# Assignment 2

Deadline: 8th April 2019, 23:59h

## Exercise - Robust Optimization 2

Assume the following program (1a) - (1f) based on a version of the production example from the exercise on Robust Optimization (19-03-2019). The nomenclature can be found in Table 1.

The goal is to find the capacity setting with minimum cost while fulfilling the demand $d_p$ of each product $p$. Therefore, we have to decide how many machines of each machine type $m$, we are going to to install ($y_m$). However, the production time $t_{p,m}$ of product $p$ on machine type $m$ is uncertain.

$$\min \sum_{m \in M} \left[ c_m^M y_m + \sum_{p \in P} c_p^P x_{p,m} \right] \tag{1a}$$

$$s.t. \sum_{m \in M} x_{p,m} \geq d_p \qquad \forall p \in P \tag{1b}$$

$$\sum_{p \in P} \tilde{t}_{p,m} x_{p,m} \leq T_m y_m \qquad \forall m \in M, \tilde{t}_{p,m} \in [\bar{t}_{p,m} - t_{p,m}, \bar{t}_{p,m} + t_{p,m}] \tag{1c}$$

$$x_{p,m} \leq BigM_{m,p} a_{p,m} y_m \qquad \forall m \in M, p \in P \tag{1d}$$

$$y_m \geq 0 \text{ and integer} \qquad \forall m \in M \tag{1e}$$

$$x_{p,m} \geq 0 \qquad \forall m \in M, p \in P \tag{1f}$$

where $\tilde{t}_{p,m}$ represents the uncertain production time and $BigM_{m,p}$ a large enough constant (here: $\frac{T_m}{\bar{t}_{p,m} - t_{p,m}}$).
The objective function (1a) minimizes the cost for installing machines and the expected production cost.

The task is to introduce an artificial full recourse in the form of a Linear Decision Rule (**LDR**) to the robust optimization problem (1a) - (1f). Solve the model for different values of the penalty term $J = 20$, $J = 100$, $J = 150$, $J = 200$, $J = 300$, $J = 500$ and $J = 1000$.

Solve your robust model with GAMS using the file `robust_model.gms` which already has some data input.

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| **Sets** | |
| $\mathcal{M}$ | Machine types $m \in \mathcal{M}$ |
| $\mathcal{P}$ | Product types $p \in \mathcal{P}$ |
| $\mathcal{S}$ | Scenarios $s \in \mathcal{S}$ |
| **Parameters** | |
| $\pi_s$ | Probability of scenario $s \in \mathcal{S}$ |
| $C_m^{\text{Mach}}$ | Cost for one machine of type $m \in \mathcal{M}$ |
| $C_p^{\text{Prod}}$ | Production cost for product type $p \in \mathcal{P}$ |
| $D_p$ | Demand of product $p \in \mathcal{P}$ |
| $\overline{M}$ | Maximum number of machines in factory |
| $T_m$ | Production time available one machine of type $m \in \mathcal{M}$ |
| $A_{p,m}$ | Binary parameter, 1 = product $p \in \mathcal{P}$ can be produced on machine type $m \in \mathcal{M}$, 0 = otherwise |
| $t_{p,m}$ | Production time for one unit of product type$p \in \mathcal{P}$ on machine type $t$ |
| **Variables** | |
| $y_m$ | Number of machines of type $m \in \mathcal{M}$ |
| $x_{p,m}$ | Production amount of product $p \in \mathcal{P}$ on machine type $m \in \mathcal{M}$ |

Table 1: Nomenclature for Task 1