Logistics Management

Exercises for preparing Midterm Exam

Notice that the midterm exam questions are not limited to question types in these exercises.

1. A large chemical company in Green River, Wyoming, mines soda ash used in glass manufacturing. Soda ash is sold to a number of manufacturers through annual contracts. The glass companies release their request for soda ash against their contracts. The mining company sees demand in the form of rail-car quantities. A typical week shows demand to be normally distributed at 40 rail-car loads plus or minus 10 cars. The estimate the standard deviation at (max cars – min cars) /6 =(50-30)/6 = 3.33 cars.
   Soda ash is valued at $30 per ton, and an average rail-car load is 90,000 lb of product. Annual carrying cost for the company is 25 percent per year. Setup costs at the mine are estimated to be $500 per order. It takes one and half weeks to produce the product and/or secure the rail cars for shipment. A 90 percent in-stock probability during the lead time is desired.
   a. The company must call for cars from the railroad to fill orders. How many cars should be requested at a time? (Remember one ton is 2,000 lb. Assume the number of cars can take non-integer values)
   b. At what quantity of soda ash remaining in inventory should the request for cars be made?
   c. Suppose that the company can only use Carload transportation (i.e., the number of cars can take integer values). How the optimum number of cars to be called can be determined (Do not find the optimum value, offer a method to find the optimum value)?

Answer:

a) Use classical EOQ formula to find the result. $Q^* = \sqrt{\frac{2DS}{IC}}$

D= 40 per week or D = 40*52 = 2080 per year
S = 500 ; I = 0.25
C (value of one car ash) = (90,000 / 2,000)*30 = $1350

$Q^* = \sqrt{\frac{2DS}{IC}} = \sqrt{\frac{2\times2080\times500}{0.25\times1350}} = 78.50$ cars.

b) Use Reorder Point Control with Demand Uncertainty formulas
ROP formula ROP = d x LT + z (s'_d) ; $s'_d = s_d\sqrt{LT}$
LT= 1.5 weeks
$Z_{0.90}$ = 1.28
s_d = 3.33
$s'_d = 3.33\sqrt{1.5} = 4.0784$

ROP=40 x 1.5 x 1.28 x 4.0784 = 65.22 cars
65.22 cars capacity is equal to 65.22 x (90,000/2,000) = 2,934.9 tons of ash.

c) EOQ total cost function is a convex function with a one global minimum. If the optimum order quantity Q* is a non-integer value than the optimum integer value must be around Q*. Therefore it is required to find the total cost of two closest integer values to Q* to determine the optimum integer solution.
For the particular problem Q* = 78,50, therefore the optimum integer solution should be 78 or 79. By using the following total cost formula; we can determine which one gives the minimum cost:
$TC = \frac{DS}{Q} + IC\frac{Q}{2} + ICzs'_d + \frac{D}{Q}ks'_dE_{(z)}$

2. ATK-White manufactures a specific brand cereal (D-Flakes) from three basic raw materials: rice flour, oat flour, and barley flakes. The raw materials of the cereal are purchased from three different suppliers with the conditions given in Table 1. ATK-White pays the invoice of the oat flour and barley flakes when they are loaded to train. For rice flour, the invoice is paid when orders are received in the production plant.

Table 1. Supply conditions

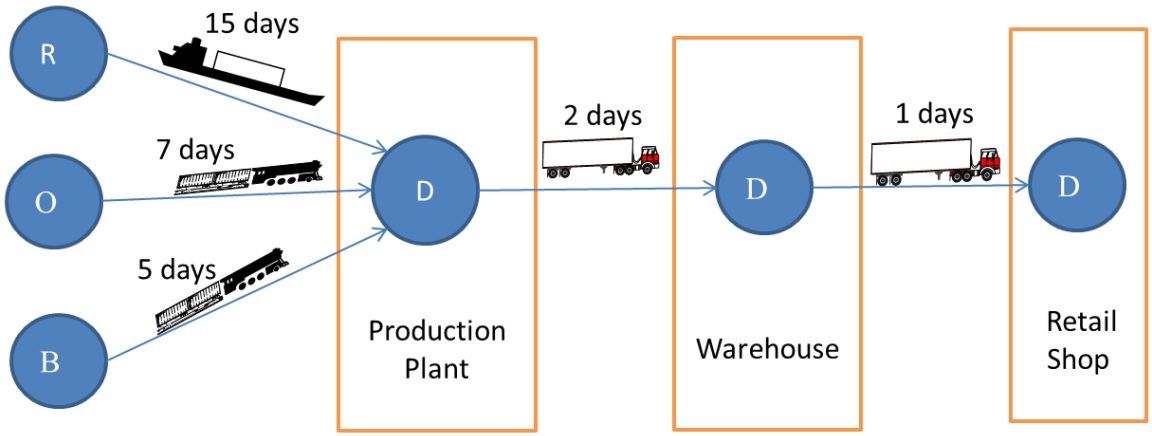
	Rice flour	Oat flour	Barney Flakes
Purchasing Price	1500 TL / ton	2500 TL / ton	3500 TL/ton
Mode and time of transport from the supplier to production Plant	Ship, 15 days	Train Car Load, 7 days	Train Car Load, 5 days
Order Quantity	100 tons	45 tons	75 tons
Cost of Transport	40TL/ton	75TL/ton	95TL/ton

The raw materials are used in fixed proportions: 80 gr. of rice flour, 160 gr. of oat flour, and 240 gr. of barley flakes per a box of cereal. The production process lasts one day, and costs approximately 0.75 TL per box of cereal (excluding the raw material and transportation costs).

After the production, the cereals are transported to a central warehouse via trucks with 20,000 boxes capacity for a price of 2,000 TL per truck in 2 days. In the warehouse the cereals are packed to a unit of cereal as 100 boxes of cereals. It lasts half days and costs 20TL/unit to package the cereals.

At the last step of the supply chain the cereals are moved to retail shops. Small trucks with capacity of 15 units are used for the transportation with a price of 300TL per truck. It costs roughly 0.5 TL per box for the retailer to handle, to present, etc. one box of cereals. The whole-sales price of D-flakes is 3.2 TL, while consumers buy the product with a price of 4.8TL. ATK-white receives the payment from the retailer when the product is sold.

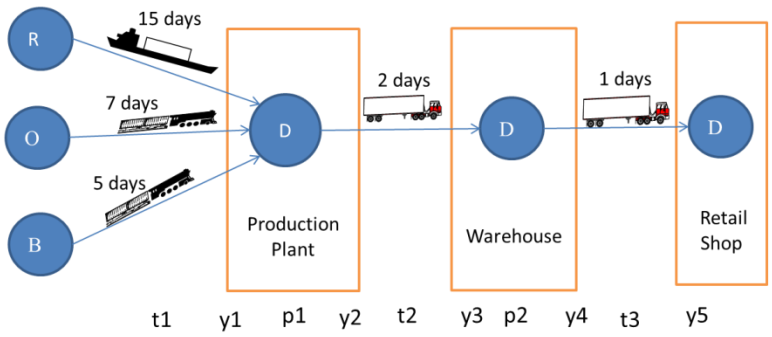
Assuming the demand is 960 units per week in average find the average inventory investment of ATK-White for D-Flakes. If the inventory holding cost is 25% per unit per year, calculate the annual inventory holding cost. Is this business profitable for ATK-White?



Answer:

The inventories can be seen at 10 different places in the given supply chain:

	Type of inventory	**Explanation**	**Formula**
t1	In-transit inventory	Raw materials transportation	For oat flour and barley flakes (C_1 : purchasing cost for each raw material) : Demand (D) * C_1 * transit time
y1	Cycle inventory	At the production plant, after transportation, waiting for manufacturing	For all raw materials : Order quantity (O)*C_2 / 2 (C_2 = C_1 + transportation cost) (O is related to previous transportation quantity)
p1	In-process inventory	At the manufacturing process	For all raw materials: D * C_2 * manufacturing time
y2	Cycle inventory	At the production plant, after manufacturing, waiting for transportation	For D-Flakes: Order quantity (O)*C_3 / 2 (C_3 = C_2 + production cost) (O is related to following transportation quantity)
t2	In-transit inventory	Product transportation from Production plant to warehouse	For D-Flakes: D * C_3 * transportation time
y3	Cycle inventory	At the warehouse, after transportation, waiting for packaging	For D-Flakes: Order quantity (O)*C_4 / 2 (C_4 = C_3 + transportation cost) (O is related to previous transportation quantity)
p2	In-process inventory	At the packaging process	For D-Flakes: D * C_4 * packaging process time
y4	Cycle inventory	At the warehouse, after packaging, waiting for transportation	For D-Flakes: Order quantity (O)*C_5 / 2 (C_5 = C_4 + packaging cost) (O is related to following transportation quantity)
t3	In-transit inventory	Product transportation from warehouse to retail shop	For D-Flakes: D * C_5 * transportation time
y5	Cycle inventory	At the retail shop, after transportation, waiting for sales	For D-Flakes: Order quantity (O)*C_6 / 2 (C_6 = C_5 + transportation cost) (O is related to previous transportation quantity)



Inventory investment calculations:

	Required calculations	Formula	Inventory investment
t1	Demand (rice)= $\frac{80gr./box \times 960unit/week \times 100box/unit \times 52week/year}{1{,}000{,}000gr./ton} = 399.36\ ton/year$	Rice is paid when it is received, so investment is not required for in-transit rice.	0
	Demand (oat) $= \frac{160gr./box \times 960unit/week \times 100box/unit \times 52week/year}{1{,}000{,}000gr./ton} = 798.72\ ton/year$	In transit inv. Invst. (oat) = 798.72*2500*7	38,294.79
	Demand (barley) $= \frac{240gr./box \times 960unit/week \times 100box/unit \times 52week/year}{1{,}000{,}000gr./ton} = 1198.08\ ton/year$	In transit inv. Invst. (barley) = 1198.08*3500*5	57,442.19
y1	C_2 (rice) = 1500 + 40 = 1540 TL/ton	Cycle inventory investment (rice) = 100*1540/2	77,000.00
	C_2 (oat) = 2500 + 75 = 2575 TL/ton	Cycle inventory investment (oat) = 45*2575/2	57,937.50
	C_2 (rice) = 3500 + 95 = 3595 TL/ton	Cycle inventory investment (oat) = 75*3595/2	134,812.50
p1		Process inventory (rice) = 399.36*1540*1/365	1,684.97
		Process inventory (oat) = 798.72*2575*1/365	5,634.81
		Process inventory (rice) = 1198.08*3595*1/365	11,800.27
y2	$C_2(D-Flakes) = \frac{80 \times C_2(rice) + 160 \times C_2(oat) + 240 \times C_2(barley)}{1{,}000{,}000} = 1.398\ TL/box$ *C_3 (D-Flakes) = C_2* + 0.75 = 2.148 TL / box	Cycle inventory investment (D-Flakes) = 20,000* 2.148/2	21,480.00
t2	Demand (D-Flakes) = 960 unit/week * 100 box / unit * 52 week / year = 4,992,000 box/year	In transit inventory (D-Flakes) = 4,992,000*2.148 *2 / 365	58,755.16
y3	C_4 = C_3 + 2,000 (TL/ truck)/20,000(box/truck) = 2.148 + 0.1 TL / box = 2.248 TL / box	Cycle inv.invst. = 20,000 * 2.248 / 2	22,480.00
p2		In-process inventory invst. = 4,992,000*2.248 * 0.5 / 365	15,372.62
y4	$\boldsymbol{C_5}$ = $\boldsymbol{C_4}$ + packaging cost = 2.248 + 20 (TL/unit) / 100 box/unit = 2.248 + 0.2 = 2.448 TL/box	Cycle inv.invst. = 1,500 * 2.248 / 2	1,836.00
t3		In transit inventory (D-Flakes) = 4,992,000*2.448 *1/365	33,480.59
y5	$\boldsymbol{C_6}$ = $\boldsymbol{C_5}$ + transportation cost = 2.448 + 300 (TL/truck) / [15 (unit/truck) *100 (box/unit)] = 2.248 + 0.2 = 2.648 TL/box	Cycle inv.invst. = 1,500 * 2.648 / 2	1,986.00
		Total Inventory Investment	539,997.40
		Inventory holding cost (Total Inv.Invst.*%25)	134,999.35

Average inventory investment for D-Flakes is TL 539,997; that costs 134,999 per year as inventory holding cost.
If we only consider the raw materials, transportation, production, and packaging cost, which sums up 2.648 TL/box, it seems profitable for ATK-White, since the whole-sale cost is TL 3.20.
If we add the inventory holding cost per unit to the total cost per unit (inventory holding cost = 134,999 / 4,992,000 = 0.027), the final cost will be TL 2.675 /box. Therefore the job is profitable for ATK-White.

3. A power plant in Texas uses MRO material at the rate of 10,000 pounds each day. The MRO material comes from Kentucky with a cost of $1 per pound, on average. Holding costs at the power plant are 25 percent. Transportation choices available are as follows:

Train	**Truck**
Lead Time = 15 days Carload(100,000 pounds) at $400 per carload Full train (70 cars) at $15,000	Lead time = 4 days LTL at $0.07 per pound Smal TL (40,000 pounds) for $2,000 Large TL (60,000 pounds) for $2600

Safety inventory of MRO material is kept at twice the consumption during the lead time of supply. What mode of transport do you recommend for MRO material? Why? Calculate total cost per day of Train CL, Train - Full Train, Truck LTL (q=10000), Small TL, and Large TL (*Hin*t: transportation cost + cycle inventory holding cost + safety inventory holding cost + in transit inventory cost).

Answer:

Total Cost = Transportation cost + inventory holding cost x average inventory

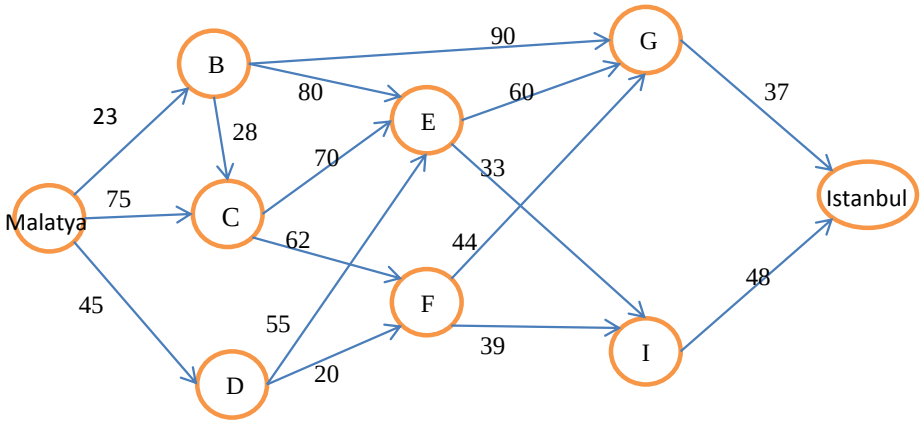
Transportation Cost (TC)= unit transportation cost x demand
Average inventory = cycle inventory + in transit inventory + safety inventory
Cycle inventory = shipment size (Q) / 2
In transit inventory = Leadtime x demand (D)
Safety inventory = Leadtime x demand (D)*2

In the following table all costs are calculated for a day (i.e. D=10,000).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Q	Unit TC	TC	Lead time	Cycle inventory	In transit inventory	safety inventory	Total average inventory	Holding Cost per day	Total cost per day
		Cost/ (1)	(2)xD		(1)/2	(4)xD	(4)xDx2	(5)+(6)+(7)	[1x0.25/365] x (8)	(3)+(9)
Train CL	100000	0,0040	40	15	50.000	150.000	300.000	500.000	342	382
Train Full train	7000000	0,0021	21,43	15	3.500.000	150.000	300.000	3.950.000	2.705	2.727
LTL	10000	0,0700	700	4	5.000	40.000	80.000	125.000	86	786
small TL	40000	0,0500	500	4	20.000	40.000	80.000	140.000	96	596
large TL	60000	0,0433	433,33	4	30.000	40.000	80.000	150.000	103	536

We recommend Tran CL that has the lowest total cost.

4. ATK-Blue, a Turkish retail chain, sells dried apricot at their stores in Istanbul. The main supplier of dried apricots is a Malatya originated company that hand overs the products in the production plant. Therefore ATK-Blue is responsible for the transport of the products from Malatya to Istanbul. The logistics department of the company discovered the possible routes of transportation as given in the following figure, where points B to I are the possible nodes to visit and arcs with the distance (in kms.) represent the possible routes. Find a route with minimum distance from Malatya to Istanbul using *shortest route method*. What is the minimum distance? Which nodes are on the minimum distance route?



Answer:

Solved nodes directly connected to unsolved nodes	**Its closest connected unsolved node**	**Total cost involved**	**Nearest note and its minimum cost**
Malatya	B	23*	B=23
Malatya B	D C	45* 23+28=51	D=45
Malatya B D	C C F	75 23+28=51* 45+20=65	C=51
B C D	E F F	23+80=103 51+62=113 45+20=65*	F=65
B C D F	E E E I	23+80=103 51+70=121 45+55=100* 65+39=104	E=100
E F	I I	100+33=133 65+39=104*	I=104
E F I	G G Istanbul	100+60=160 65+44=109* 104+48=152	G=109
G I	Istanbul Istanbul	109+37=146* 104+48=152	Istanbul=146

Minimum distance is 146 kms. The optimum route is Malatya - D - F - G – Istanbul.