

Fall, 2021, Mini 2: 94-833: Decision Analysis and Multi-Criteria Decision Making

Lecture: Tuesday & Thursday 4:40 – 6:00 PM

Recitation: Friday 8:35 – 9:55 PM

Instructor:

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Course Description:

This course complements and extends both 95-760 Decision Making under Uncertainty and the two mini sequence in Management Science (90-722 & 90-760). Management Science I: Optimization) by addressing three additional topics in managerial decision making:

- MCDM (Multi-Criteria Decision Making)
- Decision Analysis
- Decision processes

MCDM is a collection of methods for trading-off different alternatives' performance on multiple conflicting objectives; methods discussed include weighted sum scoring models, swing weights, TOPSIS, DEA, AHP, and rank-based methods.

Decision Analysis is the prescriptive model for rationally maximizing subjective expected utility in the face of uncertainty; it is particularly powerful for dealing with sequential decisions, quantifying the value of information, assessing and incorporating subjective probabilities, and doing Bayesian updates of probabilities as new information becomes available.

Decision process considerations go beyond the paradigm of a single well-defined decision maker and mathematical method. Potential topics we could cover include industrial analytics, auctions, composite indicators ("US News & World Report" style ratings), balanced scorecards, "dashboards" of key performance indicators, group processes, and matching a decision method to the circumstances at hand.

Course Objectives:

The first two topics are skills-oriented. The objective is to empower students to apply the methods in professional practice. Students should leave the class able to apply the methods to routine problems, and with a foundation for further self-study when the decision's stakes warrant use of more advanced variations of these methods.

The last component is more conceptual, providing brief exposure to issues one confronts when bridging between textbook methods and real world implementation. The twin learning goals are knowledge about the issues and ideas and developing critical thinking skills concerning the “meta decision” of when to employ which decision method, and the criteria relevant to making those judgments.

Prerequisites:

This course will normally be taken after either 95-760 Decision Making Under Uncertainty or the Management Science sequence (90-722 & 90-760), but the only formal prerequisite is fluency with algebra & Excel and knowledge of probability theory and distributions at a level obtained from having taken, or concurrently taking one of Heinz’ empirical methods courses. However, the course is pitched at a second-year level; first-year students who are comfortable with quantitative methods are welcome, but first-year students without a quantitative bent are encouraged to wait until their second-year.

Canvas:

Course materials will be posted to Canvas. You should monitor it for announcements (e.g., changes to assignments).

Readings will be posted and/or distributed in class; they should be read *before* the class in which they will be discussed.

Recitations:

Recitation are optional. During first two weeks, I’ll be asking students in recitation to vet ideas for what decision to analyze in HW #1 and HW #2. If you’re not in recitation, we can do that one on one. Originally the course didn’t have recitations, but there had been demand for “collective office hours”. Some weeks I’ll bring some exercises we can do, and I can work textbook-like problems if asked, but often the most fun is when we spend time in open-ended discussion of “structuring” homework problems, systems synthesis projects, problems from your internships & professional work, etc. Of course it is also fine to review concepts, and I predict there will be digressions into career options in analytics and how quantitative analysis and mathematical modeling plays out “in the real world”.

Grading:

Course grade weighting is TBD but in past years it was often: homework (40%), class participation (15%), project presentation/memo/technical report (20%), and the final exam (25%).

Class participation means *participation*, not just attendance. Grade grubbing by making statements just to boost participation will be penalized, not just ignored.

Project presentations will be Thursday November 18th, with other graded items related to the project due on other dates (see project description on Canvas for details).

There will likely be five written homework assignments. Type the parts that are mostly words, but you may (neatly!) handwrite parts involving algebra, decision trees, derivations, etc. that would be time consuming to type. HW is due at the beginning of class. Late assignments will receive a 0.

HW #1 & #2 must be done individually. HW #5 will be done in pairs (of your choosing). HW #3 & #4 can be done individually or in groups of two or three. If you work in a group on HW #3 or #4: (1) submit one HW for the group and everyone in the group will receive the same grade on that HW and (2) more will be expected of group HW in terms of clarity of presentation and exposition, absence of arithmetic errors, quality of writing, etc. Within a group you may collaborate in any way you choose. Across groups feel free to discuss concepts and approaches, but there should never be sharing of anything electronic or stating of answers or result obtained.

There is somewhat greater latitude for talking with others in the class about HW #1 & #2 because (as you will see) you will all be doing unique analyses, so there is no risk of copying answers from each other. Ask me for clarification if necessary.

Taping or Recording Classroom Activities

No student may record or tape any classroom activity without my express written consent. If a student believes that he/she is disabled and needs to record or tape classroom activities, he/she should contact the Office of Disability Resources to request an appropriate accommodation.

Academic Integrity:

I am not kind to cheaters. If you cheat, I will fail in you in the course, report you to the administration and support expulsion from the University.

There are homework problems (mostly in HW #1 and #2) in which each person or group works on their own individual problem, so there is no common, class-wide “answer”. There is greater latitude for discussing those problems with others without crossing the line into cheating.

If you have any questions about what might or might not constitute cheating, ask me before making any dumb decisions.

Accommodations for Students with Disabilities:

If you have a disability and have an accommodations letter from the Disability Resources office, please discuss your accommodations and needs with me as early in the semester as possible. I will work with you to ensure that accommodations are provided as appropriate

Readings & Detailed Course Outline

The required readings are mostly from chapters I have written and the decision analysis chapter (Chapter 14) from Cliff Ragsdale’s *Spreadsheet Modeling and Decision Analysis: A Practical Introduction to Management Science*, 6th, 7th, or 8th edition. The book is available in various formats from the publisher, Cengage.

Part I: Multi-Criteria Decision Making

Read the identified sections of my Chapters 1 & 2 for the following MCDM classes. It is always good to do the reading before the class in which the material is discussed, but that is absolutely imperative for the classes on AHP and rank-based methods.

Class #1: Weighted sum models: Chapter 1.1 – 1.2, 2.1 – 2.3 & Ragsdale 14.16-14.17

Class #2: Rest of weighted sum methods & TOPSIS: Read 1.6-1.7, 2.4 and watch 22 minute blackboard video on swing weights & single attribute value functions (optional Ragsdale 3.15)

Class #3: Rank-based methods: Chapter 2.7 – 2.9

Class #4: AHP: Chapter 2.5-2.6 & Ragsdale 14.18

Also read – ideally before the 2nd class – Keeney, R.L. (2013) Identifying, prioritizing, and using multiple objectives. *EURO Journal on Decision Processes*, 1:45-67.

You may want to read the rest of my Chapter 1 at some point, but it is not required. I also suggest reading:

Spradlin, T., "A Lexicon of Decision Making", DSSResources.COM, 03/05/2004.

(<http://dssresources.com/papers/features/spradlin/spradlin03052004.html>)

If you have time to read this before the first day of class, that'd great, but there is a lot of other material to read in the first week so deferring it until the 2nd or 3rd week is fine.

Other Resources on MCDM

Belton, Valerie and Theodor J Stewart (2001). *Multi Criteria Decision Analysis: An Integrated Approach*. Springer.

If you want to use MCDM professionally and wish you understood more than we could cover in this class, read this book. It is excellent on scoring models, creation of value function, and the relationship between MCDM and DEA.

Ralph Keeney is famous for observing that failure to make the right choice is often rooted in failing to correctly identify what you really care about. He espouses Value-Focused Decision making, and you can tap into his wisdom at various levels of intensity.

- Keeney, R. *Value-Focused Thinking: A Path to Creative Decision Making*. Harvard University Press, 1992. The definitive treatment.
- Keeney, R.L. (1994). Creativity in Decision Making with Value-Focused Decision Making," *Sloan Management Review*, Summer, 33-41. Quick read, with practical tips on how to identify decision criteria.

There are many books and literally thousands of articles on DEA. I do not know which is best. You can browse the web resources (e.g., <http://deazone.com/en/>) as well as I can, but I think the original papers that established the method are still useful because they were written to explain it to people who had never heard of it before,

Charnes, A., W. Cooper, & E., Rhodes (1978) "[Measuring the efficiency of decision-making units](#)," *European Journal of Operational Research* vol. 2, pp. 429–444.

Commented [JPC1]: Maybe replace with excerpts from his new book

Banker, R.D., R.F. Charnes, & W.W. Cooper (1984) "Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis, *Management Science* vol. 30, pp. 1078–1092.

For the practicalities of doing DEA in a spreadsheet without specialized software, see Section 3.14 of Ragsdale, Cliff T. *Spreadsheet Modeling and Decision Analysis: A Practical Introduction to Management Science*.

For more on TOPSIS, see:

Hwang C.L. and K. Yoon, *Multiple Attribute Decision Making: Methods and Applications*, Springer-Verlag, New York, NY, 1981.

For more on rank-based methods, see:

Börgers, Christoph (2010). *Mathematics of Social Choice: Voting Compensation and Division*, Philadelphia: SIAM.

Part II: Decision Analysis

The main text is the Decision Analysis chapter of Cliff Ragsdale's *Spreadsheet Modeling and Decision Analysis*, 6th, 7th, or 8th edition.

Read Sections 14.1 – 14.14 for the first class. Just skim Sections 14.10 & 14.12 because they are primarily about implementation in a software package that we will not be using.

Read my Chapter 3 before the 2nd class. Treat my Chapter 4.1 – 4.5 as a resource to consult after the 2nd class to reinforce anything from class that was not clear.

Read Ragsdale Section 14.15 before the 3rd class.

After the course, if you want to learn more, an easy-to-read and excellent textbook is: Clemen, Robert T. and Terrence Reilly (2004). *Making Hard Decisions with Decision Tools*, Duxbury, Pacific Grove.

The definitive advanced treatment of Decision Analysis methods is still:

Keeney, Ralph L. and Howard Raiffa (1976). *Decisions with Multiple Objectives: Preferences and Value Tradeoffs*, Wiley and Sons.

Part III: Decision Processes

Tuesday December 7th: Ranking Colleges and Grant Proposals

Read NY Times "Colleges by the Numbers"

Read NY Times "Ranking Colleges by Value"

Read Gladwell "The Order of Things: What College Rankings Tell Us"

Commented [JPC2]: May be replaced by material on the "front end" of decision making in Fall 2023!

Thursday December 9th: Engineering Excellent Decision Processes

Skim Wikipedia entry on “The Wisdom of Crowds”

Skim Adamatsky and Ilachinski, “The Wisdom of Slime”

Read Davenport & Harris, *Analytics at Work*, on Craft vs. Industrial Analytics

Read Davenport & Harris, *Analytics at Work*, on Managing Decisions as Processes

Read prep memo on “Classroom exercise on decision process design”