Overview

Cameron and Trivedi’s *Microeconometrics: Methods and Applications* is an in-depth, textbook style treatment of techniques that are commonly used in applied microeconomics. The companion text *Microeconometrics using Stata* shows how to implement these techniques in the powerful statistics software package Stata. Both texts are appropriate for PhD students already familiar with the first few chapters of an introductory text such as Greene, Hayashi or Ruud. An overview of the material covered in each book is provided at the end of this survey.

Both *Methods* and *Stata* are organized around methods, such as the bootstrap, count data, linear panel models, and multinomial outcome models. *Methods* has a broader coverage and depth of material than *Stata*, which instead focuses on having students get their hands dirty with real data sets on the computer. Both involve useful discussions for applied economists, such as common identification strategies and simulation based methods. Students will also learn about different data types and how to load and manipulate them in Stata. This sort of practical knowledge is very useful for PhD students making the transition to conducting applied research.

Two features make Cameron and Trivedi a useful addition to the applied microeconomist’s bookshelf. First, they have a broader coverage of topics and are more current than many other available texts. After a first year econometrics course, PhD students are often frustrated when they attempt to read journal articles or follow seminar presentations in applied microeconomics. Many of the methods commonly used by leading practitioners are omitted in their first year texts. The broad and up to date coverage in Cameron and Trivedi goes a long way towards filling in these gaps. Cameron and Trivedi is also very useful for practitioners who wish to quickly get up to speed on particular methods in order to read recent research.

Second, a standard first year text frequently omits material that cannot be formally and completely developed given page constraints. Many widely used methods are left out of standard texts as a result. By comparison, Cameron and Trivedi succinctly summarize widely used methods even if they are too advanced to
formally develop in the text. As a result, PhD students at least have a frame of reference for topics that they are likely to encounter in their lives after graduate school. Furthermore, the text also provides detailed discussions of sticky implementation issues that are sometimes hard to formalize, but that nevertheless are likely to be encountered in practice.

A good example of this difference in style is their coverage of instrumental variables. Cameron and Trivedi discuss the standard theory of IV which is included in first year texts. However, they also discuss a number of additional topics. First, the authors have a detailed discussion of the choice of instruments in estimating the returns to education. The choice of instruments is seldom without a bit of controversy in applied work. Many first year texts do not have detailed discussions of the difficulties that arise when trying to find a good instrument. As a result, students may be unprepared for the reaction they will face when they first begin to use IV in their own applications. Cameron and Trivedi also discuss the advantages and disadvantages of different IV-estimators, such as the Jackknife IV and Limited Information ML. While the full comparison of these estimators requires advanced theory, the authors show they are easy to implement and compare in Stata. The relevant literature is cited for those who wish to investigate the formal econometric theory.

Second, Cameron and Trivedi discuss certain theoretical pitfalls in applying IV, such as the weak instruments problem. Most first year texts omit this topic since the relevant econometric theory is too advanced. As a result, students may be puzzled when they are asked to report their first stage F-Statistic when presenting their own research. Cameron and Trivedi, by comparison, provide an intuitive explanation of the weak instruments problem, discuss several alternative diagnostic tests for weak instruments and then show how they can be implemented in Stata.

Finally, Cameron and Trivedi provide a detailed discussion of research by Kling on estimating the returns to schooling. They compare the IV to OLS estimates and discuss weak instruments in the context of this detailed application. This additional material is very useful for students in critically reading recent research papers and in preparing their own research papers for submission to peer reviewed journals.

Unfortunately, such references to the applied literature are casual and scarce. Examples tend to be chosen in order to clearly communicate the econometric
properties of a method, but they seldom help familiarize students with a major applied literature. This is not meant to be a specific criticism of Cameron and Trivedi or of any particular first year textbook. Instead, this suggests the need for a supplementary text which focuses on applications, which we will describe in the next section. The bottom line is that Cameron and Trivedi have provided an extremely valuable service to the profession by producing such a detailed and comprehensive book.

**Some Limitations of Available Econometric Texts**

As an instructor, I have found that there are two important gaps in the available graduate econometrics texts. First, they tend to underexpose students to substantive applications that occur in the major empirical literatures. Second, they draw few links between what students learn in their econometrics courses and to what they learn in their other courses – in particular to economic theory. While a broad awareness of methods common in microeconometrics is a necessary component in the training of an applied microeconomist, it is not sufficient. Students must be able to think critically about both the economic and econometric issues which occur in applied work. Without this training, students find it difficult to make the transition to writing substantive empirical applications.

An effective way to teach students how to do research is to expose them to many different empirical literatures. Students are then shown how econometrics can be used to attack a diverse array of problems in different subfields of economics. The classic Berndt text *The Practice of Econometrics* follows such an approach. Each chapter is organized around a large applied literature such as the those studying the CAPM, costs and learning curves, and the demand for electricity. In each chapter the relevant economic theory is discussed along with empirical facts, econometrics, and references to important papers.

In a chapter on wage regressions, for example, *The Practice of Econometrics* cites 164 papers (108 within 15 years of its publication) in the course of discussing human capital theory, signaling theory, econometrics and recent research. In developing the wage regressions motivated by theory, Berndt discusses the econometric issues of specifying a functional form, adding dummy variables for sex, and trying to control for the omitted variable bias resulting from unobserved ability.
Students see that a broad understanding of economics is indeed useful in conducting applied research.

Both professors and PhD students would benefit from a 21st century equivalent of the Berndt text to supplement the primary text in an econometrics course. Ideally, each chapter would focus on a major empirical literature such as hedonic home price regressions applied to estimating the value of environmental amenities, the estimation of production functions and productivity, or differentiated product demand applied to measuring market power. A given chapter would also contain one or two detailed data sets based on prominent papers written by a leading researcher within the past 15 years.

Finally, the text should have detailed problem sets with applications that forces students to apply their econometric theory in Stata. Such a supplementary text would be invaluable in teaching students how economic theory and econometrics can be used together to explore applied problems.

In no way are these comments meant to criticize Cameron and Trivedi’s excellent work. There is no reason to expand the scope of their texts since they each organized around a self contained theme. However, a text that had substantive empirical applications that cover major empirical literatures would be invaluable as a supplement to standard econometrics texts.

**Summary of Contents of Microeconometrics: Methods and Application**

**Part 1. Preliminaries.**

The first chapter is an overview which outlines the topics covered and describes some distinct aspects of microeconometric data such as discreteness and nonlinearity, greater realism, greater information content, microeconomic foundations and heterogeneity. The authors explain that these distinct aspects call for the special methods described in the text. They also provide a brief discussion on the possibility of dynamics, such as serially correlated errors.

The second chapter discusses causal and noncausal models. This chapter describes commonly used modeling approaches in applied microeconomics, including structural models, reduced form models and potential outcome models. After a providing a brief history of microeconometrics, the authors introduce the linear simultaneous equations model and present its structural model and reduced form. An important discussion on causality, interpreting structural relationships, and
identification is provided. Common identification strategies, such using natural experiments or controlling for confounders, are discussed.

The third chapter is microeconomic data structures. This chapter describes commonly used data structures such as survey data, social experiments, quasi-random experiments and natural experiments. The authors discuss random samples, multistage surveys, and sampling weights and limitations of survey data, such as survey nonresponse and measurement error. Other sources of biased sampling, such as response based sampling, length based sampling, sample selection and sample attrition are covered. Observational data is discussed, along with an introduction to cross sectional, repeated cross sectional and panel data structures. Social experiments are then covered, along with their advantages in controlling for confounders and their disadvantages, such their often prohibitive cost. Certain biases in social experiments, such as randomization and substitution bias, are discussed. The authors describe difference in difference estimation when a natural experiment is available and its advantages in achieving identification. The chapter concludes with a discussion of several common sources of microdata and provides some advice on how to manipulate, prepare and check microdata.

Part 2. Core Methods.

This section covers the core econometric theory that is the centerpiece of first year texts such as Greene, Ruud or Hayashi. However, as discussed above, Microeconometrics has a broader coverage of topics which includes more advanced methods and a more complete discussion of sticky implementation issues. Chapter 4 covers linear econometric models. Standard treatment of loss functions, their corresponding optimal estimators, and optimal predictors is covered. An example of estimating the returns to schooling is presented. The authors then discuss Ordinary Least Squares, its assumptions and identification, and provide proofs of its consistency and asymptotic normality. Heteroskedasticity-Robust standard errors are discussed. Generalized Least Squares and Feasible GLS are introduced along with their asymptotic distributions and compared with OLS. The authors then introduce Median and Quantile regression and provide an example. Different possible sources of misspecification, such as endogeneity, omitted variables and parameter heterogeneity is discussed. The authors then turn to Instrumental Variable methods. The assumptions behind IV, its consistency and asymptotic distributions, 2SLS and the Wald estimator are covered. As discussed above, in addition to standard material,
the authors discuss various problems encountered in practice with IV, such as the
difficulty of finding good instruments and the possibility of weak instruments.
Different diagnostics for detecting weak instruments, such as the first stage F statistic,
are covered. Finite-sample bias in the presence of weak instruments is discussed in
and shown in the example of Kiling (2001)’s estimate of the return to schooling.

Chapter 5 covers maximum likelihood and nonlinear least squares. The chapter
provides a formal and reasonably detailed derivation of the asymptotic theory of
maximum likelihood. Many examples of nonlinear models are presented.
Discussions of extremum and estimating equations estimators, their consistency and
asymptotic distribution, are provided. The analogy principle, whereby one estimates a
model satisfying certain population moment conditions by choosing parameters that
satisfy the analogous sample moment conditions, is presented. Maximum Likelihood
and Quasi-Maximum Likelihood are then given a detailed treatment, with discussions
of the Kullback-Leibler Information Criterion and the Linear Exponential Family of
densities in which the Quasi-MLE is consistent. A comparison of OLS, MLE and
different types of Nonlinear Least Squares is given in a simulation example. The
chapter closes with a discussion on the interpretation of coefficients and marginal
effects.

Chapter 6 covers the Generalized Method of Moments estimator and estimation
more broadly when the model is characterized by a set of population moment
conditions. The authors motivate GMM estimation by showing how the OLS, MLE
and NLS estimators in the previous chapters can be shown to be solving sample
analogues of population moment conditions. The authors then provide the standard
proofs of the consistency and asymptotic normality of GMM. The authors discuss
the information contained in additional moment restrictions, along with situations
where the model is over, under or just identified. The theory of GMM is illustrated by
discussing the examples of linear and nonlinear instrumental variables estimation.
The authors cover additional topics, such as optimal instruments and optimal moment
conditions. Also, they discuss standard topics in linear simultaneous equations such
as seemingly unrelated regressions, identification and three stage least squares. The
authors cover 2SLS, Optimal GMM, tests of overidentifying restrictions, Limited
Information Maximum Likelihood, Nonlinear IV, and various Nonlinear GMM
Estimators. Advanced topics, such as two-step moment estimators and their
distribution, Minimum distance estimation, Empirical likelihood, Linear and
Nonlinear systems of equations, Seemingly Unrelated Regressions and Systems NLS, and Systems IV are covered. The authors close with a brief discussion of moment conditions with nonadditive errors.

Chapter 7 is hypothesis testing of linear and nonlinear hypotheses. The authors discuss the Wald, Lagrange multiplier and Likelihood ratio tests and provide a variety of examples. Discussions of joint versus separate hypothesis, tests in misspecified models, confidence intervals are provided along with the standard test derivations. The chapter also includes discussions of size and power that are more detailed than the standard textbook treatment. The authors perform Monte Carlo exercises to show in practice the distinction between asymptotic and actual size and power and provide show how to implement the Wald test using the bootstrap.

Chapter 8 covers specification tests and model selection. A variety of specification tests, including m-tests, conditional m-tests, Whites Information matrix test, chi-squared goodness of fit tests, tests of omitted variables, Hausman tests, robust Hausman tests, tests of non-nested models (e.g. the Akaike information criterion, Bayesian information criterion and the Vuong likelihood ratio test of non-nested models) and their derivations are covered. The power of the Hausman test is discussed. Various consequences of testing, such as pretest estimation, order of testing, and data mining are covered. Different model diagnostics, such as variants of $R^2$ and residual analysis are included along with an example. The chapter closes with an insightful discussion about the role of specification testing in practice.

Chapter 9 is semiparametric methods. This chapter starts with a discussion of density estimation. This includes some basic asymptotic distribution theory for kernel density estimators and a discussion of practical issues such as the choice of bandwidth using the optimal bandwidth or cross validation. The authors next discuss flexible alternatives to regression including k-nearest neighbors, kernel regression, spline and series estimators and local linear regression. Finally, the chapter covers semiparametric methods including the Robinson difference estimator, semi-nonparametric MLE and semiparametric efficiency bounds. While a detailed discussion of the theory of these topics is not presented, students are at least introduced to important terminology and key concepts from the theory.

Chapter 10 is numerical optimization. The chapter starts with a discussion of standard gradient based methods for maximizing nonlinear functions including Newton-Raphson, Gauss-Newton and common modifications such as BHHH. The
authors provide an example of minimizing the criterion functions corresponding to m-estimators. Advanced method such as the EM algorithm and simulated annealing are also covered. The chapter also discusses difficulties encountered in practice, statistical packages, computational difficulties, and common sense suggestions for checking code reliability.

**Part 3. Simulation-Based Methods**

An important advance in applied microeconomics in the past two decades has been the application of computationally intensive techniques that exploit improvements in computer hardware and software. *Microeconometrics* has three chapters devoted to these methods. This is very valuable for PhD students and practitioners looking for a concise summary of recent developments in computational techniques in econometrics.

Chapter 11 is bootstrap methods. This chapter has a self-contained description of the bootstrap and a sketch of the relevant econometric theory including the consistency of the bootstrap, Edgeworth expansions and asymptotic refinements. Uses of the bootstrap in bias reduction, computing standard errors, hypothesis testing, and confidence intervals, and other topics are covered. Simulation examples are provided. Extensions to the bootstrap, such as subsampling, moving blocks bootstrap, the nested bootstrap, recentering, the jackknife are discussed. Applications of the bootstrap to heteroskedastic errors, panel and clustered data, and overidentified GMM models, nonsmooth estimators and time series are covered. The chapter closes with a discussion of some barriers than can preclude the use of the bootstrap in practice.

Chapter 12 is simulation based estimation. The chapter starts by presenting random parameter models and limited dependent variable models, such as discrete choice models, which are best dealt with by using simulation based methods. The authors then discuss methods for computing integrals, including quadrature and Monte Carlo methods, which are employed in these estimators. The chapter then describes the mechanics of setting up maximum simulated likelihood and method of simulated moments estimators. The key theorems of consistency and asymptotic normality are then presented and a helpful comparison between MSM and MSL is provided. The chapter also touches on advanced topics including indirect inference, importance sampling, variance reduction, and quasi-random numbers. The chapter closes with a detailed discussion of different methods for drawing random variables.
Chapter 13 covers Bayesian methods. The chapter includes an overview of some key elements of Bayesian statistics including Bayes Theorem, a comparison of Bayesian and classical methods, common specifications for the prior (e.g. non-informative priors, hierarchical priors, and conjugate priors), a summary of Bayesian decision theory and model selection. Bayesian methods have become increasingly common in both statistics and econometrics because of their computational advantages in certain problems. The chapter also covers Gibbs sampling, data augmentation and the Metropolis-Hastings algorithm. It is obviously difficult to adequately summarize the recent advances in Bayesian methods that have occurred in the past two decades. However, the chapter at least introduces PhD students to many important concepts and illustrates how to construct the simulators for a non-trivial simultaneous equations model.


As the introduction to the text emphasizes, a key feature of applied data is that it can be discrete, integer valued, censored or come from a selected sample. This section covers standard methods used to analyze nonlinear, limited dependent variable models.

Chapter 14 covers binary outcome models. The chapter starts with a fairly standard exposition of binary logit and probit models. Advanced topics are also discussed, including maximum score, the maximum rank correlation estimator and semiparametric ML estimation of binary models following Klein and Spady (1993). The authors provide a helpful discussion underlying the choice of a binary model, empirical considerations, model adequacy, and the predicted outcomes of binary models. General latent variable models, random utility models, and choice based sampling is covered. The authors conclude with a derivation of the logit model from the difference of type 1 extreme value distributed random variables, the foundation behind the logit model commonplace in discrete choice.

Chapter 15 covers multinomial models. Standard models, including the conditional logit, nested logit, multinomial probit, ordered, and random parameters logit, are presented. In addition, the chapter presents simulation based estimation of the multinomial logit, additive random utility models, and discusses semiparametric estimation and the independence of irrelevant alternatives. Chapter 16 is Tobit and selection models. The topics covered include the Tobit model, sample selection models and the Roy model. Heckman two-step estimators, NLS estimators and
specification tests for the Tobit model are covered. Semiparametric estimation of models with censoring and selection is also discussed. The authors provide a helpful discussion of the identification of selection models using exclusion restrictions.

Chapters 17 through 19 cover topics related to duration analysis. The coverage is quite extensive compared to standard textbooks. Chapter 17 starts with basic concepts and introduces the hazard, cumulative hazard and survivor functions. The Nelson-Aalen estimator of the hazard and Kaplan-Meir estimator of the survivor function are presented. Parametric models used in the literature, such as the Cox Proportional Hazard Model are also covered. Chapter 18 presents the use of mixtures to model unobserved heterogeneity in duration models. Chapter 19 discusses models with multiple hazards. The section concludes with chapter 20 on models of count data. This includes widely used models such as the Poisson, negative binomial and finite mixture models.

Part 5. Models for Panel Data.

Chapters 21 through 23 cover panel data, both standard theory and recent research. Chapter 21 covers the basic theory and estimators, including the pooled OLS, Between, Within, First Difference, Two-way and Random Effects estimators. The advantages, disadvantages and assumptions of each estimator is compared. A detailed discussion of the basic theory and estimators for fixed effects and random effect models is at the heart of the chapter. Standard errors and graphical analysis of panel data is also discussed. The authors also cover Hausman tests for the presence of fixed effects. The authors close the chapter with a discussion of unbalanced panels, sample attrition and attrition bias, and rotating panels.

Chapter 22 covers more advanced topics in linear panel data models including models with endogenous or lagged dependent variables. The topics covered include GMM estimation of panel data models, alternative exogeneity assumptions (e.g. contemporaneous, weak and strong exogeneity) and random and fixed effects estimators. Dynamic panel data models are discussed next along with some relevant econometric theory and estimators (e.g. Arellano-Bond). The authors have a useful discussion on the distinction between true state dependence and unobserved heterogeneity. Difference in Difference estimators, repeated cross sections, Pseudo Panels, and Mixed Linear Models are also covered.
The final panel data chapter covers nonlinear panel data models. Various parametric models and related topics such as incidental and common parameters, conditional MLE, and a number of transformations are covered. An example of Patents and R&D spending is used to compare a number of different parametric nonlinear panel models. Topics covered also include the estimation of discrete choice, selection, transition data and count data models in a panel setting. The authors conclude with discussion of semiparametric estimation and a number of practical considerations.

Part 6. Further Topics.

Chapter 24 is stratified and clustered samples. In practice, survey data sets are seldom based on random samples of the population. This chapter covers weighting schemes and the problem of endogenous stratification. In addition, techniques for clustering standard errors, such as cluster robust standard errors are presented. Different models for clustered data, diagnostics for clustering, and hierarchical linear models are also covered.

Chapter 25 covers treatment evaluation. This topic is not covered in standard introductory econometrics textbooks and is an important addition given the wide use of these methods. This chapter discusses commonly used estimators such as matching, propensity score methods, control function estimators, regression discontinuity design and difference and difference estimation. The chapter contains a fairly detailed discussion of the identification assumptions required for the alternative estimators. The different estimators and measures of treatment effects are carefully compared in an example of the effect of training on earnings.

The final chapter 26 covers the important topic of measurement error. This chapter starts with a discussion of the errors in variables model and a derivation of the biases from measurement error in regression and linear panel data models. They discuss potential strategies for correcting for measurement error including IV methods and replicated data. Finally, measurement error in a number of different nonlinear models, such as discrete choice or count regression, is discussed.

Summary of Contents of Microeconometrics using Stata
The first chapter covers a basic introduction to Stata. Stata syntax, helpfiles, do and log files, macros, looping, and user-written commands are presented. Chapter 2 is a detailed discussion of data management in Stata. Readers are shown how to input, view, modify, merge and save data files, in addition to a variety of commands used to generate new variables. Basic graph commands, such as saving and exporting graphs, are covered along with histograms, scatterplots and other graphical displays.

Chapter 3 describes the standard linear regression on a cross-section of data with a continuous dependent variable and exogenous regressors. Data on the U.S. Medicare program is used throughout the chapter while the authors show how to describe the data, construct summary statistics and tables, run regressions, and perform specification analysis. It is also shown how to run and plot a kernel density. The authors then introduce the Ordinary Least Squares estimator, some of its properties, and the assumptions required for its consistency. Heteroskedasticity and cluster robust standard errors are discussed. The authors explain how to run regressions in Stata, interpret the output tables, and quickly export such tables into common typesetting formats. Certain topics of specification analysis are discussed, such as residual plots and influential observations. Many OLS-relevant tests, such as the omitted variable, Box-Cox, functional form, heteroskedasticity, and information matrix tests, are covered along with a helpful discussion on interpreting these tests. The authors close the chapter by showing how to use sampling weights, common in most survey datasets, in Stata.

Chapter 4 describes Simulation by Monte Carlo, a useful tool for investigating econometric estimators and tests. The authors describe pseudorandom number generators and explain how to draw variables from known distributions in Stata. Basic Stata programs are introduced and shown how to be used in the powerful simulate function. The authors then show how to use these tools to simulate a wide variety of estimators and tests in order to examine their consistency, unbiasedness, power and size.

Chapter 5 shows how to perform Generalized Least Squares estimation in situations with heteroskedastic, clustered and correlated errors in single and multiple linear regression models. The theory of GLS and Feasible GLS estimation is presented before showing how to implement a FGLS estimator in Stata and perform tests for heteroskedasticity. The Seemingly Unrelated Regression estimator is introduced for the multiple linear regression model. Cross-equation constraints are
shown how to be imposed and tested for. Lastly the authors discuss survey data, how it is clustered and stratified, and how this can be used in Stata to improve the efficiency of estimators.

Chapter 6 focuses on instrumental variables methods. The use of estimators employing instruments is motivated by a discussion of endogenous regressors, and the IV, 2SLS, and GMM estimators are introduced and shown how to be implemented in Stata. The authors warn of instruments that fail to be exogenous or that instruments that are weak, as discussed before. It is shown how IV-estimators can be used to test regressor endogeneity with a Hausman test. In the overidentified case, when there are more instruments than endogenous regressors, it is shown how to test the exogeneity of the instruments in Stata. The special case of a single binary endogenous regressor is examined and shown how to be estimated using a packaged maximum likelihood setup. The authors then turn to the important subject of weak instruments, a situation of considerable importance in applied work. Diagnostics for weak instruments such as the first stage F statistic, the partial $R^2$, and others are discussed. The sensitivity of coefficients to choice of instruments in the just identified case is shown in detail. Other estimators which may have better finite sample properties, such as the Limited Information Maximum Likelihood and Jackknife IV estimators, are introduced. The authors conclude by showing how to implement 3SLS in Stata.

Chapter 7 examines Quantile Regression, both in theory and in Stata. They cover standard quantile regressions, those with bootstrapped standard errors, and quantile regressions with multiple quantiles simultaneously specified. This latter case facilitates testing whether coefficients vary across quantiles. All of these are shown to be easily implementable in Stata and the output results interpreted. The authors also provide interpretation of the coefficients of a quantile regression in general. Heteroskedasticity tests and tests of equal coefficients across quantiles are discussed. The authors lastly discuss quantile regression for count data, facilitated by recent theoretical advances, and supply the theory and show how it can be performed quickly in Stata.

Chapter 8 introduces the large and important topic of linear panel-data models. This is a topic of considerable importance in practice, with many applications involving data in a panel structure. First the authors discuss basic considerations, such as unbalanced panels, correlated errors, lagged regressors, and time-varying coefficients. A variety of panel data models are then described, such as fixed effects,
random effects, pooled, two-way effects and mixed linear models. The mechanics of implementing these estimators in Stata, such as organizing the data in a panel, and the commands for estimating each of these models is discussed in a clear and thorough way. The authors show how to interpret the output of the `summarize` command for panel data, how to quickly check the degree to which a panel is unbalanced, and how to examine the within, between, and overall variance of the data. Other visuals tools, such as individual level time series and overall and within scatterplots are mentioned. The authors go carefully and comprehensively over the interpretation of estimation output for each of the models and how to compare their output and perform Hausman tests. There is a helpful section on converting panel data from wide to long formats.

Chapter 9 covers extensions to the linear panel data model. Panel IV estimators, the Hausman-Taylor estimator, and the Arellano-Bond estimator are covered. Mixed linear, Random-intercept, Random-slopes, Random coefficient, and Two-way random effects models are all shown how to be quickly run in Stata. Clustered data is examined and the chapter closes with a discussion on hierarchical linear models. Chapter 10 is on nonlinear regression methods, including a diverse array of different models and estimators. Topics include poisson regression, nonlinear least squares, and the generalized linear model. The authors discuss standard errors in nonlinear models in theory and in Stata. Prediction, marginal effects, and elasticities are more complex in nonlinear models and are given a detailed discussion, with many of the relevant formulas, such as the marginal effects at the mean, already prepacked in Stata. Model diagnostics for nonlinear models, such as goodness-of-fit measures, information criteria, and residual analysis are supplied.

Chapter 11 concerns nonlinear optimization. This naturally follows the estimators presented in chapter 10 which are usually defined as minimizing some loss function yet possess no closed form solutions. Traditional maximization algorithms, such as Newton-Raphson and gradient methods, are introduced and related topics such as multiple maximums, stopping criteria, and numerical derivatives are discussed. The maximum likelihood commands packaged in Stata, with built in optimizers, are shown in detail with several simple examples. Debugging user commands, general debugging advice, data checking, warnings of numerical instability due to near collinearity, simulation to check consistency and standard errors are also discussed. More advanced optimizers in Stata are covered with an application to nonlinear GMM.
Chapter 12 concerns testing. Linear and nonlinear Wald tests, the Likelihood-ratio test and the Lagrange multiplier test are covered, along with simulation methods to examine test size and power. Certain specification tests, such as moment-based tests, the information matrix test, and the Chi-squared goodness-of-fit test for discrete variables are also covered. Chapter 13 covers bootstrap methods. Bootstrap methods are shown to be a powerful way to compute robust standard errors, confidence intervals, estimator bias, and a wide variety of other statistics. Situations when bootstraps can lead to asymptotic refinements are also discussed, as well as situations when the bootstrap is invalid. Bootstraps for user-written programs, two step estimators, and hausman tests are supplied. Alternative resampling schemes, such as subsampling and the jackknife, are also covered.

Chapter 14 covers binary outcome models, starting with a discussion on estimating Logit, Probit, Linear Probability, and Clog-log models. Hypothesis and specification tests for binary outcome models, measures of goodness of fit, predicted probabilities, and the computation of a variety marginal effects are covered. Two ways to deal with endogenous regressors, a common problem in applied work, are presented. The first is a structural specification of the endogenous regressor in terms of the other regressors and instruments and can be performed with a packaged routine in Stata. The second is linear probability 2SLS. The authors miss an opportunity to discuss general control function approaches which could recover a residual in the first step which is then used to control for endogeneity in a more general second step nonlinear binary outcome model.

Chapter 15 covers a diversity of multinomial models and estimation procedures. A wide variety of logit models are covered, such as the multinomial, alternative specific, nested, and random coefficients logit. Ordered outcome and multivariate outcome models, with bivariate probit a special case, are covered along with their corresponding estimators. Maximum simulated likelihood is discussed.

Chapter 16 covers Tobit and other selection models. The authors discuss several Tobit, Two-part, and Selection models and how to compute their marginal effects and form predicted values. A discussion on the value of exclusion restrictions for identification is valuable. Diagnostics and tests of normality and homoskedasticity are of presented.

Chapter 17 includes a wide variety of count data models. The Poisson negative binomial, hurdle, and finite mixture models are presented along with
examples. Structural and nonlinear IV estimators which are robust to regressor endogeneity are also covered. Chapter 18 covers nonlinear panel models. Random effect, pooled average and fixed effects for logit and poisson models, among others, are covered. The computation of predicted values and marginal effects is discussed along with generalized Tobit and count data models in a panel setting. The authors also include helpful appendices on programming and Stata's powerful matrix language.