Stochastic programming and robust optimisation

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Kick-off session

Aalto-yliopisto
Aalto-universitetet
Aalto University

EV-0017

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Outline

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Introductions

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Introductions

Please let us know:

1. Your prefered name
2. MSc or DSc?
3. Major (if MSc) or Dept. & School
   and Supervisor (if DSc)

Course overview

Course overview

Part I

- **Lectures**
  - 2/3 – Lecture
  - 1/3 – Guided tutorial

Part II

- **Seminars**
  - Article of your choice
- **Project presentations**
  - Application of your choice

Course organisation

Administratrivia

Sessions: Wednesday 9.15 am @ Y405

People:

- Lecturer: Fabricio (fabricio.oliveira@aalto.fi)

- TA: Paula (paula.weller@aalto.fi)

Support:

- MS Teams (Mon-Fri, 9-5) or Email: for short questions and bookings

- (Video) meetings: bookable in advance (no fixed office hours)
    - “Technical support”: Paula
    - Projects and papers: Fabricio

Lectures & tutorials

Topics we will cover:

- Two- and multi-stage stochastic programming
- Scenario generation and sample average approximation (SAA)
- Chance constraints and risk measures
- Decomposition methods (Progressive Hedging and SDDP)
- Static and adaptive robust optimisation

Tutorial: guided demos using Julia with examples and applications related to the topics presented.

Seminars

- You are expected to give a presentations **on a paper of your choice**
- Learning based to a large extent on the classroom discussion

Format: conference presentation: 25 + 5 minutes

- Use slides (+ whiteboard if you wish)
- Practice a few times beforehand to control time
- Some time control tips:
  - Number slides (e.g., 2/25 – current slide/total slides)
  - Break presentation in sections and know your target time stamps

Language: English

Projects

You are also expected to develop a practical application project

- **Main requirement:** employ one or more of the ideas discussed in the lectures
- **Topic of your choosing**
- **Deliverables: oral** presentation, slides, and code

Ideas

- Choose a **textbook problem** and develop a version of it under uncertainty
- Apply seen techniques to a **problem of your own choice**
- **Replicate**/extend computational experiments from a article (can be, e.g., the same presented)

Course assessment

Grading principles

Participation: 20pt

- **Proportional to attendance**
  - Present 80% (8/10) of contact sessions = 20pt
  - Otherwise proportional

Research paper presentation: 30pt

- Presentations anonymously graded by peers (1-5)
- Average of peer grades x 6.

Grading principles

Project: 50pt (graded by me)

Criteria

- Appropriate choice of techniques
- Depth of analysis
- Main conclusions

Presentation should cover in 25 + 5 minutes:

- Project scope and hypotheses (research question)
- Main conclusions (supported by numeric evidence)

Set the dates

Important dates

Choice of paper for seminar part: Friday 13.10.2023

Definition of project topic: Friday 03.11.2023

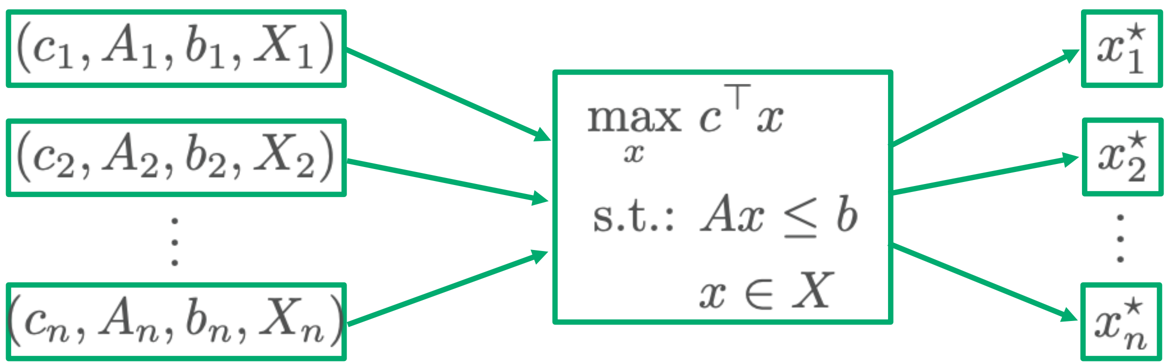
Seminar presentations		
25.10.2023	01.11.2023	(08.11.2023)

Project presentations		
15.11.2023	22.11.2023	(29.11.2023)

Lectures content

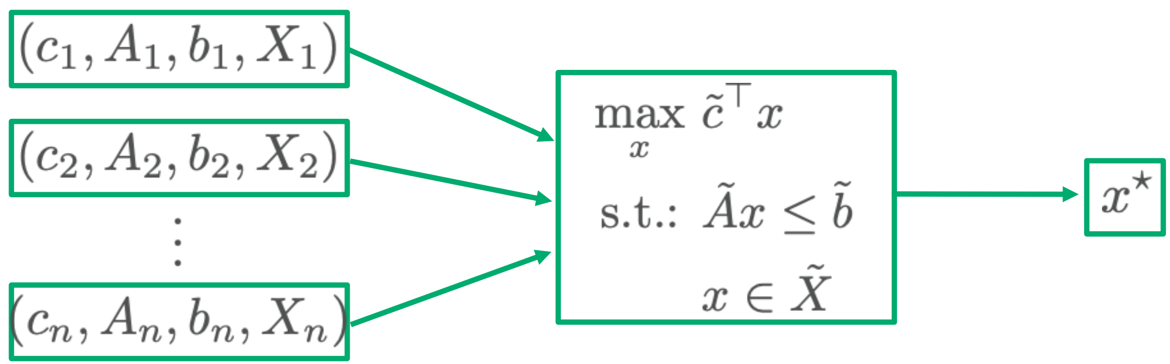
Optimisation under uncertainty

Mathematical programming-based methods are *not able to explicitly consider uncertainty* in their evaluations.



Optimisation under uncertainty

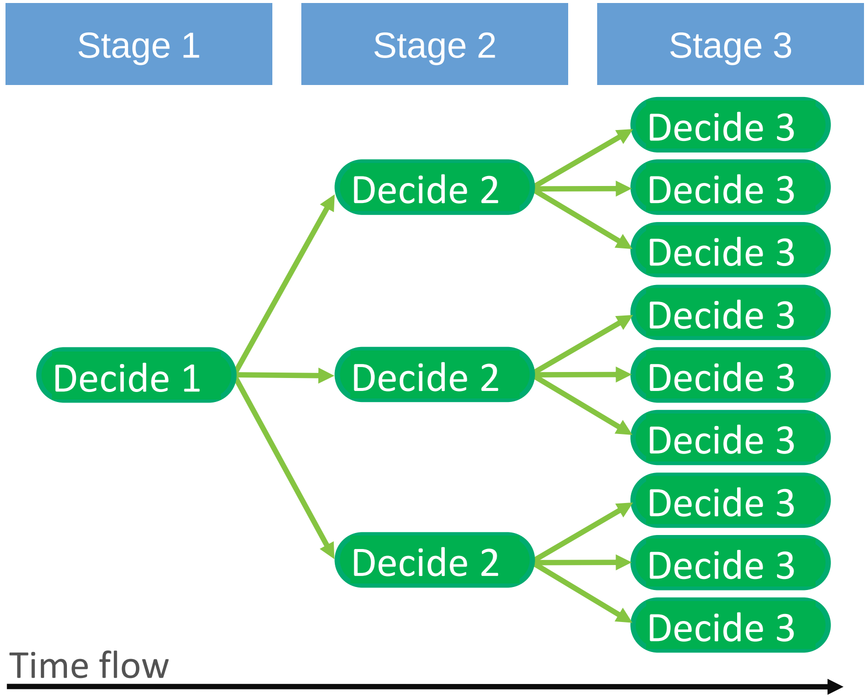
To be useful, a unique strategy must be defined *beforehand* for meaningful decision making.



K-stage problems under uncertainty

Basic steps:

1. ***Break*** **time flow into points of interest;**
2. ***Gather decisions*** **that must be made at each point;**
3. **Explicitly represent *scenarios*.**



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2-stage problems under uncertainty

In a two-stage setting, we have the following:

$$
\begin{aligned}
\max_{x} \; & c^\top x + \mathbb{E}_\Omega \left[Q(x, \omega) \right] \\
\text{s.t.:} \; & Ax \leq b \\
& x \in X
\end{aligned}
$$

where $Q(x, \omega) = \max \; q_\omega^\top y$

$$
\begin{aligned}
\text{s.t.:} \; & T_\omega x + W_\omega y = h_\omega \\
& y \in Y
\end{aligned}
$$

2-stage problems under uncertainty

Which is in turn is (deterministically) equivalent to

$$
\begin{aligned}
\max_{x,y}\ & c^\top x + \sum_{\omega \in \Omega} P_\omega \left(q_\omega^\top y_\omega \right) \\
\text{s.t.:}\ & Ax \le b \\
& x \in X \\
& T_\omega x + W_\omega y_\omega = h_\omega,\ \forall \omega \in \Omega \\
& y_\omega \in Y_\omega,\ \forall \omega \in \Omega
\end{aligned}
$$

Modelling problems under uncertainty

There are 4 main aspects that must be considered for this framework to be meaningful:

1. **How to *sync* decisions and uncertain events?**
2. **How to generate good *discrete* representations?**
3. ***Risk* tolerance profiles?**
4. **Can we *solve* these problems?**

$$
\begin{aligned}
\max_{x,y}\ & c^\top x + \sum_{\omega \in \Omega} P_\omega \left(q_\omega^\top y_\omega \right) \\
\text{s.t.:}\ & Ax \leq b \\
& x \in X \\
& T_\omega x + W_\omega y_\omega = h_\omega, \ \forall \omega \in \Omega \\
& y_\omega \in Y_\omega, \ \forall \omega \in \Omega
\end{aligned}
$$

2-stage deterministic equivalent problem

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Optimisation under uncertainty

A general toolset that requires full consideration of four aspects: