The aim of the course is to develop familiarity with a wide range of statistical and econometric techniques that have proved to be useful in applied contexts. Theoretical results will be developed as necessary and in order to allow students to apply general principles to their own research problems. Primary emphasis, however, is placed upon applicability, on the ability to understand the techniques in use in the literature, and on acquiring a minimal acquaintance with econometric computing. The material discussed is a reasonable definition of the minimum that a well-trained economics Ph.D. should know. For those of you who are primarily interested in economic theory, the course should give you some idea of the way in which economists attempt to confront theory and evidence.

Prerequisites

Economics 707 or equivalent. Familiarity with calculus, linear (matrix) algebra and basic mathematical statistics is expected. I shall also assume that students are familiar with the general linear regression model, its algebra, and estimation and inference within that framework. (Students for whom this last assumption is not true will have a hard time very quickly and should review the material at once.)

Grading

The course grade will be based on a mid-term (30%) and a final (50%) and 4-5 problem sets (20%). The final will be a 3 hours exam and will cover all material. Parts of the problem sets can be asked in the mid-term or final exams.

Academic Conduct

Students should know and understand the GRS Academic Conduct Code, see http://www.bu.edu/cas/students/graduate/forms-policies-procedures/academic-discipline-procedures/. Any suspected academic misconduct will be reported to the Dean's Office.

Texts and Notes

Good texts to review the basic notions of probability and statistics useful for this course are:


There is no required text, which we will follow closely. The course is based on a set of notes, which will be distributed at the cost of photocopying. However, it is strongly recommend that you complement these notes with one or more of the following textbooks:


You are also strongly encouraged to supplement the material discussed in class with a good introductory level book that gives an intuitive explanation of the use of the various methods. The one I recommend is:


Other useful books are:


At a more advanced and theoretical level, the following books are very useful:


An interesting book with economic applications is:

COURSE OUTLINE


2. **Properties of the Least-Squares Projection** (fitted values, residuals, measure of fit, the Frish-Waugh-Lovell Theorem).

3. **The Basic Linear Model; Finite Sample Results** (model and assumptions, properties of the least-squares estimator, the Gauss-Markov Theorem, estimation of the variance of the errors, LUS Residuals, recursive residuals).

4. **Restricted Least-squares** (the restricted OLS estimate, consequence of misspecification, geometric interpretation).

5. **Normal Distribution Theory** (exact distribution of least-squares estimates and test statistics under Normality).

6. **A Brief Review of Asymptotic Results** (convergence in probability, orders of magnitude, convergence in distribution, martingale differences).

7. **The Basic Linear Model; Asymptotic Results** (The Mann-Wald Theorem, consistency, asymptotic Normality; the basic AR(1) model; test statistics and confidence intervals).

8. **Instrumental Variables** (instruments and estimator, the GIVE estimator, two-stage interpretation).

9. **Introduction to Time Series** (preliminaries, stationarity, the autocovariance and autocorrelation function, Wold’s Theorem, the first-order autoregressive process, general AR(p) processes, moving-average processes, mixed ARMA processes).

10. **Non-spherical Errors** (properties of OLS, using OLS with corrected standard errors, consistent estimators of variance-covariance matrices robust to serial correlation and heteroskedasticity, the GLS estimator, geometric interpretation of GLS, when is OLS equivalent to GLS? feasible GLS).

11. **Nonlinear Regressions** (basic results, numerical optimization).

12. **Maximum Likelihood Estimation** (the principle of MLE, sufficient statistics, the Cramer-Rao lower bound, asymptotic distribution of the MLE, an information matrix equality, the MLE in the standard linear model, consistent estimates of the information matrix).

13. **Estimation with Serially Correlated Errors** (the covariance matrix of the errors with AR(1) errors, feasible GLS, maximum likelihood procedure, other procedures, extensions to AR(p) errors, estimation with moving-average errors).

15. **Multivariate Regressions** (seemingly unrelated regressions, multivariate regressions, goodness of fit in multivariate models).

16. **The Trinity of Test Procedures** (LR, Wald and LM tests, asymptotic distribution, geometric interpretation, when are LM, LR and Wald tests the same? the LM test in least-squares problems).

17. **The Trinity of Tests in the Classical Linear Model** (the Wald, LR and LM tests, a finite sample inequality).

18. **Examples of Test Statistics** (testing for heteroskedasticity: the Breush-Pagan LM test, White’s test; testing for autocorrelation: the Durbin-Watson test, test based on recursive residuals, Box-Pierce statistic, LR test, LM test for AR(p) errors).

19. **Other Tests of Misspecification** (Hausman type tests, tests based on nuisance parameters, test for structural change, non-nested hypothesis testing).

20. **Misspecified Models** (basic issues of the quasi-MLE, the Kullback-Leibler distance, asymptotic distribution of the quasi-MLE, hypothesis testing with potential misspecification, the information matrix test for misspecification, simplification of the information matrix test).

21. **Some Pitfalls of Testing Procedures in Nonlinear Contexts** (non-invariance of Wald tests to alternative specifications of the null hypothesis, non-invariance to units of measurements, review of testing procedures in a likelihood framework).

22. **Unit Roots, Cointegration and Spurious Regressions** (an example, unit roots, differenced versus trend stationary models, testing for a unit root, spurious regression, cointegration, error correction models, testing for cointegration).

23. **Simultaneous Equations Models** (the structural form, the reduced form, the identification problem, identification in terms of the reduced form, more on identification: basic concepts, conditions for two structures to be observationally equivalent, conditions for identifications, identification using within equation linear restrictions, identification with cross-equations restrictions).

24. **Estimation of Simultaneous Equations Models** (the inconsistency of OLS, two-stage least-squares estimator and its asymptotic distribution, three stage least-squares estimator and its asymptotic distribution).

25. **Full Information Maximum Likelihood of Simultaneous Equations Models** (the likelihood function, derivation of the FIML equations, difference with 3SLS, asymptotic distribution, testing the validity of overidentifying restrictions).
26. **Generalized Methods of Moments** (if time permits).

27. **Indirect Inference** (if time permits).

Selected Readings.

0. **Review of Matrix Algebra**: Ruud, Appendix C.


1. **Geometric Interpretation of Least-squares**: DM, ch. 2.1-2.3; Ruud, ch. 2.

2. **Properties of the Least-Squares Projection**: DM, ch. 3.4-3.5, 3.6, 3.8.

3. **The Basic Linear Model; Finite Sample Results**: DM, ch. 3.1-3.5; Ruud, ch. 6-9.


4. **Restricted Least-squares**: Ruud, ch. 4.; DM, ch. 3.7.

5. **Normal Distribution Theory**: DM., 4.1-4.4, 4.7, 5.4; Ruud, ch. 10-11.

6. **A Brief Review of Asymptotic Results**: DM, ch 4.5; Ruud, ch. 13.4.


7. **The Basic Linear Model; Asymptotic Results**: DM, ch. 4.5, 5.2.

8. **Instrumental Variables**: DM, ch. 8.1-8.4; Ruud, ch. 20.


9. **Introduction to Time Series**: DM, ch. 7.6, 13.2.


Additional references: See course outline for ECN 712.

10. **Non-spherical Errors**: DM, ch. 7.1-7.6, 5.5.


11. **Nonlinear Regressions**: DM, ch. 6; Ruud, ch. 16.


13. **Estimation with Serially Correlated Errors**: DM, ch. 7.8; Ruud, ch. 19.

14. **Estimation with Heteroskedasticity**: DM, ch. 7.5; Ruud, ch. 18.

15. **Multivariate Regressions**: DM, ch. 12; Ruud, ch. 26.2.


16. **The Trinity of Test Procedures:** DM, ch. 4.1-4.5, 10.6; Ruud, ch. 11, 17.1-17.3.


17. **The Trinity of Tests in the Classical Linear Model:** DM, ch. 4.1-4.5.


18. **Examples of Test Statistics**

1) **Testing for heteroskedasticity:** DM, ch. 7.5; Ruud, ch. 18.3.


2) **Testing for serial correlation:** DM, ch. 7.7; Ruud, ch. 19.4.


19. **Other Tests of Misspecification:** DM, ch. 8.7, 15.1-15.4; Ruud, 22.3.


20. **Misspecified Models**


21. **Some Pitfalls of Testing Procedures in Nonlinear Contexts:** Ruud, ch. 17.4.


*Econometrica* 59, 1601-1616.


22. **Unit Roots, Cointegration and Spurious Regressions:** D-M, ch 20.


Additional references: See course outline for EC 712.

23-24-25. **Simultaneous Equations Models:** DM, ch. 12.4-12.8; Ruud, ch. 26.


26. **Generalized Methods of Moments**: DM, ch. 9; Ruud, ch. 21-22.
