# OM 386 Pricing & Revenue Optimization – Fall 2012<sup>1</sup> Unique number 04210 UTC 1.130

### **Professor Sridhar Seshadri**

**Time:** MW 1100 to 1230p

Office Hours: Tue Thu 2 pm to 4 pm 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 main building blocks of revenue optimization systems.

The course is organized into four modules: price optimization – static case, price optimization – dynamic case, revenue management (which covers the tradition RM practices in the industry), and emerging topics in RM.

<sup>&</sup>lt;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.

# Textbook

Purchase the case packet at the GSB Copy Center.

Recommended: Pricing and Revenue Optimization by Robert L. Phillips, ISBN: 0804746982. This book is technical in nature and provides a good coverage of RM models. I draw upon different materials for the price optimization part of the course.

Additional readings will be provided in the case packet and Blackboard. Wherever I have said download I refer to downloading from the Blackboard.

## **Course deliverables**

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

- Class participation: Each class I will call upon <u>three</u> students. Those called upon are 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. The last assignment is worth twice the points of the other assignments.
- 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. Transportation National Group case discussed in class).

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 inclass 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 24: each team should meet with me for 30 min to discuss their project.
  - Session 26 and 27: in-class 15 min presentation (power point) and final project write-up are due.

# **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	8/29/2012W	
			Form Groups
	Module 1: Price Optimization – static case		
2	Review of Price Theory (Case: What Price Vertigo?)	9/05/2012W	
3	Market Segmentation with Differential Pricing (Case:	9/10/2012M	
C	Cambridge Software Corp.)	<i>&gt;</i> /10/2012111	
4	Ouantitative Models of Customer Demand (Case:	9/12/2012W	1. NYHC A case hand in
	Personal Training at the NY health Club: Part A)		
5	Consumer Choice Models (Case: Personal Training at the	9/17/2012M	One page project
	NY health Club: Part A continued)		proposals due
6	Dealing with Demand Data 1	9/19/2012W	
7	Dealing with Demand Data 2	9/24/2012M	
8	Pricing as Constrained Optimization	9/26/2012W	
9	Customized Pricing (Case: Fjord Motor Co.)	10/01/2012M	2. Fjord Motor Co. hand in
10	Value Pricing ( <i>case TBA</i> )	10/03/2012W	Revised one page proposal
11	Value Pricing Continued	10/08/2012M	
	Module 2: Price Optimization – dynamic case		
12	Markdown Management (Retailer Game)	10/10/2012W	
			3. NYHC Part B hand in
13	Discuss Retailer Game	10/15/2012M	
14	Dynamic Pricing in the Retailer Game	10/17/2012W	
15	Dynamic Pricing: Coconut Car Rental Company Case	10/22/2012M	
16	Dynamic Pricing: The Priceline Case	10/24/2012W	
	Module 3: Revenue Management		
17	Forecasting Demand (Hotel demand forecasting exercise)	10/29/2012M	Submit Project Progress
18	Network Revenue Management -1	10/31/2012W	Discuss if necessary your
10	Capitol Airlines case	10/51/2012 W	demand forecasts for
			rooms:
19	Network Revenue Management -2	11/5/2012M	
	Westbrook Hotel case		
20	Case Study on Network Revenue Management:	11/7/2012W	
	Transportation National Group (TNG) Case		
21	Network Revenue Management under Uncertainty	11/12/2012M	4. Submit your Hotel
			Room Allocation and Bid
			Prices
22 & 23	Applying Capacity Control with Demand Uncertainty	11/14/2012 W	
		& 11/19/2012M	
	Module 4: Emerging Topics		
24	Strategic Interactions: Hannah Montana The Tour of	11/26/2012 M	5. Submit your answers to
	Doom Case		Hannah Montana case
25	Yield Management ala Google (Everyday Medical Case)	11/28/2012 W	
	Predictive Analytics and Revenue Management		
26 and 27	Project Presentations	12/3/2012 M	Submit Final Project
		& 12/5/2012 W	Report and Presentation
	Take home final examination given on last day of		
	class		

Class 1

### Introduction

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

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

### Module 1: Price Optimization – The Static Case

### 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) - equivalent notes will
	be provided in BB
Read:	What price Vertigo? (INSEAD case in <i>case packet</i> )

- 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 – equivalent notes will be provided in BB

- 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 (Columbia case in <i>case packet</i> )
Skim:	Phillips section 3.1 (you may skip over the more technical parts) - equivalent notes will
	be provided in BB

• Download case 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;

Read:	Personal training at the NY Health Club: Part A
Skim:	Phillips section 3.2 - equivalent notes will be provided in BB

- 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) and hand in hard copy in class.

#### Class 6 and 7

#### **Dealing with Demand Data**

Lecture notes will be provided for these sessions. We will discuss how to estimate customer choice related parameters from observed choice behavior. We will also discuss when censoring of data affects our estimates and what are the typical remedies for dealing with censoring. (censoring refers to situations such as those in which we observe sales and not demand)

#### Class 8

#### Pricing as Constrained Optimization

Read: Pricing with Constrained Supply (Ch. 5 of Phillips book) – equivalent notes will be provided in BB

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 9 Customized Pricing

Read:	Customized Pricing (Ch. 11 of Phillips book) – equivalent notes will be provided in BB
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 10 and 11

#### Value Pricing - Case TBA

There are other methods that determine optimal prices and product designs based on inputs from customers. We shall briefly examine two such methods and relate them to our sessions so far in the course.

#### Please look at arunpereira.com website for material on pricing and conjoint analysis

Hand In: Email revised project proposal.

#### Module 2: Price Optimization – The Dynamic Case

Class 12

### **Markdown Management**

Read:	Retailer: A Retail Pricing Simulation Exercise (Broadie and van Ryzin) (Columbia case
	in case packet)
Skim:	Markdown Management (Ch. 10 of Phillips book) – equivalent notes will be provided in BB

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 <a href="http://www.profitlogic.com/index.htm">http://www.profitlogic.com/index.htm</a>.
- 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: <u>http://www.microsoft.com/windows/virtual-pc/download.aspx</u>
- 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.Group assignment -- Solutions to NYHC Part B; please submit assignment. Make sure you discuss your recommendation.

#### Class 13

#### **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 14

#### One Approach for 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 and 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: Read the problem on 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 15: Dynamic Pricing Illustrated for car rentals – A Second Approach

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. You can relate these ideas to the modeling decision trees if you have covered that topic previously.

### Class 16 Dynamic Pricing: The Priceline Case – Full Blown Application of the Second Appoach

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.

### Module 3: Revenue Management – The Classic Divide and Conquer Capacity Management Methods

### **Class 17: 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.

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

### Class 18

### Network RM via Linear Programming

Download:	Westbrook Hotel	and
	Capitol Airlines	cases

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

### Class 19

#### Network RM via via Linear Programming

Download:	Westbrook Hotel	and
	Capitol Airlines	cases

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

#### Class 20

#### Case Study on Network RM

Read:	Transportation National Group (TNG) (Columbia case in <i>case packet</i> )
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 21

Network Revenue Management under Uncertainty

We shall discuss the solution to the hotel forecasting and RM exercise.

### Class 22 & 23

#### **RM 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: Download Introduction to ... Yield Management (Netessine and Shumsky), pp. 34-39 (In Blackboard) Revenue Management & Capacity Allocation (Ch. 6 & 7 of Phillips) – equivalent notes will be provided in BB
- Prepare solutions for Problems 1-4 in Appendix B of the Netessine-Shumsky article, and be prepared to discuss them in class.

**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

### Module 4: Emerging RM Topics

Class 24

#### **Strategic interaction effects**

Download:	Hannah Montana data
Read:	Hannah Montana the Tour of Doom case (Columbia case in case packet)

• 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 25

### **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)

We shall briefly discuss predictive analytics and its use in RM.

### Classes 26 and 27 Final Student Project Presentations

Hand In: final project report and presentation (in power point and 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)