Part I Paper 3
Quantitative Methods in Economics
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Paper Content

Although this paper has two components (Mathematics and Statistics) the unifying principle is the application of simple analytical techniques to a range of empirical and theoretical problems in Economics. The paper outline sets out the lecture courses for the two components of the paper separately. Candidates are required to cover both components of the paper; they will not be able to pass by concentrating exclusively either on Mathematics or on Statistics. The three-hour written examination for the paper (which carries 80% of the marks for the course) will contain separate sections on Mathematics and Statistics, each carrying 40% of the mark for the whole course. Candidates will be required to answer questions from all sections of the paper. In addition there will be a 'take-home' Statistics project early in the Easter Term, which will carry 20% of the mark for the whole course. This project will test students' ability to compile their own data from published sources, and to apply economic reasoning and simple quantitative techniques to draw conclusions about economic phenomena.

Mathematics - Aims

Mathematical techniques are an indispensable tool of economics. Using mathematics, an economist can formalise and solve problems that cannot be addressed in other ways. The aim of this component of the paper is to cover the key areas of mathematical economics needed to allow candidates to tackle the compulsory papers of the Economics Tripos successfully. The general level of the mathematics concerned is roughly equivalent to A level, but some of the techniques, and almost all the applications to economics, are new for the majority of students.

Mathematics - Objectives

By the end of the paper, students should have a good understanding of key mathematical concepts and techniques and be able to apply these to economic problems. It is not expected that students will be able to carry out rigorous mathematical derivations.

Mathematics - Content

The mathematics teaching for the paper will assume that candidates are familiar with the basic material set out below (which is basically the content of the Core Mathematics modules of a standard A-Level Mathematics course). Candidates who took mathematics qualifications other than A-level (for example, IB or European qualifications) should check that they have covered all of these topics. If they have not, they should contact their Director of Studies for further information and advice on reading.

- definition of integers, rationals and real numbers
- Module C1 - indices
- pairs of simultaneous linear equations
- quadratic equations
- graphs of linear and quadratic equations, and simple coordinate geometry
- differentiation of polynomial functions
- simple integration
- Module C2 - sum of geometric progression
- unconstrained optimisation of a function of one variable
- definite integrals
- Module C3 - definition of function, domain, range and inverse function

- natural logarithm and exponential function
- differentiation of ln x and e^x
- product, quotient and chain rules for differentiation
- Module C4 - rates of change
- integration of x^{-1} and e^x
- simple integration by substitution and by parts
- vectors – addition, subtraction and scalar product

Students may find it helpful to bring their A-Level (or equivalent) notes, and any textbooks, with them to Cambridge.

Lecture courses

There are 20 lectures across the first two terms.

Mathematics for Economists: Intro to Calculus, Partial Difference, Constrained Optimization (Dr B Wallace, 8 lectures, weeks 1-4, Michaelmas Term)

Mathematics for Economists: Linear Algebra (Dr B Wallace, 4 lectures, weeks 5-8, Michaelmas Term)

Mathematics for Economists: Difference and Differential Equations (Dr G Carmona, 4 lectures, weeks 5-8, Lent Term)

Mathematics for Economists: Extended Calculus – Envelope Theorem; Comp Statics, Integration (Dr B Wallace, 4 lectures, weeks 1-4, Lent Term)

Reading

Bradley, T, *Essential Mathematics for Economics and Business*, (3rd edition), Wiley. Comprehensive coverage of most topics, sometimes a little basic. The early chapters cover A-level material which will not be taught in the course.
Sydsaeter, K and P Hammond, *Essential Mathematics for Economic Analysis* (2nd edition), Prentice Hall. Covers the course syllabus, but with a rather less basic approach than Bradley.
Chiang, A, *Fundamental Methods of Mathematical Economics,* McGraw-Hill. Harder than Bradley, more in-depth coverage of advanced topics.
Pemberton, M & N Rau, *Mathematics for Economists,* (2nd edition), Manchester University Press. Also harder than Bradley, but a good text for those who have done Further Maths modules at A Level, or who plan to take the optional Mathematics paper in Part IIA. Some material (roughly, Chapters 21-30) goes beyond the course syllabus.

Individual lecturers may advise further texts in lectures.

Examination

The Mathematics component of the 3-hour examination for this paper has two sections, labelled A and B. Section A questions are short answer questions, testing mathematical techniques, while section B questions have a more economic structure and are more complex. Candidates must answer all four questions from section A, and one question (out of two) from section B.

Past examination papers for this paper are available on the Faculty website. Note that for examinations up to and including 2008 candidates were offered a choice of questions in Section A. In 2009 and thereafter only four questions will be set, and candidates will be required to answer all of these.

The examination questions set will focus on testing the understanding of and familiarity with the mathematical techniques covered in the lectures, their application to economic problems, and the interpretation of results. They will not require complex numerical calculations. Although candidates are permitted to use approved electronic calculators in the examination, examiners will not set numerical questions (for example, questions requiring the numerical inversion of matrices) which can be answered purely by using 'built-in' features of the calculator.

Statistics – Aims

This paper deals with the manner in which statistics contribute to the study of economic and social problems and to the discussion of issues of public policy. Its main purpose is to test the candidate's ability to analyse problems in applied economics, by bringing to bear on them relevant economic theory, knowledge of statistical sources, and relatively simple statistical derivations. It does not require advanced mathematical analysis.

Statistics - Objectives

By the end of the course, students should be in possession of a good grasp of the elementary tools of descriptive statistics; should understand elementary principles of probability and statistical theory; should be competent in applying basic methods of statistical inference; and should be familiar with the use of spreadsheets to undertake graphical and statistical analysis of economic data.

Statistics – Content

The statistics teaching for the paper will assume that candidates are familiar with the basic material set out below (which is covered in the GCSE Mathematics paper). Candidates who took other mathematics qualifications should check that they have covered all of these topics. If they have not, they should contact their Director of Studies for further information and advice on reading.

- GCSE - Graphical techniques for representing data
- Histograms, scatter diagrams, time series plots
- Measures of central tendency for a dataset
- Mean, median and mode

The specific statistical concepts and techniques covered in the course are as follows.

Descriptive statistics: The use of tables, graphs, diagrams and frequency distributions in summarizing and organizing statistical data; summary measures of central tendency, dispersion and skewness; simple measures of association.
Probability: Events, outcomes and sample space; Venn diagrams; unions, intersections and complements; simple combinatorial formulae for sampling with and without replacement; conditional probability and Bayes' Theorem; the concept of a random variable;
Probability distributions: Univariate cumulative distribution functions and probability density functions; expectations, variances and higher moments; expectation and variance of sums of independent random variables; Bernoulli trials and the Binomial distribution; simple discrete and continuous probability distributions, including Uniform and Normal distributions; Chi-squared, t and F distributions.
Sampling distributions: The use of sample statistics: the concept of an estimator; unbiasedness and efficiency;
Sampling distributions (large samples): Law of Large Numbers and Central Limit Theorem (proofs not required); sample mean, sample variance, difference between sample means, difference between sample proportions;
Sampling distributions (small samples from parent normal populations): Sample mean, difference between sample means when population variances are the same; ratio of sample variances.
Estimation and hypothesis testing: A simple treatment of point and confidence interval estimation and hypothesis testing (in each case the sample statistics used are those enumerated in (iv) above); null

and alternative hypotheses; critical regions; one-tailed and two-tailed tests; Type I and Type II errors; power functions
Bivariate distributions - correlation and bivariate regression Bivariate probability distributions; the bivariate Normal distribution; conditional and marginal probability distributions; conditional expectation; statistical estimation of bivariate models where errors are independently and normally distributed with common variance; sampling distributions of regression coefficients under these assumptions; testing of simple hypotheses about regression coefficients; distribution of correlation coefficient under the null of zero correlation
Multiple regression: Interpretation of multiple regression coefficients; dummy variables; significance tests for individual regression coefficients; graphical analysis of regression residuals.
Time series: Distinction between time series and random samples; trend, cycle and seasonal factors; levels, growth rates and ratio variables for macroeconomic aggregates; use of seasonal dummy variables in regression
Computational statistics: The use of spreadsheet packages to store and organise economic data, to generate simple graphs, and to compute the statistics outlined above.

Many of the concepts and techniques set out above are covered in Modules S1-S4 of the A-level courses in Mathematics and Further Mathematics. Students may find it helpful to bring their A-Level (or equivalent) notes, and any textbooks, with them to Cambridge.

Lecture Courses

There are 24 lectures across the first two terms, and four revision classes during the Easter term.

Introduction to Statistical Inference (Dr S Srisuma, 16 lectures, weeks 1-8, Michaelmas Term)

Classes (Dr S Srisuma, 7 classes, weeks 2-8, Michaelmas Term)

Introduction to Statistical Inference (Dr S Srisuma, 8 lectures, weeks 1-8, Lent Term)

Revision Classes (Dr B Wallace, 4 classes, weeks 1-4, Easter Term)

Reading

The following texts are recommended for the Statistics component of this paper: since they all cover broadly the same material you should chose one text which you feel is at the appropriate level for you.
Lind, D, W Marchal and R Mason, *Statistical Techniques in Business and Economics*, (11th edition), McGraw-Hill.
Aczel A D and J Sounderpandian, *Complete Business Statistics,* (7th edition), McGraw-Hill.
Mann, P S, *Introductory Statistics* (3rd edition), Wiley.
Ross, S M, *Introductory Statistics,* (7th edition), Academic Press.
RJ Larsen and ML Marx, An *Introduction to Mathematical Statistics and Its Applications* (3rd Edition)

Individual lecturers will distribute specific reading lists in lectures.

Project

The Statistics component of this paper is examined through the three-hour examination (of which details are given below) and the submission of an independent project. This project, which carries 20% of the total mark for Paper 3, is assigned early in the Easter Term. Sample project questions are available on the Faculty website. The project requires students to collect suitable data (from paper or electronic sources), to analyse this data using a spreadsheet package or other statistical software provided by the Faculty, and to submit a short (1500 word) written report describing and interpreting the economic implications of their findings.

Examination

The Statistics component of the 3-hour examination for this paper has two sections, labelled C and D; section C questions are short questions, while section D questions are longer and require more detailed answers. Candidates must answer all four questions from section C, and one question (out of two) from section D.

Past examination papers for this paper are available on the Faculty website.

The examination questions set will focus on testing the understanding of and familiarity with the statistical techniques covered in the lectures, their application to economic data, and the interpretation of results. They will not require the entry of large datasets, or long and complex numerical calculations. Although candidates are permitted to use approved electronic calculators in the examination, examiners will not set numerical questions (for example, the calculation of correlation or regression coefficients from raw data) which can be answered purely by using 'built-in' features of the calculator.