Assignment 2 - Group 4

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Exercise 2.1

Exercise 2.1.a

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Exercise 2.1.b

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Exercise 2.1.c

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Exercise 2.1.d

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Exercise 2.2

Exercise 2.2.a

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Exercise 2.2.b

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Exercise 2.2.c

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Exercise 2.3

Exercise 2.3.a

The decision variables for this optimization problem are defined as quantities of the following products:

$x_1 = Carrots; x_2 = Potatos; x_3 = Bread; x_4 = Cheese; x_5 = PeanutButter$

Each product has the corresponding nutritional values: $calories_i; fat_i; protein_i; carbs_i$ These nutritional values are used to define the decision variables below:

1. $(\sum_{i=1}^{n=5} calories_i * x_i) \geq 2000$
2. $(\sum_{i=1}^{n=5} fat_i * x_i) \geq 50$
3. $(\sum_{i=1}^{n=5} protein_i * x_i) \geq 250$
4. $(\sum_{i=1}^{n=5} carbs_i * x_i) \geq 200$

Objective is to minimize the prize:

$min(\sum_{i=1}^{n=5} price_i * x_i)$

The cheapest diet that fulfills these constraints consists out of 7.72 servings of potatoes and 9.28 servings of peanut butter, and has a prize of 2.32 per serving.

Exercise 2.3.b

Increasing the price of peanut butter to 0.25cents after 5 quantities can be formulated as a peanut butter tax of 0.10cents. For that, we first add a binary constraint to the problem definition:

$$y = \begin{cases} 1 & \text{if } x_5 > 5 \\ 0 & \text{else} \end{cases}$$

And the objective incorporates binary variable y to add a peanut butter tax to the calculation as follows:

$min((\sum_{i=1}^{n=5} price_i * x_i) + 0.1y(x_5 - 5))$

Solving this problem in Excel, yields the result that peanut butter is used 5 times and potatoes 16.62 times in the cheapest diet that fulfills all nutritional constraints and will costs 2.75€ per serving. Here we can see, that peanut butter does not become a profitable item once the peanut butter tax has been introduced, but the price increases nevertheless by 0.43 cents due to the increased use of potatoes in the diet.

Exercise 2.3.c

Using an ILO model, we add the constraint of using no fractions when calculating the cheapest diet to the existing constraints from 2.3.a. The cheapest diet consists out of 9 servings of potatoes and 9 servings of peanut butter, and has a prize of 2.43 per serving. More potatos are now required to compensate for the rounded down amount of peanut butter servings.

Exercise 2.4

Exercise 2.4.a

The transportation problem was solved using a LO Model. The cheapest transportation plan that fulfills all demand and respects available supplies costs 460€

Constraints are defined as:

1. $x_{11} + x_{12} + x_{13} + x_{14} \leq 20$
2. $x_{21} + x_{22} + x_{23} + x_{24} \leq 25$
3. $x_{31} + x_{32} + x_{33} + x_{34} \leq 15$
4. $x_{11} + x_{21} + x_{31} \geq 10$
5. $x_{12} + x_{22} + x_{32} \geq 15$
6. $x_{13} + x_{23} + x_{33} \geq 15$
7. $x_{14} + x_{24} + x_{34} \geq 20$
8. $x_{ij} \geq 0, i = 1, 2, 3, j = 1, 2, 3, 4$

Objective is to find the cheapest transportation plan, such that:

$min(10x_{11} + 0x12 + 20x13 + 11x14$
$+ 12x21 + 7x22 + 9x23 + 20x24$
$+ 0x31 + 14x32 + 16x33 + 18x34)$

or

$$min \sum_{i=1}^{n=3} \sum_{j=1}^{m=4} Cost_{ij} * x_{ij}$$

TODO add quantities (from Solver Report or so)

Exercise 2.4.b

Each transportation edge has an initial cost of 100.

For this we will use the same constraints as in 2.4.a plus a decision contraint:

$$y_{ij} = \begin{cases} 1 & \text{if } x_{ij} > 0 \\ 0 & \text{else} \end{cases}$$

The objective stays also the same but also incorporates the additional cost for transporting goods from a source to a destination.

$min \sum_{i=1}^{n=3} \sum_{j=1}^{m=4} Cost_{ij} x_{ij} + 100 y_{ij}$

where y_{ij} is a binary decision variable whether edge x_{ij} has been used or not and adds the additional cost respectively.

With these fixed costs, the cheapest price for the transportation of all goods to the requested destinations is 1060€

Exercise 2.5

Exercise 2.5.a

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Exercise 2.5.b

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