Agricultural and Resource Economics **Fall Semester 2008**
University of Maryland **Professors Just and Alberini**

AREC 623

Instructors: Richard E. Just (First 60% of Course)
Anna Alberini (Last 40% of Course)

Offices: 2113 Symons Hall - Just
2210 Symons Hall - Alberini

Texts: Robert V. **Hogg**, Joseph W. McKean, and Allen T. Craig, *Introduction to Mathematical Statistics* (6th ed.), Prentice Hall (ISBN: 0130085073)
William H. **Greene**, *Econometric Analysis* (6th ed.), Prentice Hall (ISBN: 9780135132456 for 6th ed.)

TA Sessions: There will be a weekly TA session in Rm 3121 Symons Hall on Fridays from 10:00 AM-12:00 PM. The TA will be Eduardo Nakasone.

Examinations and Grading:
Grades will be based on three exams:
First midterm (30%) Second midterm (30%) Final plus Empirical Project (40%)

Homework problems will be assigned regularly through much of the course but are not graded. One problem from among the assigned homework and exercises in the course notes will be given as a quiz at the beginning of discussion section meetings prior to the first two exams. Scores on those problems will count as 15% of the first and second exam grades.

To complete the empirical project, students will write out one or more hypotheses about economics or economic behavior, and will test them by gathering a suitable set of data, estimating the appropriate regression model, and doing statistical tests of hypotheses along the lines of sections VII-IX of this syllabus. A 10-page write-up about the project is due the last day of classes.

Tentative Course Outline and Readings:
The detailed course outline and assigned readings are given below where textbooks are referenced by only their lead author. In addition, all students are strongly encouraged to peruse carefully the following materials outside of class because they will help develop a perspective on the limiting nature of assumptions that apply to the classical parametric statistical methods discussed in class:

Nonparametric Statistics: Course notes (134-136), **Hogg** Chapter 10 and 12.2, 12.4.
Bayesian Statistics: Course notes (145-147), **Hogg** Chapter 11.

Obviously, not all econometric approaches can be covered in two econometrics courses, even two such as AREC 623 and 624 that are equivalent to four courses in most universities.

Reviewing this material will help students comprehend alternative approaches based on the tools covered in class.

(3 wks.) I. Basic Statistical Concepts†

A. Elements of Probability (1-5): **Hogg** 1.1-1.4.
B. Univariate Random Variables (6-8), Probability Distribution Functions (9-10), Discrete Random Variables and Probability Mass Functions including the Bernoulli, Binomial, and Poisson Distributions (11-14), Continuous Random Variables and Probability Density Functions including the Normal, Gamma, Chi-Square, Exponential, and Beta Distributions (17- 21), and Univariate Transformations (15-16, 22-24): **Hogg** 1.5-1.7, 3.1-3.4; **Greene** App. B.1-B.2, B.4.
C. Univariate Mathematical Expectations (25), Moments (26), Jenson/Markov/ Chebyshev Inequalities (27), Moment Generating and Characteristic Functions (28-31), the Moment Generating Function Technique (32-33): **Hogg** 1.8-1.10, 4.3.3; **Greene** App. B.3, B.6.
D. Multivariate Random Vectors, Density and Distribution Functions (34-36), Expectations (37), Moments (38), Correlation (39): **Hogg** 2.1, 2.3, 2.6, 4.1; **Greene** App. B.7, B.10.
E. Marginal & Conditional Distributions (40-42), Independence (43-45): **Hogg** 2.4-2.6; **Greene** App. B.7-B.8.
F. Transformations for Discrete Random Vectors (46-47), Continuous Transformations and Jacobians (48-50), the Multinomial, Multivariate Normal, *t*-, and *F*-distributions (51-56), Order Statistics (57,143-145): **Hogg** 2.2, 2.7, 3.5-3.6, 5.2 (not 5.2.1 & 5.2.2); **Greene** App. B.5, B.9, B.11.
G. Multivariate Moment Generating and Characteristic Functions (58-60): **Hogg** 2.1.1, 2.6.

(2 wks.) II. Sampling Theory, Methods of Estimation, and Fundamentals of Hypothesis Testing for Common Distributions

A. Sampling Theory (61-62): **Hogg** 5.1, 5.5; **Greene** App. C.2-C.4, C.6.
B. Best Linear Unbiased Estimation (63), Method of Moments Estimation (64-65), Least Squares Estimation (66), Maximum Likelihood Estimation (67-69): **Hogg** 6.1, 6.4; **Greene** 15.2,16.1-16.2.
C. Estimators and Their Distributions for Common Discrete Sampling Problems (70), Estimators and Their Distribution for the Normal Distribution (70-73).
D. Sampling Small Populations without Replacement (74-76), Non-Standard Stopping Rules (77), Specifying the Right Discrete Distribution (78): **Hogg** 5.1.
E. Fundamentals of Hypothesis Testing and Power (79-80), Hypothesis Testing for Discrete Distributions (81-82), Hypothesis Testing for the Normal Distribution (83-86): **Hogg** 5.5-5.6; **Greene** App. C.7.
F. Testing Equality of Distributions (87-90).

† Numbers in parentheses refer to page numbers in course notes.

G. Confidence Interval Estimation (91-93): **Hogg** 5.4; **Greene** App. C.6.

(½ wk.) III. The Central Limit Theorem

A. Limiting Distributions and Approximation of Small Sample Probabilities (94): **Hogg** 4.3; **Greene** App. D.2.5.
B. The Central Limit Theorem (95-96): **Hogg** 4.4 (4.5 for additional reading); **Greene** App. D.2.6.
C. Approximating Small Sample Probabilities with the Normal Distribution (97).

(1 wk.) III. The Classical Linear Regression Model

A. Review of Linear Algebra and Matrix Calculus (138-142): **Greene** App. A. [**This is to be reviewed by students outside of class**.]
B. Fundamental Distributional Results for Regression Theory (98-99): **Hogg** 9.8-9.9.
C. The Classical Linear Regression Model (CLRM) (100), Estimation of the CLRM (101-102): **Hogg** 9.6, 12.3; **Greene** 2.1-2.3, 3.1-3.2, 4.3-4.7.1.
D. Distribution of Regression Estimators and Hypothesis Testing in the CLRM (103-106): **Hogg** 9.7.

(1 wk.) V. Properties of Estimators with Application to the CLRM

A. Consistency, Asymptotically Unbiased Estimators, and the Law of Large Numbers (107-109): **Hogg** 4.2; **Greene** App. D.2, 4.9.1, 4.9.3.
B. Sufficiency and the Fisher-Neyman Factorization Criterion (110-112): **Hogg** 7.1-7.2, 7.7.
C. Best Statistics, Best Unbiased or Minimum Variance Unbiased Estimators and the Rao-Blackwell Theorem (113-114): **Hogg** 7.3 (7.4-7.6 for further reading).
D. Relative Efficiency (115), Absolute Efficiency and the Rao-Cramer Inequality (115-117), Asymptotical Efficiency (117), Information (118-119), Properties of Maximum Likelihood Estimation (120-121): **Hogg** 6.2, 6.4 (7.5 for further reading); **Greene** App. C.5, D.3, 16.3-16.4.
E. Additional Reading—Monte Carlo Methods (will be covered in the January Matlab tutorial): **Hogg** 5.8; **Greene** 17.1-17.4.

(1 wk.) VI. Optimal Hypothesis Testing with Application to the CLRM

A. Best Tests, Most Powerful Tests, and the Neyman-Pearson Lemma (122-124): **Hogg** 8.1; **Greene** App. C.7.
B. Uniformly Most Powerful Tests (124-125): **Hogg** 8.2.
C. Composite Null Hypotheses (125-126).
D. Likelihood Ratio Tests (126-131): **Hogg** 6.3, 6.5, 8.3; **Greene** App. C.7, 4.7.5, 6.1-6.3.1, 17.5.

E. Additional Reading—Analysis of Variance: **Hogg** 9.1-9.5.

F. Additional Reading—Bootstrapping (will be covered later in the January Matlab tutorial): **Hogg** 5.9; **Greene** 17.6.

(1 wk) VII. CLRM—goodness of fit‡

A. Regression Residuals: Definition and Properties.
B. The R Square.
C. Use of F Tests to Assess the Goodness of the Regression.

(1 wk.) VIII. Asymptotic Properties of the OLS estimates of the CLRM‡

A. Brief Review of Maximum Likelihood Estimation.
B. Large Sample Distribution Theory: **Greene** App. D.2.
C. Likelihood Ratio (LR), Score and Wald Tests.
D. Asymptotic Properties of the OLS estimates in the CLRM: **Greene** 4.9.
E. Use of LR, Score and Wald Tests with the OLS Estimates of the CLRM.
F. Using simulated data to understand the distribution of the OLS estimates of the CLRM.

(3 wks) IX. Specification Issues Within the CLRM‡

A. Dummy Variables and Use of Splines: **Greene** 6.2.
B. Choice of the Independent Variables: **Greene 7**.2, 4.8.1.
   a. Consequences of Inclusion of Irrelevant Variables and Omission of Regressors on the OLS Estimates, R Square, Standard Error of the Regression: **Greene** 7.1-7.2.
   b. Use of F, Wald, Score and LR Tests for Testing Inclusion/Exclusion of Variables.
   c. The Hausman Test.
C. Tests of Structural Change: The Chow Test and the Wald Test: **Greene** 6.4.
D. Functional Form (e.g., Double-Log, Semi-Log, Other Functional Forms), Interpretation of the Coefficients, Comparing Non-nested Models Using the J Test, Model Selection Criteria: **Greene** 7.3-7.4.

   Additional reading: Grossman, Gene and Alan B. Krueger (1995), "Economic Growth and the Environment," *Quarterly Journal of Economics*, 110(2), 353-377.
E. Errors-in-Variables: **Greene** 12.5.

‡ Denotes material covered by Professor Alberini.

Additional Reading: Black, Dan A. and Thomas J. Kniesner (2003), **“**On the Measurement of Job Risk in Hedonic Wage Models,” *Journal of Risk and Uncertainty*, 27 (3), 205-20.

F. Using the Study Design to Test Hypotheses: The Difference-in-Difference Approach, Estimation of Average Treatment Effects (Materials TBA).

G. Regression Discontinuity Designs. Additional Reading: Imbens, Guido W. and Thomas Lemieux (2008), “Regression Discontinuity: A Guide to Practice,” *Journal of Econometrics*, 142, 615-635.

H. Alternative Ways to Compute Standard Errors: The Bootstrap and the Jackknife: **Hogg** 5.8-5.9.

Academic Integrity

The University of Maryland, College Park has a nationally recognized Code of Academic Integrity, administered by the Student Honor Council. This Code sets standards for academic integrity at Maryland for all undergraduate and graduate students. As a student you are responsible for upholding these standards for this course. It is very important for you to be aware of the consequences of cheating, fabrication, facilitation, and plagiarism. For more information on the Code of Academic Integrity of the Student Honor Council, please visit http://www.studenthonorcouncil.umd.edu/whatis.html.

Honor Pledge

The University has approved an Honor Pledge that every student is invited to hand write and sign on examinations, papers, and other academic assignments. The Pledge is:

> “I pledge on my honor that I have not given or received any unauthorized assistance on this assignment/examination.”