

# Preface

Statistical inference is oftentimes based on first-order asymptotic theory. In particular, it is a common practice to perform likelihood ratio, score and Wald tests using approximate critical values. Such critical values are obtained from the test statistic limiting distribution when the null hypothesis is true. The approximation holds when the number of observations in the sample tends to infinity, and it is thus expected to deliver reliable inferences in large samples. When the sample is not large, however, size distortions are likely to arise. That is, the effective type I error probability may not be close to the nominal size selected by the practitioner. It is thus important to have at hand alternatives that deliver more reliable inference in small samples. In this monograph, we cover analytical corrections known as Bartlett and Bartlett-type corrections. Bartlett corrections are applied to likelihood ratio test statistics whereas Bartlett-type corrections are applied to score test statistics and also to other asymptotically  $\chi^2$  criteria. The corrections deliver modified tests with error rates that decay faster toward zero. Thus, such tests can be expected to display superior finite sample behavior.

Practitioners are usually also interested in parameter estimation. Maximum likelihood estimators are typically consistent and asymptotically normal, but are usually biased. That is, the estimator expected value differs from the true parameter value, which implies the existence of a systematic error. We provide analytical and numerical approaches that can be used to reduce the bias of the maximum likelihood estimator. Preventive and corrective bias reduction schemes are presented and discussed. The former entails modifying the log likelihood or score function prior to obtaining the estimator whereas the latter entails obtaining the estimator in the usual fashion and then bias correcting it. These bias corrections can deliver modified estimators that have much smaller systematic errors than the corresponding unmodified estimators.

The material we present in this book is a compilation of analytical results and numerical evidence available in the literature. We do not include new results. Our goal is to present, in a coherent way, strategies that can be used to achieve more accurate inferences. Our main focus lies on obtaining analytical corrections to tests that are based on a first-order asymptotic approximation and also on achieving bias reduction in small samples. Numerical (Monte Carlo) results are presented in order to illustrate the gains involved in using such finite sample

corrections. We also point out that the details involved in many of the derivations were not included in the text since we intend to provide readers with a concise monograph. Further details can be found in the references listed at the end of each chapter.

The structure of our monograph was dictated by three main choices we made. First, we intend to provide readers with a concise overview of the topic. Second, we decided to focus on point estimation and testing inference. We do so by focusing on bias reduction of estimators and corrections that can be applied to test statistics. Additionally, even though our focus lies on analytical corrections we also include material on bootstrap-based inference since it is often cited as an appealing alternative to analytically corrected estimators and tests.

Finally, we would like to thank Klaus Vasconcellos for suggestions on parts of our monograph. We also gratefully acknowledge financial support from CNPq/Brazil.

Recife, February 2014

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An Introduction to Bartlett Correction and Bias  
Reduction

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2014, XI, 107 p., Softcover

ISBN: 978-3-642-55254-0