Recent Advances In Computational Finance

Editors

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Preface

The motivation for this book

In recent years, financial decision-makers have benefited from the refinement of computational techniques, new and old, to witness the maturation of a cornerstone support industry. Modern financial firms from banks to hedge funds invest substantial funds and man-hours in developing new and powerful numerical algorithms, statistical procedures and mathematical techniques, with a view towards applying them to an array of multifaceted problems. The explorative nature of this book is designed to evoke a coordinated presentation that leads the reader to an understanding of how best to approach a practical characterization of contemporary decision problems; problems that rely upon state-of-the-art computational techniques in financial modeling, portfolio optimization, risk assessment, time series forecasting and econometric analytics.

What's different about this book?

As it stands today, the spectrum of financial modeling is a very vast topic area. Upon entering a few targeted queries into a web search engine, it only takes a few seconds to render results that speak to the rapidly growing volume of academic papers, books and technical reports falling into this area. One might ask, "How did the spectrum evolve so quickly?" A decisive look back in time points to an important historical milestone, the 1999 joint IEEE/IAFE meeting titled *Computational Intelligence for Financial Engineering* (CIFEr). This meeting signaled a growing interest in advanced computation techniques for finance. The overwhelming success of this joint meeting not only set the stage for newly targeted outlets that focused on the dissemination of current findings in computational and quantitative finance but it also reinvigorated interest in computational methods for the examination of option pricing as presented at the 1996 *IEEE Computational Science and Engineering* conference managed by Barucci, E., Landi, L., and Cherubini, U.

By 2001 Abu-Mostafa, Y.S., Atiya, A.F., Magdon-Ismail, M., and White, H. added to the importance of the area by publishing the *Special Issue on Neural Networks in Financial Engineering*, in the *IEEE Transactions on Neural Networks.* This research effort brought visibility and viability to computational finance as a mainstream area of quantitative research. Continuing forward, for its clarity of purpose, the *Special issue on Computational Intelligence in Economics and Finance* (Information Sciences, 2005) by Chen, Sh.-H., and Wang, P.P. stood out as a foundation publication during this formative period of early to mid-2000. Subsequently, the recognized role and global pedagogical adoption of advanced computational methods in finance resulted in an embrace by two other premier publishers interested in quantitative finance: Springer Verlag (Springer) and North-Holland Publishing Company (North Holland). Of notable interest to the theme of this book are two publications from Springer. The first one is the 2007 *Computational Intelligence in Economics and Finance, Vol. II* contribution by Chen, Sh.-H., Wang, P. P., and Kuo, T.-W. The second one is the 2008 publication by Kontoghiorghes, E.J., Rustem, B., and Winker, P, *Computational Methods in Financial Engineering*. Those set the stage for a cohesive scientific approach to computational finance that synthesized the use of the cognitive sciences, complex computation, and classical economic analysis. Lastly, the mathematical underpinning of what by now had become an accepted computational practice appeared as a chapter titled "Mathematical Modeling and Numerical Methods in Finance*"* by Ciarlet, Ph.G in the 2009 North Holland special volume (15) *Handbook of Numerical Analysis.* This contribution provided an important unification between mathematical theory and applied methods for targeted use in computational finance.

The most important feature of this edition is its "engineering*"* point of view. The chapters of this book build upon an engineering approach in order to extend and bridge the evolution in computational finance into 2013 and beyond. This adopted approach adds to, or engineers, new detail and design specification to contemporary decision problems. For the reader, the volume purposely includes a look at numerical recipes, cognitive estimation algorithms, and implementation details for the construction of optimized and advanced real-world decision making aids. With its rich assessment of actual problem modeling this book serves as a complement to similar in-context, but theory-bound, publications that tend to provide only an occasional example problem or hypothetical decision-aiding structure. In summary, *Recent Advances in Computational Finance* will be of

interest to both researchers and practitioners alike as the book strives to blend the theory and practice of contemporary computational finance.

Whom is this book suitable for?

The book is written for researchers and practitioners who routinely examine how to best use engineering, statistical, and mathematical methods that have been impacted by increasing degrees of complexity owing to, among other factors, the rapid adoption of new business technologies. By way of example, in today's modern markets professional investors all seek to use some form of automated trading for security purchases/sales and portfolio maintenance. In this edition we address the decision maker's quest for the latest theoretical contributions to automated trading. Specifically, the reader of this volume will find chapters on how to integrate high frequency- and intra-day financial data into a stock management scheme. In keeping with the theme of the volume, this topic is buttressed with chapters that extend modern-day portfolio optimization beyond the historically simple mean-variance model. Even more discussion is added by chapter presentations on how to invoke concept maps and genetic optimization as we round-out a robust presentation that is applicable to complex financial analytics including an alternative view on efficient stock price prediction. Lastly, the book is of interest to those researchers that wish to apply cognitive methods to examine both fraud prediction and stochastic volatility spillovers.

Young researchers in statistics, applied mathematics, financial econometrics and soft computing who seek potential areas of application for their investigations and algorithms will find this volume beneficial for its organization of contemporary areas and related topics. Those with a keen interest in risk management, trading high-frequency markets using cognitive modeling tools, quantitative software development and nonparametric economic model building will find a focal point with alternative reference points within the book presentation. Certainly, we expect graduate students of finance, financial mathematics, financial engineering and soft computing to rely upon this edition as they learn how to build and extend cutting-edge mathematical and computational techniques.

Organization of the edition

This edition is composed of ten independent chapters that were selected on the basis of a peer-review process. Despite the wide and often diversifying range of application domains and techniques considered in each chapter, we have made a serious effort to maintain uniformity of style and presentation.

Chapter 1 (*Short-term market forecasting for intraday trading with neuro-evolutionary modeling* by Antonia Azzini, Mauro Dragoni, and Andrea Tettamanzi) is an example of how sophisticated, nature-inspired, computational techniques can be used to uncover complex dynamic relationships among major components of a stock market index. By means of an evolutionary neural architecture, the authors detect strong causalities in intraday (five-minute) price variations of the FTSE MIB stocks and demonstrate how experimental models can serve as the design foundation for a high- or near-high frequency trading system.

A slightly different application domain for nature-inspired techniques is presented in Chapter 2 (*Detecting fraudulent financial statements through nature inspired techniques* by Yorgos Goletsis, Christos Katsis and Evangelos Koumanakos). In this study, two swarm intelligence algorithms (Ant-miner and PSO/ACO2) are used as a decision-support tool for characterizing the legitimacy of financial statements. As a proof of the practical usefulness of the developed methodology, the authors employ the aforementioned techniques to automatically check the consistency of balance sheets and income statements in a large dataset of manufacturing firms. Apart from the opportunity to see how a real-life decision-support system is built from scratch, the reader will also appreciate the comprehensive literature review of state-of-the-art techniques for fraudulent financial statement analysis.

Chapter 3 (*High-frequency trading with type-2 fuzzy logic time series forecasting and Hilbert transforms* by Abdalla Kablan and Wing Lon Ng) is a successful case of a hybrid computational architecture intended for intraday mechanical trading. The authors combine fuzzy logic with signal processing techniques (Hilbert

transforms) to detect cyclical patterns in high-frequency Foreign Exchange market data. The proposed system is superior in several aspects when compared to more simplified versions of the hybrid architecture as well as common technical analysis indicators.

The investigation of high frequency trading continues in Chapter 4 (*Production of efficient wealth maximization using neuroeconomic behavioral drivers and continuous automated trading* by Nina Kajiji and John Forman). This chapter introduces, defines and presents an applied real-world automated trading system that successfully combines the biological micro-foundations of economic cognition (or, neuroeconomics) with near high-frequency trading. For the applied community, the chapter includes a full pseudo algorithm. Additionally, the authors introduce the micro-economic theory of production to estimate factor elasticity metrics (firm fundamental variables) to explain nonparametric returns-to-scale in producing automated trading profits. The results provide equity market traders with a production theoretic approach to select equity securities that have a better than average chance of trading profitably under the guidance of the neural network driven automated trading system.

Chapter 5 (*Applications of stochastic hybrid systems in portfolio optimization* by Erdem Kilic, Azar Karimov and Gerhard Wilhelm Weber) provides the reader with a strong theoretical background that is crucial for understanding why contemporary computational finance and statistics are needed to advance applied practice using both parametric and nonparametric methods. This chapter makes the reader aware of why extensions to the traditional, and widely accepted, mean-variance portfolio optimization method must address disturbances to the return-generating process. These disturbances are commonly observed as "jumps" (a stochastic process that has observable discrete movements) and market inefficiencies like insider trading. No matter how an investor describes a disturbance, the complexity scenario of any sudden change to market information flow tends to create a dynamic stock market that calls for quick and potentially continuous trader responses. The successful trader facing such a market has a growing need for high- and near high-frequency trading methods. The theoretical underpinnings that explain the need for more efficient portfolio optimization models is addressed superbly in this chapter.

Recent trends and applications of genetic programming (GP) in computational finance are discussed in Chapter 6 (*Genetic programming: Current trends and applications in computational finance* by Gabriel Kronberger, Michael Affenzeller and Stefan Fink). The authors provide an extended introduction to genetic programming techniques. Specifically, the authors provide detail about their current state of research contribution and the various ways their findings can be utilized in the design, improvement and implementation of new financial applications. Notably, their contribution to the literature gives special attention to two important and timely research areas: symbolic regression models on the one hand and variable interaction networks on the other. These two research areas represent more than 20 years of effort that have resulted in widely disseminated studies to support the integration of evolutionary methods in the design of financial models.

Evolutionary algorithms for portfolio optimization are the topic of Chapter 7 (*Mean-variance portfolio optimization with cardinality and class constraints using multiobjective evolutionary algorithms* by Georgios Mamanis and Konstantinos P. Anagnostopoulos). In real life the portfolio selection task is typically complicated by the presence of multiple, and possibly conflicting, objectives set by the investor. The objective specification is in addition to the diverse, yet essential, constraints guaranteeing a meaningful capital allocation. Multi-objective evolutionary optimization techniques have proven to be a very useful tool for tackling the computational difficulties emerging in such a problem setting. In a mean-variance optimization formulation, one equipped with class preference and cardinality constraints, Mamanis and Anagnostopoulos study the computational behavior of three popular heuristics (the non-dominated Sorting Genetic Algorithm II, the Strength Pareto Evolutionary Algorithm 2, and the Pareto Envelope-based Selection Algorithm). Experimental results show that evolutionary techniques are able to approximate the Pareto optimal set of solutions with sufficient accuracy assuming a general set of constraints.

In Chapter 8 (*A review of multi-criteria portfolio optimization by mathematical programming* by Bartosz Sawik) provides a comprehensive review of state-of-the art portfolio optimization methods, with an emphasis on applied combinatorial operations research (OR). The research contribution adds discrete OR methods to

quantitative finance extensions that more efficiently describe solutions to the traditional mean-variance portfolio optimization problem. With a focus on the use of percentile risk measures, such as Value-at-Risk and Conditional Value-at-Risk, the review should be of particular interest to financial decision makers who are charged with implementing new global banking regulations as promulgated by the Bank for International Settlements. As banks and other financial intermediaries attempt to manage their enterprise portfolios within the reality of evolving global regulations, the use of new discrete programming models is certain to play a key role in the risk-mitigation process. This chapter presents the reader with a timely and in-depth review of the most important mathematical programming portfolio optimization model statements available today.

An application of concept maps to stock market prediction is presented in Chapter 9 (*Predicting stock price movements from concept map information* by Ankit Soni, Nees Jan van Eck and Uzay Kaymak). Most of the commercially-available technical trading tools essentially employ a statistical or mathematical model to generate proper buy/sell signals. Hardly any system is able to process more qualitative types of information, such as news, headlines or rumors, upon which financial experts often base their decisions. The purpose of this chapter is to present an alternative stock market prediction tool that automatically classifies textual data in the form of company-related news. The important feature of the presented methodology is that it goes deeper than simply mining textual information. In fact, it is capable of analyzing the semantic content of news releases.

The objective of Chapter 10, (*Computational Practice: Multivariate Parametric or Nonparametric Modeling of European Bond Volatility Spillover?* by Nina Kajiji and Gordon H. Dash, Jr.) is to compare and contrast the efficiency of alternate multivariate models to estimate government bond volatility spillover effects across local European economies. The authors note that this modeling task is a complex one; hence, there is a question about the efficiency of using linear methods. Because vastly different conclusions are reached upon the comparison of the alternate multivariate model results the authors extend the chapter's investigation to include an interrogation of the multivariate-normal linearity assumption attached to multivariate regression. Using canonical correlation analysis, the authors are able to delve into linear structure between the set of dependent European government bond returns and predictors that include global lagged returns as well as European and US bond market spillover effects. The significant accuracy of the nonparametric artificial intelligence-based model when applied to a nonlinear volatility surface points to the importance of the multivariate artificial neural network as a significantly efficient tool for financial economists to rely upon when faced with questions about the impact of volatility spillover in fixed income markets.

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