Unit-0: Syllabus for Optimization methods in Finance(MA61061,3-0-0)

Course Coordinator:

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- Quadratic Programming and application in Finance(Markowitz models)
- Fractional Programming and application in Finance(Capital Asset Pricing models)
- Multiobjective programming application in finance(Sharpe ratio model)
- Linear programming application in finance(MAD and Min-max models)
- Integer programming and application in finance(auction and index fund)
- Stochastic programming and application in finance(Value-at-Risk and Conditional Value-at-Risk)

Books

1. Optimization Methods in Finance by Gerad Cornuejols and Reha T , Cambridge University Press.
2. Numerical Methods and Optimization in Finance by Manfred Gilli, Dietmar Maringer, Enrico Schumann. Academic Press.
3. Mean Variance Analysis in Portfolio Choice and Capital Markets by Harry M. Markowitz, Wiley.

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Evaluation Process

PROJECT:20 Marks, Quiz,Test 80 Marks in online mode

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Evaluation Process

PROJECT:20 Marks, Quiz,Test 80 Marks in online mode
In project you will be provided a research paper and you will implement the methodology of the paper in Indian financial market.

Self study

- Linear Programming: Simplex method, Revised simplex method, Artificial variable technique, Dual simplex method.

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- Linear Programming: Simplex method, Revised simplex method, Artificial variable technique, Dual simplex method.
- Integer programming: All integer and mixed integer programming technique.

Self study

- Linear Programming: Simplex method, Revised simplex method, Artificial variable technique, Dual simplex method.
- Integer programming: All integer and mixed integer programming technique.
- Explore financial webpages: BSE(www.bseindia.com),NSE , Global markets(www.bloomberg.com).

Do yourself(Optimization Part)

1. Solve the following linear programming problems first by manually by suitable linear programming technique and then verify your answer using Python.
   1. Maximize $3x_1 + 2x_2 + 5x_3$ subject to
      $x_1 + 2x_2 + x_3 \leq 430,\ \ 3x_1 + 2x_3 \leq 460,\ x_1 + 4x_2 \leq 420, x, x_2, x_3 \geq 0.$
   2. Maximize $2x_1 + 3x_2 + 10x_3$ subject to
      $x_1 + 2x_3 = 0,\ \ x_2 + x_3 = 1, x, x_2, x_3 \geq 0.$
2. Use a suitable integer programming technique to solve the following integer programming problem. Then verify your answer using Python
   Maximize $3x_1 + 3x_2 + 13x_3$ subject to
   $-3x_1 + 6x_2 + 7x_3 \leq 8,\ \ 6x_1 - 3x_2 + 7x_3 \leq 8, 0 \leq x, x_2, x_3 \leq 5,$
   and integers.

Do yourself (Finance part)

Explain the following financial terms(Hint: see www.investopedia.com):

1. Financial Market, Stock Market, Bond Market, Money Market, Derivative Market, Forex Market.
2. Asset, Share, equity, bond, mutual fund, portfolio, return of an asset/portfolio, risk of an asset/portfolio, short selling, Different market indices.
3. Explore the webpages like www.bseindia.com, www.nseindia.com
4. Try to find the historical data of the any index and any asset from www.bseindia.com or www.nseindia.com .

How to download data from BSE

- To find all stocks from different sectors, explore the webpage

$$https://www.bseindia.com/corporates/List\_Scrips.aspx$$

- In this page you will see options GROUP(A,B,C,...) and Industry(.....). Select one group and one industry say Group A+BANKS. You will see different banks. Each one has security code, security id and security name. Select one bank say IDBI. click its code.

How to download data from BSE contd..

- In this page go to Archives. Provide From date and To date and search. You will get a list of stocks containing opening price ,closing price etc. Save this as excel sheet through save option. Then select only one column either opening price or closing price. save in one excel file. save this excel file as your roll number.
- Save data of 20 stocks from different sectors(oil sector, aviation sector, IT sector, Banking sector, Infrastructure sector, SAIL, etc...) , and from different groups. Save this file of 20 assets. Throughout this course you will use this file to solve assignments, tests and project.

General Optimization Techniques

1. Linear Programming
2. Integer Programming
3. General Nonlinear Programming
4. Quadratic Programming
5. Fractional Programming
6. Stochastic Programming
7. Multi-Objective Programming

USE PYTHON PLATFORM: scipy.optimize

Linear Programming

A general Linear Programming problem may be stated as

$$
\begin{aligned}
Maximize/Minimize \quad & c_1x_1 + c_2x_2 + ... + c_nx_n \\
Subject\ \ to \quad & a_{11}x_1 + a_{12}x_2 + ... + a_{1n}x_n \quad \leq, =, \geq \quad b_1 \\
& a_{21}x_1 + a_{22}x_2 + ... + a_{2n}x_n \quad \leq, =, \geq \quad b_2 \\
& ..... \\
& a_{m1}x_1 + a_{m2}x_2 + ... + a_{mn}x_n \quad \leq, =, \geq \quad b_m \\
& x_j \geq 0, j = 1, 2, ..., n
\end{aligned}
$$

Linear Programming

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& a_{m1}x_1 + a_{m2}x_2 + ... + a_{mn}x_n \quad \leq, =, \geq \quad b_m \\
& x_j \geq 0, j = 1, 2, ..., n
\end{aligned}
$$

In matrix form LPP can be represented as

$$Maximize/Minimize\ c^T x \ \ s.to \ \ Ax \ \ \leq, =, \geq \ \ b, x \geq 0,$$

$x, c \in R^n, b \in R^m, A = (a_{ij})_{m \times n}$

Optimization Techniques used to solve this problem:

- Simplex method
- Two Phase Method
- Artificial Variable Technique
- Interior point methods: Karmakar Algorithm

Linear Integer Programming:

$$
\begin{aligned}
Maximize/Minimize \quad & c_1x_1 + c_2x_2 + ... + c_nx_n \\
Subject\ \ to \quad & a_{11}x_1 + a_{12}x_2 + ... + a_{1n}x_n \quad \leq, =, \geq \quad b_1 \\
& a_{21}x_1 + a_{22}x_2 + ... + a_{2n}x_n \quad \leq, =, \geq \quad b_2 \\
& ..... \\
& a_{m1}x_1 + a_{m2}x_2 + ... + a_{mn}x_n \quad \leq, =, \geq \quad b_m \\
& x_j \in Z, j = 1, 2, ..., n,
\end{aligned}
$$

Z is the set of integers.

Nonlinear Programming:

Nonlinear Programming problems are of two categories:

- Un-Constrained Optimization Problem

$$\min_{x \in R^n} \quad f(x)$$

- Constrained Optimization Problem

$$\begin{aligned} \min \quad & f(x) \\ subject \ \ to \ \ & g_i(x) \leq 0, i = 1, 2, ..., m \\ & h_j(x) = 0, j = 1, 2, ..., p, \quad x \in R^n \end{aligned}$$

where $f : R^n \to R$, $g_i : R^n \to R$, $h_j : R^n \to R$.

Numerical optimization algorithms

- Newton like methods
- Conjugate gradient methods
- Penalty function methods
- Derivative free methods like Nelder Mead simplex method
- Coordinate search methods