

LONG RANGE DEPENDENCE

GENNADY SAMORODNITSKY

ABSTRACT. The notion of long range dependence is discussed from a variety of points of view, and a new approach is suggested. A number of related topics is also discussed, including connections with non-stationary processes, with ergodic theory, self-similar processes and fractionally differenced processes, heavy tails and light tails, limit theorems and large deviations.

1. INTRODUCTION

Long range dependence and *long memory* are synonymous notions, that are arguably very important. This importance can be judged, for example, by the very large number of publications having one of these notions in the title, in areas such as finance (e.g. Lo (2001)), econometrics (e.g. Robinson (2003)), internet modelling (e.g. Karagiannis et al. (2004)), hydrology (e.g. Painter (1998)), climate studies (e.g. Varotsos and Kirk-Davidoff (2006)), linguistics (e.g. Alvarez-Lacalle et al. (2006)) or DNA sequencing (e.g. Karmesha and Krishnamaschhari (2004)). These publications address a great variety of issues: detection of long memory in the data, statistical estimation of parameters of long range dependence, limit theorems under long range dependence, simulation of long memory processes, and many others. Surprisingly, very few of these publications address is what long range dependence is. When definitions are given, they vary from author to author (the econometric survey Guégan (2005) mentions 11 different definitions). The notion of long range dependence can also be applied to different aspects of a given stochastic process (e.g. Heyde (2002)). More diverse definitions become possible if, instead of looking at the “usual” stationary processes, one studies *stationary point processes*, as in Daley and Vesilo (1997). It is

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Long Range Dependence Long Range Dependence

S.T Rachev



Long Range Dependence Long Range Dependence:

Theory and Applications of Long-Range Dependence Paul Doukhan, George Oppenheim, Murad Taqqu, 2002-12-13

The area of data analysis has been greatly affected by our computer age. For example, the issue of collecting and storing huge data sets has become quite simplified and has greatly affected such areas as finance and telecommunications. Even non-specialists try to analyze data sets and ask basic questions about their structure. One such question is whether one observes some type of invariance with respect to scale, a question that is closely related to the existence of long range dependence in the data. This important topic of long range dependence is the focus of this unique work written by a number of specialists on the subject. The topics selected should give a good overview from the probabilistic and statistical perspective. Included will be articles on fractional Brownian motion models, inequalities and limit theorems, periodic long range dependence, parametric, semiparametric and non parametric estimation, long memory stochastic volatility models, robust estimation and prediction for long range dependence sequences. For those graduate students and researchers who want to use the methodology and need to know the tricks of the trade, there will be a special section called Mathematical Techniques. Topics in the first part of the book are covered from probabilistic and statistical perspectives and include fractional Brownian motion models, inequalities and limit theorems, periodic long range dependence, parametric, semiparametric and non parametric estimation, long memory stochastic volatility models, robust estimation, prediction for long range dependence sequences. The reader is referred to more detailed proofs if already found in the literature. The last part of the book is devoted to applications in the areas of simulation, estimation and wavelet techniques, traffic in computer networks, econometrics and finance, multifractal models and hydrology. Diagrams and illustrations enhance the presentation. Each article begins with introductory background material and is accessible to mathematicians, a variety of practitioners and graduate students. The work serves as a state of the art reference or graduate seminar text.

Time Series with Long Memory Peter M. Robinson, 2003. Long memory processes constitute a broad class of models for stationary and nonstationary time series data in economics, finance and other fields. Their key feature is persistence with high correlation between events that are remote in time. A single memory parameter economically indexes this persistence as part of a rich parametric or nonparametric structure for the process. Unit root processes can be covered along with processes that are stationary but with stronger persistence than autoregressive moving averages, these latter being included in a broader class which describes both short memory and negative memory. Long memory processes have in recent years attracted considerable interest from both theoretical and empirical researchers in time series and econometrics. This book of readings collects articles on a variety of topics in long memory time series including modelling and statistical inference for stationary processes, stochastic volatility models, nonstationary processes and regression and fractional cointegration models. Some of the articles are highly theoretical, others contain a mix of theory and methods and an effort has been made to include empirical applications of the main approaches covered. A review article introduces the other

articles but also attempts a broader survey traces the history of the subject and includes a bibliography

Selected Statistical Papers of Sir David Cox: Volume 2, Foundations of Statistical Inference, Theoretical Statistics, Time Series and Stochastic Processes David Roxbee Cox, 2005 Sir David Cox's most important papers each the subject of a new commentary by Professor Cox

A Practical Guide to Heavy Tails Robert Adler, Raya Feldman, Murad Taqqu, 1998-10-26 Twenty four contributions intended for a wide audience from various disciplines cover a variety of applications of heavy tailed modeling involving telecommunications the Web insurance and finance Along with discussion of specific applications are several papers devoted to time series analysis regression classical signal noise detection problems and the general structure of stable processes viewed from a modeling standpoint Emphasis is placed on developments in handling the numerical problems associated with stable distribution a main technical difficulty until recently No index Annotation copyrighted by Book News Inc Portland OR

The Oxford Handbook of Quantitative Methods Todd D. Little, 2013 The Oxford Handbook of Quantitative Methods in Psychology provides an accessible and comprehensive review of the current state of the science and a one stop source for best practices in a quantitative methods across the social behavioral and educational sciences

Heavy-Tail Phenomena Sidney I. Resnick, 2007 This comprehensive text gives an interesting and useful blend of the mathematical probabilistic and statistical tools used in heavy tail analysis It is uniquely devoted to heavy tails and emphasizes both probability modeling and statistical methods for fitting models Prerequisites for the reader include a prior course in stochastic processes and probability some statistical background some familiarity with time series analysis and ability to use a statistics package This work will serve second year graduate students and researchers in the areas of applied mathematics statistics operations research electrical engineering and economics

An Introduction to the Theory of Point Processes D.J. Daley, David Vere-Jones, 2007-11-12 This is the second volume of the reworked second edition of a key work on Point Process Theory Fully revised and updated by the authors who have reworked their 1988 first edition it brings together the basic theory of random measures and point processes in a unified setting and continues with the more theoretical topics of the first edition limit theorems ergodic theory Palm theory and evolutionary behaviour via martingales and conditional intensity The very substantial new material in this second volume includes expanded discussions of marked point processes convergence to equilibrium and the structure of spatial point processes

Research Papers in Statistical Inference for Time Series and Related Models Yan Liu, Junichi Hirukawa, Yoshihide Kakizawa, 2023-05-31 This book compiles theoretical developments on statistical inference for time series and related models in honor of Masanobu Taniguchi's 70th birthday It covers models such as long range dependence models nonlinear conditionally heteroscedastic time series locally stationary processes integer valued time series Levy Processes complex valued time series categorical time series exclusive topic models and copula models Many cutting edge methods such as empirical likelihood methods quantile regression portmanteau tests rank based inference change point detection testing for the goodness of fit higher order

asymptotic expansion minimum contrast estimation optimal transportation and topological methods are proposed considered or applied to complex data based on the statistical inference for stochastic processes The performances of these methods are illustrated by a variety of data analyses This collection of original papers provides the reader with comprehensive and state of the art theoretical works on time series and related models It contains deep and profound treatments of the asymptotic theory of statistical inference In addition many specialized methodologies based on the asymptotic theory are presented in a simple way for a wide variety of statistical models This Festschrift finds its core audiences in statistics signal processing and econometrics

Handbook of Heavy Tailed Distributions in Finance S.T Rachev,2003-03-05 The Handbooks in Finance are intended to be a definitive source for comprehensive and accessible information in the field of finance Each individual volume in the series should present an accurate self contained survey of a sub field of finance suitable for use by finance and economics professors and lecturers professional researchers graduate students and as a teaching supplement The goal is to have a broad group of outstanding volumes in various areas of finance The Handbook of Heavy Tailed Distributions in Finance is the first handbook to be published in this series This volume presents current research focusing on heavy tailed distributions in finance The contributions cover methodological issues i e probabilistic statistical and econometric modelling under non Gaussian assumptions as well as the applications of the stable and other non Gaussian models in finance and risk management

Extremes in Random Fields Benjamin Yakir,2013-08-01 Presents a useful new technique for analyzing the extreme value behaviour of random fields Modern science typically involves the analysis of increasingly complex data The extreme values that emerge in the statistical analysis of complex data are often of particular interest This book focuses on the analytical approximations of the statistical significance of extreme values Several relatively complex applications of the technique to problems that emerge in practical situations are presented All the examples are difficult to analyze using classical methods and as a result the author presents a novel technique designed to be more accessible to the user Extreme value analysis is widely applied in areas such as operational research bioinformatics computer science finance and many other disciplines This book will be useful for scientists engineers and advanced graduate students who need to develop their own statistical tools for the analysis of their data Whilst this book may not provide the reader with the specific answer it will inspire them to rethink their problem in the context of random fields apply the method and produce a solution

Stationary Stochastic Models: An Introduction Riccardo Gatto,2022-06-23 This volume provides a unified mathematical introduction to stationary time series models and to continuous time stationary stochastic processes The analysis of these stationary models is carried out in time domain and in frequency domain It begins with a practical discussion on stationarity by which practical methods for obtaining stationary data are described The presented topics are illustrated by numerous examples Readers will find the following covered in a comprehensive manner At the end some selected topics such as stationary random fields simulation of Gaussian stationary processes time series for planar directions

large deviations approximations and results of information theory are presented A detailed appendix containing complementary materials will assist the reader with many technical aspects of the book

Computer Networks Piotr Gaj, Andrzej Kwiecień, Piotr Stera, 2015-05-27 This book constitutes the thoroughly refereed proceedings of the 22st International Conference on Computer Networks CN 2015 held in Brun w Poland in June 2015 The 42 revised full papers presented were carefully reviewed and selected from 79 submissions The papers in these proceedings cover the following topics computer networks distributed computer systems communications and teleinformatics

Modeling and Forecasting Electricity Loads and Prices Rafal Weron, 2007-01-30 This book offers an in depth and up to date review of different statistical tools that can be used to analyze and forecast the dynamics of two crucial for every energy company processes electricity prices and loads It provides coverage of seasonal decomposition mean reversion heavy tailed distributions exponential smoothing spike preprocessing autoregressive time series including models with exogenous variables and heteroskedastic GARCH components regime switching models interval forecasts jump diffusion models derivatives pricing and the market price of risk Modeling and Forecasting Electricity Loads and Prices is packaged with a CD containing both the data and detailed examples of implementation of different techniques in Matlab with additional examples in SAS A reader can retrace all the intermediate steps of a practical implementation of a model and test his understanding of the method and correctness of the computer code using the same input data The book will be of particular interest to the quants employed by the utilities independent power generators and marketers energy trading desks of the hedge funds and financial institutions and the executives attending courses designed to help them to brush up on their technical skills The text will be also of use to graduate students in electrical engineering econometrics and finance wanting to get a grip on advanced statistical tools applied in this hot area In fact there are sixteen Case Studies in the book making it a self contained tutorial to electricity load and price modeling and forecasting

Stochastic Models for Geodesy and Geoinformation Science Frank Neitzel, 2021-02-12 In geodesy and geoinformation science as well as in many other technical disciplines it is often not possible to directly determine the desired target quantities Therefore the unknown parameters must be linked with the measured values by a mathematical model which consists of the functional and the stochastic models The functional model describes the geometrical physical relationship between the measurements and the unknown parameters This relationship is sufficiently well known for most applications With regard to the stochastic model two problem domains of fundamental importance arise 1 How can stochastic models be set up as realistically as possible for the various geodetic observation methods and sensor systems 2 How can the stochastic information be adequately considered in appropriate least squares adjustment models Further questions include the interpretation of the stochastic properties of the computed target values with regard to precision and reliability and the use of the results for the detection of outliers in the input data measurements In this Special Issue current research results on these general questions are presented in ten peer reviewed articles The

basic findings can be applied to all technical scientific fields where measurements are used for the determination of parameters to describe geometric or physical phenomena *Quantitative Methods in Economics and Finance* Tomas Klietk, Katarina Valaskova, Maria Kovacova, 2021-04-08 The purpose of the Special Issue Quantitative Methods in Economics and Finance of the journal Risks was to provide a collection of papers that reflect the latest research and problems of pricing complex derivatives simulation pricing analysis of financial markets and volatility of exchange rates in the international context This book can be used as a reference for academicians and researchers who would like to discuss and introduce new developments in the field of quantitative methods in economics and finance and explore applications of quantitative methods in other business areas **Pattern Analysis and Machine Intelligence** Jie Yang, Yuanjie Zheng, Chen Gong, 2025-03-26 This book constitutes the referred proceedings of the First International Conference on Pattern Analysis and Machine Intelligence ICPAMI 2024 held in Shanghai China from August 30 to September 01 2024 The 28 papers presented here were carefully reviewed and selected from 56 submissions These papers have been organized under the following topical sections Computer Vision and Pattern Recognition Natural Language Processing NLP and Machine Learning Intelligent System and Optimization Algorithm **Broadband Communications** Lorne G. Mason, Augusto Casaca, 2016-01-09 Broadband communications is widely recognized as one of the most revolutionary emerging technologies of the last decade of the 20th century This book provides a comprehensive snapshot of leading edge research across a structured set of topics vital to broadband communications infrastructure for the information age Directional Statistics for Innovative Applications Ashis SenGupta, Barry C. Arnold, 2022-06-15 In commemoration of the bicentennial of the birth of the lady who gave the rose diagram to us this special contributed book pays a statistical tribute to Florence Nightingale This book presents recent phenomenal developments both in rigorous theory as well as in emerging methods for applications in directional statistics in 25 chapters with contributions from 65 renowned researchers from 25 countries With the advent of modern techniques in statistical paradigms and statistical machine learning directional statistics has become an indispensable tool Ranging from data on circles to that on the spheres tori and cylinders this book includes solutions to problems on exploratory data analysis probability distributions on manifolds maximum entropy directional regression analysis spatio directional time series optimal inference simulation statistical machine learning with big data and more with their innovative applications to emerging real life problems in astro statistics bioinformatics crystallography optimal transport statistical process control and so on **U.S. Geological Survey Water-supply Paper** ,1982 **Statistics of Financial Markets** Jürgen Franke, Wolfgang Karl Härdle, Christian Matthias Hafner, 2019-06-11 Now in its fifth edition this book offers a detailed yet concise introduction to the growing field of statistical applications in finance The reader will learn the basic methods for evaluating option contracts analyzing financial time series selecting portfolios and managing risks based on realistic assumptions about market behavior The focus is both on the fundamentals of mathematical finance and financial time series analysis and on applications to

specific problems concerning financial markets thus making the book the ideal basis for lectures seminars and crash courses on the topic All numerical calculations are transparent and reproducible using quantlets For this new edition the book has been updated and extensively revised and now includes several new aspects such as neural networks deep learning and crypto currencies Both R and Matlab code together with the data can be downloaded from the book s product page and the Quantlet platform The Quantlet platform quantlet.de quantlet.com quantlet.org is an integrated QuantNet environment consisting of different types of statistics related documents and program codes Its goal is to promote reproducibility and offer a platform for sharing validated knowledge native to the social web QuantNet and the corresponding Data Driven Documents based visualization allow readers to reproduce the tables pictures and calculations inside this Springer book This book provides an excellent introduction to the tools from probability and statistics necessary to analyze financial data Clearly written and accessible it will be very useful to students and practitioners alike Yacine Ait Sahalia Otto Hack 1903 Professor of Finance and Economics Princeton University

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