

Hand-in Assignment 1

Abstract

This hand-in assignment concerns solving each task and design linear models to describe the real systems presented in the relative sections. The models have to be then implemented and solved using Gurobi (all but task VI). Results have to be presented in the form of a short written report (max 6 pages).

N.B. only linear constraints are allowed!!! (e.g. no using Gurobi commands to model logical relations between the decision variables)

Task I: The FIAT-Chrysler case

On the top floor of the Italian head quarter *Lingotto (Torino)*, the production manager is trying to figure out how many cars have to be produced in the coming year. He is responsible for four models: three of them (*Fiat Panda*, *Lancia Musa* and *Alfa Romeo Giulia*, respectively made in the plants of *Mirafiori*, *Melfi* and *Cassino*) are produced in Italy, while the *Fiat 500* is currently manufactured in *Tychy*, Poland.

The manager obviously wants to maximize the profit for his company and this year he has been given a budget of **40 billion** Swedish crowns (why not euros...nobody knows, Mr Agnelli is an eccentric old man). Given the investment cost to build the plants, he has to produce a minimum number of cars in each of them to payback the initial expense. Also, he has to consider the different taxation imposed on each car model, the average salary to pay to the plant employees, the cost of the raw and half-processed material and the man-hours required to make each car. Also, due to marketing reasons, only **300.000** models can be produced between **Panda and Musa** (combined).

All the above-mentioned data is reported in the following table:

Plants	Mirafiori	Tychy	Melfi	Cassino
Model	Panda	500	Musa	Giulia
Tax (%)**	30	15	20	30
Price (thousands Kr)	106	136	150	427
Material Cost (%)*	57	60	55	45
Salary (Kr/month)	20000	11000	20000	26000
Manhour (h)	40	45	38	100
Min-Prod.	120000	100000	80000	15000

*to be taken as the percentage of the price

*taxation applies to the net income

Assuming that:

- each employee works 160 hours per month,
- the price is standard throughout the continent
- there are no delivery costs

design a linear program to schedule the production for the coming year such that the net income for the company is maximized. Comment on the results you get. Then try to increase\decrease the values of Budget, taxes and salary. How much can you change them before the optimal solution changes?

Task II: The Global Market

Based on the previous calculations, the manager now wants to design a more realistic model, taking into account the cost to ship the cars to other countries: he is in charge of the Swedish, Italian and Polish market in Europe and the delivery overseas to a main sale point in the US. As long as cars have to be delivered within the Schengen borders, no additional taxation is applied, while delivering to the States involves an export tax of 2.5% on the car final price. Also, the sales manager of each selling point presented the aggregated demand for their area, therefore, he has to send them **at least as many cars as they ask for**. Finally, the selling price now is different, depending on the country the car is sold in. Finally, there is **no export of Musa to the US** and **no export of Giulia to Poland**.

The following table sums up the data regarding each car and each market:

	Panda			500			Musa			Giulia		
	DI	Price	Dm	DI	Price	Dm	DI	Price	Dm	DI	Price	Dm
Poland	800	86k	75k	/	92k	20k	12k	100k	10k	/	/	/
Italy	/	106k	35k	1000	136k	40k	/	150k	80k	/	427k	8k
US	3500	150k	40k	2800	170k	50k	/	/	/	5000	550k	3k
Sweden	2000	112k	2k	1600	150k	5k	2200	170k	1k	2500	500k	1k

DI = delivery cost, Dm = demand

Formulate the linear program to calculate the new production data and the destination market of each car.

(do not take into account the restriction about the combined amount of Musa and Panda to sell)

Task III: Multi-line production

Fiat is buying the foam for the cars' seats from a supplier that makes them by mixing three components that can be processed on four different production lines (one unit of foam requires one unit of each of the three components). Each line can only work for a limited amount of time and has a different production rate (in terms of component units processed per hour), as shown in the following table:

Line	Capacity (hours)	Production Rate (units/hour)		
		Component 1	Component 2	Component 3
1	100	10	15	5
2	150	15	10	5
3	80	20	5	10
4	200	10	15	20

Determine the number of hours that each line will process each component in order to maximize the quantity of foam produced (mixing the components is done separately and it is not included in the calculations for the task).

Task IV: Retailers Localization

Fiat has decided to allocate part of last year's revenues W into opening some new retailers in Puglia. Preliminary studies helped find a set of possible locations I . Opening a retailer at the location i comes with a fixed cost F_i (purchase the land, pay administrative costs,...) and a variable cost C_i based on the retailer size, measured in hundreds of square meters. For each location the retailer centre has a minimum size L_i and maximum one U_i . Once it is open, each retailer is expected to produce revenues R_i based on its size (again measured in hundreds of square meters). Determine the set of locations to open new retail centres and their size in order to **maximize the revenues**, keeping in mind that not more than K centres can be open.

***In this task no actual data is given, therefore the model has to be formulated as a function of the given sets and parameters. ***

Task V: Investments optimization

It has been a very fruitful year for FIAT and the board of Directors decides to invest part of the revenue in a portfolio of debt securities. The budget intended for the investment is **1 billion** crowns. The pool of experts has restricted the list of potential good investments down to five, presented in the following table:

Name	Type	Moody's Rating	Duration	Revenue
A	Private	Aa	9	4.5%
B	Public	A	15	5.4%
C	Government	Aaa	4	5.1%
D	Government	Baa	3	4.4%
E	Private	Ba	2	6.1%

The board approves the choice but has some requirements about it:

- At least **40%** of the budget must be invested in **government or public** funds;
- The average duration of the investment has to be shorter than **5 years**;
- Given the following conversion rate, the average investment risk has to be smaller than **1.5**:
(Aaa = 1, Aa = 2, A = 3, Baa = 4 e Ba = 5)

Also, the taxation on the government investment is **30%** and due to the market rules, the following restrictions apply to the investments:

- Investments **C and D** are **mutually exclusive**;
- It is possible to invest in **E** only if more than **1 million** crowns are invested in **A**.