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Final Report

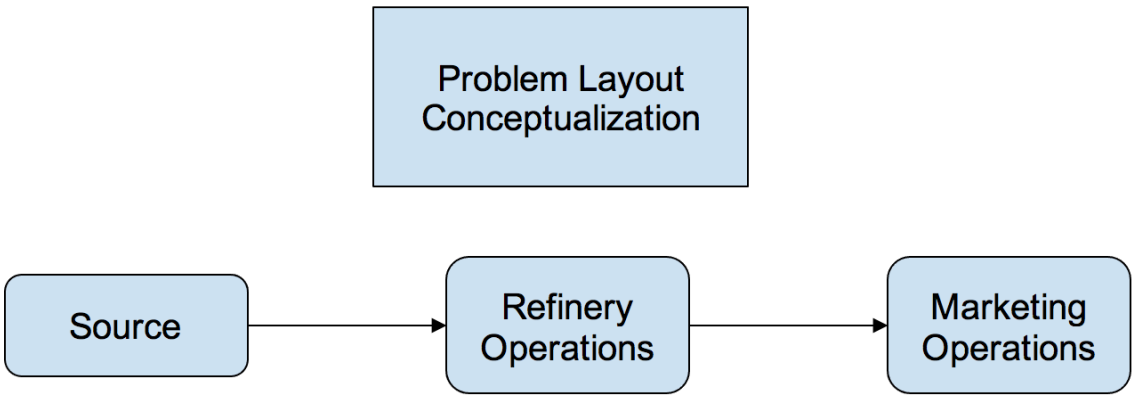
Trans World Oil Company Optimization Problem

***Part 1:* Define decision variables**

The task was to minimise the costs for the Far East Operations of the Trans World Oil Company. Our proposed solution for minimising the costs will be presented in this report.

A Linear Programming model is formulated that could be used to generate a comprehensible plan for Far East Operations of the Trans World Oil Company. The LP model is solved using MATLAB to find the optimal solution with respect to constraints.

Figure 1: Problem layout conceptualization



We chose to use the 26 variables, which are divided into 3 groups for easier understanding. These same variables can be seen in Appendix 1., where they are also colour coordinated to better understand our constraints, which we will explain later. Our chosen variables are as follows:

In the first part, sources of crude oils, we have 2 suppliers, Iran & Brunei and 2 subsidiaries for refining, Australia and Japan. Each refinery has 2 extreme intensities, Low and High. Therefore, we have table below. Unit of each variable is barrels of crude oil.

In the second part, from refinery subsidiaries to marketing subsidiaries, we have variables from x9 to x18

Costs of Crude Oil (refining and shipping included):

x1	Low Crude oil to Australia, from Brunei	aus_bru_low
x2	High Crude oil to Australia, from Brunei	aus_bru_high
x3	Low Crude oil to Australia, from Iran	aus_iran_low
x4	High Crude oil to Australia, from Iran	aus_iran_high
x5	Low Crude oil to Japan, from Brunei	jpn_bru_low
x6	High Crude oil to Japan, from Brunei	jpn_bru_high
x7	Low Crude oil to Japan, from Iran	jpn_iran_low
x8	High Crude oil to Japan, from Iran	jpn_iran_high

Moreover, there is ***Cost of tanker*** added to the total cost, we have more variables:

Costs of Shipping (gasoline and distillate):

x9	Gasoline from Australia to New Zealand	gas_aus_nz
x10	Gasoline from Australia to Philippines	gas_aus_ph
x11	Gasoline from Japan to New Zealand	gas_jpn_nz
x12	Gasoline from Japan to Philippines	gas_jpn_ph
x13	Distillate from Australia to New Zealand	dis_aus_nz
x14	Distillate from Australia to Philippines	dis_aus_ph
x15	Distillate from Japan to New Zealand	dis_jpn_nz
x16	Distillate from Japan to Philippines	dis_jpn_ph
x17	Distillate from United States to New Zealand	dis_us_nz
x18	Distillate from United States to Philippines	dis_us_ph

Demand variables are added too

x19: Number of additional independent tankers needed.

x20: Demand of gasoline for Australia.

x21: Demand of distillate for Australia.

x22: Demand of gasoline for Japan.

x23: Demand of distillate for Japan.

Part 2: Write the constraints

After careful consideration of the costs and demands given to us, we ended up with 21 constraints as the following table.

1.	$x1 + x2 + x5 + x6 = 40\,000$
2.	$x3 + x4 + x7 + x8 \leq 60\,000$
3.	$x1 + x2 + x3 + x4 \leq 50\,000$
4.	$x5 + x6 + x7 + x8 \leq 30\,000$
5.	$0{,}259x1 + 0{,}365x2 + 0{,}186x3 + 0{,}312x4 - x9 - x10 \geq x20$
6.	$0{,}688x1 + 0{,}573x2 + 0{,}732x3 + 0{,}608x4 - x13 - x14 \geq x21$
7.	$0{,}259x5 + 0{,}350x6 + 0{,}186x7 + 0{,}300x8 - x11 - x12 \geq x22$
8.	$0{,}688x5 + 0{,}588x6 + 0{,}732x7 + 0{,}620x8 - x15 - x16 \geq x23$
9.	$x9 + x11 \geq 5400$
10.	$x13 + x15 + x17 \geq 8700$
11.	$x10 + x12 \geq 5000$
12.	$x14 + x16 + x18 \geq 8000$
13.	$x17 + x18 \leq 12000$
14.	$(0{,}05x1 + 0{,}05x2 + 0{,}12x3 + 0{,}12x4 + 0{,}45x5 + 0{,}45x6 + 0{,}11x7 + 0{,}11x8 + 0{,}01x9 + 0{,}01x13 + 0{,}02x10 + 0{,}02x14 + 0{,}06x11 + 0{,}06x15 + 0{,}01x12 + 0{,}01x16) - x19 \leq 6{,}9$
15.	$x20 \geq 9000$
16.	$x21 \geq 21000$
17.	$x22 \geq 3000$
18.	$x23 \geq 12000$

<u>Part 3:</u> Write the objective function

The LP is to minimise total annual cost.

Zmin = ***(21.64x1 + 22.12x2 + 20.81x3 + 21.26x4 + 21.70x5 + 22.24x6 + 20.87x7 + 21.44x8 + 0.3x9 + 0.45x10 + 0.3x11 + 0.6x12 + 0.3x13 + 0.45x14 + 0.3x15 + 0.6x16 + 21.9x17 + 21.45x18 + 8.6x19 + 0x20 + 0x21 + 0x22 + 0x23)*365***

<u>Part 4:</u> Run the program in Matlab

We put them in Matlab and ran the program (Matlab file is included in the submission).

The optimal solution we have:
The total annual cost is 627 678 163.0705 dollars.
The number of barrels per day bought from Brunei is 40 000.
The number of barrels per day bought from Iran is 28 381.
The number of gasoline barrels per day sent to New Zealand is 5 400.
The number of gasoline barrels per day sent to the Philippines is 5 000.
The number of distillate barrels per day sent to New Zealand is 8 700.
The number of distillate barrels per day sent to the Philippines is 8 000.
The number of barrels per day bought from the US is 8 389.

Appendices

Appendix 1. Decision variables.

	unit: barrels		yields	
	crude oil	**costs**	**gas**	**dis**
x1	aus_bru_low	21.64	0.259	0.688
x2	aus_bru_high	22.12	0.365	0.573
x3	aus_iran_low	20.81	0.186	0.732
x4	aus_iran_high	21.26	0.312	0.608
x5	jpn_bru_low	21.70	0.259	0.688
x6	jpn_bru_high	22.24	0.350	0.588
x7	jpn_iran_low	20.87	0.186	0.732
x8	jpn_iran_high	21.44	0.300	0.620
	shippings			
x9	gas_aus_nz	0.3		
x10	gas_aus_ph	0.45		
x11	gas_jpn_nz	0.3		
x12	gas_jpn_ph	0.6		
x13	dis_aus_nz	0.3		
x14	dis_aus_ph	0.45		
x15	dis_jpn_nz	0.3		
x16	dis_jpn_ph	0.6		
x17	dis_us_nz	21.9		
x18	dis_us_ph	21.45		

Appendix 2. Constraints

CRUDE OIL CONSTRAINTS:															
brunei crude oil															
aus_bru_low	+	aus_bru_high	+	jpn_bru_low	+	jpn_bru_high	=	**40 000**							
iran crude oil															
aus_iran_low	+	aus_iran_high	+	jpn_iran_low	+	jpn_iran_high	<=	**60 000**							
REFINERY CAPACITY CONSTRAINTS:															
australia refineries															
aus_bru_low	+	aus_bru_high	+	aus_iran_low	+	aus_iran_high	<=	**50 000**							
japan refineries															
jpn_bru_low	+	jpn_bru_high	+	jpn_iran_low	+	jpn_iran_high	<=	**30 000**							
DEMAND CONSTRAINTS:															
australia gasoline															
aus_bru_low	+	aus_bru_high	+	aus_iran_low	+	aus_iran_high	-	gas_aus_nz	-	gas_aus_ph	>=	**9000**			
0,259		0,365		0,186		0,312									
australia distillate															
aus_bru_low	+	aus_bru_high	+	aus_iran_low	+	aus_iran_high	-	dis_aus_nz	-	dis_aus_ph	>=	**21000**			
0,688		0,573		0,732		0,608									
japan gasoline															
jpn_bru_low	+	jpn_bru_high	+	jpn_iran_low	+	jpn_iran_high	-	gas_jpn_nz	-	gas_jpn_ph	>=	**3000**			
0,259		0,350		0,186		0,300									
japan distillate															
jpn_bru_low	+	jpn_bru_high	+	jpn_iran_low	+	jpn_iran_high	-	dis_jpn_nz	-	dis_jpn_ph	>=	**12000**			
0,688		0,588		0,732		0,620									
new zealand gasoline															
gas_aus_nz	+	gas_jpn_nz	>=	**5400**											
new zealand distillate															
dis_aus_nz	+	dis_jpn_nz	+	dis_us_nz	>=	**8700**									
philippines gasoline															
gas_aus_ph	+	gas_jpn_ph	>=	**5000**											
philippines distillate															
dis_aus_ph	+	dis_jpn_ph	+	dis_us_ph	>=	**8000**									
united states distillate															
dis_us_nz		dis_us_ph	<=	**12000**											