Aalto University
School of Business

Business Analytics 1 - Introduction

- *Learning outcomes*
- *What is Management Science?*
- *Course practicalities*

To set expectations on the course content here is an example on what we will be studying:

Indexes:
$M = \{0,1,2\}$: Mills
$W = \{0, \dots, 3\}$: Warehouses
$C = \{0, \dots, 12\}$: Customer areas

Parameters:
d_j: demand in customer area j
p_i: production capacity at mill i
e_i: extra production capacity at mill i
c_{ik}^a: transportation costs per ton from mill i to warehouse k
c_{kj}^b: transportation costs per ton from warehouse k customer area j
c_i^e: cost of using the extra production capacity at mill i

Decision variables:
x_{ik}: Tons transported from mill i to warehouse k
y_{kj}: Tons transported from warehouse k customer area j
z_i: Use extra capacity at mill i

$$\min \sum_{i \in M} \sum_{k \in W} c_{ik}^a x_{ik} + \sum_{k \in W} \sum_{j \in C} c_{kj}^b y_{kj} + \sum_{i \in M} z_i c_i^e$$

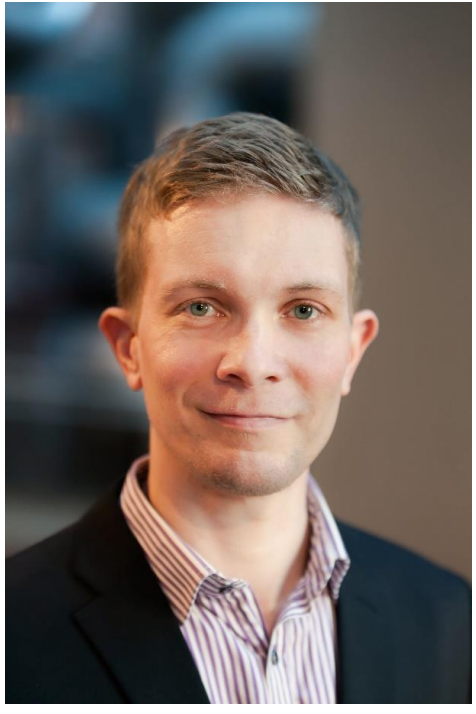
$$\sum_{k \in W} x_{ik} \leq p_i + z_i e_i, i \in M \quad (1)$$

$$\sum_{i \in M} x_{ik} = \sum_{j \in C} y_{kj}, k \in W \quad (2)$$

$$\sum_{k \in W} y_{kj} = d_j, j \in C \quad (3)$$

$$x_{ik} \geq 0, i \in M, k \in W$$
$$y_{kj} \geq 0, k \in W, j \in C$$
$$z_i \in \{0,1\}, i \in M$$

Introduction



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Research interests: prescriptive analytics, decision analysis, mathematical models for decision support

Examples of application areas: Environmental decision making, R&D portfolio selection, infrastructure asset management, planning, procurement, foresight, strategy building

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Learning Outcomes

- The fundamental aim of Business Analytics is utilizing analytical models to help make better business decisions. This course focuses on optimization models that are commonly used in business applications. After the course, the student can
  1. recognize the types of real-life business decision problems where use of the models brings added value
  2. interpret results of these models to derive defensible decision recommendations, and
  3. build and solve these models using relevant software to support business decision making.

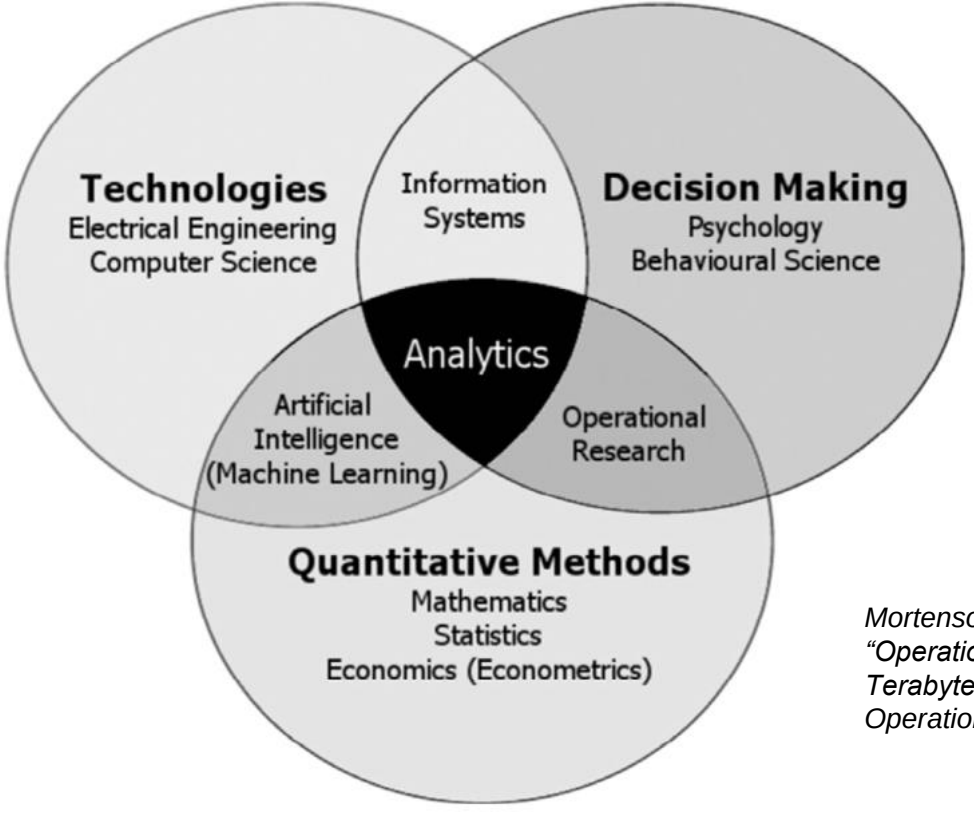
Scientific roots of Business Analytics

Business Analytics (BA) is the scientific process of transforming data into insight for making better decisions

Management science (MS) is the study of problem solving & decision making in organizations. It uses analytical methods including mathematical modelling to improve an organization's ability to enact rational and accurate management decisions by arriving at optimal solutions to complex decision problems.

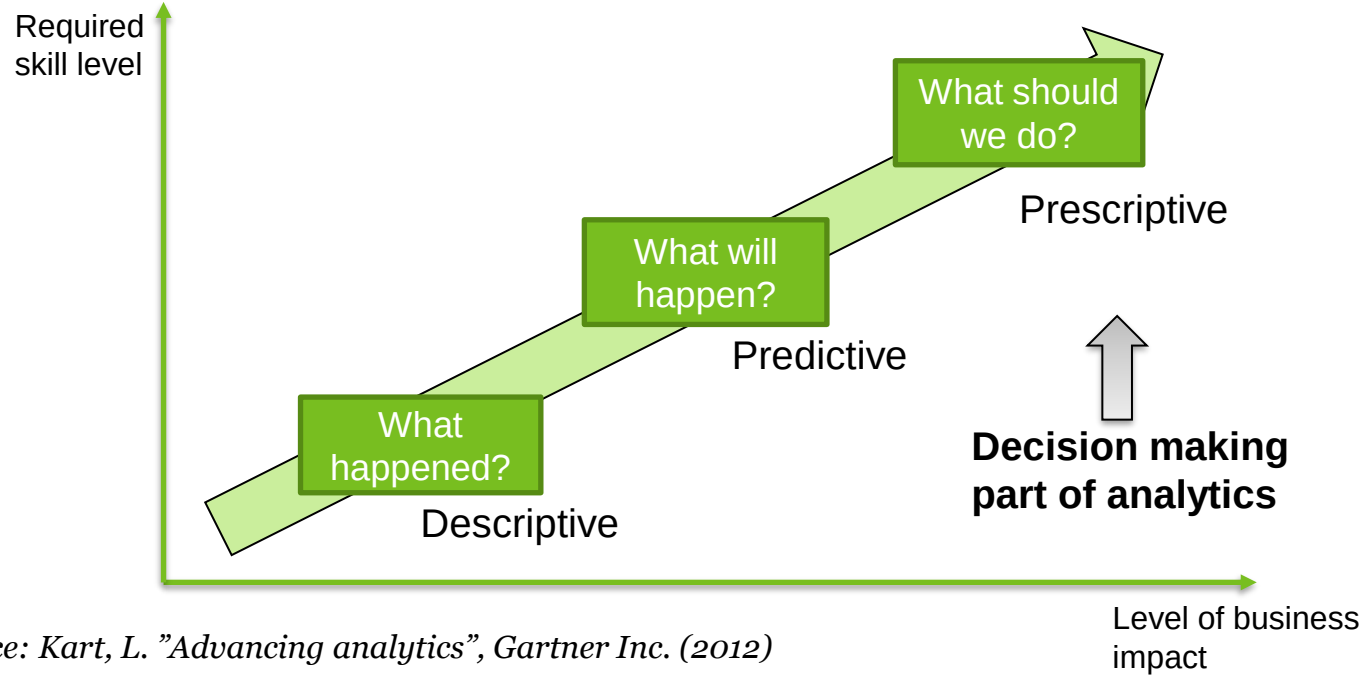
Operations research (OR) is the application of scientific & mathematical methods to the study & analysis of problems involving complex systems.

Scientific roots of Business Analytics



Mortenson, Doherty, Robinson (2015). "Operational research from Taylorism to Terabytes", European Journal of Operational Research

Levels of Business Analytics



Source: Kart, L. "Advancing analytics", Gartner Inc. (2012)

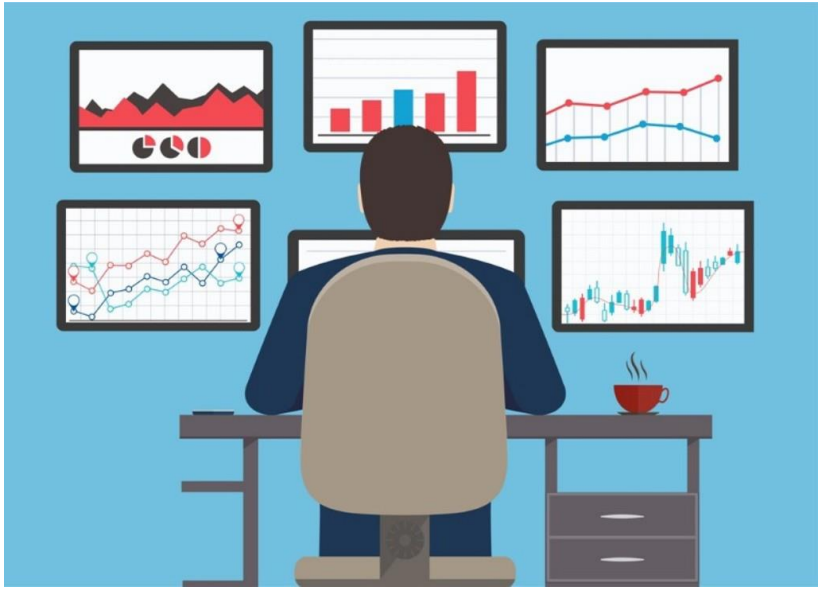
Descriptive Analytics

”What has happened?”

Methods:

- Data bases
- Reporting
- Statistics
- Data mining

Introduction to data analytics
Introduction to statistics
Data Science for Business 1



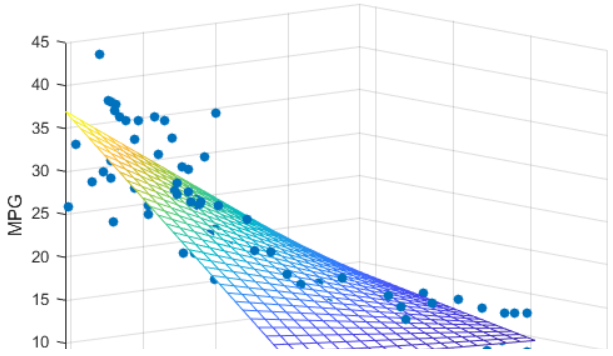
Predictive Analytics

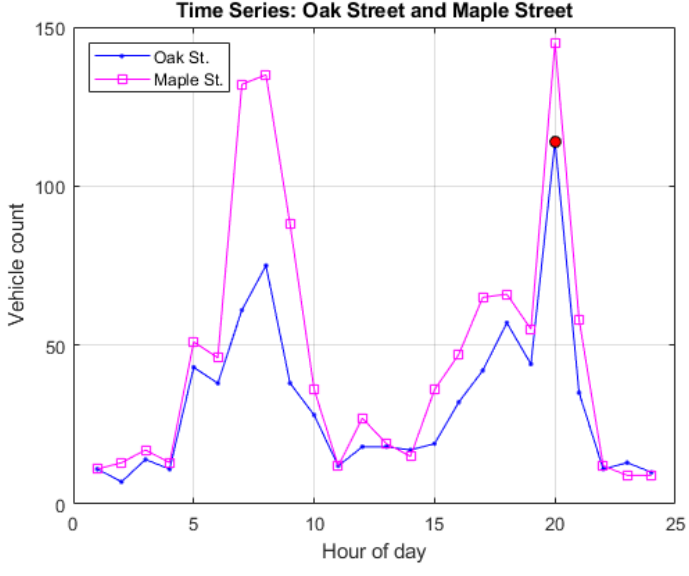
”What will happen?”

Methods:

- Regression models
- Time-series models
- Machine learning

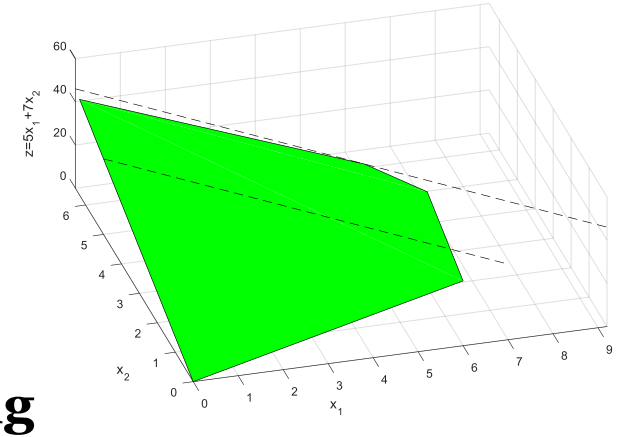
Introduction to data analytics
Introduction to statistics
Advanced course in statistics and data analytics
Data Science for Business 1
Predictive Analytics
Data Science for Business 2





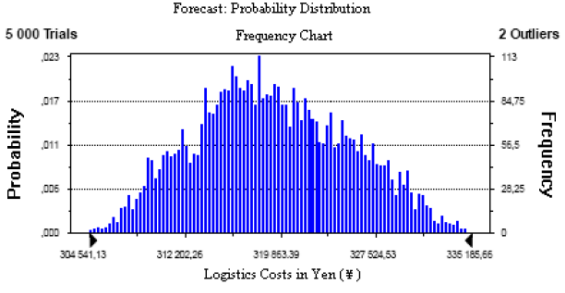
Prescriptive Analytics

"What should we do?"

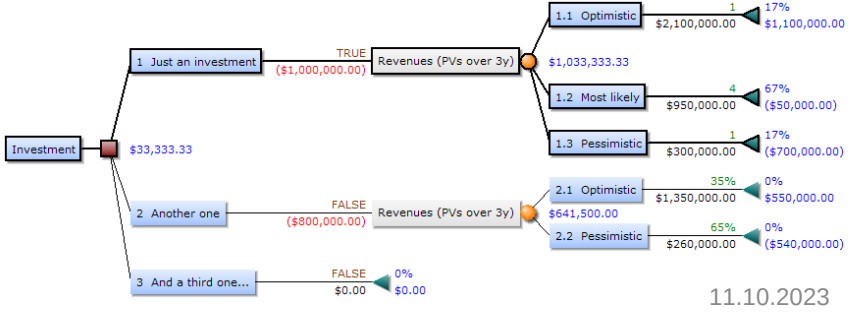


Methods:

- **Mathematical optimization / programming**
- Monte Carlo simulation
- Decision Analysis



Business Analytics 1
Business Analytics 2
Decision Making and Choice Behavior
Data Science for Business 2



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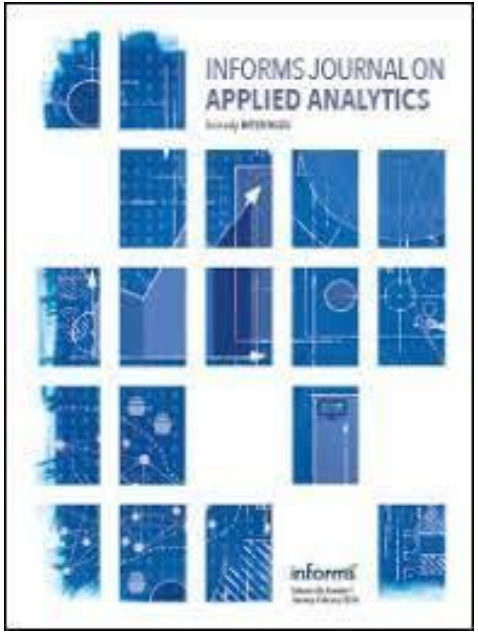
Impact of BA / MS applications: Example

Optimizing Chevron's Refineries

Kutz et al 2013, Interfaces

Chevron has developed a software modeling tool that its seven company-owned refineries use to select the most profitable raw materials, evaluate product options, optimize refinery processes, and promote efficient capital investments. The tool is a linear program with distributive recursion mathematics, which Chevron uses in operations and strategic planning. Over the past 30-plus years, the company has continually improved this application of operations research, and its complementary and supporting systems and business processes, and they are now deeply embedded into the fabric of Chevron's downstream business of reliably and efficiently supplying products to our customers. The value that these efforts bring to Chevron now approaches $1 billion annually. We estimate that the cumulative value to Chevron over the past three decades is approximately $10 billion.



More BA/MS applications at https://pubsonline.informs.org/journal/ijaa

Practicalities

Sessions & Assignments (details on MyCourses)

- 3h teaching on Mondays & Wednesdays (9:15-12:00)
  - of which about 1h is used on the assignments
- Three Assignments (A1-A3), each of which includes
  1. MyCourses Quiz (multiple tries)
  2. 4-6 spreadsheet problems returned in a single file
     (Model solutions presented after DL, they will not be published)

Week	Topics	Monday	Tuesday	Wednesday		Friday	Sunday
43	Introduction, Linear programming (LP), Applications	Lecture Exercise: A1		Lecture Exercise: A1			
44	LP Sensitivity Analysis	Lecture Exercise: A1		Lecture Exercise: A1			5.11. Deadline A1
45	Distribution and network applications of LP	Lecture Exercise: A2 Model solutions A1		Lecture Exercise: A2			
46	Mixed-Integer Linear Programming (MILP)	Lecture Exercise: A2		Lecture Exercise: A2			19.11. Deadline A2
47	Non-linear Programming (NLP), Modelling uncertainties, Multi-objective programming (MOP)	Lecture Exercise: A3 Model solutions A2		Lecture Exercise: A3			
48	Guest lecturer from business, course summary	Lecture Exercise: A3	28.11 Deadline A3	Lecture Model solutions A3			
49	Exam week					8.12. Exam	

29.1.2024 2nd exam requiring SISU registration

Grading: 50% exam, 50% assignments

- Exam
  - Modelling problems (cf. spreadsheet assignments)
  - Theory and terminology related questions (cf. quizzes and lecture slides)

- Some room for mistakes in the assignments:

$$\underbrace{\text{final pts}}_{\in [0,101]} = 0.5 \times \min(\underbrace{\text{assign. pts}}_{\in [0,112]}, 100) + 0.5 \times \underbrace{\text{exam pts}}_{\in [0,100]} + \underbrace{\text{feedback pts}}_{\in \{0,1\}}$$

- Lower bounds for grades (possibly relaxed during final grading):
  1. 50 final points
  2. 60 final points
  3. 70 final points
  4. 80 final points
  5. 90 final points

In addition, at least half of the exam points required to pass

General

Announcements

General discussion on assignments

Materials

Assignments

Assignment 1: Quiz

Assignment 1: Spreadsheets

Assignment 2: Quiz

Assignment 2: Spreadsheets

Assignment 3: Quiz

To see the general instructions click “Assignments” before clicking “Assignment X: YYYY”

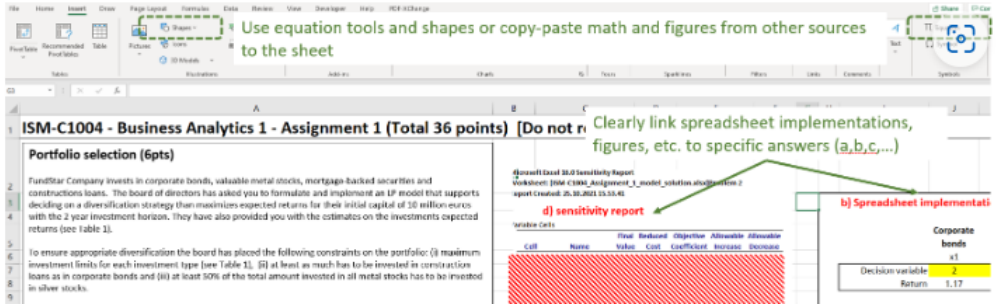
course grade as follows: >50p->1, >60p->2, >70p->3, >80p->4, and >90p->5, with the exception that at least half of the *exam_points* are required to pass. These bounds maybe relaxed during final grading.

Plagiarism

Assignments are individual work. You may discuss the problems with your colleagues, but you must return individual answers. Returning a copied answer or solution is strictly forbidden. Remember that in the exam you will need to individually solve equivalent problems. Cases of plagiarism will be handed over to the study office.

Returning a spreadsheet assignment to MyCourses

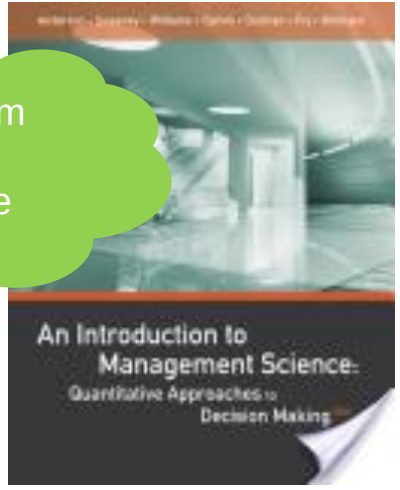
Return the original spreadsheet as a single .xlsx Workbook file. Use one sheet for each problem. Make sure that each sheet includes active formulas (not just numerical values), and that the solver is set up properly (objective, variable cells, constrains, etc.). Verbal answers, explanations and math formulation must presented in the slots reserved for them (see the figure below). Once you have submitted your xlsx-file, download it and open it in excel to make sure that it works: A non-working xlsx file will result in zero points.

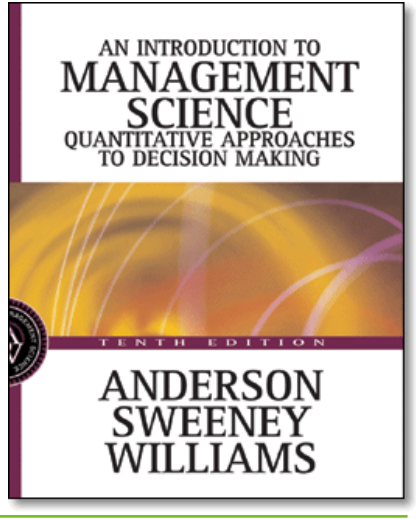


Material

- Lecture slides, example spreadsheet
- Assignments (spreadsheets, quizzes)
- Textbook
  - An Introduction to Management Science: Quantitative Approach to Decision Making
    - By Anderson, Sweeney and Williams
  - Any edition will serve as additional course material
  - Will be used also on Business Decision 2 -course

Need more problem examples? The course book is the answer!





Edition	Regular Loans	Place to find	Short Loans	Place to find	Not for Loans	Place to find
13	6	Learning Center	1	Learning Center	1	Töölö Rooftop
11	8	Learning Center	1	Learning Center	1	Töölö Rooftop
10	2	Learning Center/Tuo	0	N/A	0	N/A
9	1	Learning Center	0	N/A	0	N/A

About the chosen course structure

- Learning by doing is the best (and perhaps the only) way to learn mathematical modelling

→ Large weight on assignments in grading

  - Solving assignments with your fellow students is a much better simulation of the real-life problem-solving environment than an exam
  - Purpose of the exam is mainly to check that individual skills exist to solve problems

- Why exactly 3 assignment batches? We are balancing between
  - 1 big batch of assignments, 1 deadline:
    - Maximum flexibility for student to schedule his/her work over the six weeks
  - 12 small assignment batches, 12 deadlines:
    - Maximal incentive to solve assignments at the tempo of the course

What is expected from students?

- Allocate time to work on the assignments
  - Huge synergy with the exam
  - If stuck
    - Consult the lecture slides, spreadsheet examples and the course book (contains a lot of examples)
    - Ask the teachers & fellow students: Sessions, MyCourses general discussion
  - Make sure that you understand the errors you made in the assignments and how to correct them
    - Model solutions will be presented (not published) after each assignment deadline
    - Ask the teachers if necessary

Receiving feedback on learning

1. Instant feedback in quiz-assignments
2. Grading of spreadsheet assignments (3 times)
3. Model solutions (3 times)
4. Discussions (12 sessions)
5. Help with assignments (12 sessions)

Opportunities for feedback are available, so please make use of them!