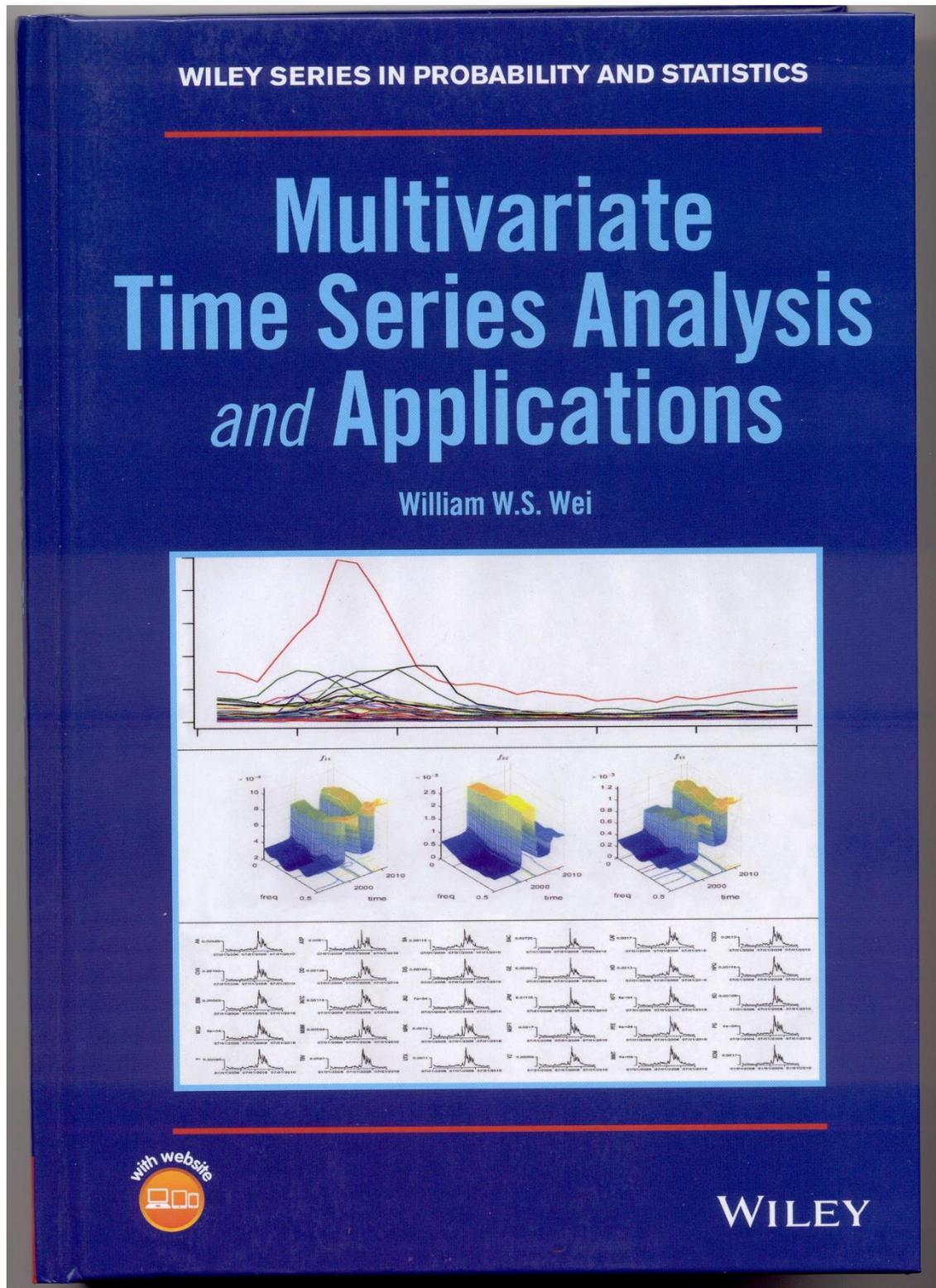


My second book, *Multivariate Time Series Analysis and Applications*, was published by Wiley in March, 2019

<https://www.wiley.com/en-us/Multivariate+Time+Series+Analysis+and+Applications-p-9781119502937>

To my grandpa, parents, wife, sons, and daughter



Multivariate Time Series Analysis and Applications

William W.S. Wei

*Department of Statistical Science
Temple University, Philadelphia, PA, USA*

WILEY

An essential guide on high dimensional multivariate time series including all the latest topics from one of the leading experts in the field

Following the highly successful and much lauded book, *Time Series Analysis—Univariate and Multivariate Methods*, this new work by William W.S. Wei focuses on high dimensional multivariate time series, and is illustrated with numerous high dimensional empirical time series. Beginning with the fundamental concepts and issues of multivariate time series analysis, this book covers many topics that are not found in general multivariate time series books. Some of these are repeated measurements, space-time series modelling, and dimension reduction. The book also looks at vector time series models, multivariate time series regression models, and principle component analysis of multivariate time series. Additionally, it provides readers with information on factor analysis of multivariate time series, multivariate GARCH models, and multivariate spectral analysis of time series.

With the development of computers and the internet, we have increased potential for data exploration. In the next few years, dimension will become a more serious problem. *Multivariate Time Series Analysis and its Applications* provides some initial solutions, which may encourage the development of related software needed for the high dimensional multivariate time series analysis.

- Written by bestselling author and leading expert in the field
- Covers topics not yet explored in current multivariate books
- Features classroom tested material
- Written specifically for time series courses

Multivariate Time Series Analysis and its Applications is designed for an advanced time series analysis course. It is a must-have for anyone studying time series analysis and is also relevant for students in economics, biostatistics, and engineering.

William W.S. Wei, PhD, is a Professor of Statistics at Temple University in Philadelphia, Pennsylvania, USA. He has been a Visiting Professor at many universities including Nankai University in China, National University of Colombia in Colombia, Korea University in Korea, National Chiao Tung University, National Sun Yat-Sen University, and National Taiwan University in Taiwan, and Middle East Technical University in Turkey. His research interests include time series analysis, forecasting methods, high dimensional problems, statistical modeling, and their applications.

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as an e-book

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About the Author

William W. S. Wei is a Professor of Statistical Science at Temple University in Philadelphia, Pennsylvania, United States of America. He earned his B.A. in Economics from the National Taiwan University (1966), B.A. in Mathematics from the University of Oregon (1969), and M.S. (1972) and Ph.D. (1974) in Statistics from the University of Wisconsin, Madison. From 1982-87, he was the Chair of the Department of Statistics at Temple University. He has been a Visiting Professor at many universities including Nankai University in China, National University of Colombia in Colombia, National Sun Yat-Sen University, National Chiao Tung University, and National Taiwan University in Taiwan. His research interests include time series analysis, forecasting methods, statistical modeling, and their applications. He has developed new methodology in seasonal adjustment, aggregation and disaggregation, outlier detection, robust estimation, and vector time series analysis. Some of his most significant contributions include extensive research on the effects of aggregation, methods of measuring information loss due to aggregation, new stochastic procedures of performing data disaggregation, model-free outlier detection techniques, robust methods of estimating autocorrelations, statistics for analyzing multivariate time series, and dimension reduction for high dimensional time series. His first book, *Time Series Analysis—Univariate and Multivariate Methods*, the first edition published in 1990 and the second edition published in 2006, has been translated into several languages and heavily cited by researchers worldwide. He has just completed his second book, *Multivariate Time Series Analysis and Applications*. He is an active educator and researcher. He has successfully supervised many Ph.D. students, who hold teaching positions at universities or leadership positions in government and industry throughout the world. He is a Fellow of the American Statistical Association, a Fellow of the Royal Statistical Society, and an Elected Member of the International Statistical Institute. He was the 2002 President of ICSA (International Chinese Statistical Association). He is currently an Associate Editor of the *Journal of Forecasting* and the *Journal of Applied Statistical Science*. In addition to teaching and research, he is also active in community service. He served on the educational advisory committee of his local school district, as the chair of the selection committee for a community high school scholarship program, and as the president of several community organizations, including the Taiwanese Hakka Associations of America. Among the many awards he has received are the 2014 Lifetime Achievement Award and the 2016 Musser Award for Excellence in Research from the Temple University Fox School of Business.

Preface

My main research area is time series analysis and forecasting. I have written a book, *Time Series Analysis – Univariate and Multivariate Methods*. Since the first edition was published in 1990 and the second edition in 2006, the book has been used by many researchers and universities worldwide, and I have received many encouraging letters and emails from researchers, instructors, and students about the usefulness of the book in their research and studies. It has been translated into several languages including Chinese, Spanish, and Portuguese. With the development of computers and the internet, we have data explosion, and many new theories and methods have been developed in high dimensional time series analysis. Many publishers have contacted me for a new edition. Because of the development of so much new material, it would be impractical to include them all in a new edition of the book. Therefore, I decided to write a new book and call it *Multivariate Time Series Analysis and Applications*. Due to the enthusiasm of multiple publishing editors, I had a difficult time deciding which publisher to choose. After consulting with Dr. Sarkar, our department chair, I decided to choose Wiley. After four stages of rigorous reviews, the Wiley directors unanimously approved the publication of this book.

Many research studies involve multivariate time series. For example, a study of monthly cancer rates in the United States during the past ten years can involve fifty or many hundred or thousand time series depending on whether we investigate the cancer rates for states, cities or counties, and a study of the quarterly sales performance of one company's different branches in the country or the world from 2010 to 2018 may involve many hundreds or thousands of time series depending on the number of products and the number of branches within the company. Multivariate time series analysis methods are needed to properly analyze the data in these studies which are different from standard statistical theory and methods based on random samples that assume independence. Dependence is the fundamental nature of time series. The use of highly correlated high dimensional time series data introduces many complications and challenges. The methods and theory to solve these issues will make up the contents of this book. After introducing the fundamental concepts and reviewing the standard vector time series models, we will explore many important issues, including multivariate time series regression, dimension reduction and model simplification, multivariate GARCH models, repeated measurement phenomenon, space-time series modeling, multivariate spectral analysis for both stationary and nonstationary vector time series, and the high dimension problem in multivariate time series analysis.

In this book, I follow the same fundamental themes of my research with a balanced emphasis on both theory and applications. Methodologies are introduced with proper theoretical justifications and illustrated with simulated and empirical data sets. It should be pointed out that this book is designed for a research-oriented second time series analysis course and therefore standard exercises normally found in the first course will not be provided. Instead, research-oriented projects will be suggested.

I am grateful to the Department of Statistical Science, Fox School of Business, and Temple University for granting me a sabbatical research leave to finish this book. Fox School is celebrating its 100-year anniversary in 2018, and this book is my way of joining in its centennial celebration. I am also grateful to my wife, Susanna, a professor at Saint Joseph's University, sons and daughter, Stephen, Stanley, and Jessica, who are all married physicians, for their help in proofreading my manuscripts even as they are so busy with their own careers and families. My very sincere thanks go to Zeda Li, Andrew Gehman, Nandi Shinjini, and Kaijun Wang, who are either my Ph.D. dissertation students, research/teaching assistants, or both, and Kevin Liu who was one of our excellent master students in the department, for their outstanding assistance in collecting data sets and developing software programs used in the book. Finally, I would like to thank Ms. Alison Oliver, Publications Manager, and Ms. Jemima Kingsly, Project Editor, John Wiley & Sons, who have been invaluable in completing this important book project.

William W. S. Wei
March 2018

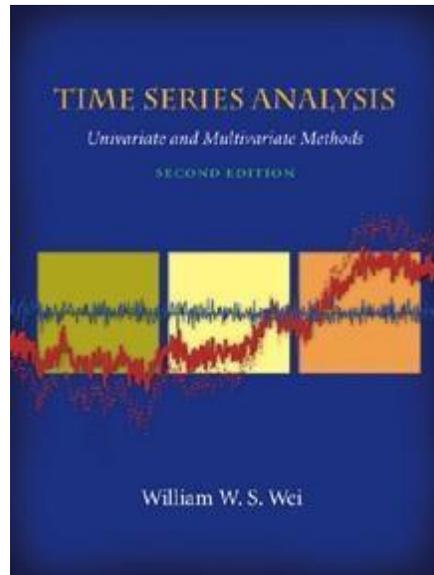
About the Companion Website

www.wiley.com/go/wei/datasets

The website includes:

-Data Appendix (Bookdata)

Scan this QR code to visit the companion website.



Time Series Analysis
Univariate & Multivariate Methods
1st Edition, 1990
2nd Edition, 2006
Classic Version, 2019

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Publisher: Pearson Addison-Wesley

Format: Cloth; 624 pp

PREFACE TO THE SECOND EDITION

Since the publication of the first edition, this book has been used by many researchers and universities worldwide. I am very grateful for the numerous encouraging letters and comments that I have received from researchers, instructors, and students. Although the original chapters in the book still form the necessary foundation for time series analysis, many new theories and methods have been developed during the past decade, and the time has come to incorporate these new developments into a more comprehensive view of the field. In the process of updating this book, I also took the opportunity to clarify certain concepts and correct previous errors.

In time series analysis, we often encounter nonstationary time series, and a formal testing procedure for a unit root has now become the standard routine in time series modeling. To address this procedure, Chapter 9 on unit root tests for both nonseasonal and seasonal models has been added.

Regression analysis is the most commonly used statistical method, and time series data are widely used in regression modeling, particularly in business and economic research. The standard assumptions of uncorrelated errors and constant variance are often violated when time series variables are used in the model. In a separate new chapter, Chapter 15, I discuss the use of time series variables in regression analysis. In particular, this chapter introduces models with

autocorrelated errors and ARCH/GARCH models for heteroscedasticity that are useful in many economic and financial studies.

Although the basic procedures of model building between univariate time series and vector time series are the same, there are some important phenomena unique to vector time series. After an introduction to various vector time series models in Chapter 16, I go on to cover cointegration, partial processes, and equivalent representations of a vector time series model in the new Chapter 17. They are useful in understanding and analyzing relationships of time series variables.

Many time series exhibit characteristics that cannot be described by linear models. Therefore, I have included Chapter 19 on long memory processes and nonlinear time series models that are useful in describing these long memory and nonlinear phenomena.

To aid understanding, I have also added supplements, Appendix 16A on multivariate linear regression models and Appendix 18A on canonical correlations. In the chapter on aggregation, I include some new results on the effects of aggregation on testing for linearity, normality, and unit roots.

In this revision, I follow the fundamental theme of the first edition and balance the emphasis between both theory and applications. Methodologies are introduced with proper theoretical justifications and illustrated with empirical data sets that may be down loaded from the web site: <http://www.sbm.temple.edu/~wwei/>. As with the first edition, exercise problems are included at the end of each chapter to enhance the reader's understanding of the subject. The book should be useful for graduate and advanced undergraduate students who have proper backgrounds and are interested in learning the subject. It should also be helpful as a reference for researchers who encounter time series data in their studies.

As indicated in the first edition, the book was developed from a one-year course given in the Department of Statistics at Temple University. Topics of univariate time series analysis from Chapters 1 through 13 were covered during the first semester, and the remaining chapters related to multivariate time series plus supplemental journal articles were discussed in the second semester. With the proper selection of topics, the book can be used for a variety of one- or two-semester courses in time series analysis, model building, and forecasting.

I wish to thank Dr. Olcay Akman of the College of Charleston, Dr. Mukhtar Ali of the University of Kentucky, Dr. H.K. Hsieh of the University of Massachusetts, Dr. Robert Miller of the University of Wisconsin, Dr. Mohsen Pourahamadi of Northern Illinois University, Dr. David Quigg of Bradley University, and Dr. Tom Short of Indiana University of Pennsylvania for their numerous suggestions and comments that have improved this revision. I am grateful to Ceylan Yozgatligil for her help in preparing some of the updated figures and tables. Finally, I would like to thank Ms. Deirdre Lynch, Senior Editor of Statistics, Addison Wesley for her continuing interest and assistance with this project as well as Ms. Kathleen Manley, Mr. Jim McLaughlin, and the staff at Progressive Publishing Alternatives who provide wonderful assistance in the production of the book.

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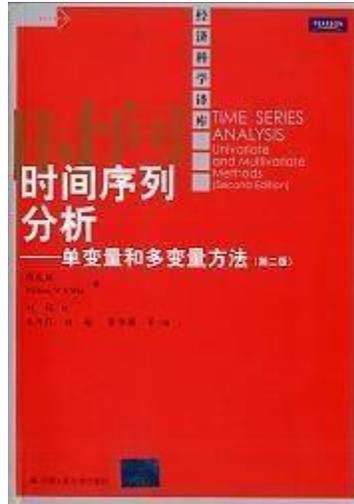
Appendix

Time Series Data Used for illustrations
Statistical Tables

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The book was translated into Chinese by Professor Danhui Yi and a group of faculty members of the School of Statistics at Renmin University of China (People's University of China) in Beijing, China, and published by People's University Press of China in April 2009.

<https://book.douban.com/subject/3704339/>

魏武雄 (William W.S. Wei)博士是宾夕法尼亚州费城天普大学 (Temple University) 的统计学教授, 自1974年就在此任教。他于1966年获得台湾大学经济学学士学位, 又于1969年获得俄勒冈大学 (University of Oregon) 的数学学士学位, 1972年和1974年分别获得威斯康星大学麦迪逊分校 (University of Wisconsin-Madison) 的统计学硕士和统计学博士学位。他的研究兴趣包括时间序列分析、预测方法、统计建模以及统计学在商业和经济中的应用。他是美国统计学会 (American Statistical Association, 简称 ASA) 院士, 英国皇家统计学会 (Royal Statistical Society, RSS) 会员, 国际统计学会 (ISI) 入选会员, 2002年泛华统计协会 (ICSA) 的主席。他还是期刊《预测》(*Journal of Forecasting*) 和《应用统计学》(*the Journal of Applied Statistical Science*) 的副编辑。

受中国人民大学出版社的委托，我们翻译了魏武雄教授编写的《时间序列分析——单变量和多变量方法》（第二版）一书。该书是针对有合适专业背景和对该学科感兴趣的研究生和高年级本科生编写的一本教材。对那些在研究中经常遇到时间序列数据的研究人员来说，本书也是一本非常有价值的参考用书。

对于本书即将出版，我们颇感欣慰。因为目前翻译出版的有关时间序列分析的书已经不少，我们担心该书没有特色，无法奉献给读者更多的知识，所以在翻译过程中付出了巨大的精力。翻译完成后，感到辛苦没有白费。

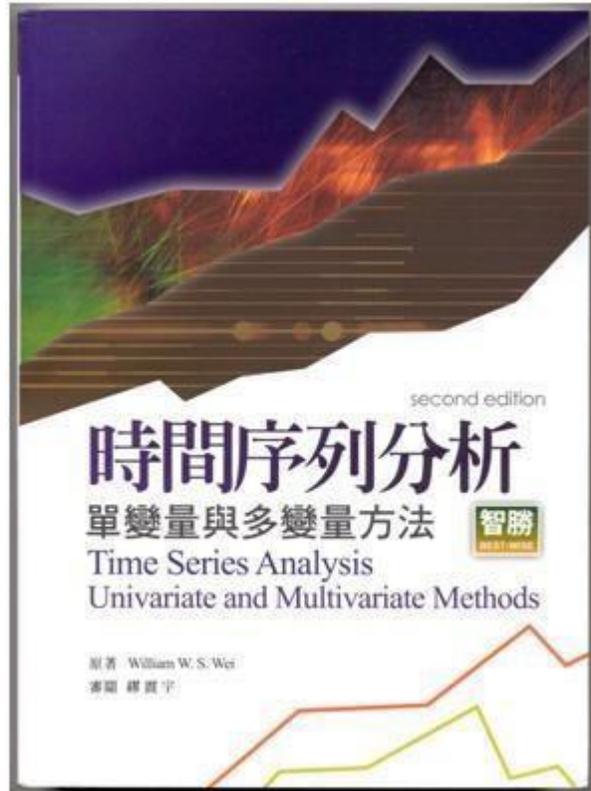
近年来，时间序列已经成为一个相当活跃的领域，出版了很多相关书籍，其中的大部分要么关注时域分析，要么关注频域分析。在这些书中，有些提供的理论背景资料不充分，有些则关于具体应用的介绍太少。而且，大部分书只是关注于单变量时间序列，即使有少量讨论多变量时间序列的书，也多局限于理论部分。

本书不仅对单变量与多变量时间序列的时域和频域分析提供了一个全面的介绍，而且在书中包含了许多单变量和多变量时间序列模型的新进展，如逆自相关函数、扩展样本自相关函数、干预分析及干预探测、向量自回归移动平均模型、偏滞后自相关矩阵函数、局部过程、状态空间模型、卡尔曼滤波、非季节和季节模型的单位根检验、向量时间序列模型中协整、局部过程和等价表示、长记忆过程和非线性时间序列模型、聚积问题等许多内容。

本书的难度适当，叙述通俗易懂，并结合大量的应用实例说明时间序列分析方法的应用，极大地方便了读者对这些方法的学习和理解。当读者完成本书学习的时候，将会理解怎样应用统计工具做出数据分析和决策。另外，还会发现所学的许多主题与方法可以用在其他课程里，包括数量经济以及统计等。本书不仅对在校的学生有用，对于那些已经参加工作、但需要运用统计方法分析问题的读者来说，也颇有意义。相信该书对在经济、财政、金融、市场、会计、管理和其他商业管理领域从业的工作者大有裨益。

本书的翻译由我及中国人民大学统计学院的部分硕士、博士共同完成。具体有：刘超、贺学强、陈堰平、王旭、童小军、陈凯。最后由刘超负责全部校对。对于他们所付出的艰辛工作，在此表示深深的感谢。

愿本书的出版能够对时间序列分析方法更广泛的应用起到积极的推动作用。



The book was also translated into traditional Chinese in Taiwan and published by Best-Wise Publishing Co., LTD, Taipei, Taiwan, in January 2012.

<http://www.bestwise.com.tw/book.aspx?bco=52WAS01801>

審閱序

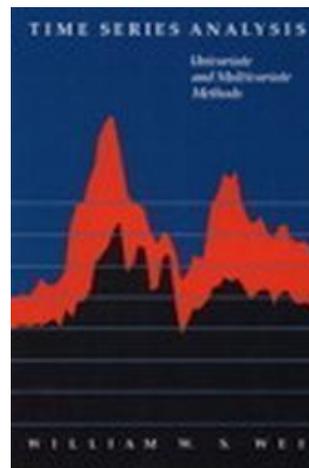
時間序列分析在實務應用與學術研究上扮演愈來愈重要的角色，國內也有不少關於時間序列的書籍，智勝文化此次將天普大學所採用的教科書引入國內則頗有深意。

本書的作者魏武雄(William W. S. Wei)教授任教於美國天普大學(Temple University)統計學系，同時還擔任多本統計學術期刊的副主編，將臺灣之光頒給魏教授可說一點也不為過。魏教授主要的研究領域即為時間序列分析，並在季節性調整、聚集以及向量時間序列分析上有許多重要的研究成果，這也使得本書特別豐富精彩。

本書的前13章介紹單變量時間序列，後半部分則為多變量時間分析，做為教科書使用時可以根據授課目標與時數加以選擇。由於第11章至第14章的內容需要較多的數學基礎，對於非數理科系的同學來說可能較為艱澀，這部分可以視程度選讀。本書對於時間序列的發展有完整深入的介紹，不僅適合做為大學部或研究所的教科書，學者在進行研究時當作參考書籍絕對也很適合。

繆震宇

2012年1月



1st Edition

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