RCF Case Study

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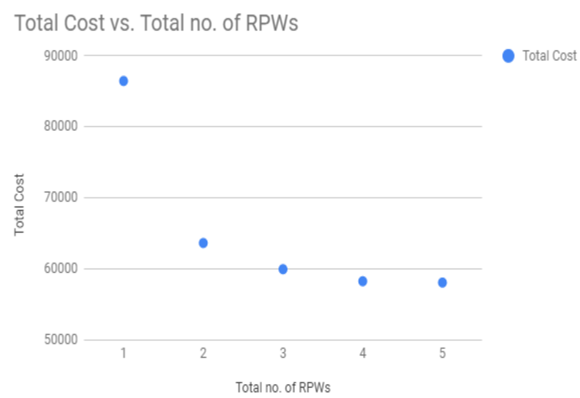
Solution 1:

Total no. of RPWs	Total Cost	Location of warehouses in the solution
1	86462	Bangalore
2	63658.375	Bangalore, Gulbarga
3	59973.625	Bangalore, Gulbarga, Raichur
4	58277.125	Bangalore,Gulbarga, Raichur, Bellary
5	58093.375	Bangalore, Gulbarga, Raichur, Bellary, Hospet



From the above graph, we observe that the total freight charges is inversely proportional to the number of rake warehouses that are being opened up (assuming the fixed cost of opening the warehouses to be zero here).
Refer to the following for a detailed model description written to obtain the above values:
Model file:
Data file:

Solution 2:

Based on some existing data on the fixed costs, we can estimate the fixed cost for any warehouse by using linear regression model by taking into account the following features:

1. **Location** : city, proximity to the railway station, geographical terrain
2. **Capacity of the Warehouse**: larger the warehouse, higher is the fixed cost
3. **Contract terms**: long term/short term(duration), mode of payment
4. **Facilities offered inside the warehouse**: cold stores, elevators ; number of trucks that can be loaded or unloaded simultaneously.

The optimisation problem is given as follows (we have considered the fixed costs as parameters in our model)
Let, $RPW_1,RPW_2\ldots,RPW_5$ be binary variables which takes the value 1 if the i^{th} RPW is opened
Let, $FPW_1,FPW_2,\ldots,FPW_9$ be binary variables which takes the value 1 if the i^{th} FPW is opened
Let x_{ij} denote the quantity transferred from the i^{th} RPW to the j^{th} FPW. i=1,..,5; j=1,..,9
Let y_i be the quantity transferred from the factory to the i^{th} RPW. i=1,..,5
Let z_i=1 if the i^{th} RPW is open. Otherwise it takes the value 0. i=1,..,5

Minimize cost = $\sum_i \mathrm{prim\_costs[i]} * \mathrm{y[i]} + \sum_{i,j} \mathrm{sec\_costs[i,j]} * \mathrm{x[i,j]} + \sum_i z[i] * fixed[i]$
subject to:
y[i] <= M*z[i] i=1,..,5   # Opening of RPW; M is a very big number

$\sum_j x[i,j] \leq y$[i] i=1,..,5; j=1,..,9   # Quantity constraint
$\sum_i x[i,j]$ >= demand[j] i=1,..,5; j=1,..,9   # Demand constraint
x_{ij}>=0 for all i,j ; #Bound constraint
y_i>=0 for all I;#Bound constraint

Solution 3:

One way to keep safety stock in order to face the scenario of fluctuations above demands is by keeping a stock of 2*sigma above the forecasted value every month and ensuring that the inventory level does not cross this number where sigma is the standard deviation observed in the forecasted values of the demand which gives a rough estimate on the variation seen in demand in a given season.

Number of RPW's opened	Estimated Standard Deviation observed in the demand	Level of Safety Stock maintained

		(on an avg) every month
1	72.33332133	144.6666
2	17.5125+55.53588= 73.04838	146.0968
3	17.5125+ 35.35887+ 20.52704 =73.39841	146.7968
4	17.5125+35.35887+3.479853+17.6759=74.02712	148.0542
5	76.08350934	152.167

***Remark: The logic behind keeping 2*sigma as the safety stock is that statistically, any general random variable takes values in the interval (avg-2*sigma,avg+2*sigma) more than 90% of the time. Here, we see that as we combine the demands of two or more RPW's, then the standard deviation of the sum is atmost the sum of the respective standard deviation, hence we need to maintain lower safety stock with lower number of RPW's. Here, the RPWs have been pooled based on the solution obtained by ques1.

Solution 4:

Total no. of RPWs	Total Cost with original transport cost	Location of warehouses in the solution with the original costs	Total Cost with some connections to be established based on the cost	Location of warehouses in the solution with some connections disrupted
1	86462	Bangalore	86462	Bangalore
2	63658.375	Bangalore, Gulbarga	67745.375	Bangalore, Gulbarga
3	59973.625	Bangalore, Gulbarga, Raichur	62085.375	Bangalore, Gulbarga, Raichur
4	58277.125	Bangalore,Gulbarga, Raichur, Bellary	59497.125	Bangalore, Gulbarga, Raichur, Bellary
5	58093.375	Bangalore, Gulbarga, Raichur, Bellary, Hospet	59497.125; W/o (G-B);(H-H) 58277.125; (G-B) allowed 59313.375; (H-H) allowed	Bangalore, Gulbarga, Raichur, Bellary

From the above solution we infer that:

For K=1: Establishing any new connection between Gulbarga – Belgaum, Bellary - Raichur and Hospet – Hassan would not lead to any cost saving since these connections are not a part of the optimal solution in either case.

For k=2: Establishing a connection between Gulbarga-Belgaum will be economically viable for RCF if this cost to be incurred monthly is less than (67745.375-63658.375)=4087.

For k=3: Establishing a connection between Gulbarga-Belgaum will be cost efficient for RCF if this cost to be incurred monthly is less than (62085.375-59973.625) = 2111.75.

For k=4: Establishing a connection between Gulbarga-Belgaum will be cost efficient for RCF if the monthly cost to be paid for this less than (59497.125-58277.125)= 1220.

For k=5: Here, one can explore 3 different scenarios:

Establishing Gulbarga-Belgaum and Hospet-Hassan if the total monthly cost to be incurred is less than: (59497.125-58093.375)= 1403.75

Establishing Gulbarga-Belgaum connection is economically viable if the monthly cost incurred for the same is less than (59497.125-58277.125) = 1220.

Establishing Hospet-Hassan connection will be economically viable if the monthly cost incurred is less than : =(59497.125-59313.375)=183.75.

Solution 5 :

Consider the following set of assumptions:

1. We assume that the order placed to the factory every month is the order placed in advanced for next month based on forecasting and a factor of fluctuation observed in the current demand.

2. From march ownward, the orders are placed twice a month and the order quantity gets divided to half the forecasted value plus some level of fluctuation observed in the month.
3. For month of March, the order for the entire month is placed in the month of February inspite of the fact that demand generated in month of March is twice.

FPW Order Placement	RPW Order Receival and Placement (2.5 days on avg)	Factory Order Receival (3.5 days on an av)	RPW Shipment Receival	FPW Shipment Receival	Pipeline Inventory Level	Order Placed for Month
September ,25	September ,27-28	October ,1	October ,22	October ,29	(28)*(f_o+k1)	October
October ,25	October ,27-28	October, 31	November,21	November,28	(28)*(f_n+k2)	November
November,25	November, 27-28	December,1	December,22	December,29	28*(f_d+k3)	December
December,25	December,27-28	December,31	January,21	January,28	28*(f_ja+k4)	January
January,25	January,27-28	January,31	Febraury,22	March,1	28*(f_f+k5)	February
Febraury,25	February,27-28	March,1	March,22	March,29	28*(f_m+k6)	March
March,10	March,12-13	March,16	April,6	April,13	28*(f_a*0.5+k7)	April,10
March,25	March,27-28	March,31	April,21	April,28	28*(f_a*0.5+k8)	April,25
April,10	April,12-13	April,16	May,7	May,14	28*(f_m*0.5+k9)	May,10
April,25	April,27-28	May,1	May,22	May,29	28*(f_m*0.5+k10)	May,25
May,10	May,12-13	May,16	June,6	June,13	28*(f_ju*0.5+k11)	June,10
May,25	May,27-28	May,31	June,21	June,28	28*(f_ju*0.5+k12)	June,25
June,10	June ,12-13	June,16	July,7	July,14	28*(f_jl*0.5+k13)	July,10
June,25	June,27-28	July,1	July,22	July,29	28*(f_jl*0.5+k14)	July,25
July,10	July,12-13	July,16	August,6	August,13	28*(f_au*0.5+k15)	August,10
July,25	July,27-28	July,31	August,21	August,28	28*(f_au*0.5+k16)	August,25
August,10	August,12-13	August,16	September,6	September,13	28*(f_s*0.5+k17)	September,10
August,25	August,27-28	August,31	September,21	September,28	28*(f_s*0.5+k18)	September,25
September,10	September,12-13	September,16	October,7	October,14	**No order placed	October

From the above simulation, we observe that from October'1-March'1, with the assumption that average forecast per month in the lean season is statistically close enough, one can observe to see roughly stagnant levels of inventory averaged around the total demand during that season every day. The system takes some 4 days to shift to a new level of inventory (the period of transition from lean season to peak season September'28 to October '1). Again, at the beginning of month of March,March'16 to September'28, one gets to observe a constant level of inventory equal to roughly half of the average demand per day in the peak season. Now, in order to get to this stable point, it takes around 37 days to settle down. (March'1 to April'6).

Solution 6 :

We assumed in this case that the total lead time can be disintegrated into two components in two different ways (fixed part(for order processing,loading/unloading) and the variable part(consignment delivery time))

Case 1: Direct delivery from the factory to FPW

Let, $z(f,0,r)=x+y(f,0,r)$ be the total lead time, where x is the fixed part and $y(f,0,r)$ is the variable part.

Here f denotes the final source which is factory and r denotes the FPW.

Case 2: Delivery via RPW

Let, $z(f,l,r)=x+y(f,l)+y(l,r)$ be the total lead time, where x is the fixed part and $y(l,r)$ is the variable part.

Here l denotes the intermediate RPW and r denotes the FPW.

Let $D(i)$ denote the average daily demand at FPW(i)

We assume that $y(i,j)$ is $=k*d(i,j)$ where $d(i,j)$ is the distance between i and j where k is appropriately defined scaling factor.

Now, let us denote $S=\{(f,j,k)/j \text{ in } \{r1,..,r5,0\},k \text{ in } \{f1,..f9\}\}$ denote the path of overall consignments delivery.

Now, let p_S be the rough pipeline inventory associated with path S.

Then, $p\_S= \{\text{Sum over } i,j\}\ z(f,i,j)*D(j)*1\{(f,i,j) \text{ in } S\}$

The above formulation can be interpreted as the total average per day demand weighted by the respective lead time associated with path S where S is well defined.