The Refinement of Econometric Estimation and Test Procedures

The small sample properties of estimators and tests are frequently too complex to be useful or are unknown. Much econometric theory is therefore developed for very large or asymptotic samples where it is assumed that the behaviour of estimators and tests will adequately represent their properties in small samples. Refined asymptotic methods adopt an intermediate position by providing improved approximations to small sample behaviour using asymptotic expansions. Dedicated to the memory of Michael Magdalinos, whose work is a major contribution to this area, this book contains chapters directly concerned with refined asymptotic methods. In addition, there are chapters focussing on new asymptotic results; the exploration through simulation of the small sample behaviour of estimators and tests in panel data models; and improvements in methodology. With contributions from leading econometricians, this collection will be essential reading for researchers and graduate students concerned with the use of asymptotic methods in econometric analysis.

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The Refinement of Econometric Estimation and Test Procedures: Finite Sample and Asymptotic Analysis

Edited by

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To Mary Magdalinos

Contents

List of figures

List of tables

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Preface

This book is dedicated to the memory of Michael Magdalinos, formerly Professor of Econometrics at the Athens University of Economics and Business, who died in August 2002 at the age of 52.

Professor Magdalinos was, in the opinion of many, the leading econometric theorist in Greece for a substantial number of years. In 1998 he was ranked among the top few econometricians in Europe, and compared favourably with the world's best, in the *Journal of Econometric Theory* rankings. In 1999 his achievements were recognised when he was appointed to a Personal Chair in Theoretical Econometrics. He had a considerable international reputation and his untimely death at the peak of his academic powers deprived not only Greece but the academic world as a whole of an outstanding scholar. However, as well as being a fine scholar he was a warm and friendly person and an inspiration to others. He was a great personality and enormous fun to be with, he was an altogether delightful man.

In November 2003 the Department of Economics of the Athens University of Economics and Business promoted a one-day conference to honour the memory and achievements of Michael Magdalinos. A distinguished group of international scholars were invited to participate in the programme. Some of them had been his co-authors and some, such as Elias Tzavalis, were former students. Others had known him for a long time and shared his academic interests while others were scholars who may not have known him well but whose work he was known to admire. Inevitably the restriction on numbers meant that many more who would have gladly participated were unable to do so. Hence those of us who presented our own tributes to his memory were conscious that we spoke not only for ourselves but also for many colleagues throughout the world.

The current book is essentially based on the papers that were presented at the conference. It does however have a few unusual features. It includes, for example, Michael's last paper, not previously published, which was

written jointly with his last PhD student George Mitsopoulos. In addition there is a chapter by Michael's son, Tassos, himself a theoretical econometrician, written jointly with Peter Phillips.

We believe that this book will be a significant contribution to the econometric literature while, at the same time, providing a fitting tribute to the memory of our great friend. It is something that his family can treasure for all time.

GARRY D. A. PHILLIPS
ELIAS TZAVALIS

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Michael Magdalinos 1949–2002

Michael Magdalinos obtained his PhD at the University of Southampton in 1983. His supervisor was Grayham Mizon while Garry Phillips was the external examiner. The thesis title was 'Applications of Refined Asymptotic Theory in Econometrics' and this work provided the foundation for much of his subsequent research. Indeed the title of this book *The Refinement of Econometric Estimation and Test Procedures: Finite Sample and Asymptotic Analysis*, while being chosen as an appropriate general description of the book's contents, is also indicative of the general thrust of his academic research.

Refined asymptotic methods use asymptotic expansions rather than first-order normal approximations and lead to a general estimation theory which, though more complicated than the theory based on first-order normal approximations, is still simple enough to render general insights and provide comparisons sufficiently simple to be of practical use. The analytical results obtained so far in this area can be used to compare the relative merits of alternative estimators, especially those of ordinary least squares (OLS), two-stage least squares (2SLS), instrumental variables (IV), maximum likelihood (ML) and limited information maximum likelihood (LIML), as well as of alternative testing procedures based on them. This volume is dedicated to the memory of Michael Magdalinos whose work constitutes a major contribution to this area of econometrics. Some of his more important publications, which are particularly illustrative of his work, are summarized as follows.

In his first major paper, published in the *Review of Economic Studies* (1985), he considered the problem of selecting the 'best' estimator among a wider class of IV estimators for simultaneous equation systems. Concentration comparisons, based on the Edgeworth approximation to the distribution of these estimators, lead to selection rules of sufficient simplicity to be useful in applied econometric work. These depend on the sample size, the number of regressors and the degree of overidentification. The rules suggest that when the sample and *a priori* information are

weak, that is, the sample size and the order of overidentification are both small, then the available sample information is not adequate to support estimation techniques more sophisticated than OLS. When the sample information is adequate but the *a priori* information is weak, then the 2SLS estimator is preferable, since it is more concentrated than the LIML estimator. Finally, when both the sample and the *a priori* information are strong, then we should prefer the LIML since it is median unbiased. The paper gave precise criteria for practical implementation of these rules.

In the *Journal of Econometrics* (1990), he compared the finite-sample performance of the three alternative classical testing principles: the Wald, likelihood ratio (LR) and Lagrange multiplier (LM) principles, as well as their instrumental variables generalizations, applied to testing a set of linear restrictions in a structural equation with stochastic regressors. By deriving the third-order local power function of these tests, he showed that the classical tests are locally biased for a subset of the parameter space in small samples. The problem is more severe for the Wald test that is calculated from the TSLS estimator. The comparison of the local power of the size-corrected tests shows that, under certain conditions, the LR test is preferred among the others since it is minimax and it is more powerful than the LM test.

In two papers in the *International Economic Review* (1988) and *Journal of Econometrics* (1996, with Symeonids) he re-examined the interpretation and the third-order power of the Anderson–Rubin–Sargan–Basmann (ARSB) tests of the validity of overidentifying structural restrictions in a classical simultaneous equation system. This work showed that a more illuminating interpretation of these tests is one of testing the orthogonality conditions only for the instruments that overidentify the equation, a characteristic that was also realized by Sargan (1958). To second-order accuracy, it was shown that the ARSB tests are unbiased against the alternative of false orthogonality conditions, whereas there is a subset of the parameter space where the tests are biased under the alternative of false structural restrictions. Building on the above work, his *Econometrica* (1994) paper proposed a ML approach for testing the admissibility of a subset of (overidentifying) stochastic instruments. Based on third-order asymptotic theory, he shows that a simple linearization of the LR test which is equal to the difference of two of Sargan's (1958) mispecification statistics (see also Hansen, 1982) based on the LIML estimator, provides a test statistic which is independent of the correlation between the regressors and the errors and performs better than other admissibility tests. As testing for orthogonality conditions involved running auxiliary regressions, respecifying the structural equations and testing again for

orthogonality until the correct set of instruments is chosen, a less cumbersome approach was to be welcomed and this was provided in the *Journal of Economics and Statistics* (2001), with Helen Kandilorou, where he suggested a new and much simpler procedure. This approach encompassed the dual problems of testing structural restrictions and orthogonality conditions and placed them in a single equation framework where, after appropriate transformations, the familiar regression techniques could be applied.

In his *Journal of Econometric Theory* (1985) and *Journal of Econometrics* (1995, with Symeonides) papers, he suggested size corrections for the Wald-test statistic in the linear regression model and for the F and t-test statistics in the linear regression model with AR(1) errors respectively, employing Cornish–Fisher expansions. The aim of these corrections was to adjust the nominal size of these tests to their true size. Apart from testing, these corrections are necessary for power comparisons (see also his *Journal of Econometrics*, 1990 paper). Whereas the Edgeworth expansion can be used to correct the critical values of the asymptotic distribution, the Cornish–Fisher expansion enables a correction of the test statistics themselves. The two types of expansion are asymptotically equivalent, but the Cornish–Fisher expansion avoids the problem of assigning negative probabilities in the tails of the distribution. To derive approximations to the distributions of the test statistics, he employed stochastic expansions of them which can significantly facilitate the derivations and the interpretation of the adjusted tests. The relationship between the stochastic expansion of a test statistic and the asymptotic approximation of its distribution is given in his comprehensive study of stochastic expansions and asymptotic approximations in his *Journal of Econometric Theory* (1992) paper. As shown in this paper, the combination of stochastic expansions and formal Edgeworth approximations, apart from being an analytically efficient method, typically leads to simple interpretable formulas that are most suitable for work in finite sample econometrics.

A characteristic of his work is its profound nature, the high standard of scholarship and the demonstration of an outstanding grasp of a relatively complex area of statistical econometrics. He was, indeed, a major figure in the field of theoretical econometrics.

Introduction

Twenty-two authors have contributed to this book which comprises 14 chapters. Chapters 1–5 are primarily concerned with econometric estimation and examine the properties of estimators in finite and asymptotic samples. The first of these, by Michael Magdalinos and Mitsopoulos, derives a partial solution for the maximum likelihood normal equations in models with autoregressive conditionally heteroscedastic errors under the assumption that the errors belong to the Pearson family of distributions. It is shown through Monte Carlo simulations that there may be significant efficiency gains for maximum likelihood estimation compared to quasi maximum likelihood estimation. This is followed in Chapter 2 by Spanos who revisits the statistical foundations of instrumental variable (IV) estimation to ascertain the reliability and precision of instrumental variable-based inference. The paper stresses that the choice of instruments and the optimality of the resulting IV estimator entails both theoretical as well as statistical considerations. Chapter 3 is by Garry Phillips and takes another look at the problem of deriving moment approximations for two-stage least squares in the classical simultaneous equation model. In particular, approximations for the first and second moments are found in a simultaneous equation model in which the disturbances follow a system autoregressive scheme. The results are compared to Nagar's original approximations for serially independent disturbances. In Chapter 4, Smith is concerned to adapt the general empirical likelihood (GEL) unconditional moment methods developed earlier, to the conditional moment context. In particular, GEL estimators are developed which achieve the semi-parametric efficiency lower bound. The requisite GEL criteria are constructed by local smoothing. The paper also provides a local GEL criterion function test statistic for parametric restrictions. Chapter 5, the final chapter of this group, by Peter Phillips and Tassos Magdalinos, focuses on an asymptotic theory for autoregressive time series with weakly dependent innovations and a root of the form $\rho_n = 1 + c/n^{\alpha}$, involving moderate deviations from unity

where $\alpha \in (0, 1)$, and follows on to their earlier work with independent errors. In the explosive case where $c > 1$ the limit theory for the serial correlation coefficient is Cauchy while for $c < 0$ and $\alpha \in (1/2, 1)$ the limiting distribution is normal and the convergence rate lies between the stationary and local to unity cases. It is also shown that weakly dependent errors induce a bias in the limiting distribution analogous to that of the local to unity case.

Chapters 6–9 fall under the general heading of issues and methods of econometric testing, commencing with a paper by Cavanagh and Rothenberg. This examines the use of higher-order approximations in distinguishing between asymptotically equivalent general likelihood-based hypothesis tests. Criteria are presented for the admissibility or otherwise of commonly used test procedures. Chapter 7 by Symeonides, Kandilorou and Tzavalis examines how in the classical regression framework with heteroscedastic errors, the standard t and F statistics can be size-corrected using Cornish–Fisher expansions. Unlike test statistics which are adjusted based upon the Edgeworth approximation, the Cornish–Fisher corrected test statistics do not have the drawback of assigning negative tail probabilities. The performance of the size-corrected tests in improving the test size is then examined in a set of simulation experiments. Chapter 8 by Li and Stengos proposes a non-nested testing procedure for discriminating between alternative sets of regressors in a non-parametric context which involves double kernel estimation. The small sample performance of the test is examined through Monte Carlo simulations and found to have good size and power properties. Chapter 9, the last in this group, is by Dhrymes and deals with the problem of testing for the presence of autocorrelation in a system of general linear models when the model is formulated as a vector autoregression with exogenous variables. The solution to the problem is presented as a generalization of Durbin's h-statistic; however, it is a feature of the paper that derivations are from first principles and do not use Durbin´s original arguments.

In Chapters 10 and 11, dynamic panel data models are the focus of interest. First, in Chapter 10, Kapetanios and Pesaran consider the analysis of large panel data models in the presence of error cross-section dependence and compare two alternative methods for estimation and inference in panels with a multifactor error structure. The two approaches based, respectively, on proxying unobserved factors with cross-sectional averages and augmenting panel regressions with factor estimates based on principal components, are compared in extensive Monte Carlo experiments. In Chapter 11, Kiviet notes that in dynamic panel data models with individual specific effects, a large number of alternative estimation

techniques have been proposed and extensive Monte Carlo simulations have examined their performance in small samples. It is argued that such studies have generally been too narrowly focused to enable fair and informative conclusions to be reached when comparing alternative inference techniques. Improvements in designing Monte Carlo contests are required and a way forward is illustrated in the context of GMM estimation of a stable first-order autoregressive panel relationship with an unknown intercept, random unobserved individual effects and i.i.d disturbances.

Chapters 12–14 do not fall into a distinct category. In Chapter 12, Abadir and Magnus note that the well-known transformation theorem is one of the very few major statistical theorems for which there is no proof in the statistical literature since it requires advanced results from real analysis. They present a simple proof which uses the idea of conditioning for continuous random variables. The approach used illustrates how conditioning can provide some short-cuts to proofs by reducing the dimensionality of statistical problems. Chapter 13 by Hillier is concerned with the derivation of the joint density of the sum and sum of squares of nonnegative random variables especially in the context of minimally sufficient statistics. A closed form expression is not so far available and Hillier uses a differential-geometric approach to derive this joint density for the class of exponential models in which either or both statistics are minimally sufficient. An application to the censored normal model is also considered. Finally, in Chapter 14 Mizon and Staszewska examine the efficacy of alternative methods of response analysis in economic policy investigations. Different types of response analysis are illustrated graphically and the non-stationary case is examined using the vector equilibrium correction model. The importance of distinguishing between responses to shocks and to policy changes is stressed as is the appropriate choice of conditioning variables and it is argued that a careful selection of the latter is preferable to arbitrary orthogonalization.