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Foreword

Special Issue Honoring Prof. George C. Tiao

"Bayesian inference, environment statistics, time series analysis, and their applications"

This special issue collects 17 articles in the areas of *Bayesian Inference, Seasonal Adjustment, Time Series Analysis*, *Spatiotemporal Statistics,* and *Statistical Applications*. They represent areas to which Professor George Tiao has made fundamental, innovative, and significant contributions during his more than half century of professional career. Some of the articles in this issue were presented at a conference celebrating Professor Tiao's 80th birthday, held in December 2013 hosted by the Institute of Statistical Science, Academia Sinica. In addition to his many research contributions, Professor Tiao is instrumental in statistical education in the greater Chinese community, and in establishing the International Chinese Statistical Association (ICSA). He is also the funding chair editor of this journal. We refer interested readers to Chan (1999) for an interview and Peña and Tsay (2010) for a conversation with Professor Tiao for his devotion to research, education, and professional service in statistics, econometrics, environmental sciences, and beyond.

Bayesian Inference

Professor Tiao is widely recognized as a leading pioneer in Bayesian statistics. During the period he was a junior faculty at University of Wisconsin (1962−1968), he published 20 articles essentially all in leading statistical journals (e.g., 12 in *Biometrika,* 3 in *JASA*, 2 in *Annals of Math Stat*, 1 in *JRSSB*), 14 of which had the phrase "Bayesian" or "Bayes' theorem" in their titles. Even today, when Bayesian methods are orders of magnitude more popular than a half century ago, it is difficult to identify junior researchers with such distinguished publication records in Bayesian statistics. Furthermore, the pioneering nature of the now classic book on Bayesian inference by Box and Tiao (1973) simply cannot be overstated. It was essentially *the* textbook, during those days when Bayesian approaches just began to enter mainstream statistics, for anyone who wanted a theoretically rigorous and practically insightful treatment of Bayesian

statistics. Much of the Bayesian statistics today is (too) occupied by computational advances such as MCMC, but the book remains a definitive reference for analytic treatment of Bayesian statistics and its philosophical underpinning.

A fruitful area where Bayesian approach is particularly useful is when we have reliable prior information or when we need coherently aggregated information in various data pieces. One such application is the so-called "Small area estimation", and in this issue Bryant and Zhang provide a detailed account on how they built a Bayesian model for population forecasting for small areas in New Zealand for the period of 2014-2038. A key advantage of their method is its ability to provide a meaningful uncertainty measure for their forecasting, thereby engaging users to confront the substantial uncertainty in the long-term forecasting.

Seasonal Adjustment

The importance of seasonal adjustment is shown by the fact that many economic policies around the world are guided by analysis of seasonally adjusted data, and the contributions of Professor Tiao to seasonal adjustment are evidenced by his Julius Shiskin Award in 2001. Cleveland and Tiao (1976) is the first to provide a statistical model for the Census X-11 seasonal adjustment program whereas Hillmer and Tiao (1982) develop a model-based approach to seasonal adjustment. This latter approach led to the developments of the Census X-12 ARIMA program and the SEATS program (Gomez and Maravall (1996)) currently used by the U.S. Census Bureau and the European Central Bank, respectively.

An important step in seasonal adjustment is ARIMA model specification with outlier detection and calendar effects. In this issue, Maravall, Pavon, and Cañete investigate model specification empirically using more than 15,000 monthly socio-economic time series from many countries. The sample sizes range from 60 to 600. Their results are impressive and insightful. In addition, Nieto, Peña, and Saboyá develop a procedure for detecting common seasonality using dynamic factor models applied directly to the observed data.

Time Series Analysis

The contributions of Professor Tiao to time series analysis are enormous. The intervention analysis of Box and Tiao (1975) is path-breaking in assessing the dynamic impact of an event of interest, with applications in various scientific areas. Chang, Tiao, and Chen (1988) generates tremendous interest with results in many subsequent publications concerning outliers in time series analysis. Box and Tiao (1977) develops a method for handling co-integration in multiple time series well before the term was coined. Tsay and Tiao (1984) develop a method for specifying mixed ARMA models and for consistent estimation of AR

parameters via iterative autoregressions. Tiao and Tsay (1989) investigate the hidden structure of multivariate time series and propose a procedure to identify parsimonious vector ARMA models.

In this issue, Lai and Tsang extend the work of Box and Tiao (1977) and Tiao and Tsay (1989) to multivariate stochastic regression and develop theory for the case of high-dimensional stochastic regressors. Liu and Chen study high-dimensional time series analysis using regime-switching factor models. Tsai, Tsay, Lin, and Cheng propose a doubly constrained factor model to achieve greater parsimony in multivariate time series analysis. Wang, Chan, and Yau investigate nonlinear error correction and multiple-threshold co-integration, further extending the seminal work of Box and Tiao (1977). Huang and Shao investigate the converge probabilities of subsampling-based confidence sets in the time series setting. Rabhi and Wiens propose a minimax robust sampling scheme for interpolating and forecasting the values at a regular grid of an approximately specified second-order stationary process.

Professor Tiao is also a believer in nonlinear time series. Montgomery et al. (1998) investigate cases under which nonlinear time series models can make significant contributions in forecasting. In this issue, Li and Tong propose an efficient algorithm to locate the threshold of a two-regime threshold autoregressive model that shows the substantial improvement in computing time over the traditional method. Lo, Li, Yu, and Li propose a new class of threshold models for modeling conditional heteroscedasticity. Chen, Huang, and Wang consider composite likelihood estimation with regularization for a hidden Markov model for time series data that is shown to be efficient and robust.

Spatiotemporal Statistics

In addition to his tremendous contributions to temporal modeling, Professor Tiao has also made significant contributions to the more complicated spatiotemporal modeling, a common task, for example, for geophysical and environmental data (e.g., Tiao et al. (1990); Niu and Tiao (1993)). Tiao et al. (1990) was particularly significant, as it led to a highly cited subsequent work (Weatherhead et al. (1998)) on estimating the number of years needed to statistically detect a trend in environmental measurements. In this issue, Aldor-Noiman, Brown, and Fox proposed an integer-valued first-order autoregressive spatiotemporal process for modeling violent crime events; the Poisson nature of the process is more suitable than the usual Gaussian process approximation because of the low-count nature of the violent crime (thank God!) Motivated by the analysis of surface meteorological data, Zhang considers the testing for additive assumption of location and time effects via a multivariate time series approach.

Statistical Applications

Many ideas of Professor Tiao's research are motivated by applications. He often mentions that statistical theory and applications should go hand-in-hand. A casual inspection of his CV reveals both the depth and breadth of Professor Tiao's involvement in applied statistics, from Box, Hamming, and Tiao (1975), which provides a first statistical analysis of Los Angeles ambient carbon monoxide data, to over three dozens of articles on analyzing ozone data (e.g., Reinsel et al. (1989); Weatherhead et al. (2000)), and to forecasting the U.S. employment rate (Montgomery et al. (1998)) and Taiwan economy and stock market (Tiao et al. (1998); Cho et al. (2003)). In this issue, Ho, Chen, and Tsai use non-parametric quantile estimate to study value at risk of integrated returns and apply the result to equity portfolios. Chen, Lei and Tu use a functional-coefficient MA model to forecast the Chinese consumer price index. Davis and Liu study the theory and inference of a class of nonlinear model and demonstrate the application to time series of counts.

In conclusion, as Professor Tiao's students and colleagues, all three of us have been inspired and motivated by his devotion to statistical and scientific research, as well as by his passion for education and professional service. We therefore feel privileged to have the opportunity to organize this special session. We hope every reader will find at least two inspirations in this issue, which would be the best "thank-you" to all authors and reviewers for their tireless effort, and the best birthday present for Professor Tiao.

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Editors for this Special Issue

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