

**OM 386 Pricing & Revenue Optimization – Fall 2011<sup>1</sup>**  
**Unique number 04220**  
**GSB 5.153**

**Professor Sridhar Seshadri**

Time: 12:30– 2:00 MW

Office Hours: Tue Thu 11 am to Noon or by appointment

**Course Description:**

Pricing and revenue optimization --or revenue management as it is also called-- 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. A familiar example comes from the airline industry, where tickets for the same flight may be sold at many different fares, the availability of which is changing as a function of purchase restrictions, the forecasted future demand, and the number of unsold seats. The adoption of such systems 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.

Through a combination of case studies, lectures, and guest speakers the course will 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. The ultimate goal is for students to learn to identify and exploit opportunities for revenue optimization in different business contexts. As the ensuing 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 behavior (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.

**Textbook**

Recommended: Pricing and Revenue Optimization by Robert L. Phillips, ISBN: 0804746982.

Additional readings will be provided in the case packet and Blackboard. Purchase the case packet at the GSB Copy Center.

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<sup>1</sup> *This syllabus has been adapted from that of Professor Costis Maglaras of Columbia University and Dr Joern Meissner of Lancaster University. Sincere thanks especially to Costis for his help in teaching this course over the last five years. Thanks to Ioana Popescu of INSEAD, Mark Ferguson of Georgia Tech and Chris Anderson of Cornell for generously sharing their notes and ideas with me. Thanks for Mike Harrison of Stanford and Garret van Ryzin of Columbia for making me see the light under Revenue Management.*

## Course deliverables

Apart from class participation (20% of the total grade), the other course deliverables consist of a set of homework assignments (20%), an individual examination (30%) and a project (30%).

- Class participation: each class I will call upon two persons. You will be expected to start the discussion and present the issues as well as possible solution approaches. This will contribute to part of your participation grade. Those not called upon but present will get full credit for that class.
- There will be five homework assignments that should be done in groups of maximum four students.
- I will give a take home examination at the end of the course. It will be done individually.
- There is a course project, which can be done in groups of up to four (4) students. Projects should study a specific PRO problem or opportunity faced by a real organization. You are free to choose a topic of your interest. The end goal is to demonstrate the use of pricing and revenue optimization techniques learned in class in a real setting.
- As broad guideline for these projects, put yourself in the shoes of a consulting team trying to help their client to analyze a particular issue that they face that is related to the content of this course. Your study should hopefully culminate with an assessment of the magnitude of the associated PRO opportunity and a blueprint of how to move forward with developing a PRO solution. This could roughly follow the outline below:
  - a. Understand and describe the application setting: industry overview, PRO question, what's currently done, etc.
  - b. Describe what is the PRO opportunity and why it is an opportunity?
  - c. Try to make a quantitative assessment of the potential value of applying a PRO solution to your proposed setting (cf. TNG case discussed in session 8).

In attempting to address the above questions it is useful to think of a model that one would want to use in practice: what data do you need, what are the optimization decisions, how will they be implemented, etc. This model will be useful in demonstrating the potential quantifiable benefits of your proposal. Access to real data is preferred for this last step, but this may or may not be easy to have depending on the company involved. This is a fairly optimistic set of goals given the timeline of this course, but still serves well in structuring your work.

- The deliverables are a project report, a presentation in power point format, and an in-class presentation. The timeline is as follows:
  - Session 5: 1-page proposal is due (by email) describing the topic, team, specific goals, and proposed project plan.
  - Before session 10: Meet with me to discuss your proposal.
  - Session 10: Revised 1-page proposal is due (by email).
  - Session 17: page progress report is due.
  - On or before session 26: each team should meet with me for 30 min to discuss their project.
  - Session 27 and 28: in-class 15 min presentation (power point) and final project write-up are due (we may need to schedule extra time for presentations)

## **Detailed course outline**

This is a new course and 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 session 1, I might make small changes to the syllabus along the way (with advance notice).

One Session below is planned for 80 minutes, but I am flexible and prefer that you understand the concepts that we discuss in depth rather than rushing through the material just for the purpose of staying with my outline. Your feedback in this process is valuable, and motivates continuous course improvement. Please do not hesitate to let me know, throughout the course, how I can improve the course and the learning experience it provides!

The course emphasizes model development, solution and interpretation. To get the full benefit of the class please bring your laptop to follow along. Please read the cases and be prepared to ask questions. Please do not browse or chat or read emails during class time.

## Course Schedule

|    | Sessions   | Dates                      | Important Events   |
|----|--|----------------------------|--|
| 1  | Introduction to Pricing and Revenue Optimization   | 8/24/2011                  | Form Groups  |
| 2  | Review of Price Theory (Case: What Price Vertigo?)   | 8/29/2011                  |  |
| 3  | Market Segmentation with Differential Pricing (Case: Cambridge Software Corp.)                 | 8/31/2011                  |  |
|    | <b>No class</b>  | 9/05/2011                  | <b>Holiday</b>   |
| 4  | Quantitative Models of Customer Demand (Case: Personal Training at the NY health Club: Part A) | 9/07/2011                  | 1. NYHC A case hand in   |
| 5  | Consumer Choice Models (Case: Personal Training at the NY health Club: Part A continued)       | 9/12/2011                  | One page project proposals due   |
| 6  | Dealing with Censored Demand Data (Case: Multiplex Cinema House sales)                         | 9/14/2011                  |  |
| 7  | Pricing as Constrained Optimization  | 9/19/2011                  |  |
| 8  | Customized Pricing (Case: Fjord Motor Co.)   | 9/21/2011                  | 2. Fjord Motor Co. hand in   |
| 9  | Value Pricing ( <i>case TBA</i> )  | 9/26/2011                  |  |
| 10 | Markdown Management (Retailer Game)  | 9/28/2011                  | Revised one page proposal;<br>3. NYHC Part B hand in                                 |
| 11 | Discuss Retailer Game  | 10/03/2011                 |  |
| 12 | Dynamic Pricing in the Retailer Game   | 10/05/2011                 |  |
| 13 | Dynamic Pricing: Coconut Car Rental Company Case   | 10/10/2011                 |  |
| 14 | Dynamic Pricing: The Priceline Case  | 10/12/2011                 |  |
| 15 | Forecasting Demand (Hotel demand forecasting exercise)   | 10/17/2011                 |  |
| 16 | Strategic Interactions: Hannah Montana The Tour of Doom Case                                   | 10/19/2011                 | 4. Submit your answers to Hannah Montana case  |
| 17 | Capacity Control via Linear Programming-1<br>Capitol Airlines case                             | 10/24/2011                 | Discuss if necessary your demand forecasts for rooms; Submit Project Progress Report |
| 18 | Capacity Control via Linear Programming-2<br>Westbrook Hotel case                              | 10/26/2011                 |  |
| 19 | Case Study on Capacity Control: Transportation National Group Case                             | 10/31/2011                 |  |
| 20 | Capacity Control with Demand Uncertainty   | 11/02/2011                 | 5. Submit your Hotel Room Allocation and Bid Prices                                  |
| 21 | Applying Capacity Control with Demand Uncertainty ( <i>case TBA</i> )                          | 11/07/2011                 |  |
| 22 | Censored Data and Revenue Management with Demand Uncertainty ( <i>Case TBA</i> )               | 11/09/2011                 |  |
| 23 | Yield Management through CRM (Harrah's Entertainment case)                                     | 11/14/2011                 |  |
| 24 | Yield Management ala Google (Everyday Medical Case)  | 11/16/2011                 |  |
| 25 | Implementation of PRO (Bloomingdale Case)  | 11/21/2011                 |  |
| 26 | <a href="#">Project Discussions</a>  | <a href="#">11/23/2011</a> | <a href="#">11/22/2011 also</a>  |
| 27 | Project Presentations  | 11/28/2011                 |  |
| 28 | Project Presentations  | 11/30/2011                 |  |
|    | <b>Take home final examination</b>   |                            |  |

## Class 1

### Introduction

Introduction and structure of the course. What is pricing and revenue optimization? History of PRO. Multi-pricing in the airline industry.

Read: Background and Introduction (Ch. 1 of Phillips)  
[http://www.revenueanalytics.com/pdf/3248\\_rpm201039a.pdf](http://www.revenueanalytics.com/pdf/3248_rpm201039a.pdf)

## Class 2

### Review of Price Theory

Capturing consumer surplus via differential pricing: personalized pricing, group pricing. Pricing with capacity constraints.

Skim: The Pricing and Revenue Optimization Process (Ch. 2 of Phillips)  
Read: What price Vertigo? (INSEAD case in *case packet*)

- Read through Chapter 2 of Phillips quickly, but be sure you understand what is meant by *the pricing waterfall*, and that you know the three “pure” approaches to pricing listed in section 2.3.
- Read “What price Vertigo?” Be ready to discuss q. 1, and prepare a solution for q. 2 using Solver.

## Class 3

### Market Segmentation with Differential Pricing

Market segmentation; versioning; bundling.

Read: Cambridge Software Corp. (HBS Case in *case packet*)  
Background: Chapter 4 of Phillips

- 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? (It is potentially hard to find the optimal product and price menu. Try to at least think about the following question: what should be the optimal product prices if CSC decides to offer the “student” and “industrial” versions of their software?)

Download and read: Versioning: The Smart Way to Sell Information by Carl Shapiro, Hal R. Varian

## Class 4

### Quantitative models of consumer demand

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

Read: Personal training at the NY Health Club: Part A  
Skim: Phillips section 3.1 (you may skip over the more technical parts)

- Download data. Read through the NYHC case and prepare answers for questions 1, 2 and 3

*Hand In:* Group assignment - Solution to NYHC Part A questions 1,2, and 3; please submit one assignment per group. Provide an executive summary.

## Class 5

### Consumer choice models (fitting data to models)

Discrete choice models; The Multinomial-Logit (MNL) model; How to fit MNL model parameters with maximum likelihood estimation; How to deal with censored demand data?

Read: Personal training at the NY Health Club: Part A  
Skim: Phillips section 3.2

- Read through the NYHC case and be prepared to discuss questions 4 and 5.
- Download data for the case

*Hand In:* 1-page proposal for your group project describing the topic, team, specific goals, and proposed project plan (by email).

## Class 6

### Dealing with Censored Demand Data

Download the write-up and data on the Multiplex Cinema House sales. Prepare to discuss how to determine the demand from the sales data.

## Class 7

### Pricing as Constrained Optimization

Read: Pricing with Constrained Supply (Ch. 5 of Phillips book)  
Download: Pricing Problems with Capacity Constraints and Data

- Using Solver, prepare solutions for questions 1 & 3 from Pricing Problems with Capacity Constraints
- Section 5.5 of Phillips discusses the important modeling issue of *diversion*, which we have already seen in the NYHC case; skim through Problem 7 at the end of the chapter, which serves to reinforce this material through a different demand model approach than the one pursued in the previous session.
- 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 8

### Customized Pricing

Read: Customized Pricing (Ch. 11 of Phillips book)  
Download: Fjord Motor Customized Fleet Pricing Case and spreadsheet

- Prepare solutions for the questions posed at the end of Customized Fleet Pricing, using data in the file Fjordmotor.xls; at a minimum try to answer problems 1 and 2.

*Hand In:* Group assignment -- Solutions to Fjord Motor (problems 1 and 2). Briefly discuss how the revenue improvement can come about? What should Fjord Motor Co. do?

## Class 9

### Value Pricing - Case TBA

Please look at [arunpereira.com](http://arunpereira.com) website for material on pricing and conjoint analysis

## Class 10

### Markdown Management

Read: Retailer: A Retail Pricing Simulation Exercise (Broadie and van Ryzin)

Skim: Markdown Management (Ch. 10 of Phillips book)

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.

The retailer code will work on macs running windows and on “32-bit windows 7 installations” following the instructions below:

To make this program work,

1. right click on retailer.exe
2. select Properties
3. click the compatibility tab
4. under compatibility mode check “run this program in compatibility mode for”
5. select windows xp from the drop down box
6. hit ok to leave the properties.
7. Run the program

If you have the 64-bit version of Windows 7 (**Professional or higher version**):

1. Go here: <http://www.microsoft.com/windows/virtual-pc/download.aspx>
2. Follow the steps to install XP mode, this requires downloading and installing three components (downloading each will take some time)
3. Restart Computer
4. Go to Windows Virtual PC on Start Menu and Start up XP Mode
5. If you are asked if you want the drives to be shared, answer yes.
6. XP Mode will set-up for about another 10 minutes
7. Go to My Computer within XP mode, find the share drive where you saved retailer
8. Run Retailer

*Hand In:*

1. Revised 1-page proposal for your group project (by email)
2. Group assignment -- Solutions to NYHC Part B; please submit assignment.
3. Make sure you discuss your recommendation.

## **Class 11**

### **Discuss the Retailer Game.**

What is the “optimal” strategy? How would it change in practice? What tools might be necessary to determine the best strategy?

## **Class 12**

### **Dynamic pricing Illustrated in Retailer Example**

The area of dynamic pricing is, depending on its definition, very large since it essentially just means that prices are potentially changed over time to adjust for a changed current and expected future market environment. However, since the dawn of Revenue Management increasingly sophisticated optimization routines are forecasting methods are applied in order to improve these dynamic price decisions. In RM, we essentially distinguish between capacity- and price-based price optimization techniques, where all the latter methods constitute the field Dynamic Pricing.

Download: Retail pricing optimization with uncertain demand and data

Try to prepare answer to questions 1 and 2. This assignment centers on the subtle and difficult idea of “backward induction,” also called “recursive optimization” or “dynamic programming.” Answer as much as you can, and think hard about the ones that stump you.

## **Class 13: Dynamic Pricing Illustrated for car rentals**

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

We illustrate the ideas behind dynamic pricing on a car rental case study and introduce the important principle of optimality in revenue optimization over time, namely 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 14 Dynamic Pricing: The Priceline Case**

Download and Read: Priceline case

Try to follow how a combination of forecasting and dynamic programming tool is used to price hotel rooms. Go to Priceline’s website and examine the method used. Be prepared to discuss the implications for customers, hoteliers and Priceline.

## **Class 15: Forecasting Demand**

Download the Hotel Forecasting Data available on Blackboard. 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.

## **Class 16**

### **Strategic interaction effects**

Download: Hannah Montana data  
Read: Hannah Montana the Tour of Doom case

- Prepare solutions to questions 1, 2 and 3.

*Hand In: Group Assignment - Solutions to Hannah Montana questions 1 2 and 3. Discuss your findings briefly.*

## **Class 17**

### **Capacity Control via Linear Programming**

Download: Westbrook Hotel and  
Capitol Airlines cases

*Hand In: 1. 2-page progress report on your group project is due (by email)*

## **Class 18**

### **Capacity Control via Linear Programming**

Download: Westbrook Hotel and  
Capitol Airlines cases

- Prepare solutions for the Westbrook Hotel and Capitol Airlines problems.

## **Class 19**

### **Case Study on Capacity Control**

Read: Transportation National Group (TNG)  
Download: Transportation National Group data

- What challenges does TNG face in managing its leases of trailers?
- What is your assessment of TNG's current lease performance measures and controls, especially its use of ROI measures?
- How might TNG implement revenue management? What ideas or approaches seem most viable in a business like this?
- Use linear programming (Solver) to answer the following question: based on the data for the Yakima branch (file TNG.XLS on the course website), what is the potential revenue opportunity at this location from optimally controlling the availability of leases of various durations?
- If TNG wanted to implement revenue management, what recommendations would you make going forward, and how would you prioritize your recommendations?

## **Class 20**

### **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.

Read: Introduction to ... Yield Management (Netessine and Shumsky), pp. 34-39 (In Blackboard)  
Revenue Management & Capacity Allocation (Ch. 6 & 7 of Phillips)

- Prepare solutions for Problems 1-4 in Appendix B of the Netessine-Shumsky article, and be prepared to discuss them in class.

## **Class 21**

### **Applying Capacity Control with Demand Uncertainty**

**Case: TBA**

**Read:** "Revenue management and e-commerce" by E. Andrew Boyd, Chief Scientist and Senior Vice President, PROS Revenue Management and Ioana C. Bilegan, LAAS-CNRS and ENAC

## **Class 22:**

### **Censored data revisited – capacity control with demand uncertainty**

**Case: TBA**

## **Class 23:**

### **Use of CRM - Yield Management in Casinos**

The principles of Revenue Management we have discussed so far are in practice often interwoven with many other business activities. In this session we discuss the case of Harrah's Entertainment, which implemented a very successful data marketing and revenue management campaign focusing on low roller customers.

Read: Harrah's Entertainment, Inc. (HBS Case 9-502-011) (Harvard case in *case packet*). This case describes a situation facing Philip Satre, chairman and CEO of Harrah's Entertainment, Inc. Satre was reading a May 2000 Wall Street Journal story that discussed the company's marketing success in targeting low rollers, the 100% growth in stock price and profits in the year to December 1999, and the revenue growth of 50%, which significantly outpaced the industry. The exciting articles aroused Satre's desire to know more about the activities of his then COO, Gary Loveman, and his team of 'propeller heads' with respect to their database marketing efforts and the Total Reward Program. Satre was interested in two questions: He wanted to know how much these marketing efforts had contributed to Harrah's overall performance and whether these marketing results were a one-shot event or could be achieved year after year, especially as the competition introduced similar programs. Please read the case and be prepared to discuss the following questions in class:

1. What are the objectives of the various Data Base marketing programs and are they working?
2. Why is it important to use the 'customer worth' in the DBM efforts rather than the observed level of play?
3. How does Harrah's integrate the various elements of its marketing strategy to deliver more than the results of Data Base marketing?

4. What is the sustainability of Harrah's actions and strategy?
5. What are the privacy and ethical issues that Harrah's should be concerned about?

## **Class 24**

### **Online pricing**

Download:       EveryDay Medical (Case)  
                  EveryDayMedical (data file)

### **EveryDay Medical**

For this class, please review the attached case and solve problems 1 – 3. You do not need to submit a report to be graded, but you should try to think and work through the problems.

Read: A Dashboard for online pricing by Baye, Gatti, Kattuman and Morgan, California Management Review, Fall 2007, Volume 50, No. 1, 202-216. (download and read in Blackboard)

## **Class 25**

### **Implementation of PRO**

Read: Bloomingdale's case study  
Download: Bloomingdale case data

The main issue in the case is how to measure and quantify the benefits of a pricing optimization system. This was a serious concern facing Bloomingdale's and the case accurately captures the relevant issues. Basically, the question I would like you to consider is this: How should Bloomingdale's use the data from their pilot study to quantify the benefits of the Profitlogic PO system? I would like you to propose an approach for answering this question. You don't have to do a detailed analysis of the data, but I would like you to think through HOW you would approach it and make a concrete recommendation. You may work in groups on this and don't have to turn anything in but I expect you to have given the question serious thought.

## **Class 26**

**Reserved for project discussions**

## **Classes 27 and 28**

### **Final Student Project Presentations**

*Hand In: final project report (in power point or word)*

### References

Revenue Management by Robert G. Cross, Publisher: Broadway (December 29, 1997)

Theory and Practice of Revenue Management, Kalyan T. Talluri, Garrett J. van Ryzin

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Important Topics not covered: IT Systems for PRRO. Ethics of pricing and revenue management. Customer and competitive reactions and acceptance. Organization issues and change management. Pricing strategy.

Useful Links:

<http://www.informs.org/Community/revenue-mgt>

<http://www.revenuemanagementconference.com/>

<http://www.palgrave-journals.com/rpm/index.html>  
(Journal of Revenue Management)