

## Assignment 4

Your company has a research and development budget of 70 thousand euros and 8 R&D projects proposals. Your boss wants you to present him the Pareto-optimal project portfolios with regard to the objectives of minimizing risk (variance) and maximization of expected return of the portfolio. The returns of the projects are assumed independent. The expected returns ( $\mu_j$ ), standard deviations ( $\sigma_j$ ) and costs of the projects (in thousands of euros) are:

Project	1	2	3	4	5	6	7	8
$\mu_j$	30	70	40	20	25	45	30	25
$\sigma_j$	15	10	5	10	10	10	10	5
Cost	25	50	30	10	20	30	25	15

a) Formulate the binary MOLP model.

b) Find and report all Pareto-optimal portfolios. Report the number of feasible portfolios (portfolios that satisfy the budget constraint) as well. Hint: Use Matlab and total enumeration of all possible portfolios  $p$  (binary vectors in 8 dimensions) identify feasible ones and finally Pareto-optimal portfolios. One possible code for total enumeration based on the binary presentation on integers  $0, 1, \dots, 2^8 - 1$ :

```

for i=0:(28 - 1)
    p=zeros(8,1);
    s=i;
    for j=8:-1:1
        if s/2j-1 ≥ 1
            s=s-2j-1;
            p(j)=1;
        end
    end
    p
end

```

- c) Your co-worker suggests that you could use the weighting method and linear integer programming to find Pareto-optimal portfolios. Find out which of the Pareto-optimal portfolios can be found with the weighting method.
- d) Present the Pareto-optimal portfolios in the objective space of expected return and variance. Highlight those that can be found with the weighting method.