# LONG WANG SHA TAN KU COMPANY

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# Outline

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# Problem Statement

- Long Wang Sha Tan Ku (Dragon King Shorts Company) locates in Shanghai, China, and sells boardshorts to companies in Europe, North America, and Australia.
- Dragon King owns two factories, WH and WX, and has a combination of 10 customers.
- Ming Chen of Dragon King Shorts Compnay needs to investigate 3 options that can potentially increase the company's profit.
- The three options are
    - Allocation between WX and WH
    - Invest in 400 extra sewing machines
    - Offer Early Bird Discount

# Assumptions

- When demand exceeds capacity in a certain month, Dragon King uses the capacity of the following month to complete the unfinished demand
- In that case, the products are sent out by airfraught since there is a one month delay for standard shipping
- If we choose to invest in additional sewing machines, the cost for those machines is calculated by their first year depreciation value
- we assume the addtional 400 machines can reach the same occupancy rate as the original machines
- The minimum production quantity for each customer in WX and WH are 200,000 pieces and 100,000 pieces, respectively

# Model Development - Allocation

Let $x_{ijkl}$ be the number of SAM for customer i in month j at factory k using the shipment method of l

Let $R_i$ be the estimate revenue/1000SAM for customer i

$D_i$ be the demand estimate for customer i

$P_{ij}$ be the proportion of demand for customer I at month j

$Wd_j$ be the number of workdays in month j

$Wm_j$ be the number of work minutes in month j

$E_{jk}$ be the efficiency of workers for month j at factory k

$W_{jk}$ be the number of workers for month j at factory k

$S_i$ be average SAM per pcs for customer i

i = 1..10, j = Oct..Sep, k = WX, WH, l=normal shipment, airfreight

# Model Development - Allocation

$$\min \sum_{j=1}^{12} \sum_{i=1}^{10} 877x_{ij11} + 809x_{ij21} + 591x_{ij12} + 557x_{ij22}$$

$$s.t. \sum_{k=1}^{2} x_{ijk1} + x_{i(j+1)k2} = D_i P_{ij} S_i \; \forall \, i = 1..10, j = 1 \ldots 12$$

$$\sum_{l=1}^{2} \sum_{i=1}^{10} x_{ijkl} \leq Wd_j Wm_j E_{jk} W_{jk} \; \forall \, j = 1..12, k = 1..2$$

$$\sum_{j=1}^{12} x_{ij11} \geq 200000 S_i \; \forall \, i = 1 \ldots 10$$

$$\sum_{j=1}^{12} x_{ij21} \geq 100000 S_i \; \forall \, i = 1 \ldots 10$$

All variables $\geq 0$

# Model Development - Expansion

- Basically the same model as the Allocation option, except with 400 more sewer machines in WH factory and more costs for the setup. In other words, different workminutes

$$\min \sum_{j=1}^{12}\sum_{i=1}^{10} 877x_{ij11} + 809x_{ij21} + 591x_{ij12} + 557x_{ij22}$$

$$s.t. \sum_{k=1}^{2} x_{ijk1} + x_{i(j+1)k2} = D_i P_{ij} S_i \; \forall \, i = 1..10, j = 1 \ldots 12$$

$$\sum_{l=1}^{2}\sum_{i=1}^{10} x_{ijkl} \leq Wd_j Wm_j E_{jk} W_{jk} \; \forall \, j = 1..12, k = 1..2$$

$$\sum_{j=1}^{12} x_{ij11} \geq 200000 S_i \; \forall \, i = 1 \ldots 10$$

$$\sum_{j=1}^{12} x_{ij21} \geq 100000 S_i \; \forall \, i = 1 \ldots 10$$

$$\text{All variables} \geq 0$$

# Model Development - Early Bird

- Allocation heuristic: Pick the ones with the lowest revenue/1000SAM so that we are giving the least discount.
- Same mathematical model as the Allocation model

| Customer | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 16.5 | 17 | 20.5 | 13 | | | | 7 | 10 | 6 | 5 | 5 | 100 |
| 2 | 4 | 4 | 5 | 8 | 12 | 14 | 13 | 12 | 10 | 7 | 6 | 5 | 100 |
| 3 | | | | 8 | 15 | 20 | 20 | 20 | 10 | 7 | | | 100 |
| 4 | | | | 10 | 10 | 15 | 20 | 20 | 15 | 10 | | | 100 |
| 5 | | | | 10 | 15 | 20 | 17.5 | 15 | 12.5 | 10 | | | 100 |
| 6 | | | 5 | 7.5 | 15 | 15 | 20 | 15 | 12.5 | 10 | | | 100 |
| 7 | | | 5 | 7.5 | 12.5 | 15 | 17.5 | 15 | 12.5 | 10 | 5 | | 100 |
| 8 | | | 4 | 10 | 15 | 18 | 16 | 15 | 10 | 7 | 5 | | 100 |
| 9 | 20 | 20 | 20 | 10 | 5 | | | | | | 10 | 15 | 100 |
| 10 | 16 | 16 | 21 | 23 | | | | | 8 | 7 | 5 | 4 | 100 |

# Base Solution

- As we can see, the Early Bird option is the most profitable one and the Allocation option is the least profitable one.
- If the early bird option is successful, there would be no airfreight cost at all. The savings from the airfreight cost is much more significant than the discounts given.
- The expansion option does save a lot of airfreight needs, but it does not fully eliminate all demand>capacity situations

| | Total Cost | Total Revenue | Profit |
|---|---|---|---|
| Allocation | 428,038,144 | 478,558,450 | 50,520,305 |
| Expansion | 405,233,514 | 478,558,450 | 73,324,936 |
| Early Bird | 396,685,207 | 477,530,739 | 80,845,532 |

# Sensitivity Analysis - 300 machines expansion

- As we can see, even though less machines mean less setup cost, more machines mean more airfreight cost savings so that the total cost is less when there are more machines.

| | Total Cost | Total Revenue | Profit |
|---|---|---|---|
| 300 machines | 406,583,135 | 478,558,450 | 69,149,065 |
| 400 machines | 405,233,514 | 478,558,450 | 73,324,936 |

# Sensitivity Analysis - Improve Efficiency

Although we are not given the way to improve efficiency, we believe it is possible to improve the efficiency in WH factory with some financial or non-financial incentives, because it has not reach the efficiency of workers in WX factory. Therefore we apply 1% improvement of efficiency in WH factory and find that we can gain **more than 1 million** profit even with only 1% improvement in one factory. We believe this is a very attractive oppotunity to gain more.

| | Total Cost | Total Revenue | Profit |
|---|---|---|---|
| Original | 428038144.7 | 478558450 | 50520305.32 |
| Improve 1% efficiency in WH factory | 426714220.3 | 478558450 | 51844229.68 |
| Gain | | | 1323924.358 |

# Conclusion

- Since the first two options has the same revenue and the third option generates very close revenue compared to the first two, so the issue here is to minimize cost with the most expensive cost coming from airfreight.
- Even though the Early Bird option generates less revenue, it saves the most money and gives the highest profit, at around 80 million Yuan. However, this option is not guranteed to success because there is no guarantee that customers will be willing to move order forward.
- If we choose the Expansion option, it is the most profitable if we choose to have 400 machines, which is the most we can have as there is space limitation.
- Efficiency of workers is a critical factor that should be consider.