

## Revenue & Yield Management

### Lecturer

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### Time and Place

Tuesday, October 28<sup>th</sup>, 2008. 1.45–3.15pm and 3.30–5.00pm. Room O 131.  
Wednesday, October 29<sup>th</sup>, 2008. 5.15–6.45pm and 7.00–8.30pm. L9, 1–2 (Room 004).  
Tuesday, November 11<sup>th</sup>, 2008. 3.30–5.00pm. Room O 131.  
Wednesday, November 12<sup>th</sup>, 2008. 5.15–6.45pm and 7.00–8.30pm. L9, 1–2 (Room 004).

### 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 or after initial demand has been observed? In this course, we focus on how to set the best prices for the offered products, a decision very often linked to the profit performance of a supply chain.

Revenue management – or yield 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. 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 has become 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, where the revenue management system are tightly integrated in the existing Supply Chain Management solutions.

In this course you will learn to identify and exploit opportunities for revenue optimization in different business contexts. You 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. 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.

### **Course Assessment**

The course assessment consists of two parts. A case report (20 points) written with up to two team members is due at the beginning of the lecture on November 11<sup>th</sup>, 2008. The exam will take place on Monday, December 15<sup>th</sup>, 2008, and will be graded on an 80-point scale.

### **Reports**

The reports are graded for both content and presentation. A good paper should clearly and succinctly state the recommendations in an executive summary at the beginning to provide the reader with an overview and a framework. The main text should each present a major part of the rationale for the recommendation in terms of the desirable and undesirable consequences of adopting it. The rationale must consider capabilities that the business system under study needs to excel at, and how the current system either provides these capabilities or fails to provide them.

Reports should be typed with double spacing and should not exceed 10 pages (or 2,500 words), not including appendices and exhibits. Some common problems in preparing reports:

**Executive Summary:**

Your detailed report should be preceded by a one page executive summary. In this summary, highlight your findings as you would in an internal document aimed for senior management. Therefore, assume that the reader is intimately familiar with the company background and the decision situation. Focus only on your recommendations and your analyses. Be very careful not to waste space by just repeating facts from the case.

**Presentation:**

A good report is not a chronology of analysis (i.e., answering the questions listed in sequence), but a clearly articulated statement of recommendation and support. If there are options under consideration in the case that are rejected by you, a clear rationale for your decision should be provided. Facts stated in the case need not be restated unless used to make a point. I will assume that the most important issues are raised in the report and that all else is less important to the writer. Both desirable and undesirable consequences should be factually stated and supported. In the overall evaluation of the report the discussion of all consequences of the recommendation is of the greatest importance. You must clearly discuss how your recommendations aid in the development of capabilities that are important for the logistics system under study.

**Analysis:**

Other reports suffer from inadequate analysis. Analysis for a report is a time consuming and intellectually challenging task. Each case has a set of questions that are essentially a guide to help you with the analysis. The objective is to evaluate a complete range of alternatives and anticipate and discuss the full consequences of your recommendation. However, please note that these questions are just providing a starting point for your analysis; so answering the questions only may not be sufficient for a complete report.

### Reading and Lecture Notes

I will roughly follow this text:

- ❑ Phillips, Robert. *Pricing and Revenue Optimization*. Stanford University Press 2005. While your library might have some copies, I would recommend that you purchase this useful and moderately priced book.

The remainder of the course is self-contained; I will license and print all the cases. Participants will be able to pick them up from the departmental office one week prior to the start of the course.

### Additional optional Reading

In addition to the book by Bob Phillips, you may consult the following texts depending on your interests (these are not relevant for the exam):

- ❑ Talluri, Kalyan; van Ryzin, Garrett. *The Theory and Practice of Revenue Management*. Kluwer Academic 2004. This book provides a deeper and more mathematical treatment of the concepts of Revenue Management.
- ❑ Nagle, Thomas T.; Hogan, John. *The Strategy and Tactics of Pricing: A Guide to Growing more Profitability* (4<sup>th</sup> Edition). Prentice Hall 2005.
- ❑ Homburg, Christian; Krohmer, Harley. *Marketingmanagement: Strategie – Umsetzung – Unternehmensführung* (2<sup>nd</sup> Edition, in German). Gabler 2006. In particular relevant with regard to pricing and revenue management are chapters 2 and 12. Please also refer to Professor Homburg's lecture notes for 'Preismanagement' to review topics that we will not cover in this course.

### Resources on the Internet

The following websites provide interesting updates on current development in the area of Pricing Strategy & Revenue Management:

- ❑ INFORMS Revenue Management & Pricing Section  
<http://revenue-mgt.section.informs.org>
- ❑ Centre for Pricing Management at Lancaster University  
<http://www.pricingmanagement.com>

### Acknowledgements

The first incarnation of this course was based on the Revenue Management elective created by my doctoral advisor Professor Costis Maglaras at Columbia Business School. Doctoral candidate Arne Strauss has served as my teaching assistant many times for a similar module at Lancaster University Management School and has done a great job helping me to keep the lectures up-to-date and improve the content of this course.

## Detailed course outline

### Disclaimers

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 60 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!**

### Session 01: Introduction to Revenue & Yield Management

Revenue Management (RM) is a relatively new field currently receiving much attention of researchers and practitioners alike and essentially means setting and adjusting prices on a tactical level in order to maximize profit. Clearly, traditional well-known pricing techniques are closely related, however, the new twist is that RM avails itself of sophisticated demand forecasting and optimization software that is based on research in many areas such as management science, economics, mathematics and others. In conjunction with the availability of a vast amount of data through customer relationship management systems that can be used to calibrate the models, these techniques had a tremendous impact on the airline industry where RM first was applied, and subsequently in other industries such as car rentals, cargo or hotels, just to name a few. We consider the history of pricing and revenue optimization (PRO), factors driving the PRO boom and exemplify its principles with multi-pricing in the airline industry. Furthermore, we elaborate on the workings of a RM system.

Preparation for class:

- Read: Background and Introduction (Chapter 1 of book by Bob 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 the first Saturday in December in the morning, and return from Barcelona on Sunday evening the following week. Visit the easyJet website at <http://www.easyjet.com/> 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.

## Session 02: Selling digital Products

In this session, we discuss how a 'versioning' strategy can enable a company to distinguish its products from the competition and protect its prices from collapse. Producing the first copy of an information product is often very expensive, but producing subsequent copies is very cheap. In other words, the fixed costs are high and the marginal costs are low. Because competition tends to drive prices to the level of marginal costs, information goods can easily turn into low-priced commodities, making it impossible for companies to recoup their up-front investments and eventually bringing about their demise. One way to escape that fate is to create different versions of the same core of information by tailoring it to the needs of different customers. We draw on a wide range of examples to illustrate how companies use different versioning strategies to appeal to customers with different needs.

Preparation for class:

- Read: 'Versioning: The Smart Way to Sell Information' by Carl Shapiro and Hal Varian, Harvard Business Review 1998.
- Read: Cambridge Software Corp. (HBS Case 9-191-972). Cambridge Software Corp. must decide whether or not to offer multiple versions of a new software product. The firm has identified five market segments for the software and is deciding which, if any, of three product versions (a high end 'industrial' version, a mid-range 'commercial' version, and a low-end 'student' version) to offer. The decision depends on the size of the different market segments, the customers' willingness-to-pay, and the costs of developing and producing each of the three versions. Please read the case and be prepared to discuss the following questions in class:
  1. If Cambridge Software is obliged to launch just one product, which one should it be, and how should it be priced?
  2. If several are allowed, which should be launched, and how should they be priced?

## Session 03: Models of Consumer Demand

A central task in Revenue Management is to adequately represent demand in the optimization module, i.e. we need to find a demand function that best describe a given set of observed data. This process is called parametric or non-parametric estimation depending on whether or not we prescribe a certain functional form of the desired demand function. Clearly, even a perfectly designed revenue optimization module will deliver miserable results if it is based on a faulty demand model. Therefore we discuss various models of consumer demand based on reservation prices and demonstrate how to practically apply these methodologies via an illustrative case study. Customers typically do not just face simple buy or not buy decisions, but rather are given alternatives and need to choose one of them. Currently, incorporation of customer choice into RM model is a big issue and we outline its first principles.

Preparation for class:

- Read: Chapter 2 and 3 of Phillips book

### Session 04: Pricing – Constrained Optimization

Pricing is straightforward in the somewhat artificial situation that a firm does not need to consider any constraints on the amount of products that they want to produce and that they know with certainty the price-demand curve, namely the optimal price is given at the point where marginal cost equals marginal revenue. However, in practice these assumptions naturally often do not hold, in particular supply constraints apply. For this context, we investigate methods on how to find optimal prices for one or several products that are being sold over one or several time periods. The central concept to handle problems of this type is called opportunity costs: Imposing a supply constraint can result in a reduction in contribution, and precisely this reduction is referred to as opportunity cost. Therefore, the marginal opportunity cost can be seen as value of one additional unit of capacity. Marginal opportunity cost is used in price control policies since they represent information on the associated cost of a transaction. Virtually every Revenue Management application makes heavy use of this concept, so it is a fundamental issue that needs to be understood thoroughly.

Preparation for class:

- Read: Pricing with Constrained Supply (Chapter 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.

### Session 05: Implementation Issues

Pricing management takes place at different levels, namely at an industry level where factors influencing prices across the industry are being analyzed, so for example demand and supply, technological advances and many more. Within each market segment then, products have to be positioned on the market with respect to their value in comparison with competing products. This level includes setting list prices and target or base prices. Finally, on the transaction level we need to decide on discounts and other potential incentives that we might want to grant to certain transactions.

In this session, we present a tool that is crucial for successfully implementing transaction-level pricing strategies in practice: The price waterfall. Many companies still solely focus on finding the best list price, however, due to all kind of discounts like order size and competitive discounts, freight, promotions etc the price that the customer actually pays often vastly differs. For that reason it is indispensable to analyze all these components and to focus on the pocket price instead, i.e. the revenue that the company can actually put in its 'pocket'.

Another topic important for practical implementation is market sizing and segmentation. We demonstrate how the price waterfall can be used to size a market and present several brief case studies illustrating how to segment it.

### Session 06: Value Based Pricing

This session is about how to position a product right relative to competitors, based on the products' value as perceived by the customers, and how to develop a corresponding pricing strategy. Value equals perceived benefits minus perceived price, and both attributes are not easy to capture. A very important tool in this context is the value map which pricing managers use to show how customers perceive the tradeoff between price and benefits of the firm's product compared to competing products. Any company seeking to excel with their pricing strategy needs to thoroughly understand what constitutes value to their customers and then plan how to position itself on the value map. The 'Atlantic Computer' case study illustrates the process of identifying value and developing value-based pricing strategies.

Preparation for class:

- Prepare and **turn in for bonus point *before* start of the class**: Atlantic Computer: A Bundle of Pricing Options (HBS Brief Case 2078, included in course pack). Atlantic Computer, a leading player in the high-end server market, has detected a marketplace opportunity in the basic server segment. They have developed a new server, the Tronn, to meet the needs of this segment. In addition, they have created a software tool, called the 'Performance Enhancing Server Accelerator,' or PESA, that allows the Tronn to perform up to four times faster than its standard speed. The central question revolves around how to price the Tronn and PESA. Although cost-plus, competition-based, and status-quo pricing are the most common means by which firms establish prices for their offerings, these approaches may prevent firms from fully realizing the benefits that are due to them. Provides an opportunity to optimize value capture for the firm by utilizing value-in-use pricing (i.e., examining the value that a firm's offering creates for the customer, and using the savings generated as the basis for developing prices). Also allows for the exploration of the challenges surrounding the implementation of a value-in-use pricing strategy. These include the reactions of competitors, customers, and stakeholders within the firm. Please read the case and be prepared to discuss it in class. The following questions can serve as guideline for your case analysis, but please make sure not to answer them point by point in your report:
  1. What price should Jowers charge DayTraderJournal.com for the Atlantic Bundle (i.e. Tronn servers + PESA software tool)?
  2. Think broadly about the revenue implications from each of the four alternative pricing strategies. Approximately how much money over the next three years will be left on the table if the firm were to give away the software tool away (i.e. status quo pricing) versus utilizing one of the other pricing approaches?
  3. How is Matzer likely to react to your recommendation?

4. How is Cadena's sales force likely to react to your recommendation? What can Jowers recommend to get Cadena's hardware-oriented sales force to understand and sell the value of the PESA software effectively?
5. How are customers in your target market likely to react to your recommended pricing strategy? What response can be provided to overcome any objections?

### Session 07: Markdown Management

The classic application of markdown management is the fashion industry: As we get closer towards the end of the season, clothes are being marked down and eventually will be replaced by the new season's apparel. While in former times fashion retailers manually controlled the timing and magnitude of markdown, recent implementations of revenue management software that supports these decisions based on demand forecasts have proven to increase revenues by up to 10–15%. We distinguish between promotions on the one hand (just temporary price reductions), and markdowns on the other which are permanently, i.e. after a markdown prices will typically not increase again. In this session, we discuss the basic methods markdown management software relies upon.

Preparation for class:

- Skim: Markdown Management (Chapter 10 of Phillips book)
- Read: 'Before Christmas, Wal-Mart was stirring' (New York Times, Jan 2005). Access it here: <http://www.nytimes.com/2005/01/05/business/05walmart.html>
- Download: The *Retailer* game by Mark Broadie and Garrett van Ryzin and its data file and extract the archive into a folder 'retail.'
- Read the Instructions related to the simulator called *Retailer* begin on page 7 of the included File 'Retailer: A Retail Pricing Simulation Exercise.' Read pages 7–9 carefully, trying to infer the structure of the model that underlies the simulator (note particularly the footnotes on page 8).
- Open 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 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.



- ❑ You may want to browse through the website of Profitlogic (now part of Oracle), the leader in retail markdown management services (i.e., provider of analytical software and consulting services in this area) at: <http://www.oracle.com/profitlogic/>
- ❑ Check the easyJet website <http://www.easyjet.com/> 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*.

### **Session 08: Nonlinear, Dynamic & other innovative Pricing Strategies**

A common pricing strategy is nonlinear pricing, i.e., the price increase for purchasing the next unit of a product or service does not necessarily increase in a linear fashion. As an example, a mobile phone companies usually offer tariffs with a fixed monthly payment including a certain number of “free” minutes. Once the customer exceeds this limit, additional minutes need to be paid. This simple principle can be varied in many ways, leading to different price curves. We investigate some innovative ways of pricing as encountered in practice, among other brief case studies the strategy of easyInternet café, a subsidiary of the easyGroup which also includes the well-known airline easyJet.

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. 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.

Preparation for class:

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

### **Session 09: Capacity Control via Linear Programming**

In Revenue Management we distinguish between price- and quantity-based revenue optimization techniques: The former refer to methods that use price as a control whereas the latter impose booking limits to control the availability of the firm’s products on the market and comes also under the name capacity control. Due to the way that legacy carriers’ booking systems are designed one mostly finds quantity-based optimization techniques in this line of business, and likewise in the hotel industry, just to name the two biggest areas of application. We discuss such methods based on linear programming and use the opportunity

cost principle to derive optimal control policies, i.e. the best decision rules that tell us whether to accept or to deny a certain product request given known demand data.

Preparation for class:

- Prepare: Westbrook Hotel and Capitol Airlines (included in course pack)

### **Session 10: Revenue Management & CRM**

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.

- Prepare: Harrah's Entertainment, Inc. (HBS Case 9-502-011). 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?

### **Session 11: Customer Acceptance and Legal Issues in PRO (if we have time left)**

In this session we discuss customer perception of dynamic pricing and price differentiation and how it affects the success of firms. We give examples of unsuccessful or badly perceived actions. We then proceed to discuss tactics for avoiding misperceptions and perceptions of unfairness and their implications for pricing strategy.

Preparation for class:

- Read: PRO and Customer Acceptance (Chapter 12 of Phillips book)

- ❑ Read: 'What Price Fairness?' by Paul Krugman (Nobel Prize Winner in Economics in 2008!), New York Times, 2000. You can access this article here:  
<http://query.nytimes.com/gst/fullpage.html?res=990DE0D6103DF937A35753C1A9669C8B63&sec=&spon=&pagewanted=all>
- ❑ Food for thought: 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](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?