Syllabus

Mathematical Statistics

1. **Name of the Course:** Mathematical Statistics

   - **Lecturer:** Péter Elek
   - **Department:** Department of Economics
   - **Semester and year:** Fall term, 2014/2015
   - **Course level:** MA 1st year core (compulsory) course
   - **Number of credits:** 3 CEU credits (6 ECTS credits)
   - **Pre-requisites:** Pre-session Mathematics
   - **Course e-learning site:** http://ceulearning.ceu.hu/
   - **Office hours:** T. B. A.

2. **Course Description:** The course discusses the basic statistical theory that is frequently used in econometric analysis. Students passing the exam should be familiar with the basic statistical concepts used intensively in econometrics, so that the later course (Econometrics I.) could focus on econometric issues instead of the technicalities.

3. **Learning Outcomes:** A good understanding of the following topics:

   - Essentials in probability theory
   - Samples and sampling distributions
   - Estimators
   - Finite sample properties of estimators
   - Asymptotic properties of estimators
   - General methods to prepare estimators
   - Interval estimation
   - Hypothesis testing

4. **Course Requirements:**

   - Problem sets during the term with a total weight of 30%. Some problem sets should be solved individually while others will be assigned to the study groups, where one solution from each group is expected to be submitted.

- Final exam for a total weight of 70%
- The final course grade will be assigned on a curve.

5. **Assumed Background:**

   - Basic calculus (at the level of pre-session maths)
   - Basic linear algebra (at the level of pre-session maths)

6. **Textbooks:**

   - Jeffrey Wooldridge: Introductory Econometrics, A Modern Approach, 4th edition, 2009 (later denoted by W).
     - The Appendix of this textbook contains an intuitive overview of the basic statistical concepts that are used later in Econometrics I.
   - Takeshi Amemiya: Introduction to Statistics and Econometrics, 1994 (later denoted by A).
     - A good graduate level introduction to statistics. Not all details are needed in the course (e.g. proofs are not required and some examples are merely illustrative).
   - Charles Henry Brase and Corrinne Pellillo Brase: Understandable Statistics, 9th edition, 2009 (later denoted by BB).
     - Recommended for those who need a bit more help for understanding the basic concepts.

Course schedule

WEEK 1: Essentials in probability theory

- Random variables, probability distributions
- Measures of central tendency and variability; higher order moments
- Other descriptive measures of distributions
- Joint distributions, conditional distributions, definitions of independence
- Conditional expectation, covariance, correlation
- Frequently used distributions and their properties
- The normal distribution and its properties

- Chi-squared, t- and F-distributions and their properties
- Material:
  - W Appendix B
  - A 1-5 (except for the proofs, the material around Theorem 3.6.3, section 3.7, definition 5.3.1, section 5.4)

WEEK 2: Samples, estimators and their finite sample properties

- Populations and samples
- Different types of samples
- Sample statistics and sampling distributions
- Properties of sample means and variances
- Sampling from the normal distribution
- Parameters and estimators
- Unbiasedness
- Efficiency
- Comparison of estimators: Mean Squared Error (MSE)
- Best unbiased estimators
- Best linear unbiased estimators (BLUE)
- Examples
- Material:
  - W Appendix C.1-C.2
  - A 1, 7.1-7.2 (except for sections 7.1.3, 7.2.2, 7.2.4, 7.2.6)

WEEK 3: Asymptotic Properties of Estimators

- Asymptotic unbiasedness of an estimator
- Probability limit (convergence in probability) and its properties
- Continuous mapping theorem
- Weak law of large numbers
- Consistency of an estimator
- Convergence in distribution and its properties
- Central limit theorem
- Asymptotic normality of an estimator
- Asymptotic variance and asymptotic efficiency of an estimator
- Examples
- Material:
  - W Appendix C.3
  - A 6 (except for definition 6.1.3, Theorem 6.1.1, Theorem 6.2.3, Example 6.4.2) and section 7.2.6

WEEK 4: General Approaches to Parameter Estimation

- Method of moments (MM-) estimators
- Maximum likelihood (ML-) estimators and its properties
- Least squares (LS-) estimators
- Different estimators of the parameters of frequently used distributions
- Examples
- Material:
  - W Appendix C.4
  - A 7.1.1, 7.3, 7.4.4 (and the remaining parts of 7.4 for the supplementary material)

WEEK 5: Interval Estimation

- Concept of interval estimation
- Confidence intervals for means and variances from a normal distribution
- Determination of the sample size
- Asymptotic confidence intervals for non-normal (e.g. binomial) distributions
- Examples
- Material:
  - W Appendix C.5
  - A 8.1-8.2

WEEK 6: Hypothesis Testing

- Concept of hypothesis testing
- Null- and alternative hypothesis
- Type-I and type-II errors
- Significance levels and powers of the tests
- p-values
- Tests for the expected value and variance of random variables
- Relationship between confidence intervals and hypothesis testing
- Practical versus statistical significance
- Examples
- Material:
  - W Appendix C.6
  - A 9.1, 9.2, 9.6 (except for Theorem 9.2.1) and the beginning of 9.4