



Mathematical Computing and Operations Research

Harvard University

Keywords: Statistics, Modeling, Computation, Management Science, optimization, Multiple Criteria Decision Making (MCDM)

Recommendation: This is a project-based program for students who are interested in and/or have a background in mathematics, data science, market analysis, MCDM, and management science. After the program, the students are encouraged to have some wonderful research outputs, such as a conference paper or a journal article.

Abstract: Operations research and computers interact in many scientific fields of vital importance to our society. These include, among others, transportation, economics, investment strategy, inventory control, logistics, safety, reliability, urban planning, and ecology. This program provides a forum for the application of computers and operations research techniques to problems in these and related fields. The common element in all the scientific areas that this program addresses is the need for some optimization methodology for determining viable solutions to problems, using computers and the techniques of operations research. However, it is not only the methodology which is of interest: the applications are of equal importance. The two are mutually supportive, since understanding the application helps one greatly to comprehend the optimization methods used, and vice versa. This program will therefore concern itself with these scientific fields of application, and will be accordingly broad in scope of subject matter. The outputs contain original research results, and demonstrate constructive algorithmic complexity and extensive numerical experiments. Numerical illustrations (examples) are not sufficient: the numerical experiments have a scientific value of their own, particularly with comparisons to other approaches. In addition, the research performed should represent novel and significant work relative to the relevant literature. The use of real-world data is also valued.

Through hands-on quantitative real-world projects, various classical methods related to mathematical analytics and operations research in the decision-making process (e.g., weighting, aggregating, and grouping) will be detailly introduced, such as Entropy, TOPSIS, RSR, CA, PCA/CFA, etc. Whilst, some commonly used mathematical software tools, such as MATLAB and SPSS, will also be

introduced during the program. Moreover, the research apprentices will learn the usage of EndNote, a reference management software package used to manage bibliographies and references when writing journal articles. In addition, AutoCAD, a computer-aided design (CAD) and drafting software, will be demonstrated for the applications in visualization and real design. Overall, by attending this program, the apprentices will have a significant improvement in discovering, analyzing, and solving practical problems from the mathematical perspective, which are closely related to their future studies and careers.

Specific techniques and tools that would be delivered in this program:

- **Data collection:** Various databases at international, regional, and national levels
- **Data pre-processing:** Data cleaning and data normalization
- **Weighting:** Entropy Method and Analytic Hierarchy Process (AHP)
- **Aggregating:** TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution)
- **Robustness analyses:** Correlation analysis
- **Grouping:** RSR (Rank-Sum Ratio), Regressions, Clustering Analysis (CA), and Multiple Correspondence Analysis (MCA)
- **Robustness analyses:** Principal Component Analysis (PCA) and Common Factor Analysis (CFA)
- Data decomposition and deconstruction
- **Visualization:** AutoCAD Drawing
- **Coding:** MATLAB and SPSS
- **Reference Management:** EndNote
- **Paper Writing:** Journal article or Conference paper writing