



MSc Operational Research Management Science Department, Strathclyde Business School

Website - <http://www.strath.ac.uk/mansci/>
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Class Descriptions - Core Classes

(1) Foundations of Operational Research & Business Analysis

Rationale

Students who commence the MSc in Operational Research and MSc in Business Analysis & Consulting come from a variety of backgrounds. Some may have already studied Operational Research or Business Analysis and are thus familiar with some, or all, of the problem solving processes that will be studied and with the methods, or techniques and tools associated with them. However, many of the students on the degrees will be new to the subject area. This class therefore provides an introduction to and overview of the fields of Operational Research and Business Analysis. For full-time and part-time students it will be taught early in the first semester. For distance learning students it will be the first class which they will take.

Class description/introduction

The class will explore the generic problem solving process which underpins the provision of decision support. In particular, it will consider the role of modelling in that process. The activities of problem structuring, data collection and analysis, identification and evaluation of options, communication and implementation of learning, findings and recommendations will each be discussed along with the issues pertaining to each of them. In addition, the links between each of these activities will be explored. Basic methodological issues will be considered and debated. Relevant and up-to-date case studies will be used to illustrate key points and to initiate debate. Time will be spent appreciating the role of problem structuring methods and a variety of other approaches to modelling will be briefly discussed in order to introduce students to key techniques and tools in the field. Links will be made to other classes in the degree where these techniques will be taught in more detail.

Class aims

To introduce, and provide an overview of, the fields of Operational Research and Business Analysis. This will involve gaining an appreciation of the generic problem solving process, an exploration of basic methodological issues, plus an introduction to and overview of key modelling tools and techniques. The class will provide a framework for understanding how these modelling techniques, which will be explored in greater depth in other classes, fit together.

Learning outcomes

1. subject specific knowledge and skills
 - To develop an understanding of the problem solving process required when supporting management decision-making
 - To gain an understanding of the different elements involved in the problem-solving process
 - To appreciate the role of modelling in supporting each element of the problem-solving process
 - To develop an understanding of problem structuring methods
 - To gain an appreciation of a variety of key modelling tools and techniques and how each can support the management decision-making process

2. cognitive abilities and non-subject specific skills
 - Critical thinking
 - Team working skills through group work
 - Communication skills, both verbal and written

(2) Quantitative Business Analysis

Rationale

The analysis of data and development of empirical models plays a vital role in business analysis and operational research. This module will provide a basis for students to learn a range of widely used methods ranging from effective presentation of data to development of sophisticated statistical models.

Class description/introduction

Quantitative Business Analysis runs over one semester but in two parts. The first part provides an introduction to the basic theory and application of statistical modelling. Topics covered included data analysis, probability theory, distributions and moments, estimation and hypothesis testing. The second part focuses mainly on two areas - regression modelling and multivariate analysis. While key background theory will be presented, the emphasis is on the generation and interpretation of

output from commercially available software. Throughout, there is an emphasis on the use of statistical analysis to help support decision-making and the management of business and industrial problems. Cases are used to illustrate topical issues.

Class aims

The aim of the course is to introduce statistical modelling to support business and management decisions.

Learning outcomes

1. subject specific knowledge and skills

- To display and interpret data using appropriate visual displays.
- Select, construct and interpret summary statistics.
- Understand probabilistic reasoning and compute probabilities for simple problems.
- Use graphical methods to identify appropriate models and estimate parameters.
- Apply and interpret formal statistical estimation procedures and goodness-of-fit tests.
- To develop and validate appropriate simple and multiple linear regression models
- Understand the basic principles of classification methods
- Understand the basic principles of ANalysis Of VAriance (ANOVA).

2. cognitive abilities and non-subject specific skills

- Develop students ability to construct numerical argument
- Critical thinking with respect to quantitative analysis
- An ability to express problems in forms conducive for the software support available

(3) Managing Business Operations

Rationale

Knowledge and practical understanding of the principles, tools and techniques required for the effective management of business operations is indispensable for Operational Research practitioners and business consultants.

Class description/introduction

This class teaches essential principles, tools and techniques of Operations Management – both in general and as applied to specific manufacturing or service businesses. A section of the class focuses on service operations, where specific subjects and operational issues surrounding services will be discussed. This class is a core class for both the MSc in Operational Research and the MSc in Business Analysis & Consulting.

Class aims

- Students should understand the principles of Operations Management as a management function and as a set of management decisions concerning the design, planning and control, and improvement of operating systems in both manufacturing and service organisations.
- Students should understand the key concepts of Operations Management and be able to apply relevant analytical tools, models and quantitative methods.
- Students should understand the differences between manufacturing and service operations, and also specific managerial challenges and decisions related to the former and the latter.

Learning outcomes

1. Subject specific knowledge and skills

- Describe the design, planning and control, and improvement decisions to be taken in the Operations Management function, and explain the link between operations strategy and business strategy.
- Analyse and explain the interrelationships between the performance objectives in Operations Management and the design of an operating system, for any given manufacturing or service organisation.
- Identify the main aspects of process and layout design, and evaluate the trade-offs between these aspects, and use relevant quantitative methods in support of layout design.
- Explain key concepts in supply chain planning and control, and evaluate the trade-offs between performance objectives in this area, and apply independent-demand inventory control systems to minimise inventory
- Explain key concepts in Enterprise Resource Planning.
- Use appropriate network planning methods for effective project planning and control.
- Explain key concepts in quality planning and control, and statistical process control and acceptance sampling to effectively manage quality costs.
- Understand specific characteristics of a typical service operation and the use of service classification models.
- Appreciate the concept of service package and its relationship with service encounter.

- Identify the most suitable approach to design in different service operations.
- Understand the concept of Yield Management in services.
- Appreciate the challenges surrounding the traditional concept of 'productivity' in services and its relationship with quality.
- Understand the links between employee, customer and profit in services.
- Explain potential effects of organisational culture on service employees and service consumers.
- Be aware of some of the new developments in services (such as Service Science).

2. Cognitive abilities and non-subject specific skills

- Present a reasoned argument in writing based on a thorough knowledge and understanding of the relevant academic literature and supported, where required, by analytical discussion and/or appropriate quantitative analysis.
- Being able to use conceptual modelling techniques to study and analyse factors affecting business operations.

(4) Spreadsheet Modelling & Demand Forecasting

Rationale

Spreadsheets provide an easily accessible tool to support business modelling and analysis. Spreadsheets are a popular modelling support tool because they facilitate easy manipulation of data and thus greatly reduce the time necessary to set-up and modify models. Analysis carried out in a spreadsheet is easily transferred into other software packages or presented visually, so that it provides a good platform for report writing.

Class description/introduction

This module will demonstrate how spreadsheets can be used to support the analytical techniques whose theory is taught on other modules, for example, forecasting, simulation, optimisation, data analysis, as well as being used to support technical report writing. Most prominence is given to demand forecasting and students will be introduced to different types of forecasting technique for short term smoothing through to decompositional analysis. These methods will be implemented using spreadsheet models. This module also extends the basics of using a spreadsheet to explore the principles of effective computer programming through the development of macros to automate the functionality available within spreadsheets.

Class aims

The aim of this module is to develop an understanding of how spreadsheets can be used to effectively support business modelling, particularly in relation to the development of demand forecasting systems for which students will be introduced to the toolbox of commonly used techniques.

Learning outcomes

1. subject specific knowledge and skills:

- Create simple but appropriately organised spreadsheet models for complex problems;
- Use the spreadsheet to support traditional operational research techniques such as forecasting, optimisation and simulation;
- Describe the main categories of forecasting technique, their data requirements and applicability to different operational situations;
- Construct and interpret forecasts using smoothing methods and decompositional analysis;
- Compute forecast errors to track accuracy of forecasts;
- Understand the nature of effective forecasting systems;
- Understand basic principles of computer programming;
- Understand the basic elements of VBA for developing macros within Excel.

2. cognitive abilities and non-subject specific skills:

- Further develop ability to see patterns in numerical data;
- Develop students ability to express modelling process algorithmically;
- Develop student's ability to express problems in forms conducive for the software support available.

(5) Operational Research Methods

Rationale

Operational Research analysts need to support decision-makers in modelling problems in the presence of uncertainty and to inform efficient resource allocation. To do achieve this requires skills in developing stochastic models and algorithms for optimisation. In this module both deterministic and stochastic OR methods are introduced. The problems to which these methods are applicable are described, the mathematical formulations of the methods are derived and the algorithms developed.

Class description/introduction

This module introduces the fundamental deterministic and stochastic methods of OR. Probabilistic modelling is fundamental to appreciating uncertainty and risk. This element of the class provides much of the foundations that underpin the tools and techniques that are taught on other classes of the MSc such as statistics, forecasting, risk and simulation. The module also introduces students into the basic deterministic models and methods of OR. Unstructured problem descriptions are formulated using mathematical notation. These problems are classified and appropriate solution methods are selected where they exist. The solution methods are covered in detail for certain classes of problem.

Class aims

The aim of the class is to introduce the basic deterministic methods and stochastic processes used in OR.

Learning outcomes

1. subject specific knowledge and skills

- To demonstrate probabilistic modelling
- To understand the key results for discrete and continuous Markov chains, queuing models and Poisson point processes
- To be able to apply stochastic models to a variety of operations problems
- To understand the basic models, methods and techniques used in optimisation
- To be able to classify optimization problems according the following classes: combinatorial (transportation, network flow, integer programming problems) and continuous optimization problems (linear programming, quadratic programming, linear complementarity, convex programming and general nonlinear programming problems)
- To understand methods for solving combinatorial and continuous optimization problems
- To conduct sensitivity analysis of solutions, and report on this in a matter understandable and useful to a client.

2. cognitive abilities and non-subject specific skills

- To read mathematical texts to broaden and deepen understanding of probability and its applications
- To write about models and analysis in a coherent manner
- To improve problem structuring skills
- To communicate using mathematical models and their solutions

(6) Becoming an effective OR modeller

The other taught modules on the programme introduce a variety of operational research models and approaches to the student. However, the practical reality of applying OR models in the real world is often far removed from the classroom. Working with managers to model real problems presents a variety of challenges. For example, data required by a model may be hard to come by, it may be far from obvious which OR models can best be applied and managers will need to be convinced of the business merits of any suggested solutions arising from the application of OR models. While traditional teaching can alert students to such issues, understanding needs to be reinforced by experience.

This class runs through both semesters of the degree, in parallel with the other modules. It introduces students, mostly through experiential learning, to as much as possible of the practical reality of becoming an effective OR modeller and the key skills required to function effectively in this area.

The *Becoming an effective OR modeller* class consists of:

- A series of semi- or unstructured modelling problems, typically introduced by a manager from an outside organisation. The problems will typically relate to an OR model/method recently covered in one of the other modules. Students spend time tackling unstructured problems, usually in groups, and present and compare their findings. These sessions include "workshops" in which students analyse real problems presented by managers as guests of the Department (in addition, practitioners give more general talks to the class on OR modelling within their own organisations). Following these case studies reflective sessions will be held which focuses on the development of reflective practitioner skills.
- Experience is augmented, and integrated with, the rest of the course by a series of informal workshops on directly related topics that will provide guidance on key skills development. This will include development of both technical modelling skills and skills required to carry out a successful modelling process.

Class Descriptions - Elective Classes

Students choose three of the four electives.

(1) Business Simulation Methods

Rationale

This class will form part of the MSc in Operational Research and MSc in Business Analysis and Consulting. Both of these courses are focussed on introducing students to modelling techniques that can be used to help support decision-makers. Business simulations are one such important modelling technique. This class focuses on two

specific business simulation techniques; discrete-event simulation and system dynamics.

The Operational Research technique of discrete-event simulation provides a decision maker/client with the equivalent of a flight simulator of their factory or service operation. This is done by modelling every significant resource and event in the operation and displaying them on a computer screen as icons which move/work with simulated time. This enables the decision maker/client to try out different ways of operating the system without experimenting with the real system.

System dynamics has been around for over 50 years. It was originally created to help decision-makers to design improved management policies and organizational structures. System dynamics is increasingly used in organizations all around the world and has been applied to a wide variety of issues including organizational change, climate change, healthcare and project management.

Class description/introduction

The course will begin by introducing students to business simulations in general. It will then focus on the main two forms of business simulation; discrete-event simulation and system dynamics (a continuous simulation technique). For discrete event simulation (DES) the class will start with an introduction to DES aiming to familiarise students with the concept and its use as well as specific features of a typical DES tool. The class continues with discussing a rational approach to simulation using a number of examples from manufacturing and service operations. The link between simulation and performance measurement is discussed at this part. This is followed by a detailed discussion on the use of probabilistic distributions in simulation where the emphasis is on 'relevance for use' rather than the underlined statistical theories and techniques. The issues of certainty of out put and validation of the model are discussed in the next stage where students understand the importance of trials in simulation. While the main emphasis is on DES in general, a number of basic and advanced techniques of Simul8 (a popular DES software) are explained and demonstrated for students. The discussion on DES concludes with addressing some practical issues with regard to doing a DES project for a business client.

For system dynamics the class will provide a background to system dynamics including its links to other modelling techniques being taught on the course. In particular, its links to problem structuring methods. A complete approach to system dynamics modelling is then covered in detail. The behaviour of various systems, in particular complex business problems, are examined through the construction of causal loop diagrams. The class then goes on to introduce computer software used specifically for system dynamics modelling. After familiarisation with the package, students will be expected to use it to model and investigate a variety of systems. In particular, the class will explore how such models can be used to investigate complex business problems and how they can be used to decide upon managerial actions that should be taken to help alleviate the problems.

The class will end by getting students to reflect on the two forms of business simulation and how they differ from one another. In addition, the class will explore the

types of business problems for which these techniques are appropriate, so that a student is aware when these techniques should be chosen out of the toolbox of kits being taught on the course.

Class aims

To introduce students to two simulation methods widely used in business. The first, discrete-event simulation, is a visual interactive tool that facilitates decision making in an operating system. The objective is to make students competent in applying DES in any operation system and specifically to enable them to use a popular DES software (Simu8) for this purpose. The second, a form of continuous simulation, is system dynamics. This technique is used to help provide understanding about complex systems through the construction of qualitative diagrams and quantitative simulation models.

Learning outcomes

1. subject specific knowledge and skills

- To understand the main uses of business simulations and when to use the two different types; discrete event simulation and system dynamics
- To understand specific features of discrete event simulation
- To be able to approach a DES project in a rational way, using performance measures
- To be able to investigate certainty of output and validation of a DES model
- To understand how to use features like trials and warm up period to make the model and its outcome more reliable
- To be able to work with Simul8 software and some of its advanced tools
- To understand and appreciate practical issues involved with a typical DES project
- To be able to determine the type of systems whose behaviour can be investigated using system dynamics
- To develop an understanding of the elements involved in the basic construction of a causal loop diagram;
- To appreciate how a verbal description of a system can be translated into a causal loop diagram and used to examine the system's behaviour;
- To appreciate how a causal loop diagram, representing a given system, can be translated into a quantitative system dynamics model;
- To develop an understanding of the procedures used to validate a system dynamics model;
- To appreciate the process by which system dynamics models can be used to investigate systems behaviours so that practical recommendations can be made to help improve the system;

2. cognitive abilities and non-subject specific skills

The learning activities are designed within the class to develop the students within the following areas:

- Problem structuring skills
- Written Communication skills
- Presenting and reporting skills
- Express problems in forms conducive for the software support available

(2) Decision Analysis

Rationale

Good decision making is a fundamental element of Operational Research. This class gives an overview of some of the most important approaches to decision modelling, covering decision making under uncertainty, an introduction to the principles of game theory, and multi-criteria decision making.

Class description/introduction

The first half of the course covers the basic ideas of decision making under uncertainty. Graphical modelling using Bayesian Nets (Influence diagrams and Belief nets) are used to structure models. The basic notions of probability, utility and value of information are covered. In the second half of the course, trade-offs between different desirable attributes are covered through multiattribute value theory and multiattribute utility theory. A short introduction is given to game theory in order to highlight the differences in approach required when making decisions to work against an intelligent opponent as opposed to an unknown and undirected "state of nature". The course builds on the introduction to probability given in Quantitative Business Analysis.

Class aims

To enable students to build models that support decision making under uncertainty, using decision analysis software. To make them aware of models that enable them to support decisions involving trade-offs or which have the character of strategic games.

Learning outcomes

1. subject specific knowledge and skills
 - Understand the notion of subjective probability and the axioms for rational decision making
 - Learn how to structure a model with decisions, uncertainties and consequences
 - Build graphical models of decision problems and exploit them to solve problems, including the use of sensitivity analysis
 - Understand and apply Expected Monetary Value and Expected Utility criteria to support a decision maker

- Apply value of information techniques to support a decision maker in spending resources to reduce uncertainties
- Understand and apply the concept of constant risk aversion
- Learn about value functions and trade-offs.
- Be able to apply the even swaps method to determine trade offs.
- Understand the concept of Pareto optimality
- Use of different criteria and sensitivity analysis to explore the impact of different stakeholder viewpoints
- Be aware of the basic types of games and be able to perform calculations involving simple non-cooperative games.
- Be able to use state of the art software for modelling decisions under uncertainty and multicriteria problems.

2. cognitive abilities and non-subject specific skills

- Improved problem structuring skills
- Report writing
- Work effectively in a team

(3) Risk Analysis and Management

Rationale

Risk analysis plays an important role in most business operations. This module is concerned with assessment and measurement of risk, and with the development of risk mitigation strategies that address stakeholder concerns.

Class description/introduction

Through this module we will explore the entire process of structuring a risk problem, modelling it, supporting and communicating recommendations, both theoretically and in practice. Risk management is linked with decision analysis in so far as we explore decision making under uncertainty and it has links with quantitative business analysis as we explore the use of statistics in understanding risk. However, the topic has some unique attributes such as risk communication and the role that experts play in risk assessment.

Class aims

The aim of this module is to develop an understanding of the fundamental techniques used with risk analysis and explore how these are used within practice.

Learning outcomes

1. subject specific knowledge and skills

- Understand theory that underpins standard approaches to elicitation of expert judgment
- Understand basic theory of fault and event tree modelling
- Understand the standard approaches to modelling dependency between random variables
- Develop the ability to assess the robustness of a risk model
- Understand the standard methods used in ALARP decision making
- Appreciate the consequences of choosing specific measures for risk
- Appreciate the implications of different communication strategies

2. cognitive abilities and non-subject specific skills

- Develop students ability to construct rational arguments
- Critical thinking
- An ability to express problems in forms conducive for the software support available

(4) Advanced Operational Research Modelling using specialist software tools

Rationale

Sophisticated software tools are used by business and industry to implement Operational Research (OR) models. This module seeks to build upon the theory and methods introduced within core modules to extend the OR toolset and hence help prepare graduates to work with larger scale problems. A select number of methods and commercial software tools (e.g. SAS, Xpress-MP) will be considered to allow students to understand their use in some depth, but position students to transfer this knowledge to other tools that they may meet in practice.

Class description/introduction

This module builds upon the methods introduced in core modules in deterministic and stochastic OR. In particular, OR methods, quantitative business analysis, decision analysis. In the core modules, the theory and application of methods to relatively small problems are considered. This module extends the approach to consider larger scale modelling and more advanced techniques using appropriate specialist software.

Class aims

To introduce students to commercially used software that supports advanced methods capable of dealing with larger scale OR problems

Learning outcomes

1. subject specific knowledge and skills

- To appreciate the role of software tools used in OR modelling
- To develop stochastic models for analysis of business data using SAS
- To develop linear-, linear integer- and quadratic programming models using MOSEL, the modelling language of XPRESS-MP
- To properly use different solvers of XPRESS-MP
- To solve and analyse the solutions of the XPRESS-MP

2. cognitive abilities and non-subject specific skills

- To develop skills in using sophisticated software tools
- To prepare technical reports
- To present models and solutions
- To work effectively as a team