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MANAGEMENT SCHOOL

MSCI 381 – Demand Forecasting and Revenue Management

Course Co-ordinator

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Lecturers

Dr Sven F. Crone (s.crone [at] lancaster.ac.uk; Room A53a)
Prof Robert Fildes (r.fildes [at] lancaster.ac.uk; Room A53)
Dr Joern Meissner (j.meissner [at] lancaster.ac.uk; Room A48)

Time and Place

Monday 2:00 pm – 3:00 pm, George Fox LT3
Wednesday 10:00 am – 11:00 am, Flyde LT 3
Thursday 1:00 pm – 2:00 pm, Flyde LT 3

Practical Labs take place in:
Thursday 1:00 pm – 2:00 pm, Computer Lab A1 in the Management School

Course Website

http://www.lums.lancs.ac.uk/ugModules/MSCI381/

Course Description

Every firm eventually has to sell its products. Questions that arise in this context are, for example: What sales channels should the firm use? How should a product be priced in the different channels? How can the firm prevent cannibalization across channels? How should prices be adjusted due to seasonality? How should a firm react after initial demand has been observed? In this course, we focus on two elementary parts of this decision process namely, how to forecast the arising demand and how to set the best prices for the offered products.

Forecasting is used throughout most organisations. There are many approaches to producing forecasts, some of which rely on the judgement of individuals, whilst other methods are more formal and are based on statistical models. This course introduces

the two most common statistical approaches: extrapolation, where the history of the variable being forecast is all that is used to produce a forecast, and causal modelling which seeks an explanation for changes.

Every organisation uses forecasts to help it organise and plan its activities. It is a key input into operational decisions, market planning, and budgeting and financial analysis. This course will consider how forecasts are used in an organisation to help its short-term operational decisions and its longer term marketing activities. The first part of the course will discuss how forecasts are used by organisations and how they are produced. Different techniques are appropriate for these different problems. Short-term extrapolative models are primarily used in operations. This course will introduce the basic statistics of time series analysis, and examine one common extrapolative methods in depth, exponential smoothing and introduces another approach, Autoregressive modelling. The evaluation of such forecasting methods will be explained and computer software used as part of the assessment to give students experience of using professional packages.

For longer-term market forecasts building a causal model of the market (using regression analysis) is very useful, where the forecasters attempts to understand and model the underlying drivers that determine why the variable fluctuates.

Building on earlier statistics courses, the course will show how the simple regression model can be extended to include many alternative specifications. Regression diagnostics will be discussed, concentrating on the particular problems experienced in time series regression.

Judgmental forecasts are the most common type of forecasts and the course will illustrate how biases in the way humans respond to information lead to inaccurate and inefficient forecasts. This part of the course will conclude with a brief discussion organisational forecasting practices.

The second part of the course focuses on how a firm should set and update pricing and product availability decisions across its various selling channels in order to maximize its profitability. The most familiar example probably comes from the airline industry, where tickets for the same flight may be sold at many different fares throughout the booking horizon depending on product restrictions as well as the remaining time until departure and the number of unsold seats. The use of such strategies has transformed the transportation and hospitality industries, and is increasingly important in retail, telecommunications, entertainment, financial services, health care and manufacturing. In parallel, pricing and revenue optimization has become a rapidly expanding practice in consulting services, and a growing area of software and IT development.

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Course Objectives and Learning Outcomes

The course aims to give students an appreciation of modern business forecasting methods. More explicitly, it aims to ensure that the successful student is capable of developing a validated quantitative set of forecasts using both extrapolative and causal forecasting methods. By the end of the course students should be able to choose and apply an appropriate forecasting method to a business-forecasting problem. Students will also have some appreciation of modern statistical forecasting software and the use of spreadsheets in forecasting.

In the second part of the course, you learn to identify and exploit opportunities for revenue optimization in different business contexts. You review the main methodologies that are used in each of these areas, discuss legal issues associated with different pricing strategies, and survey current practices in different industries. As the course outline reveals, most of the topics covered in the course are either directly or indirectly related to pricing issues faced by firms that operate in environments where they enjoy some degree of market power. Within the broader area of pricing theory, the course places particular emphasis on tactical optimization of pricing and capacity allocation decisions, tackled using quantitative models of consumer behaviour (e.g. captured via appropriate price-response relations), demand forecasts and market uncertainty, and the tools of constrained optimization – the two main building blocks of revenue optimization systems.

In summary the course aims:

- To show the importance of forecasting in organisations
- To describe the various approaches to forecasting and how they should be evaluated
- To demonstrate how to develop and use various quantitative forecasting methods, in particular exponential smoothing and regression
- To understand the advantages and disadvantages of different forecasting methods and the role that judgment can usefully play in organisational forecasting.

Subject specific knowledge and skills

- The role of demand forecasting in revenue management
- How to carry out exploratory analysis of time series data
- How to develop various extrapolative forecasting methods including exponential smoothing
- How to measure forecast error and compare different forecasting methods

- The use of Excel to produce forecasts
- How to develop a meaningful causal model of demand
- How to model revenue management problems as constrained optimization problems
- Ability to understand the implication of a markdown strategy
- How to use Excel's Solver to determine profit-maximizing prices
- The basic principle behind the idea of dynamic programming.

Cognitive abilities and non-subject specific skills

- Research and data collection
- Report writing skills
- Team working and group work

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Course assessment

There are two pieces of assessed coursework, equally weighted:

- The first is an individual forecasting exercise. This will be due in end of week 7.
- For the revenue management part, there will be a problem set that is an individual assignment.

Estimated Workload

Beyond the lectures and practical labs, two assignments are required. The first assignment requires approximately 10 hours of work. The revenue management problem set will require approximately 10 hours of work as well.

Reading and Lecture Notes

- There is a computer-based learning tool available to support the forecasting aspect of the course.
- Phillips, Robert: Pricing and Revenue Optimization, Stanford University Press 2005. This useful and moderately priced textbook is **mandatory**. The Waterstone university bookstore has stocked it.
- Further material and lecture notes will be posted on LUVLE.

Additional optional reading

- Makridakis, Spyros, Wheelwright, Steven, and Hyndman, Rob. 1998. Forecasting: Methods and Application. Wiley, New York. (On short loan in the library)
- Diebold, Francis. Elements of Forecasting (3rd Edition). 2003. Thomson Learning, Stamford. (Optional alternative reading)
- Kalyan Talluri and Garrett van Ryzin. 2004. The Theory and Practice of Revenue Management, Kluwer Academic Amsterdam (optional alternative reading with a deeper and more mathematical treatment of Revenue Management).

Related Information on the Web

- Principles of Forecasting Site:
  http://www-marketing.wharton.upenn.edu/forecast/welcome.html

- Lancaster Centre for Forecasting:
  http://www.lums.lancs.ac.uk/research/centres/Forecasting/
- INFORMS Section on Revenue Management and Pricing:
  http://revenue-mgt.section.informs.org/
- Pricing Strategy & Revenue Management Executive Education Programme:
  http://www.pricingmanagement.com

Acknowledgements

The Revenue Management part of the class is partly based on a course created by Prof. Costis Maglaras at Columbia Business School.

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Detailed course outline

Disclaimers

This is a new course and especially the area of revenue management is still "hot", hence a lecture on this topic will, for the time being, always be a work-in-progress. While the topics that we will cover and their emphasis will follow what I describe in class 1, I will be making small changes on the syllabus along the way (with advance notice).

The speaker line-up is still not finalized and, moreover, some of the placeholders on the syllabus may move around a little. Please make sure you come to class when we have a speaker, and that you come on time.

Class 1 (Wednesday, October 10)

Lecturer: Dr Joern Meissner

Overview of the Course

Logistics, Assessment and other administrative things. Brief overview of the topics discussed in this course.

Class 2 (Thursday, October 11)

Lecturer: Sven F. Crone

Introduction to Demand Planning

Why forecast? Hierarchies & objects of forecasting for demand planning & revenue management. Classes of forecasting methods. Forecasting process.

Preparation for class:

- Read: Makridakis/Wheelwright/Hydman Chapter 1, pp 2–16

Class 3 (Monday, October 15)

Lecturer: Sven F. Crone

Time Series I: Data Analysis & Decomposition

Time Series components & patterns. Classical decomposition of time series into components.

Preparation for class:

- Read: Makridakis/Wheelwright/Hydman Chapter 3, pp 106–126

Class 4 (Wednesday, October 17)

Lecturer: Sven F. Crone

Time Series II: Naïve Methods & Averages

Introduction to Naïve forecasting methods. Averages, moving averages and weighted moving averages for filtering & forecasting.

Preparation for class:

- Read: Makridakis/Wheelwright/Hydman Chapter 3: pp 89–100 and Chapter 4: pp 136–146

Practical Lab 1 (Thursday, October 18)

Lecturer: Sven F. Crone

LAB1: Naïve, Averages & Smoothing

MS Excel exercises of averages, naïve methods and exponential smoothing methods.

Class 5 (Monday, October 22)

Lecturer: Sven F. Crone

Time Series III: Exponential Smoothing

From Averages to Exponential Smoothing. Single, Double, Linear, Seasonal Exponential Smoothing methods.

Preparation for class

- Read: Makridakis/Wheelwright/Hydman Chapter 4: pp 147–178

Class 6 (Wednesday, October 24)

Lecturer: Sven F. Crone

Time Series IV: Advanced Exponential Smoothing Issues

Dampened Trend Exponential Smoothing. Finding Parameters. Selecting Methods.

Practical Lab 2 (Thursday, October 25)

Lecturer: Sven F. Crone

LAB2: Naïve, Averages & Smoothing

MS Excel exercises of averages, naïve methods and exponential smoothing methods.

Class 7 (Monday, October 29)

Lecturer: Sven F. Crone

Causal Methods I: Simple Regression

Introduction to Regression. Regression on time series data.

Preparation for class:

- Read: Makridakis/Wheelwright/Hydman Chapter 5: pp 186–227

Class 8 (Wednesday, October 31)

Lecturer: Sven F. Crone

Causal Methods II: Multiple Regression

Extension of simple regression to multiple causal variables. Residual analysis. Testing.

Preparation for class:

- Read: Makridakis/Wheelwright/Hydman Chapter 6: pp 241–302

Practical Lab 3 (Thursday, November 1)

Lecturer: Sven F. Crone

LAB3: Regression

MS Excel exercises of regression methods.

Class 9 (Monday, November 5)

Lecturer: Sven F. Crone

Time Series Methods V: ARIMA-Methods

Model Identification. AR-terms. MA-terms. Degree of integration.

Preparation for class:

- Read: Makridakis/Wheelwright/Hydman Chapter 7: pp 311–373

Class 10 (Wednesday, November 7)

Lecturer: Sven F. Crone

Time Series VI: Advanced Forecasting techniques / Neuronal Networks

Artificial neural networks for forecasting. Regression & decision trees. Data mining methods.

Practical Lab 4 (Thursday, November 9)

Lecturer: Sven F. Crone

LAB4: Expert system ForecastPro

Exponential smoothing & ARIMA forecasting with ForecastPro software system

Class 11 (Monday, November 12)

Lecturer: Sven F. Crone

TBA

Class 12 (Wednesday, November 14)

Lecturer: Sven F. Crone

TBA

Class 13 (Thursday, November 15)

Lecturer: Sven F. Crone

TBA

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Class 14 (Monday, November 19)

Lecturer: Dr Joern Meissner

Introduction to Revenue Management

History of Pricing and Revenue Optimization (PRO). Factors driving the PRO boom. Multi-pricing in the airline industry. The workings of a revenue management system.

Preparation for class:

- Read: Background and Introduction (Ch. 1 of book by Phillips)
- Imagine that you are married with two children aged 5 and 9, you live in Cambridge, England, and are planning a family vacation to Barcelona. Your ideal is to leave London Stansted (the London airport most convenient to Cambridge) on Saturday morning, February 19 (2005), and return from Barcelona on Sunday evening, February 27. Visit the easyJet website http://www.easyjet.com/en/book/index.asp to determine the cost of round-trip airfare for your family, assuming that the tickets are purchased immediately. Does the information presented on the website motivate you to adjust your plan? Over the course of the next four weeks you will be asked to re-visit the easyJet website and monitor changes in the price of this vacation.

Class 16 (Wednesday, November 21)

Lecturer: Dr Joern Meissner

Review of Price Theory

Capturing consumer surplus via differential pricing: personalized pricing, group pricing, versioning, and quantity discounts. Pricing with capacity constraints.

Preparation for class:

- Read: The Pricing and Revenue Optimization Process (Ch. 2 of book by Phillips). You can read through Chapter 2 of Phillips quickly, but be sure you understand what the *pricing waterfall* means, and that you know the three "pure" approaches to pricing listed in section 2.3.
- Download: Football Stadium Pricing Problem. Use Solver to determine a profit-maximizing pair of prices (one for students, one for the general public) in the Football Stadium Pricing Problem, given a stadium capacity of 53,000. Also, if you can, determine the marginal value of an additional stadium seat. If a single price must be charged, what is the optimal choice? Is total consumer surplus larger or smaller when a single price is charged? What about profit?

Class 17 (Monday, November 26)

Lecturer: Dr Joern Meissner

Market Segmentation with Differential Pricing

Preparation for class:

- Read: Versioning: The Smart Way to Sell Informatin (Shapiro and Varian, Harvard Business Review Article, will be posted on Domino)
- Read: Cambridge Software Corp. (HBS Case, will be posted on Domino). If Cambridge Software is obliged to launch just one product, which one should it be, and how should it be priced? If several are allowed, which should be launched, and how should they be priced?

Class 18 (Thursday, November 29)

Lecturer: Dr Joern Meissner

Models of consumer demand

Models of consumer choice; Reservation prices; Aggregate demand models; Bundling.

Preparation for class:

- Download: Problems on bundling
- Prepare a solution to problem 1 from the Bundling handout.
- Check the easyJet website http://www.easyjet.com/en/book/index.asp to determine the cost of round-trip air fare for the family vacation described in the assignment for Class 1, assuming that the tickets are purchased *today*.

Class 19 (Monday, December 3)

Lecturer: Dr Joern Meissner

Pricing as Constrained Optimization

Preparation for class:

- Read: Pricing with Constrained Supply (Ch. 5 of Phillips book)
- Download: Pricing Problems with Capacity Constraints
- Using Solver, prepare solutions for the Pricing Problems with Capacity Constraints

- Section 5.5 of Phillips introduces the important modeling issue of *diversion*; skim through Problem 7 at the end of the chapter, which serves to reinforce this material.
- Sections 5.5 and 5.6 merit your careful attention: the theme park example developed in section 5.5 is representative of an important application domain, and section 5.6 describes variants of peak-load pricing that are economically important in other industries.

Class 20 (Wednesday, December 5)

Lecturer: Dr Joern Meissner

Markdown Management

Preparation for class:

- Read: Retailer: A Retail Pricing Simulation Exercise (Broadie and van Ryzin)
- Skim: Markdown Management (Ch. 10 of Phillips book)
- Before Christmas, Wal-Mart was stirring (NYT, Jan 2005)
- Download: The *Retailer* game and its data file (detailed instructions below)
- You may want to browse through the website of Profitlogic, the leader in retail markdown management services (i.e., provider of analytical software and consulting services in this area) at http://www.profitlogic.com/index.htm.
- Instructions related to the simulator called *Retailer* begin on page 7 of the assigned reading. Read pages 7-9 carefully, trying to infer the structure of the model that underlies the simulator (note particularly the footnotes on page 8).
- Download the data file Retailer.xls and, heeding the suggestions offered on pages 8-9 of the assigned reading, analyze this data to extract the information needed to formulate a markdown strategy. (An artificial element of this exercise is that all the items included in the historical data had a list price of $60, which happily is the list price for the item to be considered in the simulation.) Before starting the simulation exercise itself, work out at least a crude markdown strategy based on your data analysis, again paying careful attention to the suggestions offered on pages 8-9.
- Now download the zip file Retail.zip to a new folder called "Retail." Extract all files into this folder and play five iterations of the *Retailer* game, following the strategy you have formulated. (To get started, double click on Retailer.exe, the icon that contains a dollar sign. To begin an iteration click (Re)Start on the menu bar. With a little experimentation it should become clear how the

mechanics work.) Come to class prepared to discuss your results, the reasoning behind your strategy, and any second thoughts you may now have about that strategy.

- Check the easyJet website http://www.easyjet.com/en/book/index.asp to determine the cost of round-trip air fare for the family vacation described in assignment for Class 1, assuming that the tickets are purchased *today*.

Class 21 (Thursday, December 6)

Lecturer: Dr Joern Meissner

Dynamic pricing

Preparation for class:

- Download: Coconut Rental Car Company. Prepare answers for the questions posed in the Coconut Car Rental Company mini-case.

Today's lecture centers on the subtle and difficult idea of "backward induction," also called "recursive optimization" or "dynamic programming." The assignment below introduces the general method through an example. Answer as many questions as you can, and think hard about the ones that stump you, so you are well positioned to learn from the ensuing class discussion.

Class 22 (Monday, December 10)

Lecturer: Dr Joern Meissner

Capacity Control via Linear Programming

Preparation for class:

- Download: Westbrook Hotel
- Download: Capitol Airlines
- Look at the Hotel Forecasting Data available to download. The data in this file concern reservations and registrations for one-day stays at the hotel's highest daily rate (one of many "rate products" that the hotel sells). The meanings of the various data entries are explained by the heading at the top of the file and the explanatory note at the end. Be prepared to propose one or more common-sense methods, and at least one more sophisticated method, to forecast the number of room registrations for that same rate product on Monday, December 17, 2001. Think first of how to generate a point estimate, then how to generate a probability distribution.
- Prepare solutions for the Westbrook Hotel and Capitol Airlines problems.

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Class 23 (Wednesday, December 12)

Lecturer: Dr Joern Meissner

Capacity Control with Demand Uncertainty

Booking limits and protection levels. Critical fractile solution of the static allocation problem with two fare classes. Nested booking limits and dynamic booking control; introduction to overbooking.

Preparation for class:

- Read: Introduction to ... Yield Management (Netessine and Shumsky), pp. 34-39
- Read: Revenue Management & Capacity Allocation (Ch. 6 & 7 of Phillips)
- Download: Football Stadium Booking Control
- Prepare solutions for Problems 1-4 in Appendix B of the Netessine-Shumsky article, and be prepared to discuss them in class.
- Prepare solutions for the two questions posed in Football Stadium Booking Control, and come prepared to discuss them in class.
- The last third of this class session will treat the mechanics of dynamic booking control, specifically in an airline setting, discussing the elaborate systems that have been built around a few relatively simple formulas for determining booking limits.

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Class 24 (Thursday, December 13)

Lecturer: Dr Joern Meissner

Customer Acceptance and Legal Issues in PRO

Customer perception of dynamic pricing and price differentiation. Behavioral issues and prospect theory. Examples of unsuccessful or badly-perceived actions. Tactics for avoiding misperceptions and perceptions of unfairness. Implications for pricing strategy.

Preparation for class:

- Read: PRO and Customer Acceptance (Ch. 12 of Phillips book)
- Read: What Price Fairness? (Krugman, New York Times, 2000)
- We have already discussed in this course various practices that companies adopt in pursuit of "revenue optimization." Speaking strictly as a consumer, which of those practices do you find distasteful enough to affect your buying behavior?
- In your view, is economic life in the U.S. getting more or less "fair" as internet-based commerce increases in volume and importance?
- Visit the website http://papers.ssrn.com/sol3/papers.cfm?abstract_id=429762 to read at least the abstract of Andrew Odlyzko's 2003 paper titled Privacy, Economics and Price Discrimination on the Internet. (The entire paper can be downloaded from that site, and its long introductory section is both stimulating and enjoyable.) Assuming that Odlyzko is right in linking privacy erosion to price discrimination, and right about the inevitable public indignation, does this suggest to you any emerging business opportunities?