

MASTER'S THESIS

A statistical mechanical study of fat tails in financial time series

Cheng, Tak Sum

Date of Award:
2002

[Link to publication](#)

General rights

Copyright and intellectual property rights for the publications made accessible in HKBU Scholars are retained by the authors and/or other copyright owners. In addition to the restrictions prescribed by the Copyright Ordinance of Hong Kong, all users and readers must also observe the following terms of use:

- Users may download and print one copy of any publication from HKBU Scholars for the purpose of private study or research
- Users cannot further distribute the material or use it for any profit-making activity or commercial gain
- To share publications in HKBU Scholars with others, users are welcome to freely distribute the permanent URL assigned to the publication

**A Statistical Mechanical Study of Fat Tails
in Financial Time Series**

CHENG Tak Sum

A thesis submitted in partial fulfillment of the requirements
for the degree of
Master of Philosophy

Principal Supervisor: Dr. TANG Lei Han

Hong Kong Baptist University

September 2002

Abstract

Financial prices variations have been found to show some universal characteristics. Fat-tails, which are fatter than the gaussian tails, and short-time correlations play a key role in fundamental research as well as in risk management. In the first part, an empirical analysis on four years min-by-min Hang Seng Index have been performed to demonstrate the existence of these two features. Power-law fat-tail and slightly under-damping correlations were found. From the economic literature we already know that the underlying mechanism for the occurrence of fat-tails is the collective behavior of traders in a market. Fund managers, forecasts made by financial analysts and trust among traders all contribute to the "herding behavior".

In the second part, microscopic simulations are carried out on the original Cont-Bouchaud herding model to study the link of herding behavior of traders and the fat tails of price moves.

In the third part, a modified financial market herding model which uses the strategies of different traders to explain the short-time correlation is developed as well. We have been able to find a set of parameters which fit both the fat-tail and the short-time correlation of the Hong Kong financial market.

In the last part, a microscopic simulation approach has been applied to study the relations between microscopic behavior and macroscopic phenomena in financial markets. By changing the value of the parameters, some extreme cases are studied to explore the predictive power of the model for real markets.

Table of Contents

Declaration	i
Abstract	ii
Acknowledgment	iv
Table of Contents	v
List of Tables	viii
List of Figures	ix
Chapter 1 General Introduction	1
1.1 A Brief Introduction of Econophysics	1
1.2 Financial Time Series	2
1.2.1 Probability Density Function	3
1.2.2 Gaussian vs. Nongaussian (Fat Tails)	4
1.2.3 Moments	6
1.2.4 Time Correlation	7
1.3 Financial Market Modelling	8
1.4 Microscopic Simulation	9
1.5 Organization of the Thesis	10
Chapter 2 Empirical Analysis on Hang Seng Index	11

2.1	Introduction	11
2.2	Fat Tails	13
2.3	Moments	14
2.4	Time Correlations	17
2.5	Summary	18
Chapter 3 Microscopic Simulation to Cont-Bouchaud Herding Model		29
3.1	Introduction	29
3.2	Cont and Bouchaud Herding Model	30
3.3	Simulation Results	33
3.4	Discussion	37
3.5	Summary	37
Chapter 4 Financial Market Modelling		41
4.1	Introduction	41
4.2	The Hybrid Model of a Financial Market	42
4.3	Simulation Results	48
4.4	Discussion	51
4.5	Summary	52
Chapter 5 Analysis of the Financial Market Model		59
5.1	Introduction	59
5.2	Effect of Individual Parameters on the Market Statistics	59

5.2.1 Cluster Size Distribution	59
5.2.2 Trading Probability	60
5.2.3 Fraction of Noise Traders	61
5.2.4 Buying Drifts	62
5.2.5 Total Number of Agents	63
5.3 Discussion	64
5.4 Summary	65
Chapter 6 Conclusions and Future Work	78
6.1 Conclusions	78
6.2 Evaluation of the Model	79
6.3 Future Work	79
Appendix	81
List of References	86
Conference Attended	91
Curriculum Vitae	92