

BOOK REVIEW

Econometric Theory and Methods

by Russell Davidson and James G. MacKinnon
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REVIEWED BY
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1. INTRODUCTION

Teaching graduate econometrics means covering three different kinds of subject matter: a grounding in the theory of econometrics, a long laundry list of available econometric techniques, and an introduction to the fact that the practice of linking models and data is every bit as untidy as mathematical statistics is neat. I assign *Econometric Theory and Methods (ETM)* as a primary text in our first Ph.D. econometrics course. *ETM* is in charge of getting the students their theoretical grounding. I also assign Greene's excellent *Econometric Analysis* (2003) for its coverage of a long list of techniques. My laptop, EViews, and I, together with a whole lot of real data, are responsible for being untidy.

ETM's forte is that it presents econometric theory in a consistent, methodical sequence that gives students mathematical tools immediately applicable to econometric theory. Written by renowned econometricians, *ETM* reflects the authors' personal tastes in choice of which mathematical techniques to emphasize. The book contains what the authors find most important and leaves out other material. There is considerable use of projection matrices, artificial regressions, and Gauss–Newton regressions, and more space than is usual is spent on the geometry of least squares. The method of moments is the underlying statistical principle through most of the text. Bootstrapping is introduced early on. Although occasionally idiosyncratic in their choice of material, the authors keep the book to the point and, admirably, on the short side. *ETM* is 750 pages. As comparisons, Greene (2003) is 1,026 pages; Hayashi's *Econometrics* (2000) is 683 pages; Ruud's *An Introduction to Classical Econometric Theory* (2000) is 951 pages; the authors' 1993 *Estimation and Inference in Econometrics* (1993) is 874 pages.¹ As an indication of how much more econometrics there is now, the 1984 vintage third edition of Johnston's *Econometric Methods*—a favorite of many connoisseurs—is only 508 pages.

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In their preface the authors discuss two themes that help organize the book: advances in computation and the use of unbiased estimating equations. Keeping to these themes is clearly an important element in the book's straightforward presentation. (Note that "advances in computation" means mostly bootstrapping and the use of artificial regressions. There is a discussion of the method of simulated moments, but not for example Markov Chain Monte Carlo [MCMC] methods.)

So what's missing? *ETM* is much less an encyclopedia or reference book than is Greene. As an example, *ETM* spends 50 pages on discrete and limited dependent variables. Greene spends 140 pages. Similarly *ETM* gives an excellent 5-page introduction to the vector autoregression (VAR). Greene uses 19 pages and discusses more aspects. Both approaches are valuable, and there is limited time in a first-year econometrics course. A student using *ETM* will know the basics of limited dependent variable models and what a VAR is but will have to look elsewhere to bring his or her knowledge to the level where the techniques can be applied.

The more striking omission is that *ETM* contains neither illustrative applications nor any examples using data. (There are a small number of applied examples in the chapter end exercises. Data for these are on the text Web site.) This would be fatal in a self-teaching book. Fortunately, the market for self-taught graduate econometrics is vanishingly small, and *ETM* use will invariably be accompanied by a skilled and lively graduate econometrics instructor. In other words, *ETM* needs to be supplemented with another source for all the practical stuff.

2. CHAPTER-BY-CHAPTER REVIEW

The opening chapter of *ETM* is called "Regression Models." The book opens with the definition of a simple linear regression,

$$y_i = \beta_1 + \beta_2 x_i + u_i. \quad (2.1)$$

This first chapter gives a good sense of the flavor of the book, both in terms of strengths and in noting practical areas that require some supplementation.

The opening pages talk through equation (2.1) sufficiently clearly that after only three pages a reader has a basic understanding of what you get out of a regression. On the other hand, the simple regression is illustrated with equation (2.1) but without the traditional scatter diagram showing points in (y, x) . It is hard to imagine that a student who has never seen a regression can learn from the equation without a picture.

Major negative? Not necessarily. First, students starting a graduate econometrics course almost certainly bring with them a rough idea of what a regression is. Second, it's not difficult to show the traditional scatter diagram in class. On the other hand, the absence of a scatter diagram surely makes the concept

of a residual less intuitive. (For comparison, Greene does provide a scatter diagram; Hayashi does not.)

ETM announces that equation (2.1) might be a consumption function relating household consumption in year t to measured disposable income; β_2 is the marginal propensity to consume; and β_1 is autonomous consumption. It is not that difficult to teach graduate students to regress y on x and to then give an interpretation of the resulting computer output. It is extraordinarily difficult to dissuade students from running regressions with endogenous variables on the right-hand side. (I find it somewhat effective to have my labor economist wife make a guest appearance during lecture to threaten mayhem upon any student who runs such a regression. But this option may not be available to most econometricians.) Page 1 of a text is not the place to bring up endogeneity, but couldn't we have an example that doesn't leave something to unlearn? Mind you, both Greene and Hayashi open with the Keynesian consumption function as the first example.

Writing style is probably less important than content. On the other hand, students are going to—it is hoped—spend many, many hours with the text. Davidson and MacKinnon write delightfully and are unafraid to say what they mean in a straightforward way. I find their use of language engaging. Here is one example taken from a footnote:

In this book, all logarithms are natural logarithms. . . . Some authors use “ln” to denote natural logarithms and “log” to denote base 10 logarithms. Since econometricians should never have any use for base 10 logarithms, we avoid this aesthetically displeasing notation.

Chapter 2 presents the geometry of linear regression. A thorough review of the geometry of vector spaces is followed by everything you ever wanted students to know about the geometry of least squares. Emphasis is given to the use of projection matrices because these play an important role in the algebra of regressions. The Frisch–Waugh–Lovell (FWL) theorem is proved and discussed at length. FWL states that β_1 in the regression $y = X_1\beta_1 + X_2\beta_2 + u$ can be estimated by forming the residuals from a regression of y on X_2 and the residuals from a regression of X_1 on X_2 and regressing the former on the latter. Three applications of FWL are given: sweeping out the dummies, removing a deterministic time trend from a regression, and the relation between several measures of goodness of fit. The final section discusses influential observations and leverage.

The third chapter turns to the statistical properties of ordinary least squares (OLS). Least squares is shown to be unbiased if the right-hand-side variables are exogenous, implying $E(u|X) = 0$, but not necessarily if the right-hand-side variables are merely predetermined, $E(u_t|X_t) = 0$. As an algebraic illustration of the latter point the authors consider the regression of y_t on y_{t-1} given independent and identically distributed (i.i.d.) errors, pointing out that least squares is not unbiased. This is true but not helpful. Endogeneity is an important source

of bias in least squares. Measurement error is an important source of bias. Selection is an important source of bias. Lagged dependent variables with serially correlated errors are an important source of bias. The presence of a lagged dependent variable with i.i.d. errors is not an important source of bias. Although mathematically an estimator either is unbiased or it isn't, the untidy part of econometrics involves learning when biases are likely to be large or small. Some other example would have been better here.

Continuing, the third chapter explains probability limits and consistency, gives the covariance of OLS, proves the Gauss–Markov theorem, discusses the relation between error terms and residuals, gives a good discussion of misspecification, and concludes with defining R^2 and discussing goodness of fit.

The fourth chapter covers hypothesis testing. The chapter opens with a discussion of the principles of hypothesis testing and proceeds to work through t - and F -tests. The discussion is both thorough and succinct. As might be expected from the authors the bootstrap is introduced as a standard tool, rather than exotica relegated to the back of the book.

Chapter 5 covers confidence intervals. In addition to the obvious material, this chapter discusses bootstrap confidence regions and confidence regions in multiple dimensions. Heteroskedasticity-consistent covariance matrices are explained. So is the delta method for nonlinear hypothesis tests.

The sixth chapter takes up nonlinear regression. This is earlier than is traditional. But the early placement has two advantages. First, with modern software nonlinear regression is not much harder to execute than is linear regression. Second, this permits introduction of the Gauss–Newton regression, a tool that the authors use later in the book for computing both linear and nonlinear tests. The chapter concentrates on estimation and testing but gives little in the way of examples of useful nonlinear functional forms or in the way of guidance in the interpretation of nonlinear models. The chapter explores several basic optimization algorithms. Such algorithms are useful not only in econometrics but in the growing areas of economics that employ significant computation. The discussion of optimization is terrific, as one would expect from the authors. They make it look almost too easy, so an additional word of warning that numerical computation is a difficult field might have been in order.

Generalized least squares is introduced in chapter 7. Along with the discussion, autoregressive (AR) and moving average (MA) processes are introduced. Several tests for serial correlation are given. It is noteworthy that the Durbin–Watson (DW) statistic is explained clearly, identified as the most popular test for serial correlation, and then it is explained why the DW is now obsolete and should not be used. Panel data are briefly introduced in this chapter, and the fixed effect and random effect models are explained.

The eighth chapter covers instrumental variable estimation, beginning with brief discussions of errors-in-variables and simultaneous equation systems. (The latter is discussed in depth in chapter 12.) The discussion covers finite-sample

properties, test of overidentifying restrictions, Durbin–Wu–Hausman tests, and instrumental variable estimation of nonlinear models. Chapter 9 moves to generalized method of moments (GMM). The discussion begins with using GMM for the linear regression model, which is a good way to build intuition. Careful discussion is given to alternative formulations of the GMM estimator and to heteroskedasticity and autocorrelation consistent estimation. A variety of tests are discussed. The chapter concludes with an introduction to the method of simulated moments.

Up to this point in the text the underlying estimation theory is based on method of moments. Chapter 10 turns to maximum likelihood estimation (MLE). In addition to explaining MLE, the authors use this opportunity to introduce the likelihood ratio, Wald, and Lagrange multiplier trio. Chapter 11 begins with logit and probit models. (It would be nice if a little more time were spent on interpreting results, something students frequently—and even experts sometimes—have trouble with.) Multinomial, ordered, and nested models are then presented. Models for count data, censored and truncated models, selection models, and duration models are all introduced briefly and clearly.

Multivariate regression models are covered in chapter 12. The chapter begins with seemingly unrelated regression, including nonlinear systems. Simultaneous equation models are then covered. GMM, three-stage least squares (3SLS), full information maximum likelihood (FIML), and limited information maximum likelihood (LIML) are discussed. Structural and reduced forms are given, although there is no discussion of the interpretation of the reduced form.

Chapter 13 goes over methods for stationary time series. The chapter opens with autoregressive moving average (ARMA) models. Estimation is discussed, including some of the practical difficulties of MA estimation. Distributed lag models come next, including partial adjustment, autoregressive distributed lag, and error-correction models. Neither polynomial distributed lag nor adaptive expectations models are discussed. An unusually thorough discussion of seasonal adjustment is given. Basic autoregressive conditional heteroskedasticity (ARCH) and generalized autoregressive conditional heteroskedasticity (GARCH) models are given. VARs are discussed extremely briefly, without mention of identification issues, impulse response functions, or variance decompositions.

Chapter 14 turns to unit roots and cointegration. The chapter opens by building the idea of a random walk. The subject is then motivated with a discussion of spurious regressions. Unit root tests are discussed, followed by a discussion of cointegration and tests for cointegration.

Chapter 15 concludes the text with an examination of specification testing. A number of tests based on artificial regressions are presented. There are then a section on nonnested hypothesis tests, a very brief discussion of model selection based on the Akaike information criterion (AIC) and Bayesian information criterion (BIC), and an introduction to nonparametric estimation.

3. CONCLUSION

The cost of keeping a book focused is that some things have to be omitted. Along the theory-to-practice dimension the authors have chosen a spot in the middle, lopping off both the more theoretical and the more applied wings. Nothing in the text is going to teach a student how to derive an asymptotic distribution. From a personal perspective, I miss more the absence of practical examples. Greene illustrates most methods with an application to real data, as does Wooldridge in his fine undergraduate *Introductory Econometrics* (2003). Modern econometric software has made many “advanced” techniques readily available to the practicing econometrician. As a result, more graduate students should be taking more than just the first-year introduction to econometrics. Still, it would be nice for the introductory year book to do more to help students connect econometric theory with both data and economic models.

ETM is an excellent graduate text. Like any successful text, it champions a particular approach rather than attempting to be all things to all people. Adopters will need to find another way to get practical applications to the students, but when it comes to econometric theory you should hear the faint echo of the authors’ voices in the back of your head. Students who pick up that sound will have learned a lot of econometrics.

NOTE

1. Note that *ETM* isn’t a new edition of *Estimation and Inference*. There are significant similarities, but *ETM* is a new—and even better—book.

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