REAL LIFE APPLICATION OF TRANSPORTATION PROBLEM IN MALAYSIAN PETROCHEMICAL COMPANY

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INTRODUCTION

The Petrochemical Industry is one of the leading industries in Malaysia. From being an importer of petrochemicals, Malaysia today is an exporter of major petrochemical products. A wide range of petrochemicals such as olefins, polyofins aromatics, ethylene oxides, poly vinyl chloride are produced in these industries. The Malaysian Petrochemical Company '**Petronas**' was established in 1974 and is wholly owned by the Government of Malaysia, the corporation is vested with the entire oil and gas resources in Malaysia and is entrusted with the responsibility of developing and adding value to these resources. Fortune ranks Petronas as the 158th largest company in the world in 2019.

In 2006, Economic times published an article stating that Mitco Labuan the trading arm of the $44.3 billion Malaysian Petrochemical giant Petronas was setting up a wholly owned subsidiary to engage in trading and related in the country.

The trading company '**Mitco Labuan**', wholly owned subsidiary of the Malaysian Petrochemical Company is involved in buying and selling poly vinyl chloride polymer. The polymer is produced by four petrochemical plants in Malaysia and is exported to four destinations namely China, the Middle East, Europe and South East Asia.

APPLICATION OF TRANSPORTATION PROBLEM

The production capacity of each polymer producing Petrochemical Plant are

Polymer producing Petrochemical Plant	Production Capacity (thousands tons per annum)
P1	110
P2	75
P3	95
P4	125

The demand of the customers is

Destination	Shipment Quantity (thousands tons per annum)
China (D1)	200
Middle East (D2)	90

South East Asia (D3)	40
Europe (D4)	45

Each Plant has a fixed capacity per annum that shall be distributed to the customers. Similarly, each destination has a fixed demand per annum that must be fulfilled from the various plants.

The Shipping costs from the polymer producing petrochemical plants to the various destinations are

Unit Cost of Shipping (RM ’000) (RM = Malaysian Ringgit)

Plant	China	Middle East	South East Asia	Europe
P1	200	300	100	600
P2	400	350	150	650
P3	300	250	150	600
P4	500	400	200	700

The unit cost of shipping varies as a result of differences in among others distance and also currencies exchange rates. Hence, allocating the production capacities to the various demand destinations in the optimal way to minimize total cost of shipping is crucial for the trading company.

Mathematical and spreadsheet formulation

The formulation of the transportation problem for this case study is aimed at determining the optimum allocation of production capacity to each demand destinations to minimize the cost of shipping. There are four polymer producing plants and four demand destination under consideration.

	Destinations				
Units Costs	D1	D2	D3	D4	Production Capacity
P1	200	300	100	600	110
P2	400	350	150	650	75
P3	300	250	150	600	95
P4	500	400	200	700	125
Demand	200	90	40	45	

(Unit Cost RM ’000) (Demand and Production Capacity ’000)

The demand is not equal to the production capacity therefore the solution is not balanced. To balance the solution, we assume a dummy column D5 with a demand of 30. Now Demand = Production Capacity thus the solution is balanced.

	Destinations					
Unit Costs	D1	D2	D3	D4	D5	Production Capacity
P1	200	300	100	600	0	110
P2	400	350	150	650	0	75
P3	300	250	150	600	0	95
P4	500	400	200	700	0	125
Demand	200	90	40	45	30	405

(Unit Cost RM ’000) (Demand and Production Capacity ’000)

Using Vogel's Approximation Method (VAM)

	Destinations											
Unit Cost	D1	D2	D3	D4	D5	Production Capacity	T1	T2	T3	T4	T5	T6
P1	200 (110)	300	100	600	0	110	100	100	100	-	-	-
P2	400 (35)	350	150 (40)	650	0	75	150	200	50	50	250	250
P3	300 (5)	250 (90)	150	600	0	95	150	100	50	50	300	-
P4	500 (50)	400	200	700 (45)	0 (30)	125	200	200	100	100	200	200
Demand	200	90	40	45	30	405						
T1	100	50	50	0	0							
T2	100	50	50	0	-							
T3	100	50	-	0	-							
T4	100	100	-	50	-							
T5	100	-	-	50	-							
T6	100	-	-	50	-							

(Unit Cost RM '000) (Demand and Production Capacity '000) (T is used to indicate penalties as P is used to indicate Petrochemical plants)

Rim Condition: m+n-1 = number of allocations

m+n-1 ⟹ 4+5-1 = 8; number of allocations = 8

Therefore, the solution is non degenerate.

Using Modified Distribution Method (MODI)

For Optimality, MODI – we'll find ui and vj.

	Destinations						
Unit Cost	D1	D2	D3	D4	D5	Production Capacity	ui
P1	200(110)	300	100	600	0	110	0
P2	400(35)	350	150(40)	650	0	75	200
P3	300(5)	250(90)	150	600	0	95	100
P4	500(50)	400	200	700(45)	0(30)	125	300
Demand	200	90	40	45	30	405	
vj	200	150	-50	400	-300		

(Unit Cost RM '000) (Demand and Production Capacity '000)

For occupied cells ⟹ Cij = ui + vj

For unoccupied cells ⟹ △ij = Cij – (ui + vj)

P1D2 = 150 P2D2 = 0 P3D3 = 100 P4D2 = -50

P1D3 = 150 P2D4 = 50 P3D4 = 100 P4D3 = -50

P1D4 = 200 P2D5 = 100 P3D5 = 200

P1D5 = 300

Since △ij<=0, the solution is not optimum as P4D2 and P4D3 are -50.

After looping P4D3

Cell	Old Value	New Value
P4D3	0 +	40
P2D3	40 -	0
P2D1	35 +	75
P4D1	50 -	10

New table:

Unit Cost	Destinations D1	D2	D3	D4	D5	Production Capacity	ui
P1	200(110)	300	100	600	0	110	0
P2	400(75)	350	150	650	0	75	200
P3	300(5)	250(90)	150	600	0	95	100
P4	500(10)	400	200(40)	700(45)	0(30)	125	300
Demand	200	90	40	45	30	405	
vj	200	150	-100	400	-300		

(Unit Cost RM ’000) (Demand and Production Capacity ’000)

For occupied cells ⟹ Cij = ui + vj

For unoccupied cells ⟹ △ij = Cij – (ui + vj)

P1D2 = 150 P2D2 = 0 P3D3 = 150 P4D2 = -50

P1D3 = 200 P2D3 = 50 P3D4 = 100

P1D4 = 200 P2D4 = 50 P3D5 = 200

P1D5 = 300 P2D5 = 100

Since △ij<=0, the solution is not optimum as P4D2 is -50.

After looping P4D2

Cell	Old Value	New Value
P4D2	0 +	10
P2D3	10 -	0
P2D1	5 +	15
P4D1	90 -	80

New table:

	Destinations						
Unit Cost	D1	D2	D3	D4	D5	Production Capacity	ui
P1	200(110)	300	100	600	0	110	0
P2	400(75)	350	150	650	0	75	200
P3	300(15)	250(80)	150	600	0	95	100
P4	500	400(10)	200(40)	700(45)	0(30)	125	250
Demand	200	90	40	45	30	405	
vj	200	150	-50	450	-250		

(Unit Cost RM ’000) (Demand and Production Capacity ’000)

For occupied cells ⟹ Cij = ui + vj

For unoccupied cells ⟹ △ ij = Cij – (ui + vj)

P1D2 = 150 P2D2 = 0 P3D3 = 100 P4D1 = 50

P1D3 = 150 P2D3 = 0 P3D4 = 50

P1D4 = 150 P2D4 = 0 P3D5 = 150

P1D5 = 250 P2D5 = 50

Since △ ij>=0, the solution is optimum.

Therefore, the Optimum transportation cost (Unit Cost RM ’000) (Demand and Production Capacity ’000) =

200*110 + 400*75 + 300*15 + 250*80 + 400*10 + 200*40 + 700*45 + 0*30 = 120000

Therefore, the minimum transportation cost is 120000*1000*1000=RM 120000 million.

The solution isn’t unique as P2D2, P2D3, P2D4 = 0. Thus, Alternate optimum soln. exists.

Alternate Optimum Solution:

After looping P2D4

Cell	Old Value	New Value
P2D4	0 +	45
P4D4	45 -	0
P4D2	10 +	55
P3D2	80 -	35
P3D1	15 +	60
P2D1	75 -	30

New Table:

Unit Cost	D1	D2	D3	D4	D5	Production Capacity	ui
	Destinations						
P1	200(110)	300	100	600	0	110	0
P2	400(30)	350	150	650(45)	0	75	200
P3	300(60)	250(35)	150	600	0	95	100
P4	500	400(55)	200(40)	700	0(30)	125	250
Demand	200	90	40	45	30	405	
vj	200	150	-50	450	-250		

(Unit Cost RM ’000) (Demand and Production Capacity ’000)

For occupied cells ⟹ Cij = ui + vj

For unoccupied cells ⟹ △ ij = Cij – (ui + vj)

P1D2 = 150 P1D5 = 250 P2D5 = 50 P3D5 = 150

P1D3 = 150 P2D2 = 0 P3D3 = 100 P4D1 = 50

P1D4 = 150 P2D2 = 0 P3D4 = 50 P4D4 = 0 △ij>=0, the solution is optimum.

Therefore, Optimum Transportation Cost (Unit Cost RM ’000) (Demand and Production Capacity ’000) = RM 120000 million (200*110 + 400*30 + 300*60 + 250*35 + 400*55 + 200*40 + 650*45 + 0*30 = 120000* 1000 *1000)

Another Alternate optimum soln. exists as P2D2, P2D3, P4D4 = 0 (Another Alternate solution to be found to match the optimum solution provided in the research paper so one more looping is to be done from P2D2.)

After looping P2D2

Cell	Old Value	New Value
P2D2	0 +	30
P2D1	30 -	0
P3D1	60 +	90
P3D2	35 -	5

New table:

	Destinations						
Unit Cost	D1	D2	D3	D4	D5	Production Capacity	ui
P1	200(110)	300	100	600	0	110	0
P2	400	350(30)	150	650(45)	0	75	200
P3	300(90)	250(5)	150	600	0	95	100
P4	500	400(55)	200(40)	700	0(30)	125	250
Demand	200	90	40	45	30	405	
vj	200	150	-50	450	-250		

(Unit Cost RM ’000) (Demand and Production Capacity ’000)

For occupied cells ⟹ Cij = ui + vj

For unoccupied cells ⟹ △ij = Cij – (ui + vj)

P1D2 = 150 P2D1 = 0 P3D3 = 100 P4D1 = 50

P1D3 = 150 P2D3 = 0 P3D4 = 50 P4D4 = 0

P1D4 = 150 P2D5 = 50 P3D5 = 150

P1D5 = 250

Since △ ij>=0, the solution is optimum.

Therefore, the Optimal transportation cost (Unit Cost RM ’000) (Demand and Production Capacity ’000) =

200*110 + 300*90 + 350*30 + 250*5 +400*55 + 200*40 + 650* 45 + 0*30 = 120000

Therefore, the minimum transportation cost is 120000*1000*1000=RM 120000 million.

Transportation Schedule:

Cell	Cost (RM'000)	Allocation ('000)	Total Cost ('000)
P1D1	200	110	22000
P3D1	300	90	27000
P2D2	350	30	10500
P3D2	250	5	1250
P4D2	400	55	22000
P4D3	200	40	8000
P2D4	650	45	29250
P4D5	0	30	0
		OPTIMUM COST	RM 120000 million

CONCLUSION

Effective and efficient movement of products or services from point of supply to points of demand is crucial for any business. Transporting finished products to the market at the lowest possible costs leads to huge potential of cost savings and consequently maximize company's profits. As such, the Company seeks to optimize their distribution plan for their products in relation to the cost of transportation with the help of a trading company.

The study highlighted the applications of VAM and MODI in form of linear programming and spreadsheet in a case study of a transportation problem of a Malaysian Petrochemical Company.

Optimum plan and solution to minimize the total cost of transportation were formulated and analysed.

After VAM, MODI was used to check the optimality of the allocations. But on examining it was inferred that $\triangle$wo vales of ij were negative. So looping was performed not once but twice to remo$\triangle$e the negativity of ij.

Since all the $\triangle$ ij values were non negative, the solution was optimal. Although there were multiple values of $\triangle$ ij to be zero therefore the solution wasn't unique and hence alternate solutions were possible. Consequently, the alternate solutions resulted in identical output as in the research paper

The optimal transportation cost is RM 120000 million.

Therefore, we can conclude that linear programming is an alternative decision tool available to engineers and managers alike in ensuring their operations are conducted effectively and efficiently at the lowest cost possible and consequently helps company maximize its profits.

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