Module Layout
ERM502 Advanced Quantitative Methods for Managers

Faculty	FEAM FSS	FACULTY OF ECONOMICS AND MANAGEMENT FACULTY OF SOCIAL SCIENCES		
Programme of Study	ERM	MASTER IN ENTERPRISE RISK MANAGEMENT		
Module	ERM502	Advanced Quantitative Methods for Managers		
Level	**Undergraduate**	**Graduate**		
		Master	***Doctoral***	
		√ *(Διαπανεπιστημιακό)*		
Language of Instruction	ENGLISH			
Teaching Method	DISTANCE LEARNING			
Module Type	***Mandatory***	***Optional***		
	√			
Number of Cohort Tutorial Meetings	***Total***	***Physical Presence***	***Web conferences***	
	10	*0*	*10*	
Number of Exercises	-			
Number of Assignments	*4*			
Final Grade Calculation	***Exercises***	***Assignments***	***Final Exams***	
	-	*30* %	*70*%	
Number of European Credit Transfer System (ECTS)	*20*			

Module Description

Econometrics is an important and difficult subject. Without it, economic theory becomes pure introspection and economics as a discipline loses any basis upon which to be considered scientific. Econometrics, properly done, allows us to test various theoretic models against one another and arrive at a better understanding of economic and social phenomena. When there is a widely accepted theoretical explanation, econometrics can be used to form predictions regarding the future values of variables that are of interest to policy makers, the financial sector, or the population at large. Perhaps more importantly, econometrics allows us to examine the impacts of hypothetical policy changes without actually having to implement them.

The difficult in mastering econometrics stems from the fact that it is essentially a combination of economics, statistics, and data collection and manipulation. To do econometrics well requires knowledge of all of these areas, and students should thoroughly master all of these aspects of the subject. Whenever possible, econometric analysis will be motivated by an appeal to economic theory. Economic theory is required to determine which variables are properly thought of as endogenous (in a given modeling context), and which should be thought of as exogenous, or at least predetermined.

On some occasions, economic theory will place restrictions on the functional relationship between the exogenous variables and the endogenous ones, and these restrictions should be reflected in the specification of the econometric model. Less frequently, economic theory may provide guidance regarding the distribution or interpretation of the unobservable variables in the econometric model (known collectively as the "disturbance terms," "shocks," "error terms," etc.). The parameters that we estimate when performing applied econometrics research should always have a sound economic interpretation, and this means that any econometric specification should be derived from solid economic reasoning. The course is emphasizing this aspect of econometric work throughout.

In that respect, this course is designed to introduce students to econometric techniques and their applications in economic analysis and decision making. The main objective of the course is to train students in (i) handling economic data; (ii) quantitative analysis of economic models with probabilistic tools; (iii) econometric techniques, their application as well as their statistical and practical interpretation; (iv) implementing these techniques on any given econometric software.

The course focuses on practical and conceptual issues involved in substantive applications of econometric techniques. Estimation and inference procedures are formally analyzed for simple econometric models and illustrated by empirical case studies using real-life data. The course covers linear regression models, simultaneous-equations models, discrete choice models, time series models, and panel data models. Estimation and inference is conducted using least squares, instrumental variable, and likelihood based techniques.

Module Prerequisites	

Final Grade Composition			
Assessment Method	***Percentage on Overall Grade***	***Workload***	
		Hours	***ECTS***
Weekly Study *(32 weeks *15 hours of study)*	*0* %	~*480*~512	*16*
Assignment 1	*7.5* %	*30*	*1*
Assignment 2	*7.5* %	*30*	*1*
Assignment 3	*7.5* %	*30*	*1*
Assignment 4	*7.5* %	*30*	*1*
Final Exam	*70.0* %	*3*	*0*
Total	**100%**	***~600~635***	***20***

Grading Policies and Evaluation Methods

- Students are evaluated with 10, if they collect 100% of the possible grade. Students are evaluated with 9, if they collect 90% of the possible grade, meaning, 90%*10=9, etc.
- Students have to submit four (4) written assignments in each module. Students have the right not to submit one written assignment. In order for a student to be able to participate in the final examination he/she should have gathered a total of at least 20 points from all of his/her submitted written assignments
- The average is calculated as a simple average of the 4 written assignments. The average grade of the written assignments is worth 30% of the final grade and is valid only for students who have successfully passed the final exam. The rest 70% of the total module grade is obtained from the final exam paper.
- The criteria for written assignments evaluation will be clear in each one of the four assignments that are due during the academic year. Each one of the written assignments will be based on the corresponding material according to the academic schedule.

Main Competencies that needs to be developed

After completing this module students will be able to do the following:

- Estimate a relation between two variables using Ordinary Least Squares (OLS), explain how OLS estimators behave in terms of their probability distributions, test hypotheses on the relation between variables using t-values and p-values, and measure goodness of fit in a regression
- Estimate a relation between three or more variables using the OLS method, and test two or more hypotheses jointly using F-tests or chi-square tests
- Make use of dummy variables to measure categorical explanatory variables, then test for any associated structural change in the relation between variables
- Explain the effects of non-constant error variance in estimation and hypothesis tests, and how to adjust the tests and/or estimation to account for these problems
- Make use of an econometric computer program to implement the methods listed above

Intended Learning Outcomes

After course completion, students will be able to:

Comprehension

- Understand the basic principles of econometric analysis;
- Understand both the fundamental techniques and wide array of applications involving linear regression estimation;
- Understand the assumptions that underpin the classical regression model;
- Understand the basic tools for analyzing and comparing static and dynamic economic data.
- Understand empirically-oriented courses.

Application

- Make use of empirical tools in their dissertations, if the dissertation is to be empirically oriented.
- Apply regression analysis to real-world economic examples and datasets for hypothesis testing and prediction
- Develop the student's ability to understand and properly apply selected statistical and econometric tools which are commonly used in empirical economics and business analysis.
- Develop knowledge of basic methods of discovering correlations, causes and outcomes relating to economic phenomena.
- Develop ability to analyze economic data with the use of statistical software.
- Develop desired transferable skills in writing analytical reports during the preparation of the written assignment students will.

Synthesis
- Make adjustments for a number of common regression problems.

Evaluation
- Interpret a range of economic data.

Bibliography

The main readings for this course is:

1. Wooldridge, J.M. Introductory Econometrics, 5th edition, 2013, South-Western.
2. Gujarati, D. and D. Porter, Basic Econometrics, 5th edition, McGraw-Hill, 2009.

However, if you wish to read further, then we can recommend the following books:

1. Stock, J.H. and M.W. Watson, Introduction to Econometrics, 2nd edition, 2007, Pearson Education: Addison Wesley.
2. Newbold, P., Statistics for Business and Economics, any edition, 2010, Prentice Hall.
3. Baltagi, B., Introduction to Econometrics, Springer-Verlag, 2005.
4. Dougherty, C. (2011), Introduction to Econometrics, 4th ed., Oxford University Press.

Additional reading materials will be introduced through the e-class. These additional readings are important supplementary learning aids and the students are expected to take these reading materials seriously.

STUDY SCHEDULE			
Week	***Learning Outcomes***	***Educational Activities***	***Estimated student work time (hours)***
1	• Introduction to Econometrics: The unification of the three viewpoints of statistics, economic theory, and mathematics. • Econometric Modeling: Theoretical propositions provide the basis for an econometric study. Given an appropriate data set, we investigate whether the theory appears to be consistent with the observed facts. • Data and Methodology: Applied econometric methods will be used for estimation of important quantities, analysis of economic outcomes, markets or individual behavior, testing theories, and for forecasting. • Plan of the course: description of the necessary material used and how this can be useful in the next steps.	• Main study material and module overview • Additional bibliography • General guidelines for the preparation of the written assignments during the academic curriculum • Instructions about the use of e-class platform for TM and communication with the tutor and other students. • ***1st Group Advisory Meeting***	• ≈13hrs study time • ≈2hrs 1st Group Advisory Meeting
2	• Matrix algebra: Symmetric, diagonal, scalar, identity and triangular matrices. • Algebraic Manipulation of Matrices • Equality of Matrices: Same dimensions and equal corresponding elements. • Transposition: The transpose of a column vector is a row vector. • Matrix Addition: Matrices cannot be added, unless they have the same dimensions - they are conformable for addition. • Vector Multiplication: Matrices are multiplies using the inner product. • A Notation for Rows and Columns of a Matrix: An untransposed vector is considered to be a column vector. Notation needed for a column vector that is the transpose of a row of a matrix.	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • ***1st Written Assignment is announced***	• ≈15hrs study time
3	• Matrix Multiplication and Scalar Multiplication: To multiply two matrices, the number of	• Studying the relevant material through	• ≈15hrs study

	columns in the first matrix must be equal to the number of rows in the second. Conformable for multiplication. Associative law. Distributive law. Transpose of a product. Transpose of an extended product. Sums of Values. • A Useful Idempotent Matrix: A fundamental matrix in statistics is the one that is used to transform data to deviations from their mean. • Geometry of Matrices: graphical representation • Vector Spaces: Scalar multiplication and addition. A vector space is any space that is closed under scalar multiplication and addition. • Linear Combinations of Vectors and Basis Vectors: A set of vectors is a basis for a vector space if any vector of that space can be written as a linear combination of that set of vectors.	the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	time • ≈10hrs for Written assignment
4	• Linear Dependence: A set of vectors is linearly dependent, if any one of the vectors in the set can be written as a linear combination of the others. Linear independence. Basis for a vector space. • Subspaces: Spanning vectors • Rank of a Matrix: The column space of a matrix is the vector space that is spanned by its column vectors. The column rank of a matrix is the dimension of the vector space that is spanned by its column vectors. Equality of row and column rank. • Determinant of a Matrix: The determinant of a matrix is nonzero, if and only if it has full rank. • A Least Squares Problem: Length of a vector. Orthogonal vectors. The cosine law.	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	• ≈15hrs study time • ≈10hrs for Written assignment
5	• Conditioning in a Bivariate Distribution: In a bivariate distribution there is a conditional distribution over *y* for each value of *x*. • Regression: The Conditional Mean. The conditional mean function is called the regression of y on x. • Conditional Variance: A conditional variance is the variance of the conditional distributuions. • Relationships Among Marginal and Conditional Moments" Law of iterated expectations. Covariance. Moments in a linear regression. Decompositions of variance. Residual	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises • ***1st WA is due***	• ≈13hrs study time • ≈10hrs for Written assignment • ≈2hrs *1st* teleconference

	variance in a regression. Linear regression and homoscedasticity. • The Analysis of Variance. • Regression variance. • Residual variance • Coefficient of determination. • The Bivariate Normal Distribution: definitions and empirical use • Multivariate Distributions: definitions, moments, sets of linear functions. Non-linear functions, empirical applications.	• ***1st Teleconference***	
6	• Probability and distribution theory and its use in risk analysis • Random Variables • Discrete and continuous variables • Outcome. Data generating process. • Definition of random variable. • Probability Distributions: The probability density function. • Cumulative Distribution Function: The cumulative distribution function (CDF) gives the cumulative probability associated with a distribution. Specifically, it gives the area under the probability density function, up to the value you specify • Expectations of a Random Variable: Mean of a random variable. Measures of central tendency. Mean. Mode. Variance of a random variable. Standard deviation. Chebychev inequality. Central moments.	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	• ≈15hrs study time
7	• Some Specific Probability Distributions and their empirical use • The Normal Distribution: The normal distribution is the limiting case of a discrete binomial distribution as the sample size becomes large. An arbitrary normal distribution can be converted to a standard normal distribution by changing variables. • The Chi-Squared: The chi-squared distribution with k degrees of freedom is the distribution of a sum of the squares of k independent standard normal random variables	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	• ≈15hrs study time

	• The Student's t distribution: probability distribution that is used to estimate population parameters when the sample size is small and/or when the population variance is unknown • The F distribution • Distributions With Large Degrees of Freedom • Size Distributions. • The Lognormal Distribution • The Gamma and Exponential Distributions		
8	• The Beta Distribution: A general type of statistical distribution which is related to the gamma distribution. Beta distributions have two free parameters, which are labeled according to one of two notational conventions. • The Logistic Distribution: The logistic distribution is a thicker tailed alternative to the normal distribution. • Discrete Random Variables: Variables that take integer values. We can build up a class of models for discrete random variables from the Bernoulli distribution. • The Distribution of a Function of a Random Variable: There are three types of transformation to consider: from a discrete variable to another discrete variable, a continuous variable into a discrete one, and a continuous variable into another continuous variable. • Representations of a Probability Distribution: Survival function. Hazard function. Moment generating functions. The contagion property.	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises • ***2nd Group Advisory Meeting***	• ≈13hrs study time • ≈2hrs 2nd Group Advisory Meeting
9	• Estimation and Inference: The goal of statistical inference in econometrics is to use the principles of mathematical statistics to combine theoretical distributions and the observed data into an empirical model of the economy. • Samples and Random Sampling: Random sample. Independent. Identically distributed. • Cross section data • Time series data • Descriptive Statistics: Summary statistics. Mean, median, sample midrange, standard	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	• ≈15hrs study time

	deviation, skewness, kyrtosis, covariance, correlation. • Statistics as estimators • Sampling distributions statistics • Sample distribution of the sample mean.		
10	• Point Estimation of Parameters: Point estimate, Standard error, Sampling variance, Interval estimate, Estimator, Finite sample properties, Asymptotic properties. • Estimation in a Finite Sample: Some finite sample estimation criteria for estimating a single parameter. Unbiased estimator. Efficient unbiased estimator. Mean-squared error. • Efficient Unbiased Estimation: Cramer-Rao lower bound. • Minimum variance linear unbiased estimator (MVLUE) or best linear unbiased estimator (BLUE). • Interval Estimation • Pivotal quantity. • Hypothesis Testing: Acceptance vs rejection / critical region. • Classical Testing Procedures • Tests Based on Confidence Intervals • Specification tests	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises • ***2nd WA is announced*** • ***2nd Teleconference***	• ≈13hrs study time • ≈2hrs 2nd teleconference
11	• The Classical Multiple Linear Regression Model: The linear regression model is the single most useful tool for econometricians. • The Linear Regression Model and its use to study the relationship between a dependent variable and one or more independent variables. • Assumptions of the Classical Linear Regression Model • Linearity of the Regression Model	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	• ≈15hrs study time • ≈10hrs for Written assignment

	• Full Rank • Regression • Spherical Disturbances • Homoscedasticity Vs heteroscedasticity • Non autocorrelation Vs autocorrelation. • Data Generating Process for the Regressors • Normality: Except in those cases in which some alternative distribution is explicitly assumed, as in the stochastic frontier model, the normality assumption is probably quite reasonable.		
12 13	**CHRISTMAS HOLIDAYS**		
14	• Least Squares Regression: The population regression, Disturbance, Residual, Population quantity, Fitting criterion, The least squares normal equations • The Least Squares Coefficient Vector • Empirical Application for a bivariate regression model • Orthogonal regression • Algebraic Aspects of The Least Squares Solution • Projection • Residual maker • Projection matrix • Partitioned Regression and Partial Regression: It is common to specify a multiple regression model, when interest centers on only one or a subset of the full set of variables. • Normal equations • Orthogonal Partitioned Regression • Frisch–Waugh Theorem	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	• ≈15hrs study time • ≈12hrs for Written assignment

15	• Partial Regression and Partial Correlation Coefficients: The use of multiple regression involves a conceptual experiment that might not be able to be carried out in practice, the ceteris paribus analysis familiar in economics. • Diagonal elements of the inverse of a moment matrix. Change in the sum of squares when a variable is added to a regression • Goodness of Fit and the Analysis of Variance • Total variation • Coefficient of determination • Analysis of variance table • The Adjusted R-Squared and a Measure of Fit • Change in R^2 When a Variable Is Added to a Regression • The prediction criterion • R-Squared and the Constant Term in the Model • Comparing Models: one should be wary in the calculation and interpretation of fit measures for regressions without constant terms	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises • ***2nd WA is due*** • ***3rd Group Advisory Meeting***	• ≈13hrs study time • ≈15hrs for Written assignment • ≈2hrs 3rd Group Advisory Meeting
16	• Finite-Sample Properties of the Least Squares Estimator • Examination of the least squares estimator from a statistical viewpoint. • The question of which estimator to choose is usually based on the statistical properties of the candidates, such as unbiasedness, efficiency and precision. • Motivating Least Squares • The Population Orthogonality Conditions • Minimum Mean Squared Error Predictor • Optimal linear predictor. • Minimum Variance Linear Unbiased Estimation • Linear unbiased estimator	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	• ≈15hrs study time

	• Unbiased Estimation • The Variance of the Least Squares Estimator • The Gauss Markov Theorem		
17	• The Implications of Stochastic Regressors A convenient method of obtaining the unconditional statistical properties of b is to obtain the desired results conditioned on X first, then find the unconditional result by “averaging” the conditional distributions. • Estimating the Variance of the Least Squares Estimator • The Normality Assumption and Basic Statistical Inference • Testing a Hypothesis About a Coefficient Independence of b and s^2 • Confidence Intervals for Parameters • Confidence Interval for a Linear Combination of Coefficients • The Oaxaca Decomposition. Oaxaca’s (1973) decomposition provides a frequently used application. • Testing the Significance of the Regression • Marginal Distributions of the Test Statistics	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	• ≈15hrs study time
18	• Finite-Sample Properties of Least Squares • Data Problems: Three practical problems that arise in the setting of regression analysis, multicollinearity, missing observations and outliers • Multicollinearity: The case of an exact linear relationship among the regressors is a serious failure of the assumptions of the model, not of the data. • Missing Observations: It is fairly common for a data set to have gaps, for a variety of reasons. Perhaps the most common occurrence of this problem is in survey data, in	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises • ***3rd WA is announced***	• ≈13hrs study time • ≈2hrs *3rd* teleconference

	which it often happens that respondents simply fail to answer the questions. The ignorable case • Regression Diagnostics and Influential Data Points: Even in the absence of data problems, it is worthwhile to examine for outliers which, particular observations are especially influential in the results.	• ***3rd Teleconference***	
19	• Inference and Prediction: Examination of some applications of hypothesis tests using the classical model. • Restrictions and Nested Models: A theory is said to have testable implications if it implies some testable restrictions on the model • Two Approaches to Testing Hypotheses: We assume normally distributed disturbances, to obtain the exact distributions of the test statistics • The F Statistic and the Least Squares Discrepancy: Given the least squares estimator b, our interest centers on the discrepancy vector. • The Restricted Least Squares Estimator: The constrained solution is equal to the unconstrained solution plus a term that accounts for the failure of the unrestricted solution to satisfy the constraints. • The Loss of Fit from Restricted Least Squares	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	• ≈15hrs study time • ≈10hrs for Written assignment
20	• Non-normal Disturbances and Large Sample Tests: Large-sample results suggest that although the usual t and F statistics are still usable, in the more general case without the special assumption of normality, they are viewed as approximations whose quality improves as the sample size increases. Limiting Distribution of the Wald Statistic • Testing Nonlinear Restrictions: The general problem is that of testing a hypothesis that involves a nonlinear function of the regression coefficients • Prediction: After the estimation of parameters, a common use of regression is for	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	• ≈15hrs study time • ≈10hrs for Written assignment

	prediction. Various measures have been proposed for assessing the predictive accuracy of forecasting models. Most of these measures are designed to evaluate ex post forecasts for which the independent variables do not themselves have to be forecasted.		
21	• Models for Panel Data: Data sets that combine time series and cross sections are common in economics. Recently constructed longitudinal data sets contain observations on thousands of individuals or families, each observed at several points in time. Other empirical studies have analyzed time-series data on sets of firms, states, countries, or industries simultaneously • Panel Data Models: Panel data sets are more oriented toward cross-section analyses; they are wide but typically short. Heterogeneity across units is an integral part, often the central focus, of the analysis. • Fixed Effects: This formulation of the model assumes that differences across units can be captured in differences in the constant term. • Testing the Significance of the Group Effects • The Within- and Between-Groups Estimators • Fixed Time and Group Effects • Unbalanced Panels and Fixed Effects	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises • ***3rd WA is due***	• ≈15hrs study time • ≈10hrs for Written assignment
22	• Random Effects: If the individual effects are strictly uncorrelated with the regressors, then it might be appropriate to model the individual specific constant terms as randomly distributed across cross-sectional units. This view would be appropriate if we believed that sampled cross-sectional units were drawn from a large population. • Generalized Least Squares: The variance components are usually not known, so we must first estimate the disturbance variances and then use an FGLS procedure. • Feasible Generalized Least Squares When Σ Is Unknown	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises • ***4th WA is announced***	• ≈13hrs study time • ≈2hrs 4th Group advisory meeting

	• Testing for Random Effects: Breusch and Pagan (1980) have devised a Lagrange multiplier test for the random effects model based on the OLS residuals • Hausman's Specification Test for the Random Effects Model • Instrumental Variables Estimation of the Random Effects Model	• ***4th Group Advisory Meeting***	
23	• Systems of Regression Equations • The Seemingly Unrelated Regressions Model • Generalized Least Squares • Seemingly Unrelated Regressions with Identical Regressors: the case of identical regressors is quite common, notably in the capital asset pricing model in empirical finance. In this special case it is equivalent to equation by equation ordinary least squares • Feasible Generalized Least Squares • Maximum Likelihood Estimation: Maximum likelihood enjoys no advantages over FGLS in its asymptotic properties. Preferable in a small sample depending on the particular data set. • An Application from Financial Econometrics: The Capital Asset Pricing Model • Maximum Likelihood Estimation of the Seemingly Unrelated Regressions Model with a Block of Zeros in the Coefficient Matrix • Autocorrelation and Heteroscedasticity	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	• ≈15hrs study time • ≈10hrs for Written assignment
24	• Time-Series Models: Researchers have observed that the large simultaneous-equations macroeconomic models constructed in the 1960s frequently have poorer forecasting performance than fairly simple, univariate time-series models based on just a few parameters and compact specifications. • Stationary Stochastic Processes: The essential building block for the models to be discussed in this chapter is the white noise time-series process.	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	• ≈15hrs study time • ≈10hrs for Written assignment

	• A univariate time-series model describes the behavior of a variable in terms of its own past values • Autoregressive Moving-Average Processes • Stationarity and Invertibility • Covariance Stationarity • Autocorrelations of a Stationary Stochastic Process • Partial Autocorrelations of a Stationary Stochastic Process • Partial Autocorrelation Coefficient		
25	• Modeling Univariate Time Series Box and Jenkins (1984) pioneered a forecasting framework based on the preceding that has been used in a great many fields and that has, certainly in terms of numbers of applications, largely supplanted the use of large integrated econometric models. • Wold's Decomposition Theorem: The linearly deterministic component • Estimation of the Parameters of a Univariate Time Series: The broad problem of regression estimation with time series data, is that the consistency and asymptotic normality results that we derived based on random sampling will no longer apply • The Frequency Domain Much contemporary economic analysis, has dealt with more disaggregated, microlevel data, observed at far greater frequency • Theoretical Results • Empirical Counterparts	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises • ***4th Teleconference*** • ***4th WA is due***	• ≈13hrs study time • ≈10hrs for Written assignment • ≈2hrs *4th* teleconference
26	• Estimation and Inference in Binary Choice Models: The method of scoring for the logit model. • Robust Covariance Matrix Estimation The probit maximum likelihood estimator is often labeled a quasi-maximum likelihood estimator (QMLE) in view of the possibility that the normal probability model might be	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography	• ≈15hrs study time

	misspecified • Marginal Effects: To compute standard errors, we can use the linear approximation approach (delta method). • Hypothesis Tests: For testing hypotheses about the coefficients, the full menu of procedures is available. The simplest method for a single restriction would be based on the usual t tests, using the standard errors from the information matrix. Using the normal distribution of the estimator, we would use the standard normal table rather than the t table for critical points. For more involved restrictions, it is possible to use the Wald test.	• Self-assessment exercises (~≈2hrs)	
27	• Specification Tests for Binary Choice Models If we ignore heteroscedasticity, although the LS estimator is still unbiased and consistent, it is inefficient and the usual estimate of its sampling covariance matrix is inappropriate. Yatchew and Griliches (1984) have examined issues in the setting of the probit and logit models. • Omitted Variables • Heteroscedasticity • A Specification Test for Nonnested Models • Testing for the Distribution: whether the logit or probit form, or some third alternative, is the best specification for a discrete choice model is a perennial question. Building on the logic of the PE test, Silva (2001) has suggested a score test which may be useful in this regard. • Measuring Goodness of Fit • Analysis of Proportions Data: Data for the analysis of binary responses will be in one of two forms: individual and grouped data that consist of counts or proportions.	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	• ≈15hrs study time
28	• Bivariate and Multivariate Probit Models: A natural extension of the probit model would be to allow more than one equation, with correlated disturbances, in the same spirit as	• Studying the relevant material through the literature and the readers	• ≈13hrs study time

	the seemingly unrelated regressions model. • Maximum Likelihood Estimation • Testing for Zero Correlation • The Lagrange multiplier statistic is a convenient device for testing for the absence of correlation in this model. Under the null hypothesis that ρ equals zero, the model consists of independent probit equations, which can be estimated separately. • Marginal Effects • Sample Selection • A Multivariate Probit Model: Lerman and Manski (1981) suggested that one might approximate multivariate normal probabilities by random sampling • Application: Gender Economics Courses in Liberal Arts Colleges	• Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises • ***5th Teleconference***	• ≈2hrs *5th* teleconference
29	• Logit Models for Multiple Choices: Examining two broad types of choice sets, ordered and unordered. • The Multinomial Logit Model • The Conditional Logit Model: The appropriate model when the data consist of choice-specific attributes instead of individual-specific characteristics. • The Independence from Irrelevant Alternatives • Nested Logit Models: If the independence from irrelevant alternatives test fails, then an alternative to the multinomial logit model will be needed. • A Heteroscedastic Logit Model: Bhat (1995) and Allenby and Ginter (1995) developed an extension of the conditional logit model, around the difficulty of specifying the tree for a nested model. • Multinomial Models Based on the Normal Distribution • A Random Parameters Model • Application: Conditional Logit Model for Travel Mode Choice	• Studying the relevant material through the literature and the readers • Working on review questions relevant to the taught material • Additional bibliography • Self-assessment exercises	• ≈15hrs study time

30	**EASTER HOLIDAYS**		
31			
32-36	Revision of the material taught and preparation for the final exams	• Review of the written assignments past and current Review of the material taught • Solving student's questions • ***5th Group Advisory Meeting***	• ≈63hrs study time • ≈2hrs 5th Group advisory meeting
	Formal Assessment	Final Exam	• ≈3hrs
		Total	600hrs