

# Long Wang Sha Tan Ku

CASE STUDY TO OPTIMIZE COSTS AND MAXIMIZE PROFITS

## Questions

- How should customer orders be allocated between the two factories in order to reduce airfreight cost and maximize contribution ?
- Should Dragon King invest in 400 extra sewing machines in the WH factory in order to increase production capacity ?
- Could offering an Early Bird Discount increase contribution ?

## Calculate required values calculated in Excel

- Average SAM per piece = 24
- Average price per piece = 24.466
- Average revenue considered per 1000 SAM = 1019 CNY
- Average variable costs irrespective of customer =  $(877 + 809)/2 = 843$
- Average freight cost considered per 1000 SAM = 305 CNY

All calculations are in the excel sheet attached

## Information Available (Calculated in Excel)

Total Estimated Order(Pieces)	Average SAM per piece irrespective of customer	Average Revenue per 1000 SAM irrespective of customer	Average Price per piece irrespective of customer	Total Estimated Revenue	Total Estimated SAM
19755000	24	1019	24.466	483325830	474120000

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Estimated Orders(SAM)	12750000	12496800	21697800	40816200	60055200	70065600	74533200	67147200	49683600	35764800	16180800	12928800	474120000
WX Production Capacity(SAM)	29203200	26956800	29203200	31674240	34459152	38953824	37455600	37455600	37455600	36220080	31590000	28080000	398707296
WH Production Capacity(SAM)	17216160	15891840	17216160	18882720	20333334	22985508	22101450	22101450	22101450	21600072	18623250	16554000	235607394
Total Production Capacity – Estimated Orders	33669360	30351840	24721560	9740760	-5262714	-8126268	-14976150	-7590150	9873450	22055352	34032450	31705200	160194690

## Preliminary Analysis

- The efforts for Estimated orders that has to be supplied on freights is  
 $= 5262714 + 8126268 + 14976150 + 7590150$   
 $= 35955282$  SAM
- Given that Air Freight Cost / 1000 SAM is 305 CNY
- So the Total Estimated Freight cost that can be possible is  
 $= (35955282 * 305) / 1000$   
 $= 10966361$  CNY
- Average Revenue / 1000 SAM is 1019 (Average From Exhibit 2)
- Average Production Costs / 1000 SAM is 843 (Average from Exhibit 4)
- Hence Average Revenue for all Orders  
 $= (474120000 * 1019) / 1000$   
 $= 483128280$  CNY
- Also Average costs irrespective of factory  
 $= (474120000 * 843) / 1000$   
 $= 399683160$  CNY

## Preliminary Analysis (Continued)

- Total Estimated Profit is  
= Estimated Revenue – Production Costs – Freight Costs  
= 483128280 – 399683160 – 10966361  
= 72478759 CNY  
= 7.24 Crores
- If Dragon King can avoid these freights it can save 10966361 CNY more which is approximately 1.09 Crores(15% of total profit). Then the profit would be 8.34 Crores
- Hence avoiding these freight costs is very important and can increase the annual profits by 1.09 Crores which is nearly equal to 11 million CNY

## Assumptions

Let us assume the following:

- The demand won't change much & will be as per the estimations through out the year
- Dragon King has the space to store any excess stock produced in a month as inventory
- There is adequate funds to purchase new machines

## Question 1 - Solution

- In order to understand the contribution between the factories exactly along with restrictions we need to have variables that define the production at each factory for each customer in each month
- For example
- Production at WX for Customer 1 in October can be defined as  $PWxC1Oct$
- Similarly for 10 customers in October will be like  $PWxC2Oct$ ,  $PWxC3Oct$ ,..... $PWxC10Oct$  which will be 10 variables
- Similarly for all 12 months there will be  $12*10 = 120$  variables
- For the second factory WH also has the same kind of variable. So the total variable that has to be used for Production at a factory for a customer in a month will be  $120 * 2 = 240$  variables in total
- Apart from this we need to have other variables that indicate Inventory, Demand, whether production is there or not in a month, etc.
- So there will be so many variables and equations which can't be solved using solver. Hence we will simplify by considering production at factory irrespective of customers



## Question 1 Solution – Define variables

So the decision variables are as follows:

- $P_{wxi}$  = Production at  $W_x$  in month  $i$  in pieces
- $P_{whi}$  = Production at  $W_h$  in month  $i$  in pieces
- $D_i$  = Demand in month  $i$  in pieces
- $I_i$  = Inventory in month  $i$  in pieces
- $K_{wxi}$  = Production happens or not in month  $i$ , belongs to  $\{0,1\}$
- $K_{whi}$  = Production happens or not in month  $i$ , belongs to  $\{0,1\}$

Where  $i = 10, 11, 12, 1, 2, 3, 4, 5, 6, 7, 8, 9$

1 is considered as January and 12 as December for readability to avoid confusion

## Question 1 Solution – Define objective function

Let  $F_i$  be the freight costs in month  $i$

Given that Air Freight / Piece is 7.25 CNY (From Exhibit 6)

- $F_i = 7.25 * (D_{i-1} - P_{wxi} - P_{whi})$
- $F_{10} = 0$  (assumed as in October the capacity is more than demand)

Where  $i = 10, 11, 12, 1, 2, 3, 4, 5, 6, 7, 8, 9$

1 is considered as January and 12 as December for readability to avoid confusion

So the objective function will be as follows:

$$\mathbf{Z \text{ Min} = F_{10} + F_{11} + F_{12} + F_1 + F_2 + F_3 + F_4 + F_5 + F_6 + F_7 + F_8 + F_9}$$

## Question 1 Solution – Define constraints

- $D_i - P_{wxi} - P_{whi} + I_i - I_{i-1} = 0$
- $I_{10} = 0$  (assumed)
- $I_9 = 0$  (assumed)

Production at Wx is either 0 or  $\geq 200000$

- $P_{wxi} \leq 1623076 * K_{wxi}$
- $P_{wxi} - 1623076 * K_{wxi} \geq -1423076$

Production at Wh is either 0 or  $\geq 100000$

- $P_{whi} \leq 957730 * K_{whi}$
- $P_{whi} - 957730 * K_{whi} \geq -857730$

Where  $i = 10, 11, 12, 1, 2, 3, 4, 5, 6, 7, 8, 9$

1 is considered as January and 12 as December for readability to avoid confusion

## Question 1 Solution – Define constraints

Production is less than production capacity at any factory in a month

- $P_{wxi} \leq \text{Sewing capacity in } i \text{ month at WX}$
- $P_{whi} \leq \text{Sewing capacity in } i \text{ month at WH}$
- $\text{Sigma } P_{wxi} \leq \text{Total capacity at WX}$
- $\text{Sigma } P_{whi} \leq \text{Total capacity at WH}$

Where  $i = 10, 11, 12, 1, 2, 3, 4, 5, 6, 7, 8, 9$   
1 is considered as January and 12 as December for readability to avoid confusion

Month	Sewing Capacity WX in pieces	Sewing Capacity WH in pieces
Oct	1216800	717340
Nov	1123200	662160
Dec	1216800	717340
Jan	1319760	786780
Feb	1435798	847222.25
Mar	1623076	957729.5
Apr	1560650	920893.75
May	1560650	920893.75
Jun	1560650	920893.75
Jul	1509170	900003
Aug	1316250	775968.75
Sep	1170000	689750
Total	16612804	9816974.75

## Question 1 Solution – Solve using Excel Solver

- Fill the sheet as per equations including objective function
- Add all the constraints and solve using Simplex LP algorithm

Solver Parameters

Set Objective:

To: ☐ Max ☒ Min ☐ Value Of:

By Changing Variable Cells:

Subject to the Constraints:

☒ Make Unconstrained Variables Non-Negative

Select a Solving Method:

Options

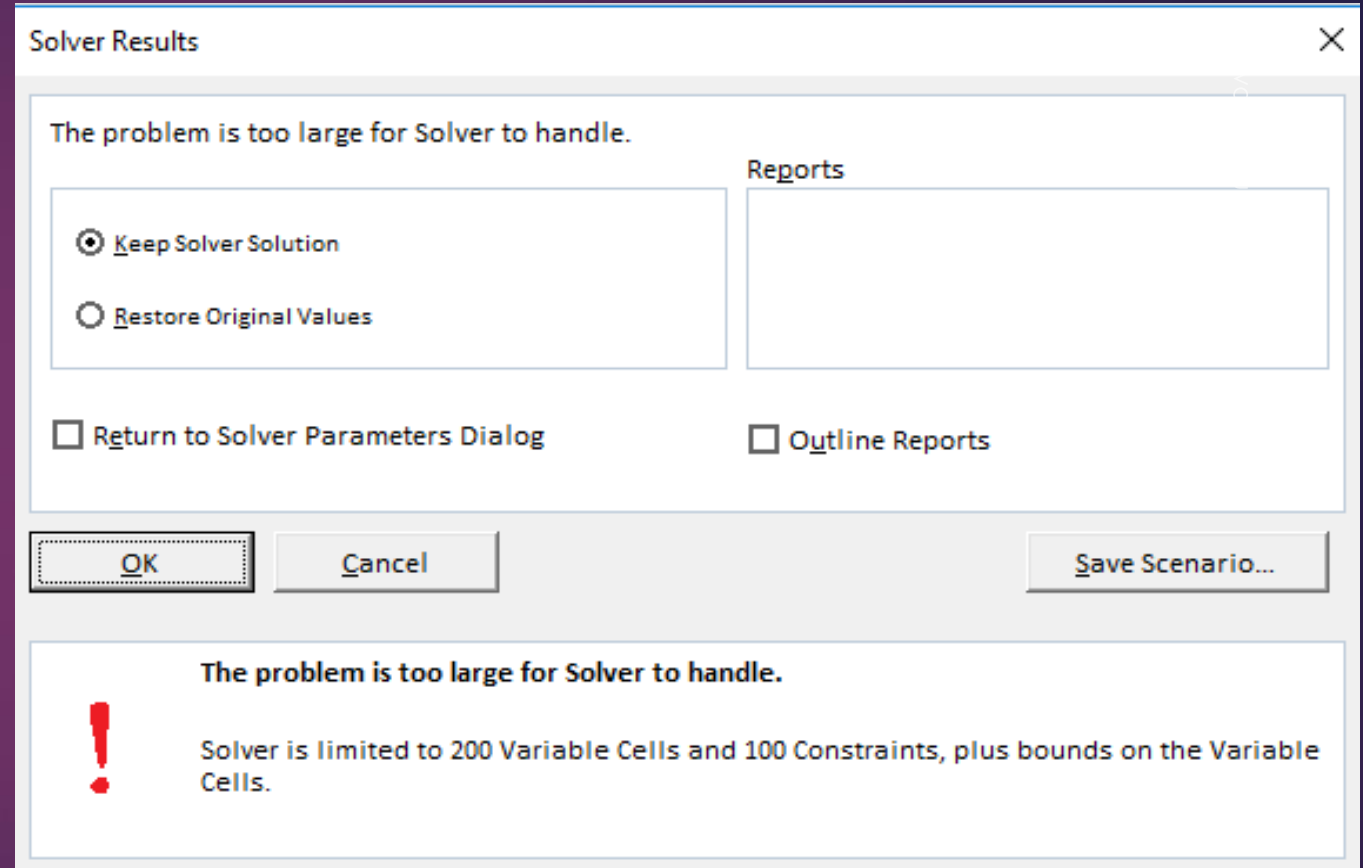
Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Help Solve Close

## Question 1 Solution – Solve using Excel Solver

- Excel Solver is not able to solve this due to too many variables and constraints as per the message in popup
- As this is limitation in Excel solver we will go by a different approach



## Question 1 Solution – Values calculated in Excel

- Dragon King won't be able to meet demand in the months of Feb, March, April and May as estimated orders exceed total production capacity in these months.
- In all the remaining months, the capacity is more than demand where they can produce more than demand.
- Lag in these 4 months is 14,98,136 pieces which is nearly 15 Lakhs.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
<b>Estimated Orders(# of pieces)</b>	531250	520700	904075	1700675	2502300	2919400	3105550	2797800	2070150	1490200	674200	538700	19755000
<b>Sewing Capacity WX in pieces</b>	1216800	1123200	1216800	1319760	1435798	1623076	1560650	1560650	1560650	1509170	1316250	1170000	16612804
<b>Sewing Capacity WH in pieces</b>	717340	662160	717340	786780	847222.3	957729.5	920893.8	920893.8	920893.8	900003	775968.8	689750	9816975
<b>No of pieces that can be made in month in excess</b>	1402890	1264660	1030065	405865	-219280	-338595	-624006	-316256	411393.8	918973	1418019	1321050	6674779

## Question 1 Solution – Values calculated in Excel

Suggest to produce 4 Lakhs more pieces in the months of Oct, Nov, Dec and Jan as the production capacity permits. The excess of 1 Lakh can be maintained as inventory which can be adjusted in months June to Sep based on the situation.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
<b>Monthly Production in excess than demand(Pieces)</b>	1402890	1264660	1030065	405865	-219280	-338595	-624006	-316256	411393.8	918973	1418019	1321050
<b>Suggested Production month wise(Pieces)</b>	931250	920700	1304075	2100675	2102300	2519400	2705550	2397800	2070150	1490200	674200	538700



## Question 2 Solution - Values calculated in Excel

- Average Revenue per 1000 SAM irrespective of Customer = 1019 CNY (Calculated from Exhibit 2)
- Difference between production costs per 1000 SAM is =  $877 - 809 = 68$  CNY
- SAM Capacities are calculated in Exhibit 3b and other calculations in Exhibit 2 and New Machines tabs

<b>WX Estimated Revenue 2600 mac</b>	406282734.6
<b>WH Estimated Revenue 1550 mac</b>	240083934.5
<b>WX Estimated Revenue 2600 mac less extra prod</b>	344327518.3
<b>WH Estimated Revenue 1950 mac</b>	302039150.8

<b>WX Estimated Prod Cost 2600 mac</b>	349666298.6
<b>WH Estimated Prod Cost 1550 mac</b>	190606381.7
<b>WX Estimated Prod Cost 2600 mac less extra prod</b>	296344684.6
<b>WH Estimated Prod Cost 1950 mac</b>	239793594.7

## Question 2 Solution - Values calculated in Excel

Profit is higher by 13 lakhs even after depreciation of machines in 1st year. Hence recommend purchase of new machines.

<b>WX 2600 and WH 1550 Estimated Profit</b>	106093988.8	10.61 Cr
<b>WX 2600 and WH 1950 Estimated Profit</b>	110228389.9	11.02 Cr
<b>WX 2600 and WH 1950 Estimated Profit with deprecation costs in year 1</b>	107393389.9	10.74 Cr
<b>Profit after including deprecation costs</b>	1299401.088	13 Lakhs

### Question 3 Solution – Calculations for April

- Profit for the stock that has to be transported by Air Freight if in case the same will be delivered with discount under Early Bird Offer is 2635802 CNY
- Minimum expected discount(1%) is 152607 CNY
- There will be profit till 17% of discount. If discount exceeds that then there won't be any profit in delivering early and also there will be loss

So recommend not to extend discount more than 17% under Early Bird schemes

	<b>SAM</b>
Demand	74533200
WX capacity	37455600
WH capacity	22101450
Can't be produced	14976150

No of pieces	624006.3
Revenue for above SAM	15260697
Freight Costs	4567726
Profit If sent on freight(Loss)	-1931923
Prod Costs	12624894
<b>Profit(Revenue-Prod Costs)</b>	<b>2635802</b>
Revenue for early bird eligible(Min 1%)	152607

Discount on Price	Amount	Profit/Loss
1%	152606.9685	Profit
2%	305213.937	Profit
3%	457820.9055	Profit
4%	610427.874	Profit
5%	763034.8425	Profit
6%	915641.811	Profit
7%	1068248.78	Profit
8%	1220855.748	Profit
9%	1373462.717	Profit
10%	1526069.685	Profit
11%	1678676.654	Profit
12%	1831283.622	Profit
13%	1983890.591	Profit
14%	2136497.559	Profit
15%	2289104.528	Profit
16%	2441711.496	Profit
17%	2594318.465	Profit
18%	2746925.433	Loss
19%	2899532.402	Loss
20%	3052139.37	Loss

### Question 3 Solution – Calculations for May

- Profit for the stock that has to be transported by Air Freight if in case the same will be delivered with discount under Early Bird Offer is 1335866 CNY
- Minimum expected discount(1%) is 77343 CNY
- There will be profit till 17% of discount. If discount exceeds that then there won't be any profit in delivering early and also there will be loss

So recommend not to extend discount more than 17% under Early Bird schemes

	<b>SAM</b>
Demand	67147200
WX capacity	37455600
WH capacity	22101450
cant be produced	7590150

No of pieces	316256.3
Revenue for above SAM	7734363
Freight Costs	2314996
Profit If sent on freight(Loss)	-979129
Prod Costs	6398496
<b>Profit(Revenue-Prod Costs)</b>	<b>1335866</b>
Revenue for early bird eligible(Min 1%)	77343.63

Discount on Price	Amount	Profit/Loss
1%	77343.6285	Profit
2%	154687.257	Profit
3%	232030.8855	Profit
4%	309374.514	Profit
5%	386718.1425	Profit
6%	464061.771	Profit
7%	541405.3995	Profit
8%	618749.028	Profit
9%	696092.6565	Profit
10%	773436.285	Profit
11%	850779.9135	Profit
12%	928123.542	Profit
13%	1005467.171	Profit
14%	1082810.799	Profit
15%	1160154.428	Profit
16%	1237498.056	Profit
17%	1314841.685	Profit
18%	1392185.313	Loss
19%	1469528.942	Loss
20%	1546872.57	Loss

## Overall Recommendation

- Suggest to produce 4 Lakhs more pieces in the months of Oct, Nov, Dec and Jan to meet the 15 Lakhs pieces lag in later months. Excess of 1 Lakh pieces produced can be maintained as inventory which can be adjusted in months June to Sep based on the situation. This will help in increasing the profits by avoiding freight charges. Also this can improve customer satisfaction as receiving freight stock is not very convenient to customers.
- Purchase 400 new machines and increase production at WH such that production in WX:WH will be nearly 1:1 (Currently it is nearly 2:1). This helps in reducing the variable costs and will improve the profits.
- Do not give discount more than 17% of the revenue under Early Bird offers in order to avoid freights as discount more than this threshold will lead to losses. Suggest to make it 7% such that Dragon King can make profits up to 10% more keeping the customers also happy at the same time.

## Learnings from the case

- Optimize the profits by understanding revenues, demand and supply
- Identify suitable parameters and transform them to mathematical equations
- Applying linear programming techniques and identify optimal values of critical parameters that lead to several benefits