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Xiaolian Zheng and Ben M. Chen

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# Stock Market Modeling and Forecasting

A System Adaptation Approach

 Springer

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*To My Parents*

*X. Zheng*

*To My Granduncle, Paul, and My Dad, Joseph*

*B. M. Chen*

# Preface

In recent decades, modeling of financial markets has aroused great interests in the academia and in the financial industry worldwide. Financial market is a highly complex system involving a large number of interacting factors ranging from psychological, social and political aspects to general economic performance. There is no conclusive knowledge of the influence of these factors and the corresponding market responses, even the public opinions on decisive factors to a particular financial event are usually diversified. The financial market is also known for its noisy data, non-linearity and dynamic behavior, all of which make its modeling extremely difficult. These challenges call for a comprehensive study of the market behavior. Systems theory provides a totally different angle to investigate financial market modeling problems by analyzing the market as a complex system. It is a powerful tool in studying the interconnections and interactions inside the market and between the market and its environment. A framework that combines various foundations of both systems concepts and financial markets can thus provide more meaningful insights into market behaviors.

This monograph aims to develop a general framework or model structure based on systems theory to depict and analyze the financial markets, in particular the stock markets, and to provide accurate predictions of market prices and major market revisions, i.e., turning periods. The framework is carefully designed to consider both internal characters of the market and external influential factors, and thus is capable of capturing different types of market dynamics and behaviors. The structure of the framework and the processing of information inside and outside the market are to be addressed in detail. The applications of our framework in finding features in the stock markets from the U.S., China, Hong Kong, and Singapore, examples of both developed and emerging markets, are given and analyzed. Some interesting observations related to our framework and results, and possible future research directions that would further extend our study and understanding of the stock market, are also to be highlighted.

The intended audience for this monograph includes graduate students, researchers in areas related to financial modeling and analysts in financial sectors. It is assumed

that the reader has some previous knowledge in financial modeling and statistics as well as in basic systems theory.

The authors have benefited a great deal from many fruitful discussions with our colleagues and research teammates at the National University of Singapore. Particularly, we would like to thank Dr. Nan Jiang, Dr. Feng Lin, Mr. Limiao Bai, Professor Delin Chu, Professor Qing-Guo Wang and Professor Cheng Xiang for their valuable comments and help during the course of studies and preparation of this monograph. We are also indebted to Dr. Sen Yan of Xiamen University, Ms. Jie Zheng of Rice University, Dr. Shanle Wu of UBS AG and Dr. Lichao Cheng of China Life Asset Management Company for their insightful suggestions and their generous assistance.

This monograph was typeset by the authors using  $\text{\LaTeX}$ . All simulations, case studies and numerical computations were carried out in MATLAB. Diagrams were generated using XFIG and MATLAB with SIMULINK.

Kent Ridge, Singapore

Xiaolian Zheng  
Ben M. Chen

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# Abbreviations

AIC	Akaike Information Criterion
ANN	Artificial Neural Network
AMH	Adaptive Market Hypothesis
AR	Autoregressive
ARCH	Autoregressive Conditional Heteroscedasticity
ARIMA	Autoregressive Integrated Moving Average
ARMA	Autoregressive Moving Average
ARMAX	Autoregressive Moving Average Model with Exogenous Input
BDI	Baltic Dry Index
CAPM	Capital Asset Pricing Model
CBOE	Chicago Board Options Exchange
CBR	Case Based Reasoning
CNY	Chinese Yuan
CPI	Consumer Price Index
DJIA	Dow Jones Industrial Average
DEFFR	Daily Effective Federal Funds Rate
EIU	Economist Intelligence Unit
EMA	Exponential Moving Average
EMH	Efficient Market Hypothesis
EUR/JPY	Euro versus Japanese Yen
FFFR	Federal Funds Future Rate
FFR	Federal Funds Rate
FFRT	Federal Funds Rate Target
FFT	Fast Fourier Transform
FMH	Fractal Market Hypothesis
FTSE	Financial Times and Stock Exchange
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
GDP	Gross Domestic Product
GUI	Graphical User Interfaces
GUIDE	GUI Development Environment
HKAB	Hong Kong Association of Banks

HKD	Hong Kong Dollar
HKDISR	Hong Kong Dollar Interest Settlement Rates
HSI	Hang Seng Index
IFRI	Inflation Rate Indicator
IRI	Interest Rate Indicator
ISMI	International Stock Market Indicator
JPY	Japanese Yen
LIBOR	London Inter Bank Offered Rate
LM	Lagrange Multiplier
MA	Moving Average
MACD	Moving Average Convergence/Divergence
MAE	Mean Absolute Error
MARMA	Multivariate Autoregressive Moving Average
MAS	Monetary Authority of Singapore
MISO	Multiple Input and Single Output
ML	Maximum Likelihood
NASDAQ	National Association of Securities Dealers Automated Quotations
NVR	Noise Variance Ratio
NYSE	New York Stock Exchange
OE	Output Error
OP	Oil Price
PPI	Producer Price Index
RBF	Radial Basis Function
RWH	Random Walk Hypothesis
RMSE	Root Mean Squared Error
S&P	Standard & Poor's
SGD	Singapore Dollar
SGD/USD	Singapore Dollar versus U.S. Dollar
SGX	Singapore Stock Exchange
SHIBOR	Shanghai Interbank Offered Rate
SIBOR	Singapore Interbank Overnight Rate
SORA	Singapore Overnight Rate Average
SSE	Shanghai Stock Exchange
STI	Straits Times Index
STII	Straits Times Industrial Index
SVM	Support Vector Machine
T-TAS	Toolkit for Technical Analysis of Stocks
USD	U.S. Dollar
USD/CNY	U.S. Dollar versus Chinese Yuan
VAR	Vector Autoregressive
VHSI	HSI Volatility Index
VIX	Chicago Board Options Exchange Volatility Index
VXD	Chicago Board Options Exchange DJIA Volatility Index