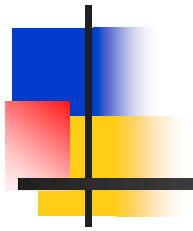
Statistical Physics of Stock Price Fluctuations : Multifractal Approach



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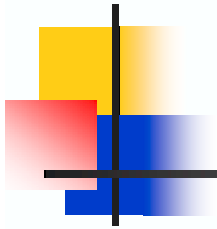
Motivation and Question

- ***What we want to study:***
  Statistical properties of Stock fluctuations
- ***Why?***
  To quantify fluctuation of stock price
- ***Why fluctuation is important?***
  Studying fluctuation help us to quantify the risk of loss or gain

Question: ***What are the statistical properties for stock fluctuations?***



What statistical properties?

- The correlation in stock fluctuations
  - Correlation in different time resolution
  - Correlation in the price change, time difference and volume change
- Our results:
  - Correlation in volume change isn't similar to that of price change or time difference
  - Compare to large fluctuations , small fluctuations have different correlation

Methods to study correlation

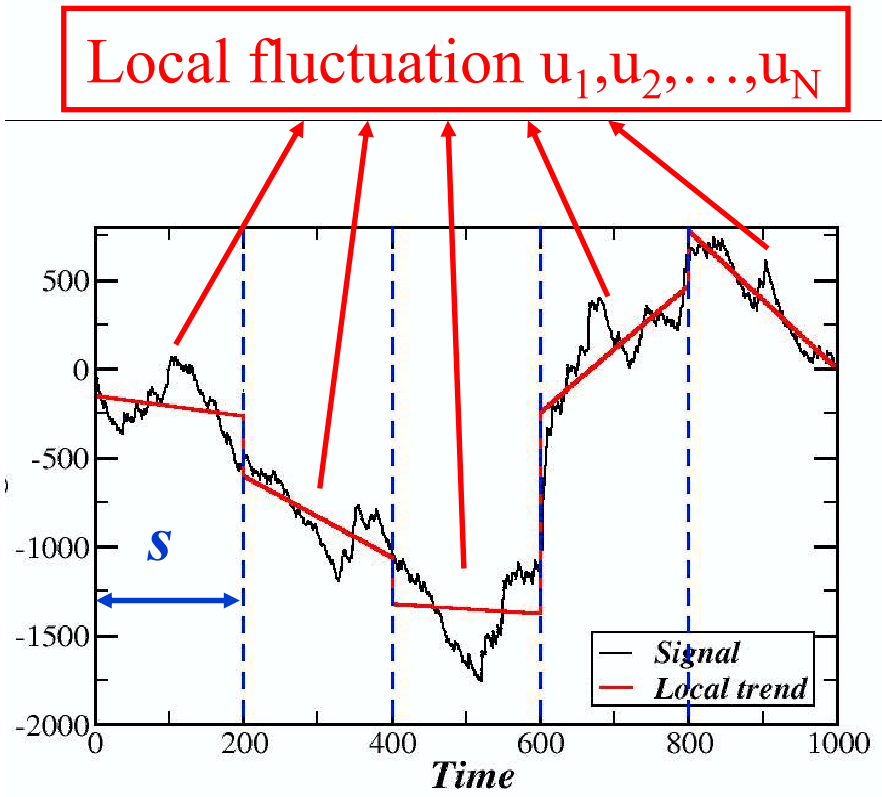
- Autocorrelation function
- Power spectrum

⇒ *Work for stationary data*

- Detrended fluctuation analysis (DFA)

⇒ *Also works for nonstationary data*

What is DFA method?



Avg. fluctuation

$$F_q(s) = \frac{1}{N}\sum_{i=1}^{N} u_i^{\,q} \sim s^{\tau(q)}$$

Hurst exponent

$$H = d\tau / dq$$

- H>0.5, positive correlation
- H=0.5, no correlation
- H<0.5, negative correlation

*Jan W. Kantelhardt et al, Physica A 316(2002) 87-114

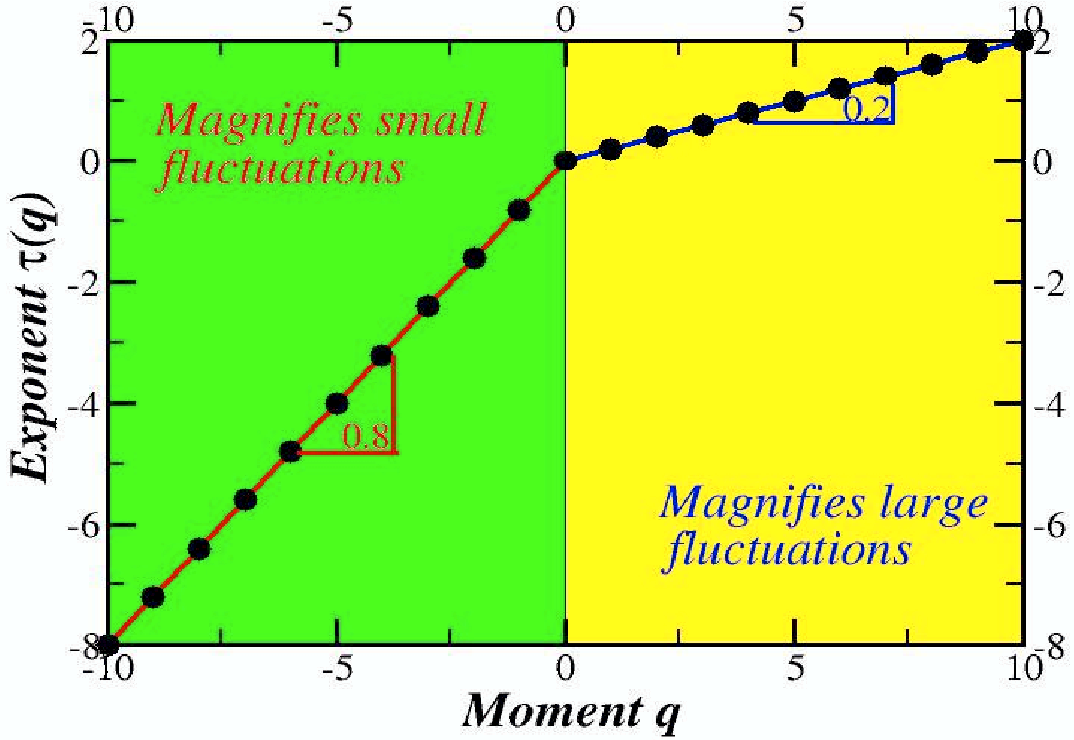
Result sample

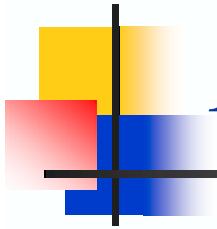
Avg. fluctuation

$$F_q(s) = \frac{1}{N}\sum_{i=1}^{N} u_i^{\,q} \sim s^{\tau(q)}$$

Hurst exponent

$$H = d\tau / dq$$





Database

- 500 company stocks, which composes ***Standard and Poor's 500 Index*** (SP500)
- All trades for those stocks in 1994
- Information about time, price, volume and so on of trades are provided
- Average number of trades is ~52,000 times per stock

Data sample

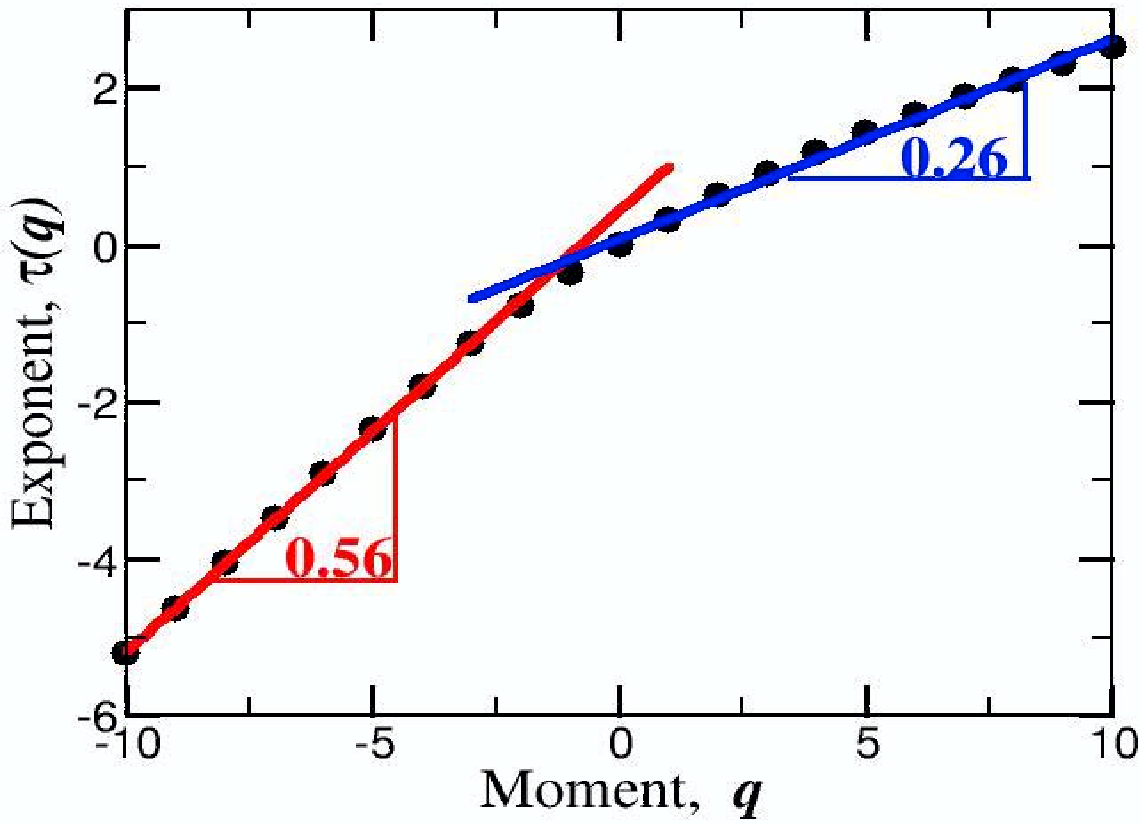
SYMBOL	DATE	TIME	PRICE	VOLUME
IBM	01/03/1994	9:30:07	56.88	18100
IBM	01/03/1994	9:30:31	56.8925	4000
IBM	01/03/1994	9:30:39	56.9275	1800
IBM	01/03/1994	9:30:41	56.97	3500
IBM	01/03/1994	9:30:42	56.9925	2200

$\Delta t = t_2 - t_1$, ***time difference*** between trades

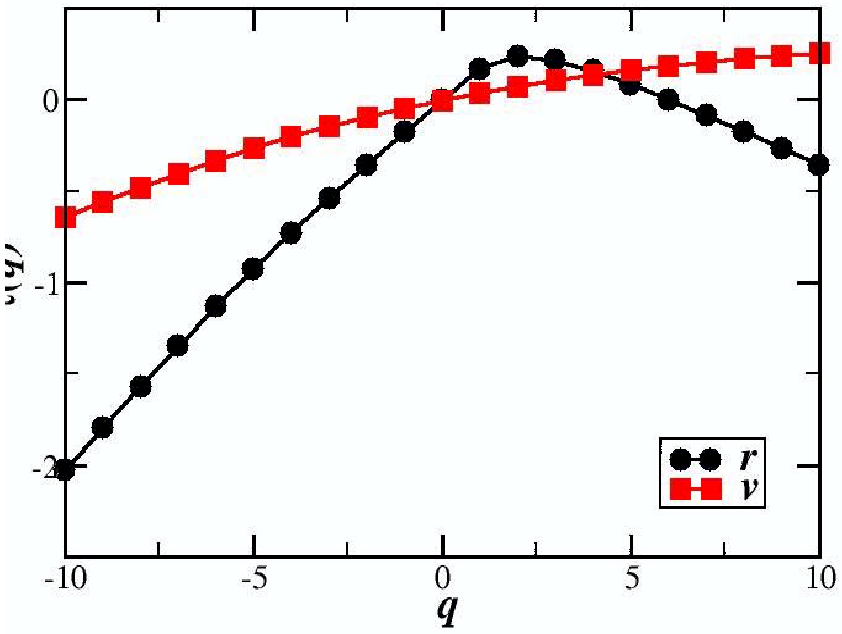
$r = \log(\text{price}(t_2)/\text{price}(t_1))$, ***price change***

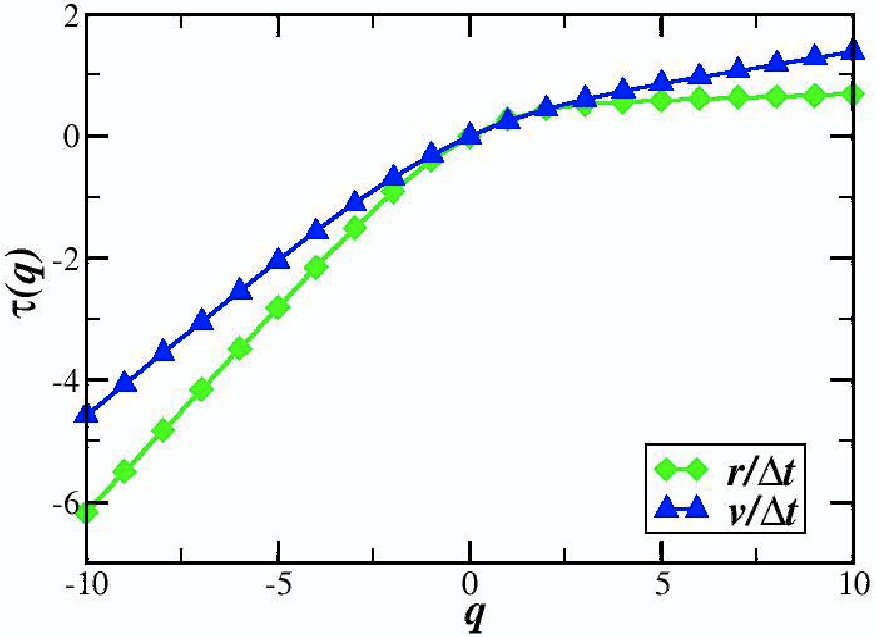
$v = \log(\text{volume}(t_2)/\text{volume}(t_1))$, ***volume change***

Result: time difference Δt



Result : more quantities

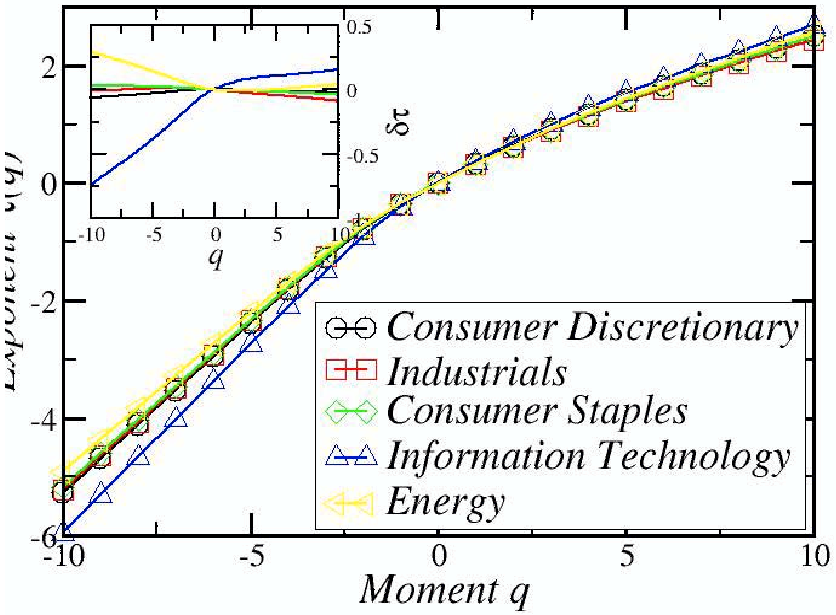


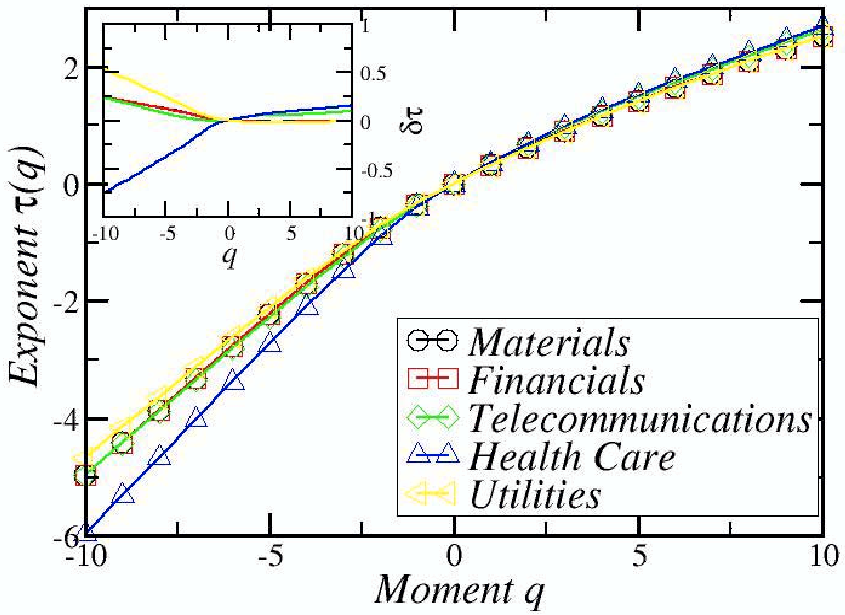


Sectors of SP500 stocks

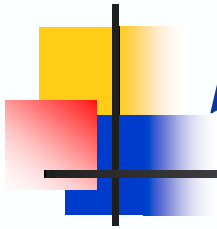
✓ Consumer Discretionary	99
✓ Consumer Staples	48
✓ Energy	30
✓ Financials	62
✓ Health Care	32
✓ Industrials	94
✓ Information Technology	38
✓ Materials	61
✓ Telecommunication Services	13
✓ Utilities	39
Total	500

Analysis of sectors





The insert is the ***difference*** between τ ***for the whole index*** and τ ***for each sector***



Summary

- Price change, time difference, ratio $r/\Delta t$ and $v/\Delta t$ of SP500 stocks have bi-fractal behaviors, while volume change has a multifractal curve.
- Properties in each sector of SP500 stocks are similar to that of the whole index.
- We will study properties for more indices, and we will try to model why this is observed.