coordinated\_ordering9

GroupB

28/07/2020

Table of Contents

# Data preparation

## Convert to Boxes

Convert demand , quantity and unit price all from part to box which is the capacity of a box for part .

Demand for box with part .

Price for box with material .

value of box

# Separate Ordering (SO)

ordering cost for part

stock holding cost rate based on unit price and interest rate therefore

calculate EOQ for each part i:

$$ q\_i^\* = \sqrt \frac{2 \cdot y\_i \cdot (c\_i^{or}+c^{-or})}{pr\_i \cdot h}$$

Min EOQ, used in starting feasible solution.

$$ q\_i^\* = \sqrt \frac{2 \cdot y\_i \cdot (c\_i^{or})} {pr\_i \cdot h}$$

## EOQ modelling

## Lane Occupation

sorting column lenght or width.This determines the lane width

if sorted by length then the value is width and vice versa, used for rack lenght.

Add and to product\_data table

E.g Using box\_ID 6203060, sorted by length , Also for material ID 7305667+74 with therefore,

*1.* Number of boxes in a lane:

*2.* How many lanes part will occupy if you order some number of boxes

$$lane\_i=q\_i \cdot \frac {b\_i^{-1}}{rack\_{length}}=214 \cdot \frac {297}{6000}=10.593= 11 \space lanes $$

1. Do we meet the capacity contraint?

*3.* Total number of lanes constraints

Collapsing Rack 4 levels in a rack and joining the 8 racks to become 1 level.

Total rack width available:

Overflow in mm

relative overflow in %

Please note the coefficients are are different for every ith item except racklength which is the same for all items.Also the left and right hand side of the equation need to be in mm.

As seen above contraint was voilated by , this means that we ordered too much, therefore we need to optimize

Using our example to get number of the total width i.e (summation of lanes) in : Summation of lanes can simply be:

Using equation (1) to prove this concept.

1. Adjust Q by reducing it:

no of orders for part .

average inventory for part

## Constrained EOQ optimization

Subject to:

removing waste of 150 for every 32 levels

## No constraint

## Compare results

Remember, was dropped from the objective function as it is not decision relevant. \* *Total costs using EOQ* This has no constraint.

* *Total costs with Capacity constraint Optimized*
* *Total costs with no Capacity constraint Optimized* This is using EOQ.min

Optimum costs with no capacity constraint using EOQ.max considers is €172279.7, with no capacity constraint optimized using EOQ.min is €124508.6, with capacity constraint, it costs €205079.8 This cost is expected to be higher when capacity constraint is included, as limited capacity will not allow to take advantage of cost savings.

Plot EOQ cost vs cost

cost function per item

The above result shows that If there is no capacity constraint, the cost will be lower.

* Notice that 26 blue dots which represents the more expensive items when capacity is accounted for.
* Also the notice , for most items where the blue is larger than black (non constraint items)(the variance is much more) the difference is much larger. the reverse is the case when black is larger than blue.

# Joint Ordering (JO)

Using Joint replenishment problem

Assumptions:

* One supplier with outbound storage.
* products
* Demand rates:
* Stock\_holding cost rates:
* Specific setup costs:
* General setup costs:
* Cycle time of product :

## Objective Function with no capacity constraint

* basic cycle time
* Holding cost multiplier are $H\_0 \space and \space H\_i$

$$ subject \space to: \quad \quad \quad \quad \quad \quad \quad \quad \quad$$

–> an important side note is that the JRP is basically a quite standard EOQ problem which uses the substitution , i.e., . Then, you substitute ans result in the JRP (adding the common ordering cost).

* *Cycle Time*

we determine and

$$B=\sqrt \frac {\sum\_{i=0}^n \frac {c\_i^{or}}{m\_i}}{\sum\_{i=0}^n m\_i \cdot H\_i} $$

Reoptimizing basic cycle time yields and the total cost are 4.99433410^{4}

The order quantities are given by multiplying the cycle times with demand rates , i.e.  such that

–> Now the question is: Is this feasible? –> no:

When you try to optimize the JRP directly, without introducing the substitution you need to update the JRP function as follows

## Including capacity constraint

–> You should integrate the shelf capacity constraint –> I also recommmend to stick with the basic period approach

This is formally defined as

Thus, with the substitution above, the left-hand side changes to

Thus, you can change the constraint function quite easily

Then, you can use the original JRP function and update the model by including the capacity constraint. Therefore I recommend that you fix to some appropriate value based on the feasible solution above

Afterwards, you have to find a layout scheme such that a precise shelf layout results.

As you rightly point out you need to calculate the number of lanes required for each product given a certain order quantity (integer number of boxes):

whereby is the number of boxes per lane dedicated to product . I.e.,

. Thus, for the solution of the JRP we have:

Now, these lanes have to be assigned to the levels of the shelves. Therefore, we first need to determine the types of lanes required. The lanes are just described by their width. Due to the safety margins we should round the lane width to full centimeter. I.e., we need to assign lanes with the following widths

Now comes the tricky part: We have to decide how many lanes of a certain width should be assigned for each level. Luckily, there is only a small number of useful patterns of lanes per level. To be precise there are 9 efficient patterns to arrange these 3 lane types (assuming we use each level exhaustively):

Let indicate the number of lanes of type associated to pattern . Now we need to assess the number of lanes per required of each type. As outlined above, we know the number of lanes per product , thus we can deduce the demand for lane type () by summing up the for each lane type, i.e., :

Need to reduce 70 units to 64

## Illustration

* *Demand vs Quantity*

which is the capacity of a box for part . Demand in Years for item Demand per day in boxes for item . Demand per day in items for item $yb\_i= $

cycle time is number of days it takes before a new order.

E.g Item 4 has lot size quantity of 18 boxes, and daily demand in boxes is 1.2

The example above shows that for item 4, it takes about 15 day to make another order.

another example, assuming we order 17 items and demand pay day in boxes is 1.6667 this mean it will take about 10 day to make another other.

* *Convert Cycles to days*
* *Calculate demand after first cycle*

Assuming that demand All Quantity has been supplied for all items in the first cycle

reduce lane assignment while fulfilling demand

* *Prove that demand is always met*

Using (T,S) policy

We are using periodic review as order intervals can be derived from order frequency for each of the items.

* Assuming demand is uniformly distributed thus the same quantity of demand repeats each time.
* Initial stock level for the 62 items are given based on lanes assigned
* Each Item has some form of order frequency which we derived cycle time from, going over a time period of 262 days. This represents order interval.
* Lead time is zero.
* At each order interval, we order up to which is the stock level based on lane assigned for each item meaning, lanes are filled.
* No Backorder
* Stock is filled to the capacity in period 1.

*Notations and Formulars*

On-hand stock S(t)

Outstanding orders O(t)

Backorders B(t)

Inventory level available units

for item 30, we changed the cycle time in days to 39 instead of 42.

In the code below, Shows (T,S) Policy, how demand is met over 262 time period. Reason for TS policy is that we can not exceed capacity, thus we order upto Lane capacity of each item. Also each item has its cycle time in days which was derived from order frequency M.

As seen from the result, only Items 12 and 30 has an service level of 98% of the result has 100% service level.

## Changes made on q

1. We assumed that there are 262 working days for the year 2020 according to <https://hr.uiowa.edu/pay/payroll-services/payroll-calendars/working-day-payroll-calendar-2020>
2. rack\_total\_width which was 56,000 mm, looking at the 9 patterns all of which have 150 mm in waste, meaning all 32 levels will have 150 mm waste each. Therefor thereby changing rack total width 51,200.
3. These changes then affects the values of q for all the 62 items involved.

To fulfill lane demands from the items are 15 lanes with with 200, 15 lanes with width 400 and 64 lanes with width 600. To fulfull this demand, only 2 patterns are needed.

Assign Patterns

# Analysis

## ABC Analysis

Procedure: consumption and price of material , then 1. Calculate value share of material

1. Order materials descendingly according to value share: $v\_1^´ v\_2^´ …v\_{|I|}^´ $
2. Calculate cumulative ordered value share of each material:
3. Categorize materials according to into classes A,B and C by class limits e.g 80,95,100

## IQR Analysis

Categorization by life cycle - Inventory quality ratio

Aim is to minimize the risk of obselensce.

* Life cycle of product is the change of demand over time.
* Variation of material with respect to it’s importance. Typically associated with ABC analysis.
* The higher the value of materials, the potential risk of obscelence situation. This risk increase if this are compared to it’s demand overstocked.

There are 262 days working in consideration, 5 working days in a week, $=52.4 $ that is 52 weeks in a year. So we assume that current stock level is equivelent to stocks that can fit lane assignments for each item and

* estimated demand value per period (week).
* The current stock value.
* The accepted turnover time of material then.

We will use these thresholds : A…2 per., B..4 per. and C..6 per.

1. Calculate active inventory
2. Inventory quatlity ratio $IQR\_i= $ the closer to 1, the better.

## Cost Analysis

in the matrix above, it costs more to When capacity is an issue for both seperate Ordering and Joint Ordering. When non capacited ordering, there is far more cost savings than Separate ordering.

As seen from the table, with no constraint you tend to order far more than constrained.

Without considering capacity constraint, Using some examples for illustration,for all items using the EOQ model. for Items 1 and 2, EOQ is 97 and 108 respectively without paying extra 1500.

When ordering cost of 1500 and capacity for items 1 and 2 has order quantities of 19 and 20 respectively, thus costing far more as seen in the graph above. This is largely due to lack of capacity constraint because so little is ordered, that 1500 is paided all the time order takes place for each items.

As seen above, with no capacity, you generally have smaller order frequencies across the 62 items which shows but larger order quantity with lower cost generally.

Since we have limited capacity, we will order frequently and therefore will not take advantage of cost savings we could have gotten if we have larger capacity.