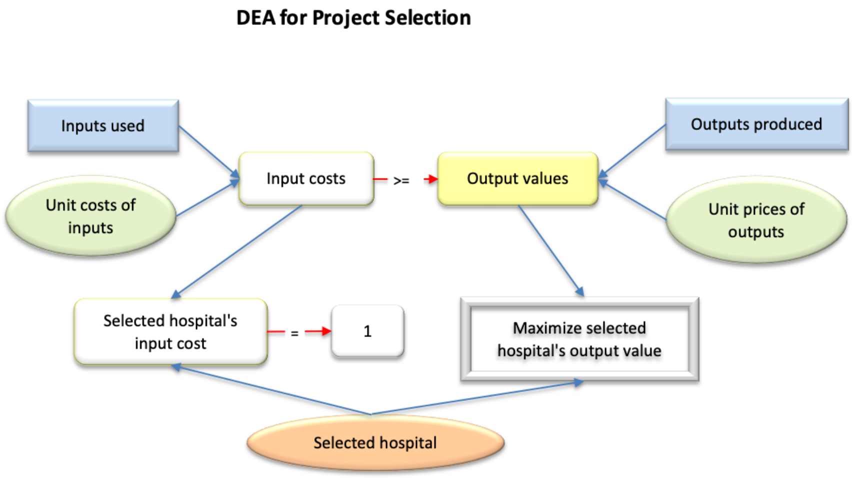
OPERATIONS ANALYTICS REPORT

Module code: BEMM463
Module Name: Operations Analytics
Candidate number:211643

1a.

To run Data Envelopment Analysis, the number of person-days required to prepare each project and computing resource measured as the computer processing unit (CPU) time (in hours) have been used as inputs and expected profit for each project are regarded as outputs. Because the person-days and CPU time are resources a company must have to generate out of project being completed and to earn profits.



The idea is that each Project should look its best. To put it differently, the inputs and outputs should be valued in such a way that one Project compares favourably with the others. For each output and input, the model determines a price per unit as well as a cost per unit. respectively. Then the efficiency of a Project is defined by formulae

Efficiency of project = value of projects output's/ value of projects input's

1b.

Data Envelopment analysis:

A spreadsheet must be designed with all the data relating to all 8 projects. The respective person-days values and CPU time will be inserted under first input column and second input column for each project row respectively. Likewise expected profits from each project will be under output1 column.

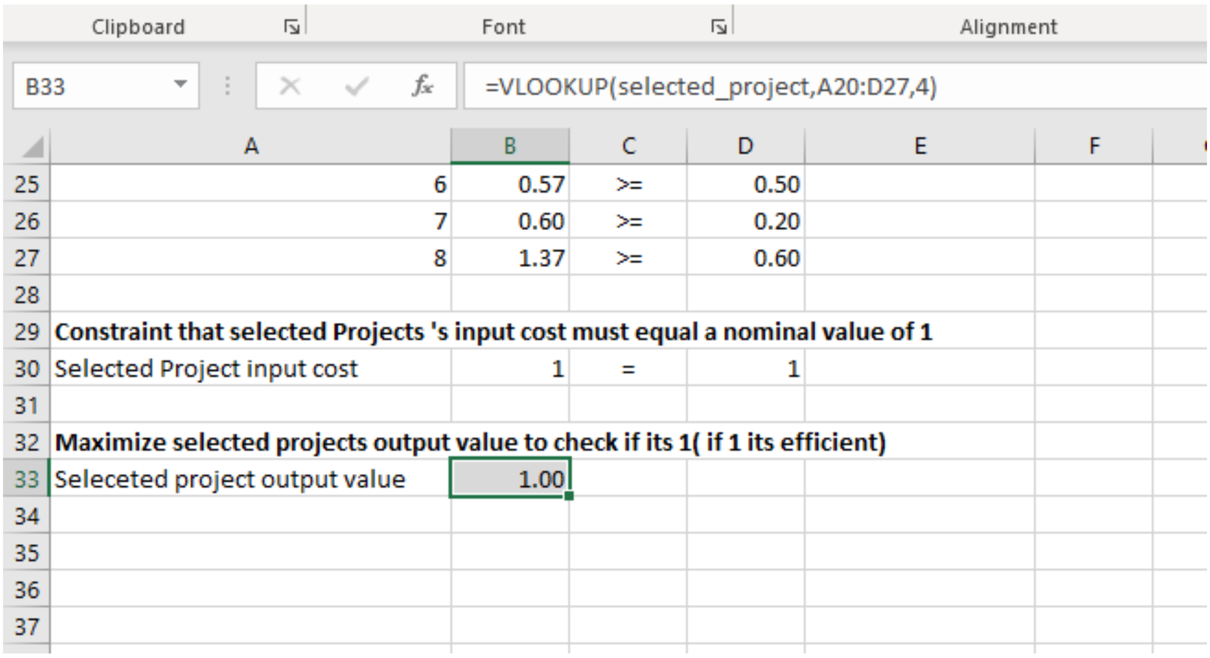
	A	B	C	D	E	F	G	H	I
1	**DEA model for checking efficiency of a selected project**								
2									
3	**Selected Project**	3							
4									
5								**Range names Used**	
6	**Inputs Used**	Input 1	Input 2		**Outputs Produced**	Output 1		Inputs_costs	=Sheet1!$B$20:$B$27
7	Project 1	550	200		Project 1	2.1		Output_costs	=Sheet1!$D$20:$D$27
8	Project 2	400	250		Project 2	0.5		Output_Values	=Sheet1!$D$20:$D$27
9	Project 3	300	400		Project 3	3		selected_project	=Sheet1!$B$3
10	Project 4	350	450		Project 4	2		selected_project_input_cost	=Sheet1!$B$30
11	Project 5	450	300		Project 5	1		unit_output_values	=Sheet1!$F$16
12	Project 6	500	150		Project 6	1.5		units_input_costs	=Sheet1!$B$16:$C$16
13	Project 7	350	200		Project 7	0.6			
14	Project 8	200	600		Project 8	1.8			
15									
16	unit cost of inputs	0.0005	0.002125		Units output value	0.333333			

For Selected project: Any project (1-8) should be entered in cell B3 depending on which project we wish to analyse. Then, trail values for unit cost of inputs and unit price of output is allotted.

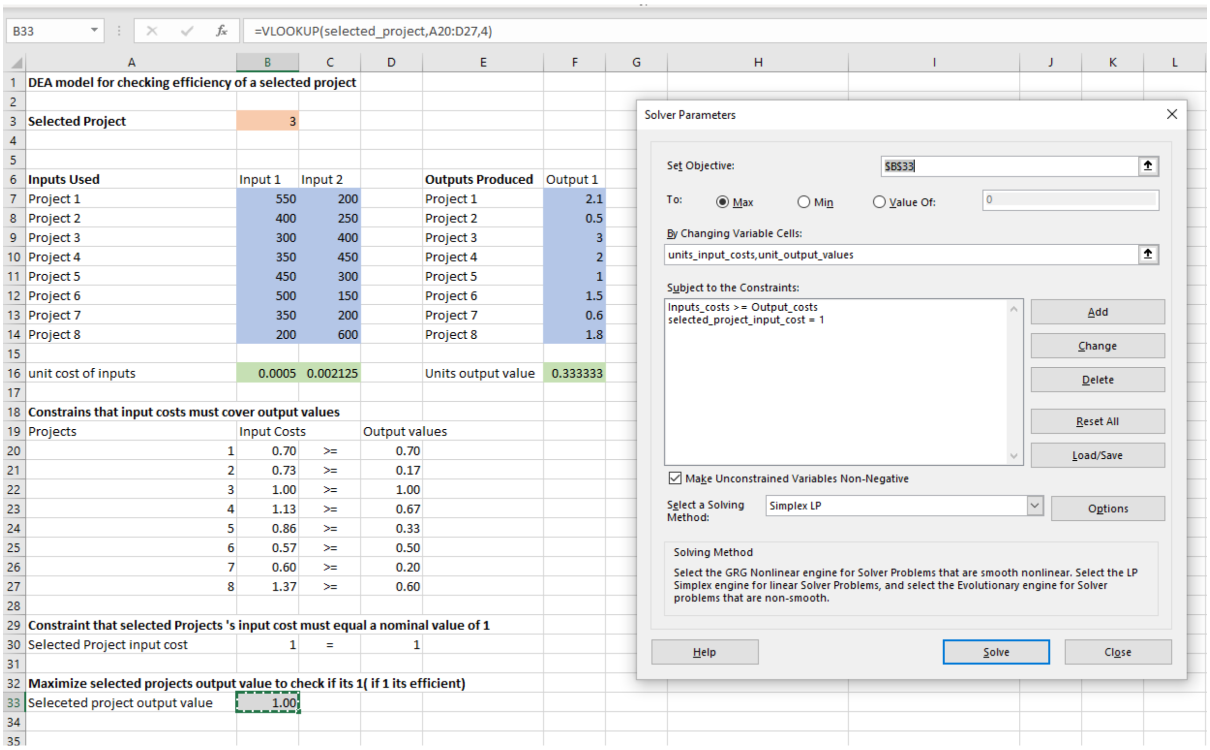
17					
18	**Constrains that input costs must cover output values**				
19	Projects	Input Costs		Output values	
20	1	0.70	>=	0.70	
21	2	0.73	>=	0.17	
22	3	1.00	>=	1.00	
23	4	1.13	>=	0.67	
24	5	0.86	>=	0.33	
25	6	0.57	>=	0.50	
26	7	0.60	>=	0.20	
27	8	1.37	>=	0.60	
28					

Each project's total input costs and output values are calculated. Input cost are calculated using formulae **=SUMPRODUCT (units_input_costs,B7:C7)**for all the projects and respective output values are created using formulae **=SUMPRODUCT(unit_output_values,F7).**These input cost and output values are created for all the projects so that the selected project has reference values to be compared against.

Then we use VLOOKUP function to calculate total input cost and output values of the selected project. For input the formulae used is =VLOOKUP(selected_project,A20:B27,2) and for output the formulae used =VLOOKUP(selected_project,A20:D27,4). A constrain is applied that total input cost of selected project is 1 so that output value will be efficient.



Then we use a solver to determine if the selected project is efficient or not, where



Set objective will refer to the selected project and is set to Max. the unit cost inputs and unite price outputs will be the decision variables. The constrain Input cost >= output values are added to ensure to limit the efficiency of all projects to 100% and selected projects input cost will be equal to 1. then Simplex LP method is chosen to solve for obtaining optimal solution.

This process is repeated for all 8 projects, and we get the efficiencies of each project.

1c.

I would recommend project 3 and 1 because both the projects are efficient.

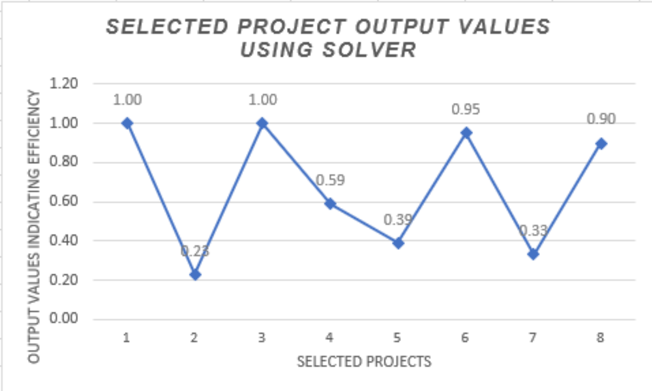
Project 3 has higher expected profits i.e., 3 million compared to 2.1 million of project 1 and almost 50% fewer number of person-days required than project. However, project 1 requires exactly half the numbers of CPU hours as project 3.

Get & Transform Data | Queries & Connections | Data Types | Sort & Filte

O10

The output values/efficiences listed are generated using solver in the sheet Probect 1 b for respective projects

Project	output values from solver
1	1.00
2	0.23
3	1.00
4	0.59
5	0.39
6	0.95
7	0.33
8	0.90



1d.

For the given data in the question projects 1 and 3 were efficient (original recommendations). However, I improved my recommendation by adding project 9 and project 10 which have input values closer the mean of input values of project 1 and 3. So the number of person-days values for project 9 and 10 will be closer to average of 550 and 300 and CPU time will be closer to averages of 200 and 400. This will improve the efficiency of the new inputs.

I developed a spreadsheet with these new values as shown below.

H51

	A	B	C	D	E	F	G	H
1	DEA model for checking efficiency of a selected project With New Sets of inputs and outputs							
2								
3	Selected project	8						
4								
5								
6								
7								
8	Inputs Used	Input 1	Input 2			Outputs Produced	Output 1	
9	Project 1	550	200			Project 1	2.1	
10	Project 2	400	250			Project 2	0.5	
11	Project 3	300	400			Project 3	3	
12	Project 4	350	450			Project 4	2	
13	Project 5	450	300			Project 5	1	
14	Project 6	500	150			Project 6	1.5	
15	Project 7	350	200			Project 7	0.6	
16	Project 8	200	600			Project 8	1.8	
17	Project 9	420	130			Project 9	4	
18	Project 10	280	220			Project 10	5	
19								

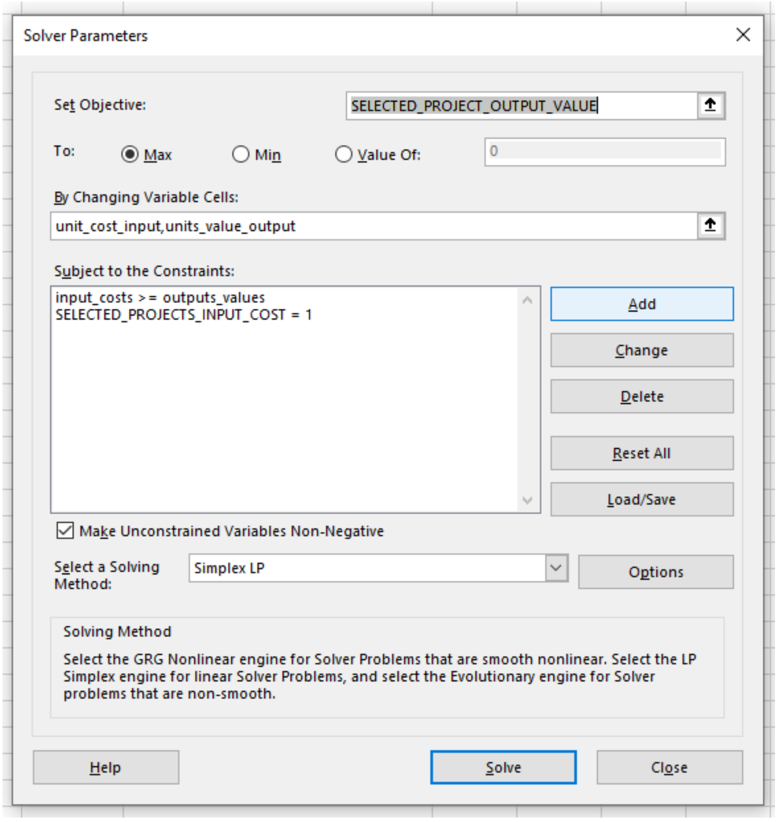
I have then proceeded to normalise all the input values (input 1& input 2) per 1 million pounds output values by dividing the inputs by outputs.

All the steps in 1b are performed on this table, which contains the normalised inputs and trail values for the unit cost of inputs and unit value of outputs. SUMPRODUCT is used to calculate input costs and output values. VLOOKUP formulae are used to generate input cost and output value for selected projects.

B22 =B9/G9

	A	B	C	D	E
19					
20	Normalisation of outputs				
21		Input 1	input 2		output1
22	Project 1	261.9048	95.2381		1
23	Project 2	800	500		1
24	Project 3	100	133.3333		1
25	Project 4	175	225		1
26	Project 5	450	300		1
27	Project 6	333.3333	100		1
28	Project 7	583.3333	333.3333		1
29	Project 8	111.1111	333.3333		1
30	Project 9	105	32.5		1
31	Project 10	56	44		1
32					
33	units costs	0.009	0		0.504
34					
35	Constrains that input costs must cover output values				
36	Project	input costs		output value	
37	1	2.357143	>=	0.504	
38	2	7.2	>=	0.504	
39	3	0.9	>=	0.504	
40	4	1.575	>=	0.504	
41	5	4.05	>=	0.504	
42	6	3	>=	0.504	
43	7	5.25	>=	0.504	
44	8	1	>=	0.504	
45	9	0.945	>=	0.504	
46	10	0.504	>=	0.504	
47					
48					
49					
50	Constraint that selected Projects 's input cost must equal a nominal value of 1				
51	selected project input cost	1	=	1	
52					
53					
54	Maximize selected projects output value to check if its 1(if 1 its efficient)				
55	selected project output val	0.504			
56					

H	I
Range names used	
input_costs	='project 1 d'!$B$37:$B$46
output_values	=#REF!#REF!
outputs_values	='project 1 d'!$D$37:$D$46
SELECTED_PROJECT_OUTPUT_VALUE	='project 1 d'!$B$55
SELECTED_PROJECTS_INPUT_COST	='project 1 d'!$B$51
unit_cost_input	='project 1 d'!$B$33:$C$33
unit_input_cost	=#REF!#REF!
units_output_values	=#REF!#REF!
units_value_output	='project 1 d'!$E$33



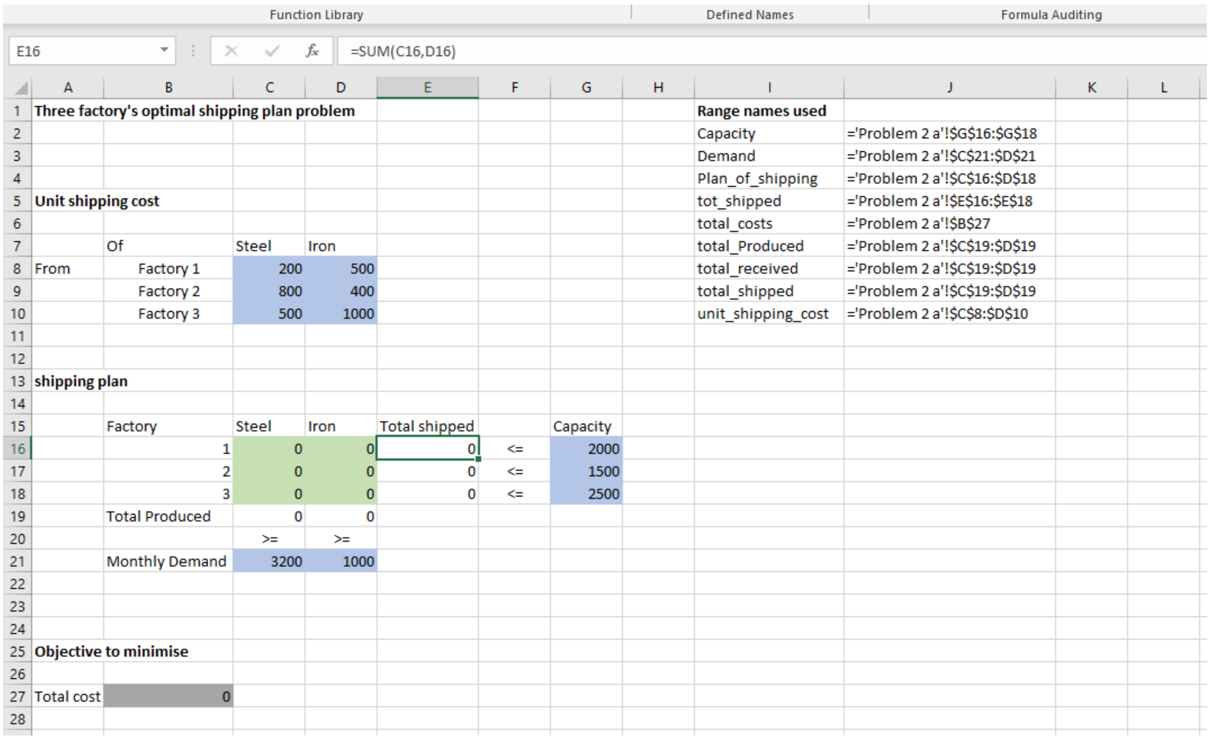
We apply the solver to the output values using the same constraint as in 1b. According to our observation, Project 9 and Project 10 are more efficient than Project 1 and Project 3. It is because Projects 9 and 10 consume less input resources and still generate greater profits than Projects 1 and 3, which were previously highly efficient.

1e.

If the projects are considered from different industries to make them more comparable, will choose to used data relating to capital require to successfully complete the project i.e., Pounds in millions required to complete the projects which includes people cost such as salaries and administrative, recourse cost and compare them to the project expected profits as outputs. To make visualization easier we can normalize expected profits to a million pounds and compare who much I should be investing into each project to make the same profit. Using this information, I will rank my projects which require least investment to make a million pounds profit as my first preference and arrange all the projects from highest preference to least preference (highest capital investments required to make a million pounds profit).

2a.

To determine the optimal monthly assignment plan for each factory we first need to develop a spread sheet as below inputting all the given values such as unit shipping cost, demand and capacity of each of the 3 factories. Light blue cells indicate the given values.



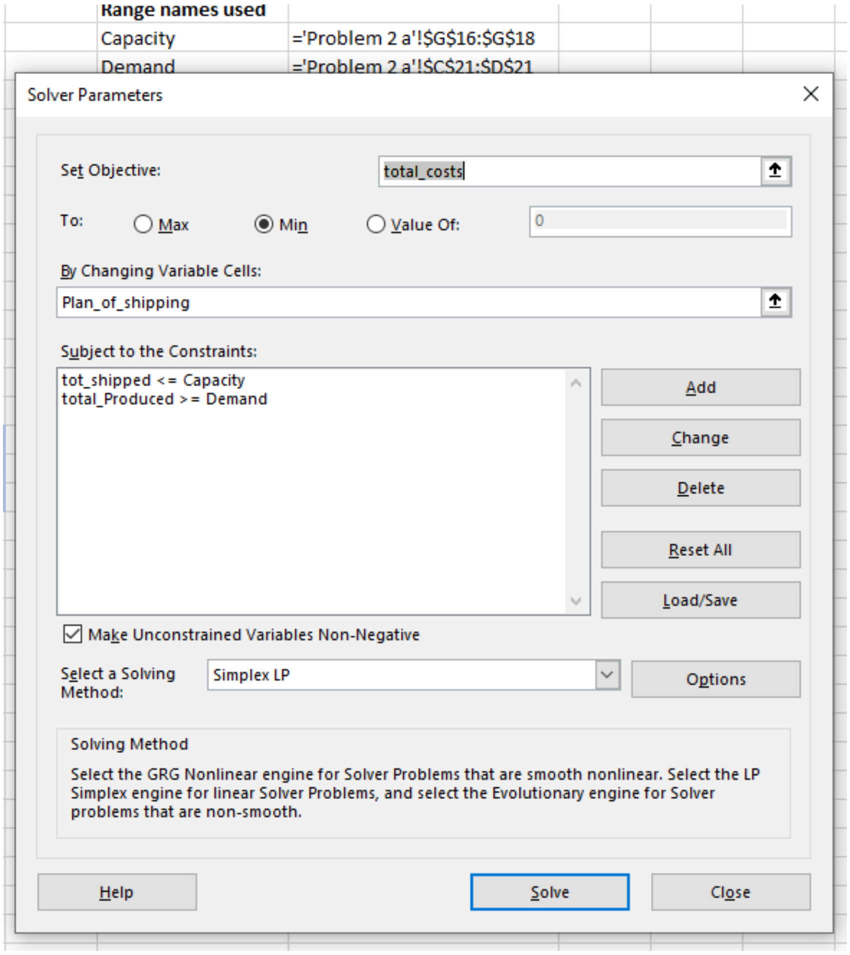
	A	B	C	D	E	F	G	H	I	J	K	L
1	Three factory's optimal shipping plan problem								Range names used			
2									Capacity	='Problem 2 a'!$G$16:$G$18		
3									Demand	='Problem 2 a'!$C$21:$D$21		
4									Plan_of_shipping	='Problem 2 a'!$C$16:$D$18		
5	Unit shipping cost								tot_shipped	='Problem 2 a'!$E$16:$E$18		
6									total_costs	='Problem 2 a'!$B$27		
7		Of	Steel	Iron					total_Produced	='Problem 2 a'!$C$19:$D$19		
8	From	Factory 1	200	500					total_received	='Problem 2 a'!$C$19:$D$19		
9		Factory 2	800	400					total_shipped	='Problem 2 a'!$C$19:$D$19		
10		Factory 3	500	1000					unit_shipping_cost	='Problem 2 a'!$C$8:$D$10		
11												
12												
13	shipping plan											
14												
15		Factory	Steel	Iron	Total shipped		Capacity					
16		1	0	0	0	<=	2000					
17		2	0	0	0	<=	1500					
18		3	0	0	0	<=	2500					
19		Total Produced	0	0								
20			>=	>=								
21		Monthly Demand	3200	1000								
22												
23												
24												
25	Objective to minimise											
26												
27	Total cost	0										
28												

Total shipped of an individual factory is calculated by adding its respective steel and iron shipped quantities i.e., to get E16 value we apply summation on C16:D16.

Total produced is created by adding all the steel produced across all 3 factories and all the iron produced across all 3 factories i.e., D19 = SUM (D16:D18).

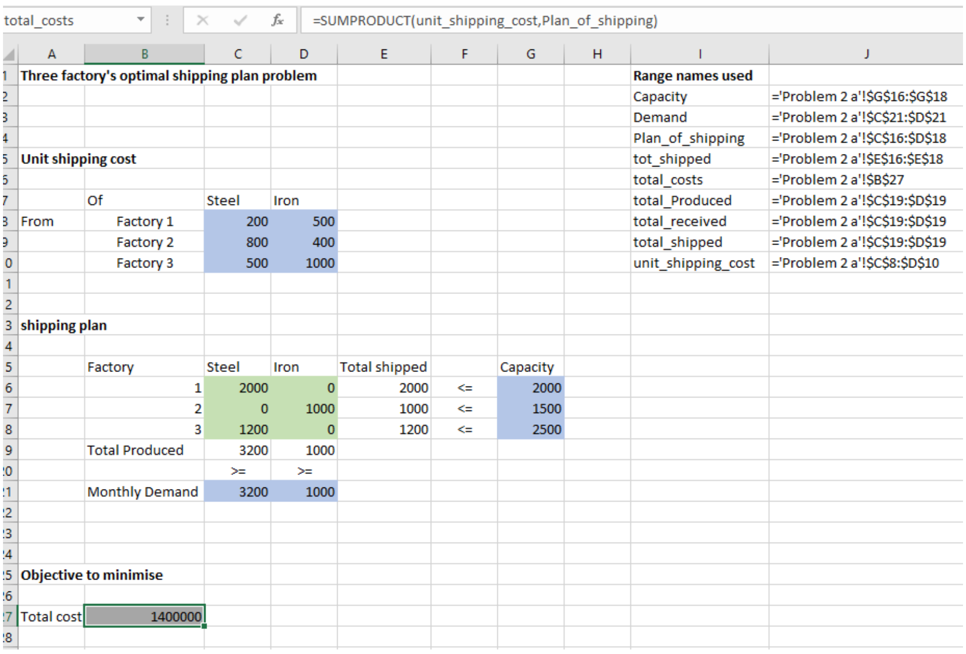
I have used SUMPRODUCT function to define total cost of the shipping operation. **i.e, =SUMPRODUCT(unit_shipping_cost,Plan_of_shipping)** . The plan of shipping is highlighted in light green and unit shipping cost are given values in the first matrix, highlighted in light blue. This formula produces the aggregate of product of values from both these highlighted matrixes.

Using solver:
I have used solver on the total cost cell with objective to minimise the costs and used shipping plan matrix as variable cells. And used two logical constraints that **total shipped** by each factory **should always be less than equal** to **capacity** of each factory and **total production** of each of Steel and Iron **should always be greater than or equal** to **Demand.**



And applied Simplex LP solving method for optimizing the total cost.

After applying the solver, I obtained the following results:



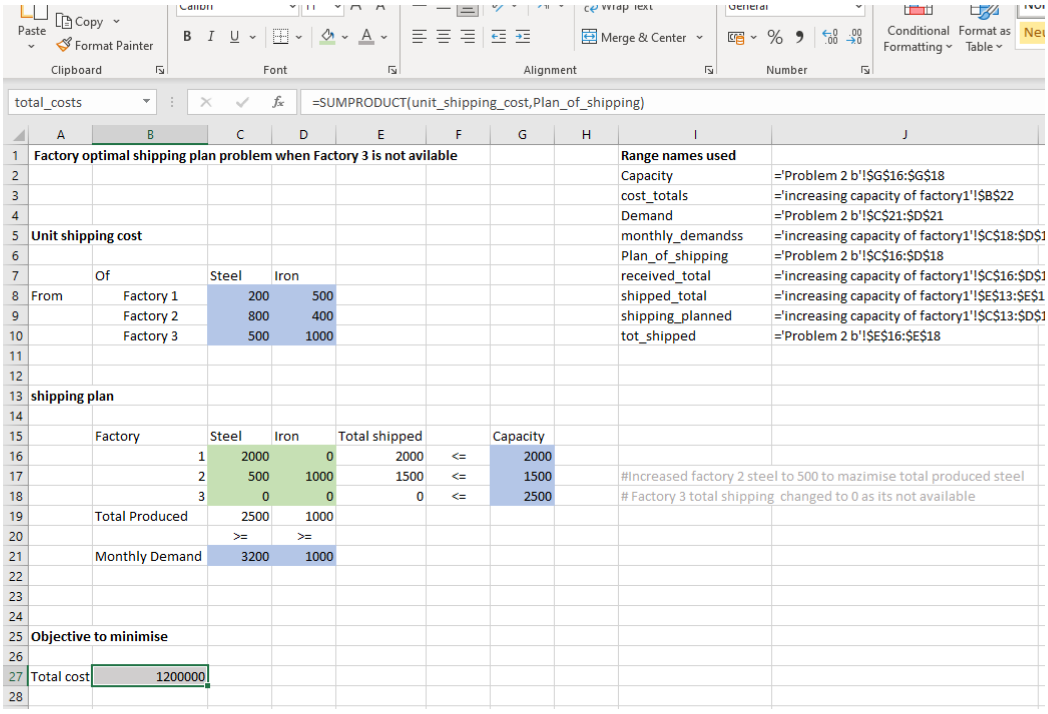
total_costs =SUMPRODUCT(unit_shipping_cost,Plan_of_shipping)

	A	B	C	D	E	F	G	H	I	J
1	Three factory's optimal shipping plan problem								Range names used	
2									Capacity	='Problem 2 a'!$G$16:$G$18
3									Demand	='Problem 2 a'!$C$21:$D$21
4									Plan_of_shipping	='Problem 2 a'!$C$16:$D$18
5	Unit shipping cost								tot_shipped	='Problem 2 a'!$E$16:$E$18
6									total_costs	='Problem 2 a'!$B$27
7		Of	Steel	Iron					total_Produced	='Problem 2 a'!$C$19:$D$19
8	From	Factory 1	200	500					total_received	='Problem 2 a'!$C$19:$D$19
9		Factory 2	800	400					total_shipped	='Problem 2 a'!$C$19:$D$19
10		Factory 3	500	1000					unit_shipping_cost	='Problem 2 a'!$C$8:$D$10
11										
12										
13	shipping plan									
14										
15		Factory	Steel	Iron	Total shipped		Capacity			
16		1	2000	0	2000	<=	2000			
17		2	0	1000	1000	<=	1500			
18		3	1200	0	1200	<=	2500			
19		Total Produced	3200	1000						
20			>=	>=						
21		Monthly Demand	3200	1000						
22										
23										
24										
25	Objective to minimise									
26										
27	Total cost	1400000								
28										

So, the company incurs a total shipping cost of 14,00,000 pounds and the optimal shipping plan is that factory 1 ships 2000 tons of steel and not Iron. Factory 2 ships only Iron of 1000 tonnes and factory 3 ships 1200 tons of o steel only to meet the capacity constraint and monthly demand.

2b.

When Factory 3 is non-operational, we observe that the steel produced will be only 2000 tonnes and even if we try to optimise it by increasing the capacity of factory 2, it can only produce 500 tons of steel because its already producing 100 tons of iron and its total capacity is only 1500 tonnes.



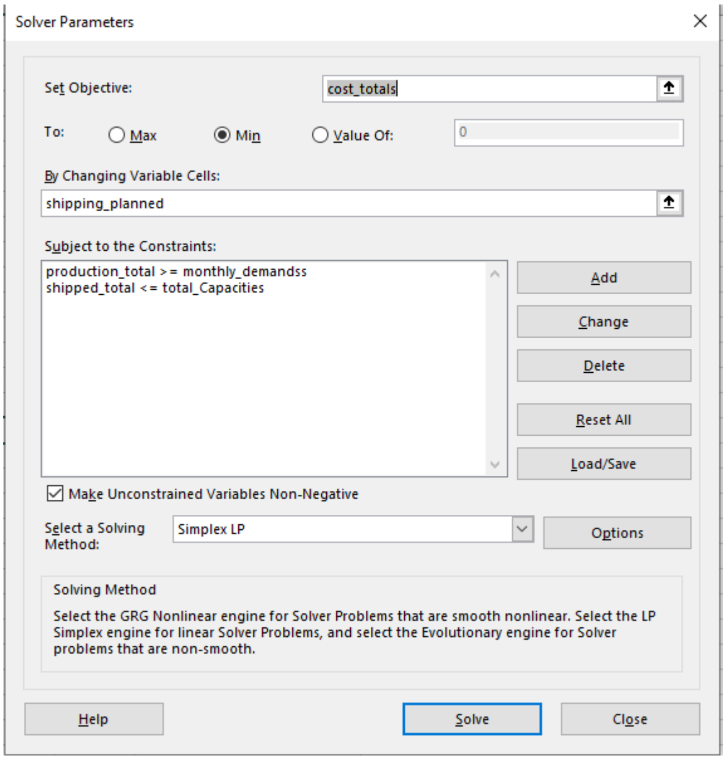
total_costs =SUMPRODUCT(unit_shipping_cost,Plan_of_shipping)

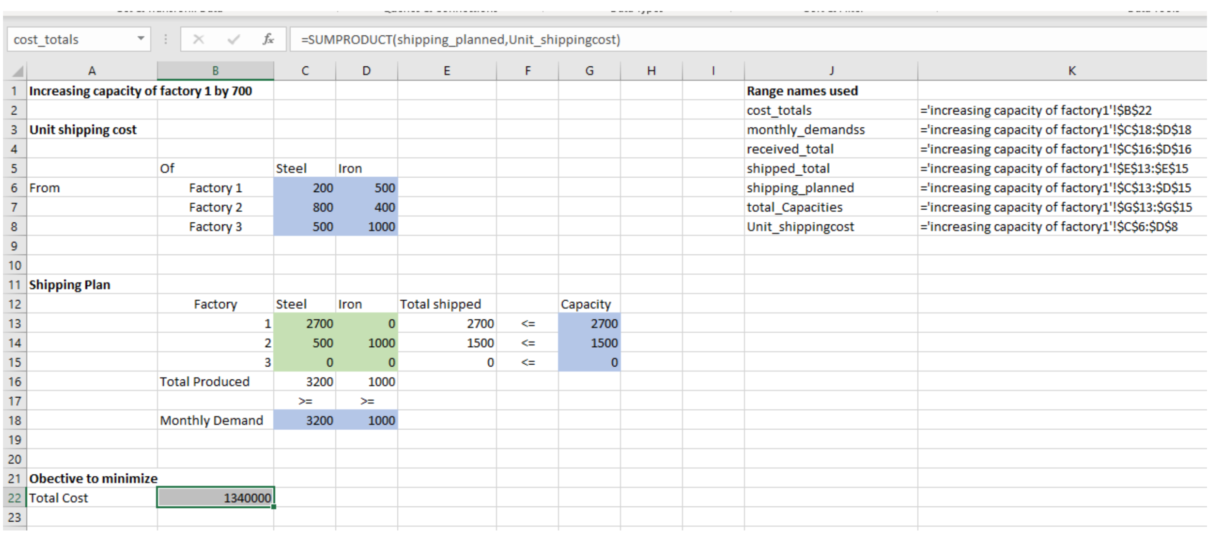
	A	B	C	D	E	F	G	H	I	J
1	**Factory optimal shipping plan problem when Factory 3 is not avilable**								**Range names used**	
2									Capacity	='Problem 2 b'!$G$16:$G$18
3									cost_totals	='increasing capacity of factory1'!$B$22
4									Demand	='Problem 2 b'!$C$21:$D$21
5	**Unit shipping cost**								monthly_demandss	='increasing capacity of factory1'!$C$18:$D$1
6									Plan_of_shipping	='Problem 2 b'!$C$16:$D$18
7		Of	Steel	Iron					received_total	='increasing capacity of factory1'!$C$16:$D$1
8	From	Factory 1	200	500					shipped_total	='increasing capacity of factory1'!$E$13:$E$1
9		Factory 2	800	400					shipping_planned	='increasing capacity of factory1'!$C$13:$D$1
10		Factory 3	500	1000					tot_shipped	='Problem 2 b'!$E$16:$E$18
13	**shipping plan**									
15		Factory	Steel	Iron	Total shipped		Capacity			
16		1	2000	0	2000	<=	2000			
17		2	500	1000	1500	<=	1500		#Increased factory 2 steel to 500 to mazimise total produced steel	
18		3	0	0	0	<=	2500		# Factory 3 total shipping changed to 0 as its not available	
19		Total Produced	2500	1000						
20			>=	>=						
21		Monthly Demand	3200	1000						
25	**Objective to minimise**									
27	Total cost	1200000								

So, if Factory 3 is not available the company **will not be able** to meet the demands. There is a **shortage of 700 tonnes** of steel produce in this scenario.

In order to fulfil the demand when factory 3 not available, either we have increased the capacity of Factory 1 or factory 2 or both. And to fulfil steel demand, it's cheaper to increase capacity of factory 1 than factory 2 based on the unit shipping cost of each of the factories.

Hence, I have **increased the capacity of factory 1 by 700 tonnes** making its total capacity 2700. And apply the solve as is 2a, with same constraints.





cost_totals =SUMPRODUCT(shipping_planned,Unit_shippingcost)

	A	B	C	D	E	F	G	H	I	J	K
1	**Increasing capacity of factory 1 by 700**									**Range names used**	
2										cost_totals	='increasing capacity of factory1'!$B$22
3	**Unit shipping cost**									monthly_demandss	='increasing capacity of factory1'!$C$18:$D$18
4										received_total	='increasing capacity of factory1'!$C$16:$D$16
5		Of	Steel	Iron						shipped_total	='increasing capacity of factory1'!$E$13:$E$15
6	From	Factory 1	200	500						shipping_planned	='increasing capacity of factory1'!$C$13:$D$15
7		Factory 2	800	400						total_Capacities	='increasing capacity of factory1'!$G$13:$G$15
8		Factory 3	500	1000						Unit_shippingcost	='increasing capacity of factory1'!$C$6:$D$8
9											
10											
11	**Shipping Plan**										
12		Factory	Steel	Iron	Total shipped		Capacity				
13		1	2700	0	2700	<=	2700				
14		2	500	1000	1500	<=	1500				
15		3	0	0	0	<=	0				
16		Total Produced	3200	1000							
17			>=	>=							
18		Monthly Demand	3200	1000							
19											
20											
21	**Obective to minimize**										
22	Total Cost	1340000									
23											

The solver optimises the shipping plan as shown in the image above, and indicates it costs the company a minimum **total cost 13,40,000** pounds to carry out its operation to meeting all the given demands.

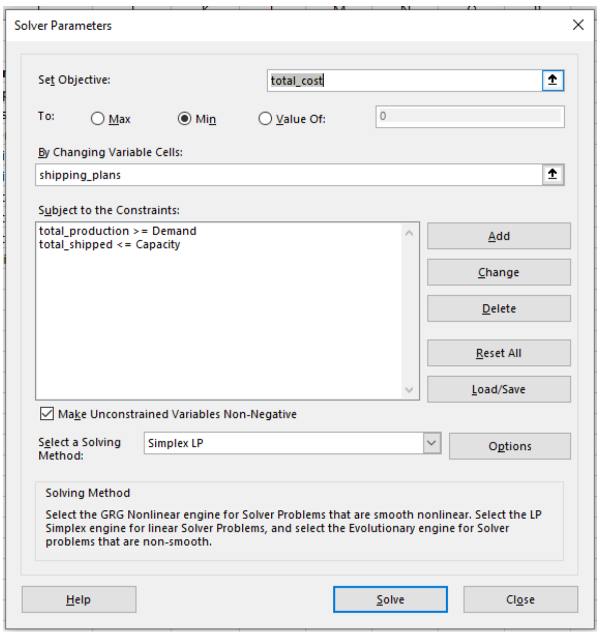
2c.

If we consider raw material cost as well, I have added them to the existing unit shipping costs and to create a new matrix for input values, however the capacity and demand stays the same.

C18 =SUM(C8,I8)

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Three factory's optimal shipping plan including raw material cost**												
2													
3													
4													
5	**Unit shipping cost**						**Cost of Raw materials**						
6													
7		Of	Steel	Iron				Of	Steel Raw mater	Iron Raw material cost			
8	From	Factory 1	200	500			For	Factory 1	50	100			
9		Factory 2	800	400				Factory 2	70	120			
10		Factory 3	500	1000				Factory 3	45	130			
11													
12													
13													
14													
15	**Unit shipping cost including raw materal cost**								**Range names used**				
16									Capacity	=Sheet1!$G$26:$G$28			
17	From	Of	Steel	Iron					cost_raw_materi	=Sheet1!$I$8:$J$10			
18		Factory 1	250	600					Demand	=Sheet1!$C$31:$D$31			
19		Factory 2	870	520					shipping_cost_w	=Sheet1!$C$18:$D$20			
20		Factory 3	545	1130					shipping_plans	=Sheet1!$C$26:$D$28			
21									total_cost	=Sheet1!$B$37			
22									total_received	=Sheet1!$C$29:$D$29			
23	**Shipping Plan**								total_shipped	=Sheet1!$E$26:$E$28			
24									unit_shipping_cc	=Sheet1!$C$8:$D$10			

Then performed the same steps as in 2a and apply solver with the constrains as follows.



total_cost | =SUMPRODUCT(shipping_plans,shipping_cost_with_raw_material_cost)

	A	B	C	D	E	F	G	H	I	J	K
13											
14											
15	**Unit shipping cost including raw materal cost**								**Range names used**		
16									Capacity	=Sheet1!$G$26:$G$28	
17	From	Of	Steel	Iron					cost_raw_materi	=Sheet1!$I$8:$J$10	
18		Factory 1	250	600					Demand	=Sheet1!$C$31:$D$31	
19		Factory 2	870	520					shipping_cost_w	=Sheet1!$C$18:$D$20	
20		Factory 3	545	1130					shipping_plans	=Sheet1!$C$26:$D$28	
21									total_cost	=Sheet1!$B$37	
22									total_received	=Sheet1!$C$29:$D$29	
23	**Shipping Plan**								total_shipped	=Sheet1!$E$26:$E$28	
24									unit_shipping_cc	=Sheet1!$C$8:$D$10	
25		Factory	Steel	Iron	Total shipped		Capacity				
26		1	2000	0	2000	<=	2000				
27		2	0	1000	1000	<=	1500				
28		3	1200	0	1200	<=	2500				
29		Total Production	3200	1000							
30			>=	>=							
31		Demand	3200	1000							
32											
33											
34											
35	objective to minimise total cost										
36											
37	total cost	1674000									
38											

We get the following outputs, where the minimal total cost **is 16,74,000 pounds**.

3a.

I would recommend my client the shortest path form influencer 1 to influencer 12 as this is more economical and effective and decreases the cost of investment. Hence, I would recommend the path from influencer-to- influencers as: **1-->2-->13-->3-->8-->6-->12.**

I generated the shortest path by developing a spreadsheet and running a solver.
First, for each arc in the graphical network, I have created a list of all the node connections and name these columns Origin and destination and populated the respective distance under Distance column, the column flow will indicate if we are taking that path or not and this column will be a solver changing variable.

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K5 =SUMIF(Orgin,J5,Flow)-SUMIF(Destination,J5,Flow)

Shortest path model

Network Structure and Flow

Origin	Destination	Distance	Flow
1	2	2	
1	5	27	
2	1	2	
2	13	4	
3	4	8	
3	8	15	
3	13	5	
4	3	8	
4	5	7	
4	11	3	
4	13	10	
5	1	27	
5	4	7	
6	8	9	
6	7	3	
6	12	6	
7	6	9	
7	11	3	
8	3	15	
8	6	3	
8	9	12	
8	10	15	
9	8	12	
9	10	6	
10	9	6	
10	8	15	
11	4	3	
11	7	3	
12	6	6	
13	2	4	
13	3	5	
13	4	10	

Flow balance constraints

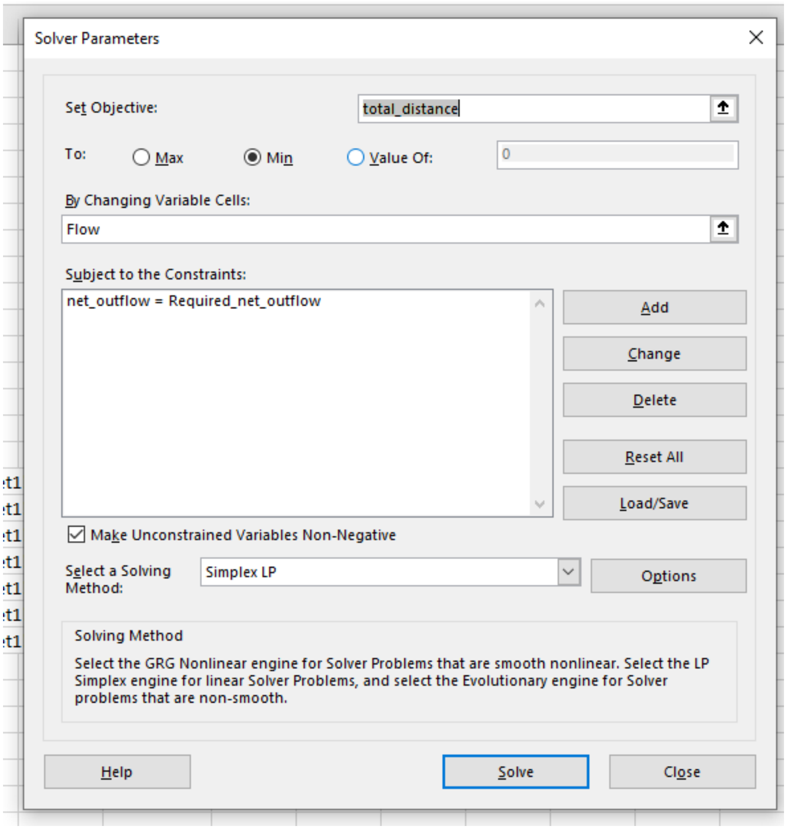
Node	Net outflow		Required Net outflow
1	0	=	1
2	0	=	0
3	0	=	0
4	0	=	0
5	0	=	0
6	0	=	0
7	0	=	0
8	0	=	0
9	0	=	0
10	0	=	0
11	0	=	0
12	0	=	-1
13	0	=	0

Range Names Used

Destination	=Sheet1!$B$6:$B$37
Distance	=Sheet1!$C$6:$C$37
Flow	=Sheet1!$D$6:$D$37
net_outflow	=Sheet1!$K$5:$K$17
Orgin	=Sheet1!$A$6:$A$37
Required_net_o	=Sheet1!$M$5:$M$17
total_distance	=Sheet1!$B$41

For all nodes from 1-13, net outflow is calculated using SUMIF function and this column is populated using the formulae **=SUMIF(Orgin,J5,Flow)-SUMIF(Destination,J5,Flow)** and simultaneous required net outflows are populated based on outflow and negative inflows.

The main goal is to minimise the Total distance is defined by formula
= SUMPRODUCT(Distance,Flow) .

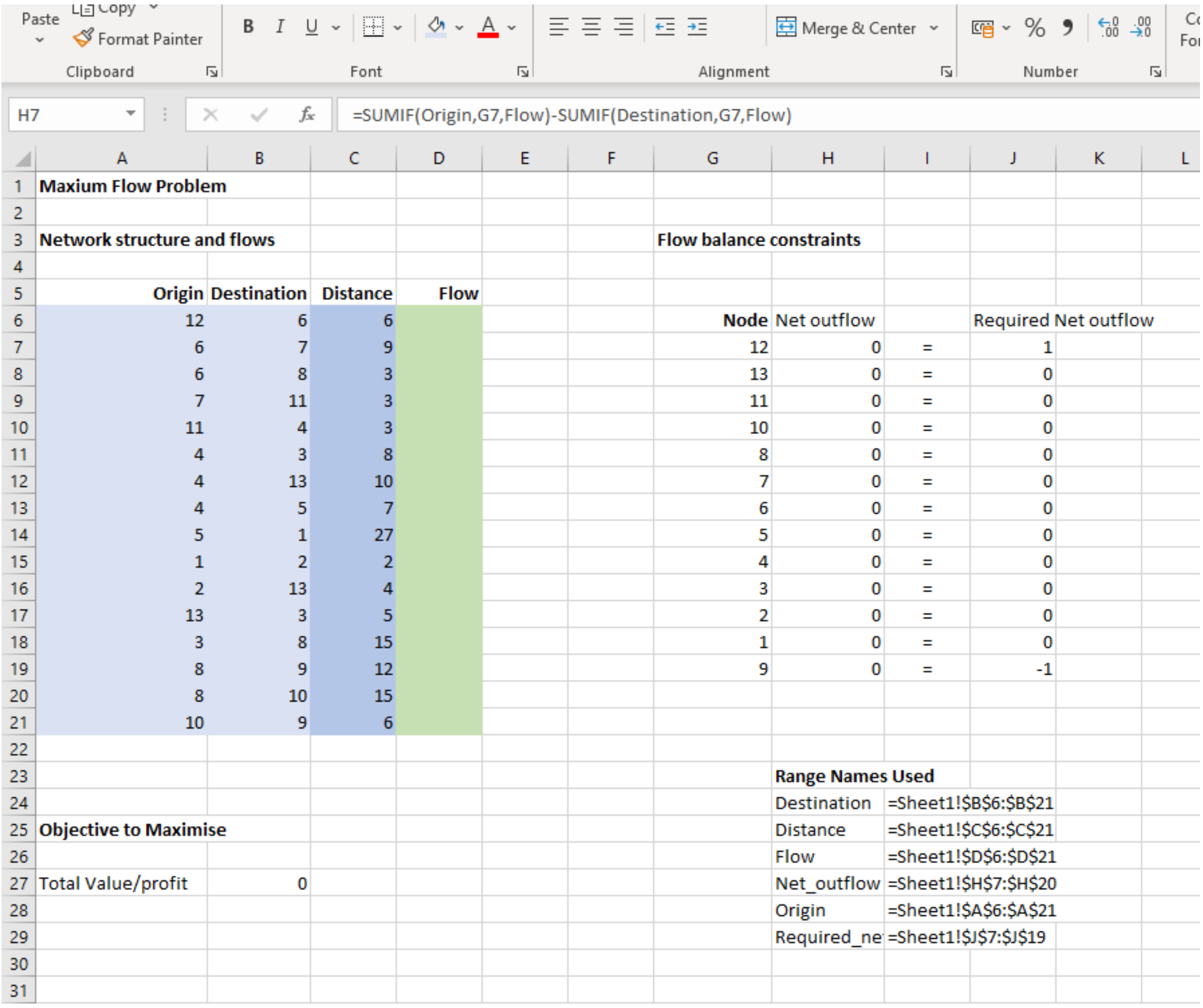


Running solver on the total distance using the constrains as above and selecting variable cells as flow column with an objective to minimise the total distance the final solver generated answer will be **35.**

3b.

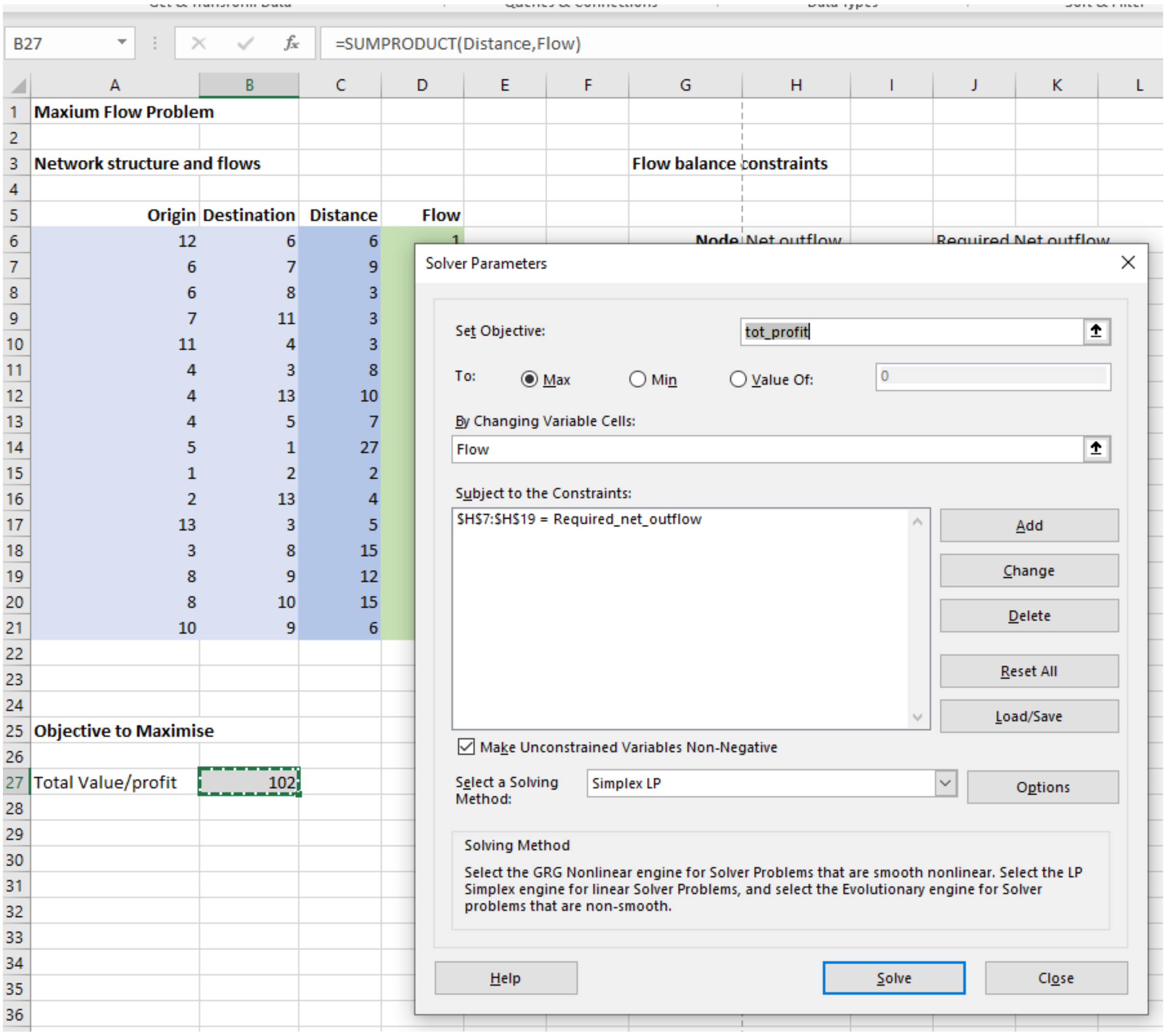
To maximise the company's profit, I would recommend the path for project undertaking as: **12-->6-->7-->11-->4-->5-->1-->2-->13-->3-->8-->10-->9.** This path makes sure that all projects are undertaken and hence increases the profit of the company.

The maximum flow problem is adapted in this spread sheet and all the origins and destination are mentioned as below with their respective distances which indicate the profits. All the values are considered in a unidirectional. That is when a project is completed, we don't go back to its node again.



	A	B	C	D	E	F	G	H	I	J	K	L
1	**Maxium Flow Problem**											
2												
3	**Network structure and flows**						**Flow balance constraints**					
4												
5	**Origin**	**Destination**	**Distance**	**Flow**								
6	12	6	6				**Node**	Net outflow		Required Net outflow		
7	6	7	9				12	0	=	1		
8	6	8	3				13	0	=	0		
9	7	11	3				11	0	=	0		
10	11	4	3				10	0	=	0		
11	4	3	8				8	0	=	0		
12	4	13	10				7	0	=	0		
13	4	5	7				6	0	=	0		
14	5	1	27				5	0	=	0		
15	1	2	2				4	0	=	0		
16	2	13	4				3	0	=	0		
17	13	3	5				2	0	=	0		
18	3	8	15				1	0	=	0		
19	8	9	12				9	0	=	-1		
20	8	10	15									
21	10	9	6									
22												
23								**Range Names Used**				
24								Destination	=Sheet1!$B$6:$B$21			
25	**Objective to Maximise**							Distance	=Sheet1!$C$6:$C$21			
26								Flow	=Sheet1!$D$6:$D$21			
27	Total Value/profit	0						Net_outflow	=Sheet1!$H$7:$H$20			
28								Origin	=Sheet1!$A$6:$A$21			
29								Required_ne	=Sheet1!$J$7:$J$19			
30												
31												

As in 3a Net outflow is calculated using SUMIF function i.e. =SUMIF(Origin,G7,Flow)-SUMIF(Destination,G7,Flow)and Required net outflow values are populated according to the path chosen. I have applied the solver using constrains as in the image below to generate maximum profits.



The solver generated a total output value of **102(in million pounds)** which will be the maximum profit generated as per constrains used.

3c.

In a network flow model, the nodes are connected by lines called arc which have numbers on them called weights.
the method of finding shortest /distance between node 1 or a vertice1 to any other node in the network is called shortest path problem. To put it in graphical terms it is a method of finding shortest path between two points on a graph. (Winston & Albright, n.d.)
The shortest path models are used across different industries to calculate minimum measures of time, cost, etc.
Example of application for shortest path problem:

- IP routing: short path model is applied to find the best shortest path between the origin router and destination router. OSPF(Open-shortest-path-first) (*Social Network for*

Programmers and Developers, n.d.)is one such routing protocol that widely depends on the workings of shortest pat problem.

- Travel agenda: shortest path problem can be used to plan a shortest/ quickest travelling route. For example, if we have access to all airports and flight data including specific flights origin and destination airport and respective times of flight one can determine the earliest path to reach a destination.

Maximum flow problem: The primary goal of maximum flow problems is to determine a feasible flow path that will obtain the maximal possible flow rate through a flow network.
Application of maximum flow problem:

- Maximum flow problem can be used to determine the capacity of a transportation network That is then a source and destination are given to transport something from one point to another like in an underground pipeline maximum flow problem can be applied to determine fastest rate of transportation. *researchgate*. (n.d.).
- In production line: Maximum flow problem is used to determine the flow of products in a production line of a manufacturing company. (*The Maximal Flow Problem | Introduction to Management Science (10th Edition)*, n.d.)

References

Social Network for Programmers and Developers. (n.d.). Morioh.com. https://morioh.com/p/cdc55aea2dba

The Maximal Flow Problem | Introduction to Management Science (10th Edition). (n.d.). Flylib.com. Retrieved August 5, 2022, from https://flylib.com/books/en/3.287.1.99/1/

Winston, W. L., & Albright, S. C. (n.d.). *Pratical Management science*.

researchgate. (n.d.). Retrieved from www.researchgate.net: https://www.researchgate.net/publication/41940710_Applications_of_Maximal_Network_Flow_Problems_in_Transportation_and_Assignment_Problems