spread in changes in fractal patterns. The corresponding difference in the fractal spectrum provides an insight into the change in frequency.

DATA ANALYSIS

We have analyzed fluctuation moments Fq(s) for a range of order q and evaluated the Hurst index h(q) and the singularity spectrum f(α). Figure 1 shows the variation of the Hurst index h(q) with q for ETF fund in China. Corresponding values of the singularity spectrum is presented in figure 2.

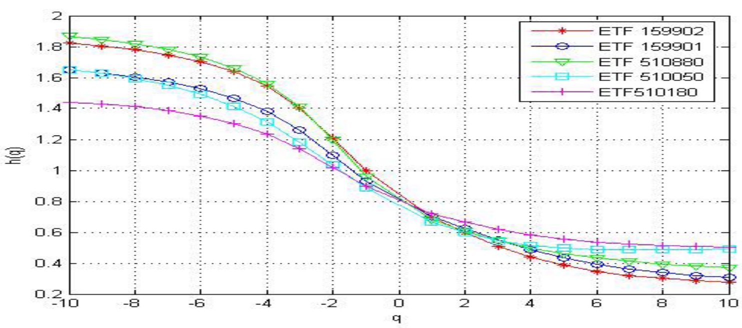

Figure 1
Variation of the Hurst Index h(q) with q for ETF Funds

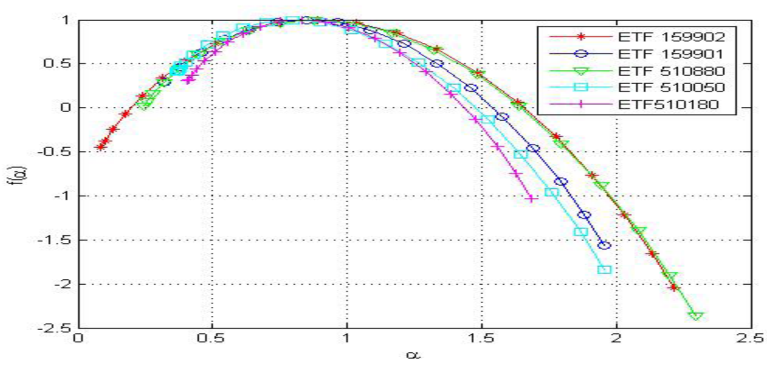

Figure 2
Variation of the Singularity Spectrum f(α) for ETF Funds

Different values of the Hurst index h(q) for different order q clearly exhibits multifractality. Differences in the multifractal patterns among the ETF funds, from figure 2,we can see the narrowest of singularity exponent α of ETF180 (ETF510180), and the widest of singularity exponent α of small and middle cap boards ETF (ETF159902), it means ETF 180 have small risk, and small and midldle cap ETF (ETF 159902) have large risk, the risk level of ETF 180 (510180), ETF50 (ETF 510050), Bonus ETF(510880), Shengzhen ETF 100 (ETF 159901), small and middle cap boards ETF (ETF 159902) increase gradually. The multifractal patterns of the sigularity spectrum show the number of higher return are more than that of lower return for this 5 ETF fund. Further, the magnitude of h(q) is close to 0.5, which shows short-range correlation in the fluctuations in the share price.

CONCLUSION

Patterns of the fluctuation moments of the share prices of an ETF funds for about a year exhibit multifractality. Our analysis consists of evaluating the Hurst exponent h(q) and its scaling with the order of the share price fluctuation moment q and the associated singularity spectrum f(α). We find that the trends in price return of each index are described by a specific Hurst index h(q) which shows variations, with the order q of the fluctuation moments at higher $q \geq 0$. The spread in the singularity spectrum could be a measure of relative risk. Among the share price fluctuations of the indices, we find that the small and middle cap ETF is relatively more risky, and ETF 180 appears to have the lowest risk.

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