Nonequilibrium Statistical Physics of Complex Systems 2022

KYUNG HEE UNIVERSITY

Inter-record time distribution for the Korean stock market and housing market

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Introduction

- Record statistics in the real world:
  - Records in sports such as Olympic games
  - Change of stock prices in stock exchange markets
  - Change of temperature (global warming)
- In physics, record statistics plays an important role to understand the behavior of the stochastic systems:
  - A domain wall in metallic ferromagnetic materials
  - A model for the growth of networks based on record events
  - Understanding magnetization of superconductors and spin-glasses
  - An alternative indicator of quantum chaos in kicked rotor model
- Record statistics is closely related to the first passage process [1]
- Basic questions in the first-passage process in the stock market [1]
  1) Will I eventually break even?
  2) How long do I have to wait until I break even?
  3) While I am waiting to break even, how low might the stock price go?
  4) Is it a good idea to place a limit order?

Motivation

- The inter-record time (IRT;record-age) distribution has been rarely investigated.
- We study the behavior of IRT distribution for Lévy walks with drift.
- We find that the IRT distribution can be useful to analyze finite single time series.
- Based on the analytical results for IRT distribution, we analyze the statistical properties of records in the Korean stock market and housing market.

1-D Lévy walks with constant drift c and staying probability p_0

Let x_n be the position of a walker at the n-th step.

$$\begin{cases} x_n = x_{n-1} \;\; (with\;\; p_0) \\ x_n = x_{n-1} + \eta_n + c \;\; (with\;\; 1-p_0) \end{cases}$$

1) For the Korean stock market: $p_0 = 0$ (same with [2].)
2) For Seoul's housing market: $p_0 = 0.910608$
3) p_0 only affects the mean record number.

Jump length distribution: $\varphi(\eta) = \int_{-\infty}^{\infty} \hat{\varphi}(k) e^{ik\eta} dk$

Characteristic function of $\varphi(\eta)$: $\hat{\varphi}(k) = \exp(-|lk|^{\mu})$, specially $l = 1$ in simulation.

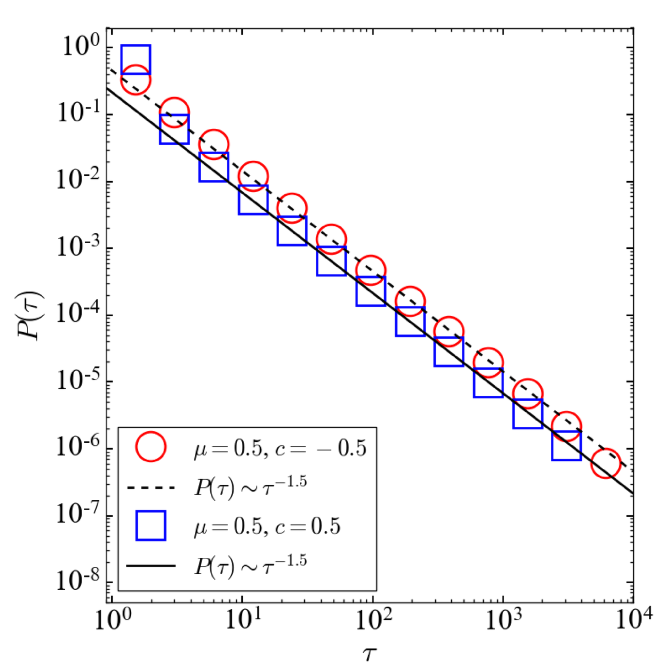
IRT distributions on 1-D Lévy walk with constant drift

- IRT distribution $P(\tau)$ corresponds to first-passage probability $f_{-}(\tau)$.
- $f_{-}(\tau)$ could be represented by survival probability $q_{-}(\tau)$, the relation between them is as followed. $f_{-}(\tau) = -\frac{\partial}{\partial\tau} q_{-}(\tau)$.

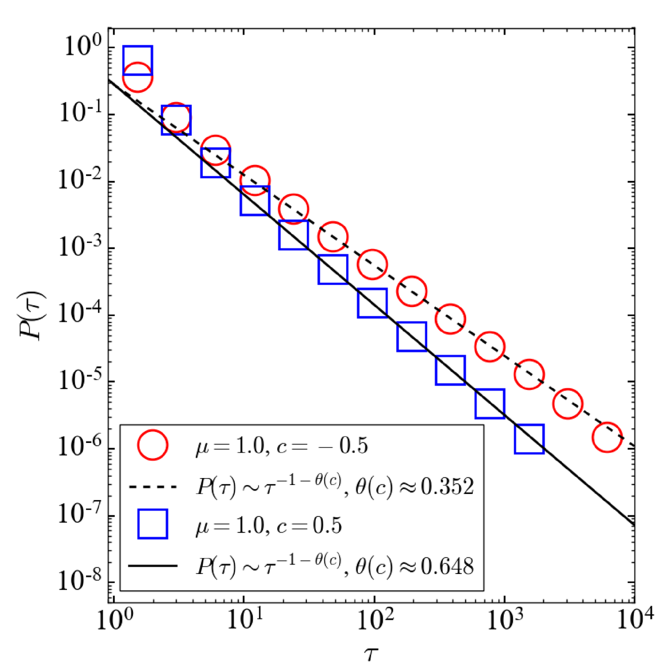
	Regime 1 $0<\mu<1$ $c \in (-\infty,\infty)$	Regime 2 $\mu = 1$ $c \in (-\infty,\infty)$	Regime 3 $1<\mu<2$ $c \in (0,\infty)$	Regime 4 $\mu = 2$ $c \in (0,\infty)$	Regime 5 $1<\mu\le 2$ $c \in (-\infty,0)$
$P(\tau)$	$P(\tau)\sim\tau^{-1.5}$	$P(\tau)\sim\tau^{-1-\theta(c)}$	$P(\tau)\sim\tau^{-1-\mu}$	$P(\tau)\sim e^{-\frac{c^2\tau}{2\sigma^2}}\left(\frac{c^2}{2\sigma^2}\tau^{-1.5}+\frac{3}{2}\tau^{-2.5}\right)$	$P(\tau)\sim\tau^{-\mu}$

$\theta(c) = \frac{1}{2} + \frac{1}{\pi}\arctan(c)$

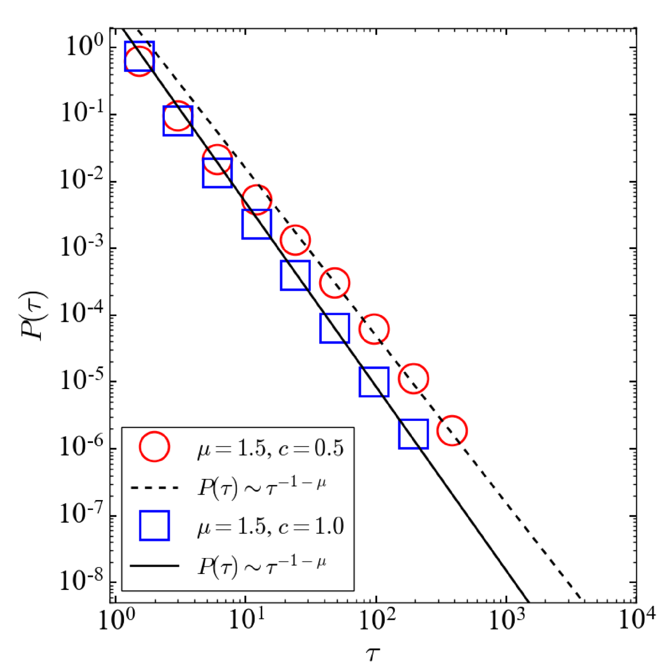
$\sigma = \sqrt{2}l$



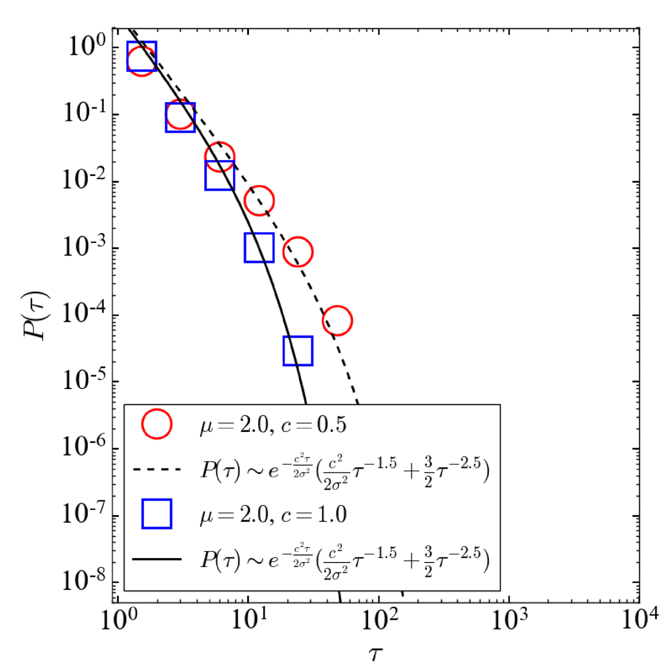
Regime 1



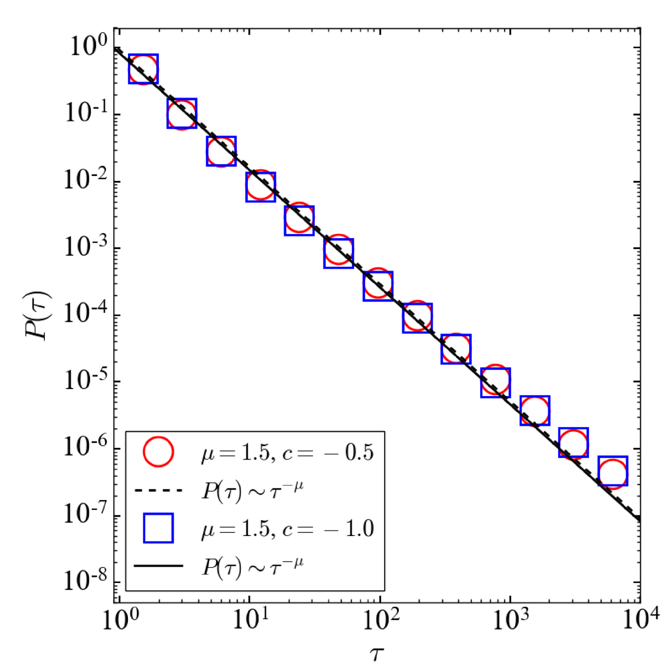
Regime 2



Regime 3



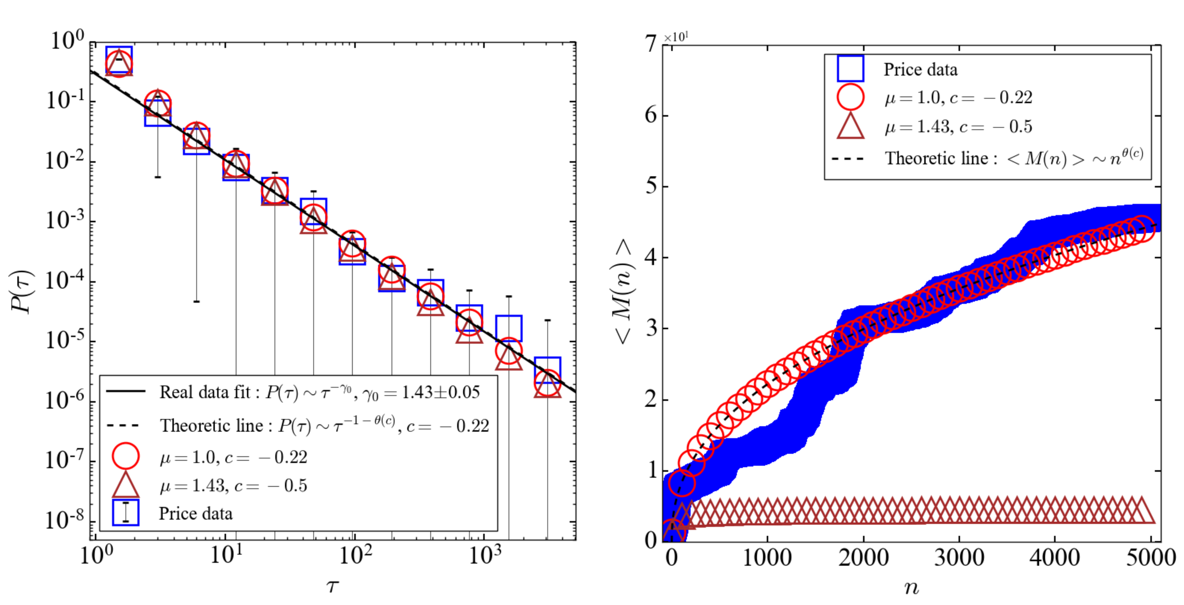
Regime 4



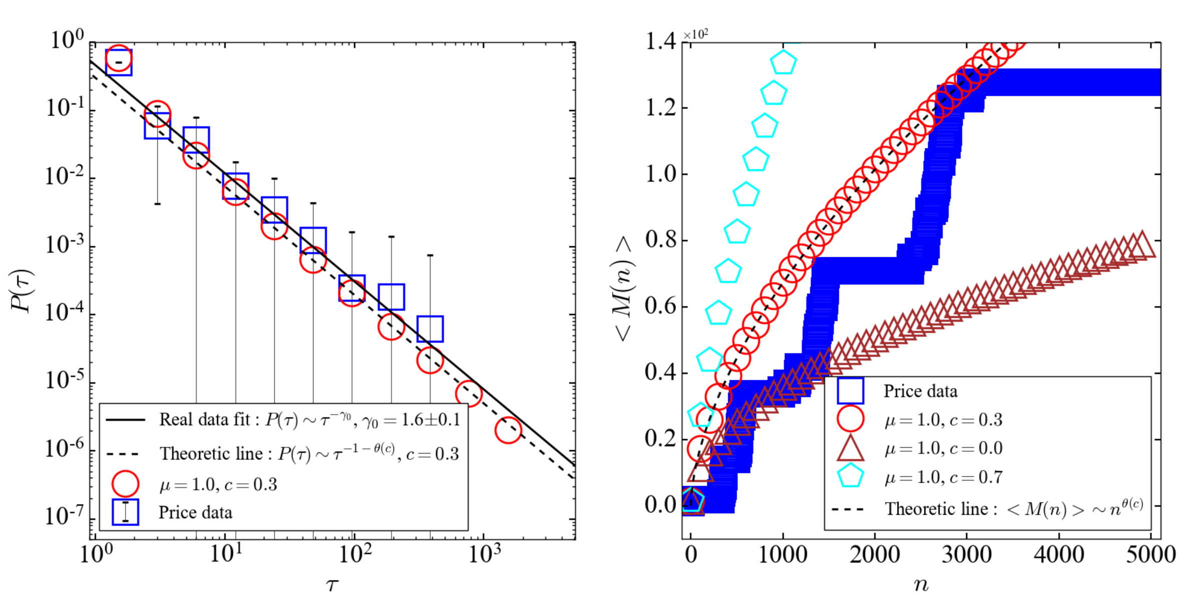
Regime 5

Record statistics in empirical data

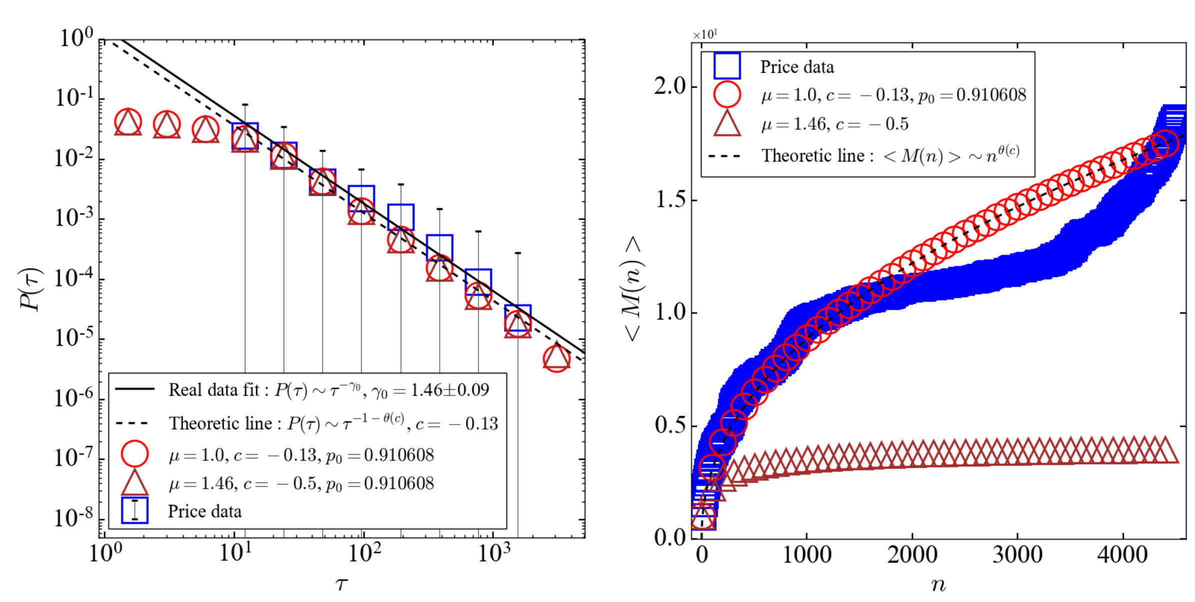
- Korean stock market: KOSPI and KOSDAQ stock price data from the Korea exchange market (KRX). 2000.01.02~2020.04.02 (5,000 days)
- Seoul's housing market: Daily price data per square meter for 332 administrative Dongs. 2006.01.01~2018.05.21 (4,523 days)
- Figures for each data are the IRT distribution $P(\tau)$ and the mean record number $\langle M(n)\rangle$.



Korean stock market



Hyundai car stock



Seoul's housing market

Conclusion

- We analytically study the IRT distribution for Lévy walks with drift and staying probability.
- We compare the analytic results with the IRT distribution obtained from the Korean stock exchange market and housing market.
- We find that, even for the single time series, the record statistics in a stochastic process can be analyzed by the IRT distribution.

[1] S. Redner, *A Guide to First-Passage Processes* (Cambridge University Press, Cambridge, 2001)

[2] S. N. Majumdar, G. Schehr and G. Wergen,. J. Phys. A: Math. Theor. **45**, 355002 (2012)