Analytics for Logistics and Supply Chain Management

Syllabus and Class Information

Instructor: Dr. Rahul Makhijani
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Instacart
Office Hours: [TBD]

Course Website

Canvas for lecture notes and assignment submission
Piazza for class discussions

Course Description

The goal of this course is to introduce students to various optimization models and stochastic simulations to analyze problems arising from the domain of logistics and supply chains. Supply chains refer to the system of logistical operations that allow a business to produce goods and deliver them to markets (essentially connect demand to supply). Maintaining flexible and efficient supply chains are critical to modern operations. This course will introduce basic concepts in inventory management, the causes of dynamical behavior in supply chains. It will also cover optimization concepts such as linear programming that is a used tool to model complex decision making processes.

After taking this course you should develop the following skills: -

1. Approach business problems like a decision scientist - systematically think about how tools like optimization and analytics can help can improve business performance and to make better-informed decisions.

2. Have had a hands-on experience with coding and solving a linear program.

Class Schedule

Class Date	Topic	Deliverables
Session 1	• Course Overview • Introduction to Supply Chains • Introduction to Linear Programming	
Session 2	• Introduction to Pyomo • Linear Programming Modeling	
Session 3	• Linear programming Applications in Logistics	
Session 4	• Network Flow problems	
		HW 1 Due
Session 5	• Facility Location Problem • Inventory Control and EOQ Model	
Session 6	• NewsVendor Model • Continuous Review QR policy	
		HW 2 Due
Session 7	• Midterm	
Session 8	• Revenue Management	
		HW 3 Due
Session 9	• Project Presentation • Project Discussion	
Session 10	• Root Beer Game • Bull Whip Effect	

Detailed Description

1. **Module 1 Introduction to Linear Optimization**

   (a) Content overview

      i. Problem Formulation as a Linear Program (LP)
      ii. Geometric Visualization
      iii. Linear Program Modeling
      iv. Dual Values Interpretation and Sensitivity analysis
      v. Complimentary Slackness

   (b) Suggested Readings

      - Pyomo Cookbook Chapter 2

2. **Module 2 Linear programming Applications in Logistics.**

   We will learn how to model Linear programs and solve numerical problems with the help of a solver. we will also model a supply chain network as a linear program.

(a) Content overview

i. Knapsack
ii. Shortest Path
iii. Set Cover Problem (facility location)
iv. Network Flow problem and Supply Chains.
A. Network Flow Problem Description
B. Min Cost Flow Problem
C. Assignment Problem as an LP

(b) Suggested Reading

i. Network Flows

3. **Module 3 Decision Making and Inventory Control**

This module will focus on decision making in the face of uncertainty. The topics address issues of information, the critical distinction between 'here-and-now' decisions versus 'wait-and-see' decisions when making operational decisions. The concepts will be applied to analyzing the 'real options' present in many business situations.

(a) Newsvendor problem
(b) Inventory Control Introduction
(c) Lead Time Service Times
(d) EOQ policy

4. **Module 4 Simulation and Supply Chain Dynamics**

The module will comprise three topics. The first part of this module will focus on discrete time event simulation and various applications. The second part will cover basic economic concepts of inventory management and use of policies such as economic order quantity, replenishment strategies, the determination of safety stocks, and economy of scale that are associated with large warehouse operations. We will finally cover am in-class simulation to illustrate the potential for unstable dynamics in a manufacturer - distributor - retailer - customer supply chain.

(a) Discrete Time Event Simulation
(b) Supply Contracts
(c) (s,S) Policy
(d) Simulation Exercise Case Study

5. **Module 5 Revenue Management**

In this module, the focus will be on understanding pricing under capacity constrained conditions in order to maximize revenue.

(a) Price Segmentation
(b) Dynamic Pricing

TextPak

1. Data-Driven Mathematical Optimization in Python
2. Arome Bakery: Replenishment of Fresh Bakery Products HBS case study
3. Harvard Business School Press. "Supply Chain Management Simulation: Root Beer Game V2," Online Simulation Exercise, HBS Product Number 6619-HTM-ENG, published Jul 5, 2012.
4. Marico Ltd.: Distribution Network Optimization, HBS product number W25851-PDF-ENG, published May 24, 2022.

References

Although the course would does not follow a textbook, the following books are a useful reference material: -

1. Applied Mathematical Programming by Bradley, Hax and Magnati.
2. H. Paul Williams. Model Building in Mathematical Programming.
3. Understanding and Using Linear Program by Jiří Matoušek, Bernd Gärtner

Prerequisites

1. Prior exposure to multivariable calculus, probability and linear algebra.
2. Prior coding experience is highly recommended but not essential.

Requirements and Grading

The grade breakdown is as follows:

1. 3 Homeworks (HWs): 45%
2. Project and Class Presentation: 30%
3. Midterm: 20 %
4. Attendance: 5 %

Project and Class Presentation

Student teams will analyze the case - "Marico, Distrbutional Network Optimization". Teams will be of size 4. The project will provide teams with an opportunity to apply the tools they learn to a practical inventory modeling problem with real-life data. Students would make a presentation regarding the solution and present to class on the last day of the course. We will potentially discuss some of the key points of the case study at the end of the class.

Homework Assignments

Each homework comprises questions to be answered and/or hands-on tasks. The HWs will be a combination of a case studies and modeling exercises. Assignments can be done in groups of 3-4 (max four students can submit a single assignment in case you are not able to find one). You are encouraged to work with your group members and other classmates to understand how to use python to achieve what you need to do. Each group is however expected to complete the assignment on their own. You are free of course to discuss the concepts with your classmates, and to discuss similar problems to the ones in the homework.

The homework assignments will posted on Canvas. They are listed, by due date, in the class schedule. Completed assignments must be typed and handed on Canvas by midnight of the submission date.

Late Assignments

Late assignments will have their grades reduced. Assignments late by 24 hours will have the grade reduced by 25 %. Assignments late by 48 hours will have grade reduced by 50% and later than 48 hours will not be accepted.
Generally, the Course Assistant should be the first point of contact for questions about any issue with the homework. The course assistant will have the responsibility to make sure that all questions are answered in a timely fashion. If the CA cannot help you to your satisfaction, please do not hesitate to come see me.

Re-grading

If you feel that a calculation, factual, or judgment error has been made in the grading of an assignment or exam, please write a formal memo to the CA describing the error, within one week (7 days) after the class date on which that assignment was returned. Include documentation (e.g., pages in the book, a copy of class notes, etc.). If the CA answer did not satisfy your claims, please send me an email with all the required material. I will make a decision and get back to you as soon as I can.

Academic Honor Code

All students are expected to adhere to the University of California, Davis' Code of Conduct as noted here: http://sja.ucdavis.edu/files/cac.pdf. Please also note that if "academic misconduct is admitted or is determined by adjudication to have occurred," per Regulation 550 the student could potentially receive a grade of "F" not only for the assignment or project in question, but also for the entire course.