BOOK REVIEW of "Statistical Foundations for Econometric Techniques" by Asad Zaman

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Book Review

Statistical Foundations for Econometric Techniques

Asad Zaman, Academic Press, London, 1996

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1 Overview

Econometrics now has so many sub-disciplines that most of the newer textbooks in the field have necessarily become quite specialized in their coverage. Zaman's book is one such. However, as Zaman attempts, and I believe succeeds in asserting the link between classical statistics and econometrics, his book should be of great interest to both teachers of core econometrics graduate courses as well as to practitioners of the *art* of econometrics. I use the word *art.* in the previous sentence for two reasons. First, Zaman clearly points out throughout the book that applied econometricians face a plethora of choices concerning methodology, testing procedures, and estimation procedures when examining empirical relationships among economic variables. As such, choices are often determined by experience and gut instinct rather than by the obvious availability of some suitable methodology. Second, even when a method is settled on, say empirical Bayes, then there still remain an enormous amount of choices to be made, all of which involve trade offs between alternative assumptions, ideological beliefs, etc. In addition, there are so many tests for, say heteroskedasticity, that one is often left wondering which test to implement. Zaman weeds through all of these and related issues by discussing, comparing and evaluating a huge variety of cutting edge econometric and statistical techniques. Perhaps one of the most useful features of the book is that all of the techniques discussed are critiqued very carefully, with great emphasis on historical development, ease of implementation in practice, and realism of assumptions.

The book also addresses with great insight the tensions between Bayesian and classical econometricians. Indeed, Zaman straddles the two sub-cultures in econometrics throughout the book with such agility that even the fervent classical econometrician may be left with a greater understanding of how Bayesian techniques can and *should* be used in conjunction with classical techniques in the context of empirical applications. The same also holds in the opposite direction. However, as Zaman himself points out, Ms approach of evaluating Bayesian estimators on the basis of their objective characteristics, and comparing alternative prior probability distributions with the given belief that some are generally preferable to others may be distasteful to staunch Bayesians.

Zaman's book has been greatly influenced by econometricians and statisticians at Stanford. Three of these whose ideas and approaches to econometrics appear to weigh significantly in the emphasis and direction of the book are Takeshi Amemiya, Bradley Efron, and Charles Stein. Clearly, though, many others have played important roles in shaping the philosophical views espoused by Zaman. In particular, it seems to me that Judge et. al. (1985), Berndt (1991), Efron (1982), Hall (1992), and Lehman (1983, 1986) to name only a few, have written books that have played an important role in shaping the book. Zaman's treatment of econometrics from the viewpoint of mathematical statistics is perhaps most important because it gathers together a wide assortment of cutting-edge econometric tools, including: minimax, robust regression, bootstrap, empirical Bayes, hierarchical Bayes (and in particular Gibbs samplers) estimators. From a testing perspective, classical structural break, autocorrelation, heteroskedasticity. non-linearity, normality, and various other misspecification tests are discussed. Furthermore, the triumvirate of classical tests, the likelihood ratio (LR), Lagrange multiplier (LM), and Wald tests are also examined in detail, and are compared using various measures including Pitman efficiency as well as local approximations which use third order asymptotic approximations. Asymptotic theory is also covered in the book. Of particular note is the discussion of Edgeworth expansions, orders of approximation, and the bootstrap. Of note for the potential reader is that the book essentially does not discuss unit root asymptotics, or more generally nonstationary econometrics. The book also does not attempt to provide detail on limited dependent variable econometrics or panel data econometrics. Thus, for discussions of cointegration, unit root tests, discrete choice models, and panel data, the reader is referred to specialized texts in those areas. However, as discussed, above, this 570 page volume should be of interest to many econometricians using anything from Gibbs sampling to bootstrap and robust estimators in both theoretical and applied contexts.

The rest of this report is broken into four parts, each of which provides a brief description of the contents of each of the four major parts in the book. Before outlining the four parts of the text, though, it is worth noting that a 10 page introduction prefaces the book. As is the entire text, the introduction is very smartly written, and exposits beautifully Zaman's views on the Bayesian versus frequentist approaches to econometrics. There are also three short appendices in the book. Appendix A covers the multivariate normal distribution, while appendices B and C discuss uniformly most powerful tests and decision theory, respectively. Finally, each chapter in the book is prefaced with an enlightening parable, saying, or quotation. For example, one which appears before chapter 7 on uniformly most powerful invariant hypothesis tests is:

Lost in the desert, the companions were anxiously searching for water. In desperation they decided to dig. Most dug a hole here, and another one there, abandoning their holes quickly to look for a better place in their anxiety. One man however put his trust in God and calmly kept digging deeper and deeper at the same spot. He found the water and also gave the others to drink

2 Part I

Part I of the text is 123 pages long, and focuses entirely on estimators for regression models. This part begins in chapter 1 with a very nice description of least squares

using the geometry of projection. The Gram-Schmidt procedure, Kniskal's theorem, generalized least, squares, the coefficient of determination, and F tests are all examined in the chapter.

Focusing primarily on a simple linear model, Zaman goes on in chapter 2 to discuss maximum likelihood, misspecification, identification, exogeneity, two-stage least squares, and instrumental variables. Of note is that even at this early juncture in the text, Zaman already begins a lead in to Edgeworth expansions or bootstrapping as a means by which sharper approximations to the distributions of OLS estimators can be obtained, in the context of skewed or otherwise nonnormal error distributions. Further, as is done throughout, all methods are connected with the concepts of minimum variance unbiased estimators, the Cramer Rao lower bound, and related concepts.

Chapter 3 begins to incorporate Bayesian approaches into the book by discussing classical Bayesian estimates as well as empirical Bayes estimates, including hierarchical Bayes and the Gibbs sampler. Throughout the book, it is clear that Zaman finds the empirical Bayes - and in particular hierarchical Bayes - approach to be preferable to simpler approaches which involve a number of potentially unpalatable assumptions. In chapter 3 a nice parallel is also drawn between the ridge estimator and the classical Bayes estimator.

Chapter 4 begins with a discussion of Stein's discovery of the in-admissibility of MLE in 1955, continues with a discussion of minimax estimators, and ends with a discussion of appropriate priors and loss functions. Throughout these last two chapters it is emphasized that Bayesian regression techniques are usually only useful in the presence of strong and valid prior beliefs.

Chapter 5 examines robust regression techniques. Three criteria are suggested to evaluate the wide variety of robust estimators available in the literature: (i) efficiency at the normal model, (ii) resistance to small changes in distribution (bounded influence) and (iii) resistance to outliers (low breakdown). It is shown that many popular and widely used robust estimators fail to perform well according to these criteria, and alternatives are presented.

Of note is that this (and the next) part of the text are quite illuminating in their philosophical discussion of the issues at hand, and do not use space discussing many of the more well known details of the various estimation techniques.

3 Part II

The second part of the book is 135 pages long, and is concerned with hypothesis tests for regression models. Chapter 6 begins by discussing Pitman efficiency, which judges LR, LM, and Wald tests to be asymptotically equivalent, and then goes on to present 'stringency' as a performance measure for hypothesis tests. A more stringent test is defined as one which has smaller 'shortcoming', where shortcoming is defined as the gap between the power envelope and the probability that a test rejects the null for a fixed value of the parameter. The

interesting feature of this measure is that Zaman uses it to show graphically that the LR test is more stringent than LM and Wald tests. Furthermore, in chapter 13 Zaman presents the first order asymptotic theory according to which the Wald and LM tests are locally equivalent to the LR test, while noting again that this local equivalence is valid (only) up to the second order terms in asymptotic approximations. The rest of chapter 6 discusses locally most powerful tests in situations where uniformly most, powerful tests do not exist. Other tests which have better power in neighborhoods which are not local are also discussed.

Chapter 7 discusses the theory of invariance developed by Hunt and Stein (1946), in the context of which uniformly most powerful invariant hypothesis tests can be found. Chapters 8, 9, and 10 discuss a large number of more practical tests for regression models. For example, tests for the normality of errors based on the idea due to Kolmogorov of comparing empirical distribution functions, and others, such as the Jarque-Bera (1987) test, are outlined, A wide variety of autocorrelation, hetcroskedastirity, nonlinearity, and related tests are also briefly touched on. Examples include the White, Breusch-Pagan, and Goldfeld-Quandt heteroskedasticity tests, the RESET tests.

Chapters 9 and 10 treat the Chow structural break test. Constancy of parameters across observations (time and space) is an essential background assumption for the use of regression analysis. Many extensions and generalizations of the Chow and related tests are discussed; these permit extensive testing for constancy of regression coefficients and variances.

4 Part III

The third part of the book is 150 pages and 5 chapters in length, and contains a good elementary survey of asymptotic techniques and definitions. Chapter 11 gives definitions of quadratic mean convergence, convergence in probability, and almost sure convergence. Test consistency is defined, and examples of consistent tests are given. Chapter 12 discusses estimator consistency, focusing somewhat on M-estimators, but also discussing in a very interesting fashion bootstrapping a regression model, and potential failures of the bootstrap. Chapter 13 explores asymptotic distributions, including that of the LR test statistic for simple null hypotheses in cases with and without nuisance parameters. Chapters 14 and 15 are perhaps the most interesting in Part III of the book. It is pointed out that central limit theorems provide us with approximations to distributions of estimators and test statistics which may be of poor quality and require extremely large sample sizes. A number of alternatives to large sample approximations are then discussed in some detail. In particular, Edgeworth expansions and bootstrap estimates which involve higher order accuracy are examined. A guide to using the bootstrap is also given, and bootstrap-Bartlett corrections to test statistics are discussed, for example. Chapter 15 covers asymptotic efficiency, with related discussions of empirical Bayes, higher order asymptotics, first, second and third order efficiency of maximum likelihood.

5 Part IV

The fourth part of the book contains 88 pages and 3 chapters of empirical Bayes applications. Chapter 16 begins with a number of simple examples. For example, the first is from Efron and Morris (1975) who model batting averages from selected major league baseball players. In a subsequent subsection simple Stein estimates are outlined. Another example models the NBER recessions and expansions dataset examined by Gliysels (1994) using empirical Bayes methods. The next chapter discusses empirical Bayes in the context of simple OLS, and compares and contrasts a number of alternative strategies for implementing empirical Bayes. The final chapter of the book outlines in detail some approaches to hierarchical Bayes and the Gibbs sampler, and provides examples. In particular the discussion of the Gibbs sampler is quite interesting, proving a general overview, as well as discussing generating random numbers, an algorithm, required conditionals, and concrete details required for implementation.

Overall, the book is a unique text in two ways. First, there is emphasis not only on theoretical detail, but also on intuitive appeal. Second, the book brings together a very wide variety of different techniques and statistical approaches to econometrics, and does so in a rather unifying fashion. While the book does not dwell on time series or cross sectional econometrics *per se*, it is a must for the bookshelf of the practicing econometrician, as important areas such as the bootstrap, higher order asymptotics, Edgeworth expansions, empirical Bayes, and the Gibbs sampler are elucidated very clearly.

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