Engineering Tripos Part IIA, 3E3: Modelling Risk, 2019-20

Leader

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Lecturer

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Timing and Structure

Lent term. 2 lectures/week. 16 lectures.

Prerequisites

Basic probability theory and statistics and basic knowledge of using Excel of Microsoft.

Aims

The aims of the course are to:

- Provide an understanding of the mechanics of a range of management science modelling methods involving randomness, such as statistics, decision analysis, portfolio management, queueing theory, Markov chains, dynamic programming, forecasting, & regression.
- For each of the modelling areas, students will become familiar with the types of situations in which the method is useful.

Objectives

As specific objectives, by the end of the course students should be able to:

- Understand basic concepts of probability and the rationale behind statistical reasoning.
- Be able to calculate statistical measures like mean and variance, and interpret these in realistic situations.
- Use confidence intervals to quantify risk.
- Conduct hypothesis testing.
- Be able to understand decision trees and how to apply them in decision making.
- Be able to describe a Markov chain and analyse its long-term behaviour and steady state distribution.
- Understand and use simple formulas for queues in which arrivals occur as a Poisson process.
- Be able to model staged decisions by dynamic programming and to solve some dynamic programs using value iteration and policy iteration algorithms.
- Forecast data using short range extrapolative techniques such as exponential smoothing.
- Know how to take account of seasonality when forecasting.
- Apply regression techniques to estimate the way in which two variables are related.
- Be able to understand investment strategies for portfolios.
- Be able to incorporate risk into investment and decision making.

Content

"There are known knowns. These are things we know that we know. There are known unknowns. That is to say,

there are things that we know we don't know. But there are also unknown unknowns. These are things we don't know we don't know."

- Donald Rumsfeld

Inventory Management (2L)

- Basic concepts in inventory management: inventory management under deterministic demand (EOQ model), inventory management under stochastic demand (newsvendor model, (R, Q) policy).

Decision Analysis (2L)

- Events and decisions, decision trees, expected monetary value, sensitivity analysis, expected value of perfect information, expected value of sample information.

Mathematical Analysis of Stochastic Processes (6L)

- *Dynamic programming:* Bellman optimality equations, deterministic dynamic programming, probabilistic dynamic programming, value iteration algorithm, policy iteration algorithm.
- *Markov chains:* Discrete and continuous-time Markov chains, hitting times, steady-state distributions, steady state probabilities of birth and death processes.
- *Queueing theory:* Poisson arrival processes, classification of queueing systems, steady state, performance measures, Little's formula, benefits and limitations of queueing theory.

Regression Analysis and Forecasting (4L)

- Simple linear regression analysis, least squares estimates, significance of regression, multiple regression, multi-collinearity.
- Different methods for forecasting: moving average, exponential smoothing, modelling seasonality and trends.

Portfolio Management (2L)

- Basic portfolio concepts: securities, risk, arbitrage.
- The Capital Asset Pricing Model.
- Risk and expected return on a portfolio, and the efficient frontier.

Examples papers

In this course, we will have three examples classes for all students at the same time, rather than three supervisions for small groups.

- Class 1: Statistics, decision analysis and dynamic programming.
- Class 2: Queuing theory and Markov chains.
- Class 3: Regression, forecasting and portfolio analysis.

Coursework

To be announced in lectures.

There is no Full Technical Report (FTR) associated with this module.

Booklists

Please see the Booklist for Part IIA Courses [2] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

UK-SPEC

This syllabus contributes to the following areas of the UK-SPEC [4] standard:

Toggle display of UK-SPEC areas.

GT1

Develop transferable skills that will be of value in a wide range of situations. These are exemplified by the Qualifications and Curriculum Authority Higher Level Key Skills and include problem solving, communication, and working with others, as well as the effective use of general IT facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD.

IA1

Apply appropriate quantitative science and engineering tools to the analysis of problems.

KU1

Demonstrate knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinning science and mathematics.

KU2

Have an appreciation of the wider multidisciplinary engineering context and its underlying principles.

E3

Ability to apply mathematical and computer based models for solving problems in engineering, and the ability to assess the limitations of particular cases.

P8

Ability to apply engineering techniques taking account of a range of commercial and industrial constraints.

US1

A comprehensive understanding of the scientific principles of own specialisation and related disciplines.

US2

A comprehensive knowledge and understanding of mathematical and computer models relevant to the engineering discipline, and an appreciation of their limitations.

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Links
[1] mailto:fe251
[2] https://www.vle.cam.ac.uk/mod/book/view.php?id=364091&chapterid=46671
[3] https://teaching22-23.eng.cam.ac.uk/content/form-conduct-examinations
[4] https://teaching22-23.eng.cam.ac.uk/content/uk-spec