Columbia Business School

MANAGEMENT SCIENCE AND ENGINEERING

DEMAND ANALYTICS

Fall Semester 2022 Professor Awi Federgruen

How do airlines decide when to increase ticket prices? Should a hotel charge less per night for a long stay than a short one? Why do some software companies bundle very different products together? How should a fashion retailer decide when do start discounting clothes? Why do so many discounted rates end in ".99"? How should companies estimate future demand for their products?

These are only a small sample of the operational and pricing challenges all businesses regularly face. These challenges are often addressed individually and in isolation but, in reality, all of these decisions interact with each other. This class looks at the demand management challenges faced by companies in various industries and provides an introduction to the tools that can be used to address these challenges. Specific topics covered include (subject to change)

- Basics of price optimization,
- Static and dynamic price optimization,
- Market segmentation,
- Customized pricing,
- Non-linear pricing,
- Markdown pricing,
- Overbooking strategies,
- Consumer Choice Modeling

Prerequisites An understanding of both probabilistic and deterministic modeling.

Class Times TBD

Schedule TBD

Course Texts There are no required books for the class. All material will be provided in class slides. Some of the material in the class is based on the following texts:

- R.L. Phillips, *Pricing and Revenue Optimization.* Stanford University Press, 2005.
- Özer, Ö. and Phillips, R. *Oxford Handbook of Pricing Engineering.* Oxford University Press, 2012.

The following book may also be useful for reference purposes

- K. T. Talluri and G. J. van Ryzin, *The Theory and Practice of Revenue Management,* Springer, 2004.

Teacher Professor Awi Federgruen
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Teacher Office Hours See canvas.

Teaching Assistant TBD

T.A. Office Hours See canvas

Homework There will be two homework assignments. You may work with other classmates on these assignments, but each student has to turn in an

individual solution. Keep in mind that you will not be allowed to collaborate on the exam questions. Please check Canvas for due dates.

Paper presentation You will be required to study an academic paper related to the topics of this class and to present this paper in our penultimate lecture. See details following the course schedule.

Exams There will be a final in-class exam during our last class.

Grading I will calculate a grade for each student as follows

Final exam	40%
Paper project	35%
Homeworks	10%
Participation	15%

Each component will be individually curved, so that the lowest assignment in the class gets a 0, and the highest gets a 100.

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SAMPLE SCHEDULE(SUBJECT TO CHANGE)

Class	Date	Topics and Assignments
1	Tues, Sep 3rd	Introduction & Pricing Fundamentals
2	Tues, Sep 10th	Static Price Optimization
3	Tues, Sep 17th	Dynamic Price Optimization
4	Tues., Sep 24th	Price Differentiation
5	Tues, Oct 1st	Quantity-based Revenue Management
6	Tues, Oct 8th	Network Revenue Management & Overbooking
	Tues, Oct 15th	No class
	Tues, Oct 22nd	No class
7	Tues, Oct 29th	Consumer choice models
	Tues, Nov 5th	No class
8	Tues, Nov 12th	Markdowns 1
9	Tues, Nov 19th	Markdowns 2
10	Tues, Nov 26th	*Buffer class*
11	Tues, Dec 3rd	Paper presentations
12	Tues, Dec 10th	Final exam in class

Depending on how the semester progress, I might cancel one class to hold team meetings on your papers – stay tuned for a canvas announcement.

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Project Details

Fall Semester 2019 Professor Daniel Guetta

Part of your grade in this class will be based on your study of an academic paper related to the topics of this class. My rationale behind this assignment is to prepare you for jobs in which you'll often face new problems you have not encountered before. I want you to have the skills to peruse the literature yourselves and find out about the newest, greatest, and latest research you might be able to use. I also want you to develop the presentation skills (both written and oral) you might need to present these results.

Many of these papers will require some background knowledge on topics you will not yet have studied. Part of this assignment (indeed the hardest part) will be for you to figure out how to level-up on these subjects to an acceptable standard quickly and efficiently.

You will be expected to work on this project in groups of 4 people. **You must enter your team, and the paper you'll be covering, on the Google Doc linked on the Canvas homepage before the end of the second class.**

Grading for the project will be as follows:

- **25 points**: A 10 minute presentation in our penultimate class, which will be judged on the quality of the work as well as on your presentation abilities.
- **10 points**: I will require you to watch a video of your own presentation after class and write a 300-500 word critical summary of how you might improve your presentation if you were to do it again. Listening to yourself speak on video is arguably one of the most

uncomfortable things to do ever, but there is no better way to improve your presentation abilities.

- **10 points**: A summary of no more than 300 words describing the point of the paper in language any CEO could understand. This passage should explain why this paper is interesting and relevant in plain English.
- **25 points**: A summary of no more than two one-sided pages (including equations, graphs, and illustrations) summarizing the mathematics in the paper. This should be aimed to other students in the class, and should explain any pre-requisite knowledge that they might not be expected to already know. Summaries over the length limit will automatically lose half the points.
- **30 points**: At the end of the class, you will each be sent a confidential questionnaire. Each teammate will be given 40 points to distribute among team members including themselves. You may choose to distribute them equally if you feel every team member contributed equally, or unequally otherwise. If any team member does not submit their questionnaire or submits it incorrectly, they will be assigned 0 points in this category. Note that these scores will be completely confidential. I will not show them to any other team members, or even to your TAs. Only I will have access to these scores and use them to assign your final grade.

All deliverables, including the slides of your presentation, should be emailed to the TA no later than midnight on the night of the final exam for the class.

It is important to realize that this project is as much about understanding the technical material as it is about communicating it in a useful, informative format. It will be graded accordingly.

You may pick any academic paper you like for this project, as long as it is vaguely related to the topics in the class. Here is a list of potential papers you might want to use. If you decide to use any papers *not* on this list for your project, please email me first just so that I can make sure that it's appropriate. Before you pick a paper, please consult the Google Doc on the Canvas homepage to make sure another team has not selected it – I do not want two teams to cover the same project.

- *Clearance Pricing Optimization for a Fast-Fashion Retailer*, F. Caro and J. Gallien, 2012.

- *Inventory Management of a Fast-Fashion Retail Network*, F. Caro and J. Gallien, 2009. (Note this paper goes slightly further than our class – it covers supply chain management, not just pricing – but it's still in the same ballpark)
- *Two-Echelon Distribution Systems with Random Demands and Storage Constraints*, A. Federgruen, C. Guetta, G. Iyengar, 2018. (Note this paper goes slightly further than our class – it covers supply chain management, not just pricing – but it's still in the same ballpark)
- *Customer Preference and Station Network in the London Bike Share System*, E. Belavina, K. Girotra, P. He, and F. Zheng, *unpublished*.
- *MNL-Bandit: A Dynamic Learning Approach to Assortment Selection*, S. Agrawal, V. Avadhanula, V. Goyal, and A. Zeevi, *unpublished*.
- *Information Relaxations and Duality in Stochastic Dynamic Programs*, 2010.
- *Using Lagrangian Relaxation to Compute Capacity-Dependent Bid Prices in Network Revenue Management*, H. Topaloglu, 2009.
- *Model Trees for Personalization*, A. Aouad, A. Elmachtoub, K. Ferreira, and R. McNellis, *unpublished*.
- *A Practical Method for Solving Contextual Bandit Problems Using Decision Trees*, A. Elmachtoub, R. McNellis, S. Oh, and M. Petrik, *unpublished*.
- *Does Adding Inventory Increase Sales? Evidence of a Scarcity Effect in U.S. Automobile Dealerships*, G. Cachon, S. Gallino, M. Olivares, 2018.
- *ICU Admission Control: An Empirical Study of Capacity Allocation and Its Implication for Patient Outcomes*, S. Kim, C. Chan, M. Olivares, G. Escobar, 2014.
- *Integration of Online and Offline Channels in Retail: The Impact of Sharing Reliable Inventory Availability Information*, S. Gallino, A. Moreno, 2014.
- *Demand Estimation Under Incomplete Product Availability*, C. Conlon, J. Mortimer, 2013.
- *The Effectiveness of Field Price Discretion: Empirical Evidence from Auto Lending*, R. Phillips, A. Simsek, G. Van Ryzin, 2015
- *Involuntary Export Restraints on Automobiles*, S. Berry, J. Levinsohn, A. Pakes, 1999.
- *Are Consumers Strategic? Structural Estimation from the Air-Travel Industry*, J. Li, N. Granados, S. Netessine, 2014.
- *A Data-Driven Model of an Emergency Department*, W. Whitt, X. Zhang, 2016.
- *Demand Estimation Under the Multinomial Logit Model from Sales Transaction Data*, T. Abdallah, G. Vulcano, *unpublished*.

- *Estimating Primary Demand for Substitutable Products from Sales Transaction Data*, G. Vulcano, G. van Ryzin, R. Ratliff, 2012.
- *A Bayesian Hierarchical Model for Demand Curve Analytics*, Y. Ho, T. Vo, H. Chu, X. Luo, C. Le, 2016
- *A Hierarchical Bayesian Regression Model for Predicting Summer Residential Electricity Demand Across the U.S.A*, S. Wang, X. Sun, U. Lall, 2017
- *Near Optimal A-B Testing*, N. Bhat, V. Farias, C. Moallemi, and D. Sinha, 2018