UNIVERSITY OF SOUTHERN CALIFORNIA
Marshall School of Business

DSO 570 – The Analytics Edge: Data, Models, and Effective Decisions
Fall 2020
Section 16287

Syllabus
(Version: 8/15/20)

Contact Information

Instructor:	**Hiroshi Ochiumi**
Email:	**ochiumi@marshall.usc.edu**
Office:	**On-Line**
Office Hours:	**Thursday 2pm – 4pm.**

Course Description:

Companies routinely collect large volumes of data on customer profiles, point of sales transactions, and operating performance at different units. How can companies use these data to make effective decisions? How do organizations covert these data into business intelligence and insights? This course will give you the tools and methods to answer these questions, providing you with a unique analytics edge in an increasingly data-centric global business environment.

The goal of this course is to teach students how to build sophisticated models from raw data, and how to translate these models to make effective business decisions.

Course Objectives:

Upon successful completion of this course, students will be able to:
1. Build sophisticated Linear, Non-linear, Discrete, and Dynamic optimization problems based on available data and business scenarios.
2. Understand how various optimization algorithms reach an optimal point.
3. Understand the impact of uncertainty when interpreting the optimization results.

Textbook: *Data, Models, and Decisions: The Fundamentals of Management Science* by D. Bertsimas and R. M. Freund, 2nd Edition, published by Dynamic Ideas in 2004 (ISBN-13: 978-0975914601 and ISBN-10: 097591460X).
The publisher's website: https://www.dynamic-ideas.com/books/ecbcnthsfb6hnzfdezpw0aldtvl9yr

Instructional Methods: The class will consist of lectures, hands-on exercises, and case-based discussion.

Lectures: The lecture notes in PowerPoint will summarize all of the theory and concepts needed for this class. The lecture notes will be posted on Blackboard.

In-Class Exercises: We will frequently go to breakout rooms to actually work on problems. It is very important for each student to complete all exercises.

Homework Assignments and Case Studies: During the course, you will be given 3 homework assignments and 3 case studies. No late work will be accepted. You can work on the cases and assignments individually or in a team. Each team will consist of <u>at most 2</u> students. You can form different teams for different assignments.

Grading

The course grade, which will be curved, is based on a midterm, a cumulative final exam, homework assignments, case analysis, and class participation according to the following weights:

Class Participation	10%
Homework	20%
Case analysis	20%
Midterm	25%
Final Exam	25%

Class Participation

It is very important for each student to actively participate in the class discussion. Read the assigned material before the class and make sure you are familiar with the main issues to be discussed in class. You will be cold-called. Your participation is evaluated mainly on the quality of your contribution and insights. I will make every effort to call on as many students who wish to speak up as possible.

Academic Conduct:
Students are expected to make themselves aware of and abide by the University community's standards of behavior as articulated in the [Student Conduct Code](). Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, "Behavior Violating University Standards" [policy.usc.edu/scampus-part-b](). Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct at [http://policy.usc.edu/scientific-misconduct]().

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
[studenthealth.usc.edu/counseling]()
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
[suicidepreventionlifeline.org]()
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention and Services (RSVP) - (213) 740-9355(WELL), press "0" after hours – 24/7 on call
[studenthealth.usc.edu/sexual-assault]()
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED)- (213) 740-5086 | Title IX – (213) 821-8298
[equity.usc.edu](), [titleix.usc.edu]()
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following *protected characteristics*: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations. The university also prohibits sexual assault, non-consensual sexual contact, sexual misconduct, intimate partner violence, stalking, malicious dissuasion, retaliation, and violation of interim measures.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
[usc-advocate.symplicity.com/care_report]()
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity |Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776
[dsp.usc.edu]()
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710
uscsa.usc.edu
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101
diversity.usc.edu
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.

Course Disclaimer

This syllabus is an invitation to students to engage in an exciting and interactive study of the course materials. The intention of the instructor is to provide you with information, offer practice with skill sets, and enhance your capacity to use fundamental concepts to build your repertoire of analytics tools and make sound decisions. The learning environment will be collaborative and supportive; we will learn from one another both in and out of the classroom. To that end, modifications to this syllabus might be warranted as determined by the instructors as we assess the learning needs of this particular class of students. In addition, class participation grade is under the sole discretion of the instructor.

COURSE OUTLINE

Module 1: Overview and Motivation

Session 1 – 8/17/20 (Monday): Course overview
Question: What is the Analytics Edge? Why do we need it?
Learning outcomes: You will discover a range of applications that can be applied using the tools and methodologies learned in the class. Introduce a framework for effective decision-making under uncertainty.
- Define and recognize opportunities for business analytics in real-world situations
- Understand how we can use data to develop good models that drive effective decision-making
- Recognize and formulate decision problems

Optional text reading: Chapters 1.1 - 1.3.

Session 2 – 8/19/20 (Wednesday): Chocolate Game
Question: What is a "policy" in a decision analytical framework? What are the characteristics of an optimal policy for Chocolate Game?
Learning outcomes: You will play Chocolate Game to experience the complexity of real business decisions.
- Chocolate Game
- What is a policy and how can we evaluate them?
- Characteristics of an optimal policy for Chocolate Game

Optional text reading:

Module 2: Linear Optimization

Session 3 – 8/24/20 (Monday): Introduction to linear programming
Question: How do we find the optimal solution? What is a linear program? How can we use Excel to solve a linear program?
Learning outcomes: Optimization gives business a critical edge. In this class, you will learn that optimization is a powerful tool that can be applied to various business problems not limited to operations management. You will be able to formulate a linear program (LP) and solve small LP problems using Excel Solver.
- Recognize linear program as a special optimization tool
- Understand the components of a linear program
- Formulate linear programs and solve it using Excel solver
- Make decisions by utilizing optimization tools to allocate resources effectively

Optional text reading: Chapters 7.1 – 7.4

Session 4 – 8/26/20 (Wednesday): Application of LP to refinery optimization
Question: An oil refinery firm needs to decide how much of crude oil to distill, reform, crack, and blend to create different types of fuels. Given the complexity of the refinery process, how can we use the LP formulation to determine the optimal operations for the refinery?
Learning outcomes: You will acquire a hand-on experience in formulating a complex LP to maximize profitability, using actual data from a business operations.
- Formulate complex LP to optimize business operations
- Structure complex LP in Excel
- Interpret the Excel outputs for business insights

Session 5– 8/31/20 (Monday): Geometry of LP, shadow prices, and sensitivity analysis
Question: Can we use the LP techniques to solve real business problems? What are the typical business problems where LP techniques can be applied? How can we interpret sensitivity analysis reports?
Learning outcomes: You will practice more advanced linear program formulation in Excel. You will appreciate the value of the Excel reports, which help you understand how the solutions change if the conditions vary.
- Understand the impact of changes in the problem's parameters
- Interpret the sensitivity report outputs from Excel Solver
Optional text reading: Chapters 7.5 – 7.6

Session 6 – 9/2/20 (Wednesday): Multi-period LP formulation: Dealing with a large number of variables
Question: How can we use LP to develop an optimal production schedule that involves hundreds of variables? How to extend the capability of Excel Solver through OpenSolver add-in package?
Learning outcomes: You will learn about multi-period LP formulation and how to handle LPs with large number of variables. The lecture will also introduce OpenSolver, which is a powerful open-source optimizer for Excel that extends the capability of Excel Solver.
- Formulate multi-period LP for production schedule
- Structure multi-period LP in Excel
- Use OpenSolver to address large optimization problems with many variables

9/7/20 – NO CLASS (Labor Day)

Session 7 – 9/9/20 (Wednesday): LP under uncertainty
Question: How to formulate LP when there is an underlying uncertainty? How to extend LP to allow multi-period decision-making?
Learning outcomes: You will learn how to formulate a two-stage LP, and apply the formulation to multi-stage decision-making problems. You will see how to concept of probability distributions can be incorporated into a linear optimization problem.
- Recognize linear optimization problems where there is an underlying uncertainty
- Understand the two-stage LP formulation. Formulate multi-period decision-making as a two-stage LP
Optional text reading: Chapter 7.7
Due: Homework #1

Session 8 – 9/14/20 (Monday): Filatoi Riuniti Case
Case description and case questions are on pp. 389 – 397 in the textbook. Please answer all the case questions.
DUE: Case #1: Filatoi Riuniti

Module 3: Non-Linear Optimization

Session 9 – 9/16/20 (Wednesday): Introduction to nonlinear programming (NLP)
Question: What is a nonlinear programming problem? What are potential applications?
Learning outcomes: You will learn how about NLP and its applications to portfolio optimization.
- Recognize nonlinear optimization problems
- Formulate the portfolio problem as a nonlinear optimization problem
- Learn how to use Excel Solver to solve general nonlinear optimization problems
Optional text reading: Chapters 8.1 – 8.3

Session 10 – 9/21/20 (Monday): More NLP
Question: What is a nonlinear programming problem? What are potential applications?
Learning outcomes: You will work on more NLP. We will modify the problem we have previously worked on, and solve the non-linear version.
- Formulate the Gemstone Auto problem with monopoly power.

Session 11 – 9/23/20 (Wednesday): Geometry of NLP
Question: How can we use nonlinear optimization problem to determine the optimal portfolio allocation?
Learning outcomes: You will learn about the geometry of NLP and additional applications of NLP. We will discuss graphical analysis of nonlinear optimization problem and review solution methods based on Solver.
- Analyze simple nonlinear optimization problems using graphical methods
- Understand the outputs of the Solver and provide appropriate interpretation
Optional text reading: Chapter 8.5

Session 12 – 9/28/20 (Monday): Endurance Investors Case
Case description and questions are on pages 436 – 442 in the textbook. Please answers all questions: (a) - (j).
DUE: Case #2: Endurance Investors

Session 13 – 9/30/20 (Wednesday): Review for midterm

Session 14 – 10/5/20 (Monday): Midterm Exam

Module 4: Discrete Optimization

Session 15 – 10/7/20 (Wednesday): Introduction to discrete optimization
Question: Can we apply optimization tools when the decision variables are not divisible?
Learning outcomes: Optimization is more than linear and nonlinear programming. The firms cannot hire half of a person or fly a quarter of an airplane. You will be able to formulate an integer program (IP) and solve small IP problems using Excel Solver.
- Understand the components of an integer program
- Formulate integer programs and solve it using Excel solver
- Under how to use binary decision variables to model constraints in integer programming
Optional text reading: Chapters 9.1 – 9.3

Session 16 – 10/12/20 (Monday): Strategic relocation problem
Question: How to identify problems that can be solved using IP? How to use IP to solve the strategic relocation problem?
Learning outcomes: You will learn about additional applications of IP, including locating shelters, matching, and scheduling.
- Identify problems that can be formulated as an IP
- Convert business problems into an IP using appropriate variables
- Create a model for the strategic relocation problem using IP

Session 17 – 10/14/20 (Wednesday): Applications of discrete optimization in logistics
Question: How can we use IP in logistics problem?
Learning outcomes: You will have an opportunity to formulate a large-scaled IP for a logistic problem based on an actual business operation of a firm.
- Learn about the traveling salesman problem (TSP)
- Understand how to formulate the TSP and its variants in Excel
- Understand how to add a valid inequality to rule out infeasible solutions.

Session 18 – 10/19/20 (Monday): Case studies in discrete optimization
Question: How can we use discrete optimizations to help with corporate restructuring?
Learning outcomes: The International Industries, Inc. Case is a nice application of discrete optimization in strategic planning. It demonstrates the value of discrete optimization in finding a good investment strategy. You will have an opportunity to apply linear programming to actual business problems.
- Learn how to formulate strategic decisions in terms of discrete optimization problems.
- Set up the spreadsheet for complex integer programs.

Case Description: The International Industries, Inc. Case on pages 471 – 473 in the textbook
Note: This is not one of the three case assignments. We will work on the International Industries Case in class.

Session 19 – 10/21/20 (Wednesday): Branch-and-bound method
Question: How can we convert assortment optimization into a discrete optimization problem? What is a Branch-and-Bound Method? How can we use it to solve discrete optimization problems?
Learning outcomes: Branch-and-Bound method is one of the most commonly used techniques for solving discrete optimization problems. You will learn the underlying principle of the method.
- Understand how to formulate an assortment optimization problem as a DO.
- Understand the Branch-and-Bound method
- Aware of the pitfalls and issues associated with the method

Optional text reading: Chapter 9.4
DUE: Homework #2

Session 20 – 10/26/20 (Monday): Dellmar Case
The case description and questions are on pages 474 – 476 in the textbook. Please answers all questions.
DUE: Case #3: Dellmar

Module 5: Dynamic Programming

Session 21 – 10/28/20 (Wednesday): Introduction to dynamic optimization
Question: What is a dynamic optimization? What are the important features of such problems?
Learning outcomes: Many business problems require a multi-period optimization framework.   How to recognize such problems? What are the important features of these problems?
- Recognize a dynamic optimization problem
- Understand the principle for solving such problems.
- Understand the concept of value function and the dynamic programming formulation

Session 22 – 11/2/20 (Monday): Dynamic programming in Excel
Question: How do use Excel spreadsheet to implement dynamic programming and solve the dynamic optimization problem?
Learning outcomes: You will learn about value function and how it can be used to solve the dynamic programming equation. You will also implement dynamic programming on Excel
- Understand the concept of value function
- Solve for the value function in Excel

Session 23 – 11/4/20 (Wednesday): Additional applications of dynamic programming
Question: What are additional applications of dynamic programming?
Learning outcomes: You will learn about the variety of applications that can be formulated as a multi-period optimization problem and the associated dynamic programming equation.
- Recognize the variety of problems that can be formulated using dynamic programing
- Be able to write the dynamic programming equations for these problems

Session 24 – 11/9/20 (Monday): Applications of dynamic optimization to retail pricing
Question: How should a retailer set the price of its products over time in face of random demands, in order to maximize the total profit over an entire selling season?
Learning outcomes: In this session, we will discuss application of dynamic optimization to retail pricing. We will show how to formulate the problem as a dynamic program.
- Apply dynamic programming framework to a problem in retail industry
- Recognize other applications of dynamic optimization

Session 25 – 11/11/20 (Wednesday): Review for final exam
DUE: Homework #3

Final Exam is scheduled for 4:30PM-6:30PM on Wednesday November 18
(Sections 16287)
No early exam is allowed due to University Policy.