IE363 - LOGISTICS MANAGEMENT HOMEWORK 1 :

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Question 1

- Parameters:
- I Set of potential Office locations. i ∈ {LA,Tulsa,Denver,Seattle}
- J Set of client states. j ∈ {Washington, Oregon, …,Oklahoma}

Variable	Type	Description
Yi	Binary (∈{0,1})	1 if office i is opened, 0 otherwise.
Xij	Continuous (≥0)	Number of annual trips made from office i to state j.
Ai	Integer (≥0)	Number of consultants assigned to office i.
Parameter	Description	
Fi	Annual fixed cost of locating office i.	
Cij	Travel cost from office i to state j for one trip.	
Dj	Annual demand (required trips) to state j.	
K	Maximum annual trip capacity per consultant.	
M	A large number (e.g., M=1,000,000).	

- Objective Function:

$$\text{Minimize } Z = \left(\sum_{i \in I} F_i \cdot Y_i\right) + \left(\sum_{i \in I} \sum_{j \in J} C_{ij} \cdot X_{ij}\right)$$

- Constraints:

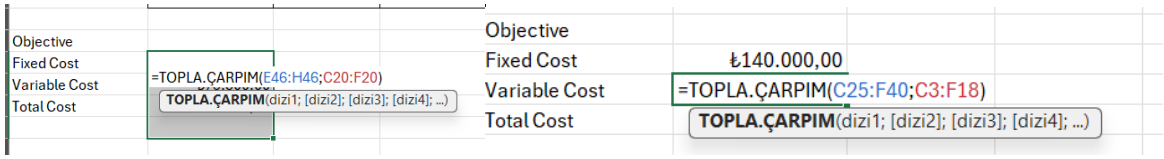
$$\sum_{i \in I} X_{ij} = D_j \quad \forall j \in J$$

$$\sum_{j \in J} X_{ij} \leq M \cdot Y_i \quad \forall i \in I$$

$$\sum_{j \in J} X_{ij} \leq K \cdot A_i \quad \forall i \in I$$

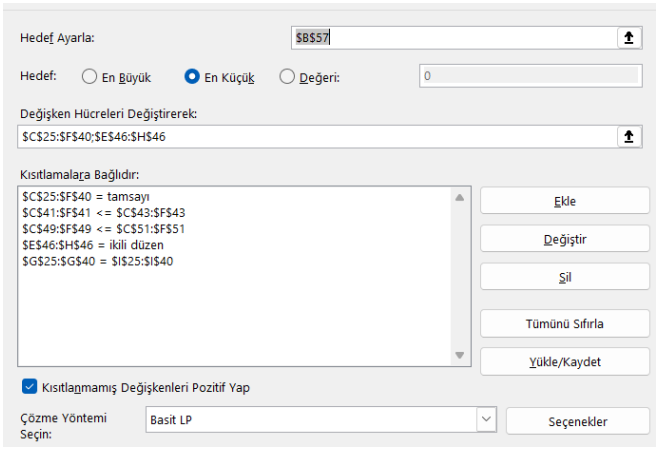
$$
\begin{aligned}
Y_i &\in \{0,1\} && \forall i \in I \\
X_{ij} &\geq 0 && \forall i \in I, j \in J \\
A_i &\geq 0 \text{ and Integer} && \forall i \in I
\end{aligned}
$$

a) The optimization problem required for option a) of the question was formulated and solved using three tables in the Ms-Excel programme. After entering the necessary variables into the table;



The total fixed costs were calculated by multiplying the fixed costs of the offices by the open/closed column of the office, depending on whether they were open or closed in the optimal solution. Subsequently, the travel costs to be incurred within the demand constraints were multiplied by the values corresponding to the optimal travel conditions in the second table using the above function, and the sum was calculated.

The capacity was set to 1 million based on the Big M rule.



Variable cells have been added by solving with simple LP. Considering that the variable cells are integers and the opening or closing status of the offices, they have been added as binary variables.

Capacity	1000000	1000000	1000000

Open or Not Open 4 possible locations	LA
	0

Constraints			
Total	0	0	675
	<=	<=	<=
Capacity	=C43*E46	0	1000000

Furthermore, the variable determining whether the office will open or not based on capacity has been created by selecting the relevant columns provided in the file. The total cost for option A is set at ₺219,500.00, and according to the optimal solution, only the Denver office should be opened.

Open or Not Open 4 possible locations	LA	Tulsa	Denver	Seattle
	0	0	1	0

b) Capacity restrictions have been imposed in option b) of the problem, limiting it to only 10 employees and a maximum of 25 travel rights, therefore the capacity is updated to 250. The solver is run again.

	<=	<=	<=	<=
Capacity	250	250	250	250

Objective	
Fixed Cost	₺416.230,00
Variable Cost	₺62.500,00
Total Cost	₺478.730,00

Open or Not Open 4 possible locations	LA	Tulsa	Denver	Seattle
	0	1	1	1

Additionally, the Tulsa, Denver, and Seattle offices will open after this restriction, and the total cost will increase.

c) All consultancy projects originating from a single state will have to be handled by a single office, so the solver table is updated from top to bottom and all demand is directed to a single office depending on whether the office is open or not. This is not a good solution due to single-source dependency. The solver result updates to 493,355.00 and presents a rather costly solution.

Question 2

The objective is to minimize the total cost of the production and distribution network (including fixed, variable production, transport and customs duties) for both Sleekfon and Sturdyfon separately, and as a single company after the merger, in order to meet specific market demands.

Key Cost Components:

1. **Fixed Facility Costs**: Annual cost of operating the facility.

2. **Variable Production Costs:** Cost per unit produced.

3. **Transportation Costs:** Cost of moving units from the production facility to the market.

4. **Customs Duties:** Import duty levied at a rate of 25% on the sum of the fixed cost per unit capacity, variable production cost, and transportation cost for shipments from one region to another.

Variable	Description
Xij	Quantity (in million units) shipped from plant i∈I to market j∈J.
Yis	1 if plant i∈I is operated at status s∈S; 0 otherwise.
Dj	Annual demand of market j.
Cij	Total unit variable cost (Production + Transport + Duty) from plant i to market j.
Fis	Annual fixed cost (in million $) of plant i if operated at status s.
Kis	Production capacity (in million units) of plant i if operated at status s.

$$\min \left(\sum_{i \in I} \sum_{j \in J} X_{ij} \cdot C_{ij} \right) + \left(\sum_{i \in I} \sum_{s \in S} F_{is} \cdot Y_{is} \right)$$

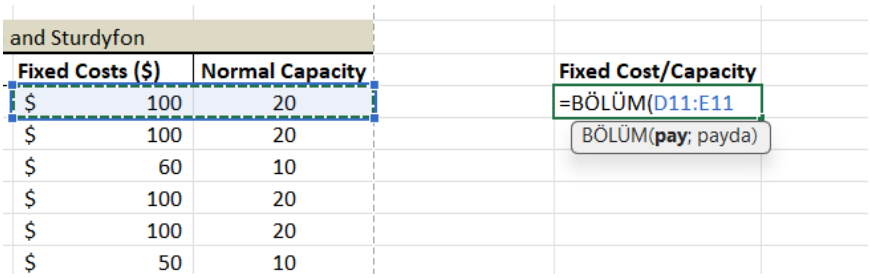
$$\sum_{s \in S} Y_{is} = 1 \quad \forall i \in I$$

$$\sum_{j \in J} X_{ij} \leq \sum_{s \in S} K_{is} \cdot Y_{is} \quad \forall i \in I \qquad \sum_{i \in I} X_{ij} = D_j \quad \forall j \in J$$

$$X_{ij} \geq 0 \quad \forall i \in I, j \in J$$

$$Y_{is} \in \{0, 1\} \quad \forall i \in I, s \in S$$

Before starting the question, total unit cost inputs must be created. A fixed cost capacity ratio must be created for the addition of customs duties.



and Sturdyfon		
Fixed Costs ($)	**Normal Capacity**	
$ 100	20	
$ 100	20	
$ 60	10	
$ 100	20	
$ 100	20	
$ 50	10	

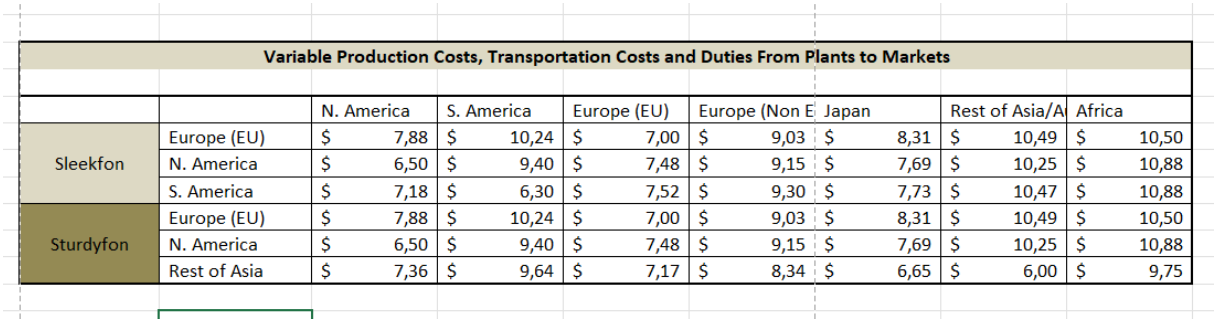
Fixed Cost/Capacity
=BÖLÜM(D11:E11

BÖLÜM(**pay**; payda)

Subsequently, a total unit cost matrix is created.

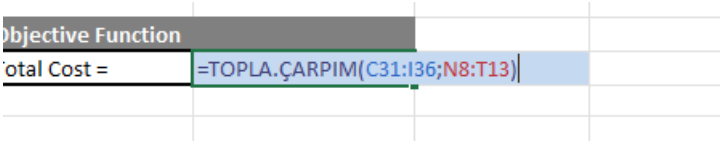
$$C_{ij} = \text{VPC}_i + \text{TC}_{ij} + \left(\text{Import Duty Rate}_j \times (\text{F/K}_i + \text{VPC}_i + \text{TC}_{ij})\right)$$

Global customs rates are indicated in the first table. A product consists of three main costs: the first is the production cost, the second is the transport cost, and the customs cost given in the question is added to these. The customs cost is calculated differently in the question. The formula is provided above. Based on this data, the total unit costs given in the question are provided in the table below.



Variable Production Costs, Transportation Costs and Duties From Plants to Markets								
		N. America	S. America	Europe (EU)	Europe (Non E	Japan	Rest of Asia/A	Africa
Sleekfon	Europe (EU)	$ 7,88	$ 10,24	$ 7,00	$ 9,03	$ 8,31	$ 10,49	$ 10,50
	N. America	$ 6,50	$ 9,40	$ 7,48	$ 9,15	$ 7,69	$ 10,25	$ 10,88
	S. America	$ 7,18	$ 6,30	$ 7,52	$ 9,30	$ 7,73	$ 10,47	$ 10,88
Sturdyfon	Europe (EU)	$ 7,88	$ 10,24	$ 7,00	$ 9,03	$ 8,31	$ 10,49	$ 10,50
	N. America	$ 6,50	$ 9,40	$ 7,48	$ 9,15	$ 7,69	$ 10,25	$ 10,88
	Rest of Asia	$ 7,36	$ 9,64	$ 7,17	$ 8,34	$ 6,65	$ 6,00	$ 9,75

a) The first question requires Sleekfon and Sturdyfon to be assessed separately. The markets each company will serve must be calculated separately. We calculate the optimal shipment quantities for the lowest cost prior to the merger.



)bjective Function	
otal Cost =	=TOPLA.ÇARPIM(C31:I36;N8:T13)

The total cost is the product of the total cost per unit multiplied by the quantity sent from the production facility. The capacities are then equated with the total quantities of products sent.

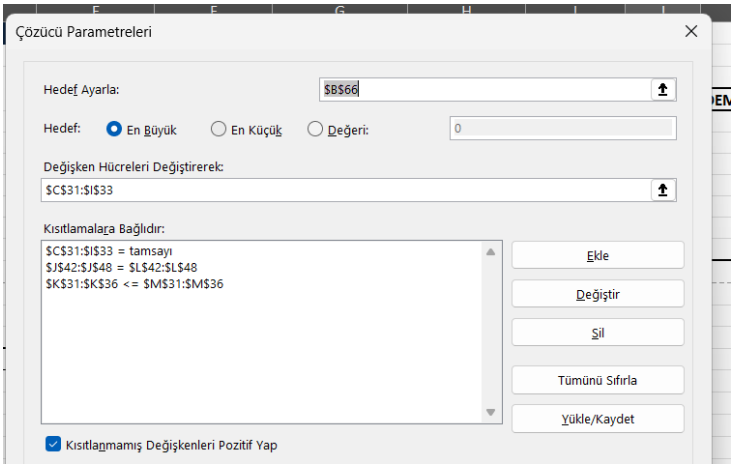
SUM OF PRODUCT		Normal Capacity
=TOPLA(C31;I31)	=	20
0	=	20
0	=	10
0	=	20
0	=	20
0	=	10

PRODUCT ALLOCATION TABLE

		Consumption Region							
Company	Production Region	N America	S America	EU	Non EU	Japan	Asia	Africa	SUI
Sleekfon	EU(1)								=TOP
	N America(1)								
	S America								
Sturdyfon	EU(2)								
	N America(2)								
	Asia								

In option A, separate calculations are performed for each company. For Sleekfon, the variable lines are selected, demand and shipment quantities are equalised, and a capacity limit is added.

The solver parameters have been added as shown in the figure.



The optimal solution for Sleekfon has been found and the total cost and demand have been met. The product total line has been entered with a <= constraint on capacity, and the product total line = demand line constraint has been used in the solver.

63			
64			
65	**Objective Function**		
66	Total Cost =	$	407,08
67			

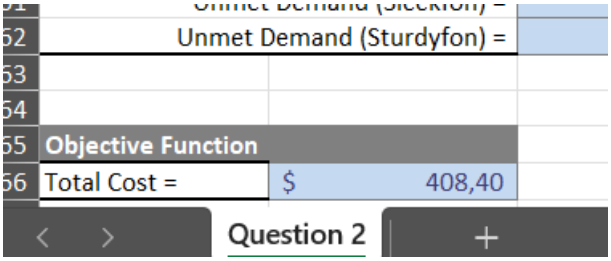
PRODUCT ALLOCATION TABLE

		Consumption Region						
Company	Production Region	N America	S America	EU	Non EU	Japan	Asia	Africa
Sleekfon	EU(1)	10	4	0	2	2	2	0
	N America(1)	0	0	11	0	8	0	1
	S America	0	0	9	1	0	0	0
Sturdyfon	EU(2)							
	N America(2)							
	Asia							

SUM OF PRODUCT		Normal Capacity
20	=	20
20	=	20
10	=	10
0	=	20
0	=	20
0	=	10

TOTAL	DEMAND	SLEEKFON	STURDYFON
10	=	10	12
4	=	4	1
20	=	20	4
3	=	3	8
2	=	2	7
2	=	2	3
1	=	1	1

When the same process is carried out for Sturdyfon;



PRODUCT ALLOCATION TABLE

		Consumption Region						
Company	Production Region	N America	S America	EU	Non EU	Japan	Asia	Africa
Sleekfon	EU(1)							
	N America(1)							
	S America							
Sturdyfon	EU(2)	9	1	0	0	10	0	0
	N America(2)	0	0	4	8	4	3	1
	Asia	3	0	0	0	7	0	0

SUM OF PRODUCT		Normal Capacity
0	=	20
0	=	20
0	=	10
20	=	20
20	=	20
10	=	10

TOTAL	DEMAND	SLEEKFON	STURDYFON
12	=	10	12
1	=	4	1
4	=	20	4
8	=	3	8
7	=	2	7
3	=	2	3
1	=	1	1

The results are obtained in this manner. The units of the calculated costs should be accepted as (M$).

b) This option is a simpler Simplex LP model compared to option A, but the constraints are combined:

Facilities: All 6 facilities (3 Sleekfon, 3 Sturdyfon) are used in a single pool.

Capacity Constraint: All 6 facilities must remain at their original capacity. No facility is downsized or closed.

Demand Constraint: The Total Demand for each market (Sleekfon Demand + Sturdyfon Demand) must be fully met. Combined Demand Quantities are taken.

The solver parameters are expanded to combine the demands of both companies under a common constraint. The solution reached when the constraints are combined is given below.

RODUCT ALLOCATION TABLE

		Consumption Region						
Company	Production Region	N America	S America	EU	Non EU	Japan	Asia	Africa
Sleekfon	EU(1)	11	0	0	0	9	0	0
	N America(1)	0	0	12	0	8	0	0
	S America	0	0	0	5	0	5	0
Sturdyfon	EU(2)	1	5	0	0	14	0	0
	N America(2)	0	0	12	6	0	0	2
	Asia	10	0	0	0	0	0	0

SUM OF PRODUCT		Normal Capacity
20	=	20
20	=	20
10	=	10
20	=	20
20	=	20
10	=	10

TOTAL	DEMAND	SLEEKFON	STURDYFON	SUM OF DEMAND
22	=	10	12	22
5	=	4	1	5
24	=	20	4	24
11	=	3	8	11
9	=	2	7	9
5	=	2	3	5
2	=	1	1	2

Total cost results screen;

Objective Function		
Total Cost =	$	827,04

has been found. Unit (M$)

c) This is a step that adds flexibility to the model and allows us to decide which facilities will remain closed and which will remain open by adding binary variables. New variables are added to the model.

$$\min \sum_{i} \mathbf{F_{is}} \cdot \mathbf{Y_{is}} + \sum_{i} \sum_{j} \mathbf{X_{ij}} \cdot \mathbf{C_{ij}}$$

Depending on the facility's opening status, variables are assigned as closed (0) and open (1).

Objective Function	
Total Cost =	
Variable Cost=	0
Fixed Cost=	=TOPLA.ÇARPIM(C54:F59;C64:F69)

Since all options a and b are open, the fixed cost was not optimized, but in option c, the fixed cost values will change for the values assigned to the binary variables 1 and 0.

	Normal Capacity	Not Open	Bat
=	0		
ÇARPIM(C55;C76)			
=	0		
=	0		
=	0		
=	0		

Capacities are redefined according to binary variables.

SUM OF PRODUCT		Normal Capacity	Not Open	Batches 10M	
0	=	0	0	0	=TOPLA(M31:O31)
0	=	0	0	0	TOPLA(sayı1; [sayı2]
0	=	0	0	0	0
0	=	0	0	0	0
0	=	0	0	0	0

The new capacity values multiplied by the binary variable result are written in place.

SUM OF PRODUCT		Normal Capacity	Not Open	Batches 10M
0	=ÇARPIM(C54;C75)			0
0	=	0	0	0
0	=	0	0	0
0	=	0	0	0
0	=	0	0	0
0	=	0	0	0

In this manner, the cost of flexible capacity values after the merger is calculated as 1056.29 million dollars based on binary variables.