ERASMUS+ KA2 Strategic Partnership
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HELP – Healthcare Logistics Education and Learning Pathway

Inventory management: basics

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0. Agenda

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Overview

1. Inventory: what ? why ?
2. Inventory optimization modeling
3. Management concepts

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1. Inventory: what ? why ?

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Inventory in logistics

Inventory, stock

- Buffers are needed if there is no perfect synchronization between in-flow and out-flow of materials
  - in-flow: in-house production (e.g. meals), goods received (e.g. drugs, medical materials, …)
  - out-flow: use
  - lack of synchronisation: i.e. amount received > amount immediately used, because e.g.
    - packaging reasons: e.g. pallet of gloves bought vs box of gloves in use
    - economies of scale: e.g. quantity discounts
    - easier planning and coordination of processes 
    - easier logistics control: e.g. fixed order quantity
    - critical stock, just-in-case safety stock

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How much inventory is needed ?

A lot … because not having it when needed can cause considerable delays in treatment, can require temporary changes in patient treatment, will jeopardize planned work, will entail higher logistics costs (e.g. rush orders), decreases impact of supplier lead times, …

Not so much … because inventory ties up capital, leads to high handling/storage cost, can perish, might never be used, takes up space, entails storage and control costs, ….

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Some (!) considerations

Inventory holding costs (C_h): capital immobilisation, risk, storage – typically *15-20 % of item value per year*

Procurement costs (C_p): order processing, good receiving, storage, picking, …

Shortage cost (C_s): usually difficult to measure, except with emergency deliveries; in optimization models often replaced by service level (α), defined as % of demand delivered from stock or probabiliy of being able to deliver from stock

Standardization of equipment and materials will allow lower stocks

Stocking kits (e.g. surgical interventions) may raise inventory and usage cost, but will lower distributions costs

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Some (!) considerations (continued)

The higher the demand, the higher the stock tends to be

More uncertainty about the demand will entail higher stocks

The availability of substitutes will lower the stock level

If supply is difficult, higher stocks will be kept (logistics criticality)

The higher the process criticality (diagnostic, treatment, intervention), the higher the stock

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Illustration

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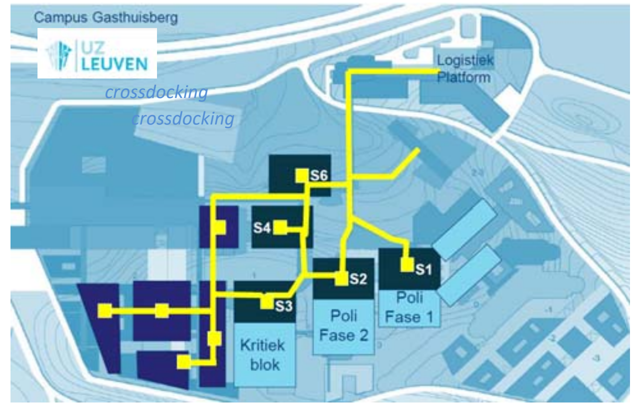
literature

Table 2.5. Challenges in healthcare logistics identified in literature

Product type	Challenge	Supporting literature
Drugs, blood	Product availability from supplier	(Gebicki et al., 2014; Mustaffa and Potter, 2009)
	Perishability and product waste	(Beier, 1995; Beliën and Forcé, 2012; Fontaine et al., 2009; Gebicki et al., 2014; Gomez et al., 2015; Hemmelmayr et al., 2009; Mustaffa and Potter, 2009; Rautonen, 2007; Ritchie et al., 2000; Stanger et al., 2012)
	Special handling of items, e.g. temperature, product safety and security	(Beier, 1995; Chircu et al., 2014; Pan and Pokharel, 2007)
Drugs, blood, surgical tools	Potential stock-outs (patient safety issue)	(Beier, 1995; Beliën and Forcé, 2012; Fredendall et al., 2009; Stanger et al., 2012; de Vries, 2011)
Sterile supply	Interruptions in process that requires focus	(Fredendall et al., 2009)
General	Integrating with supplier systems	(Elleuch et al., 2014; Rautonen, 2007)
	Ensuring the right skills (sometimes clinical for sterilizing instruments)	(Callender and Grasman, 2010; Fredendall et al., 2009; Landry and Philippe, 2004; Stanger et al., 2012)
	Overstocking	(Aptel and Pourjalali, 2001; Beier, 1995; Kumar and Rahman, 2014; de Vries, 2011)
	Balancing quality and costs	(Fredendall et al., 2009; de Vries, 2011)
	Inventory shrinkage	(Bendavid et al., 2010; Böhme et al., 2016; Kumar and Rahman, 2014; Romero and Lefebvre, 2015; Yao et al., 2012)
	SC tiers operate independently / duplication of processes	(Callender and Grasman, 2010; Landry and Philippe, 2004; Nachtmann and Pohl, 2009)
	Fragmented processes and poor inter-functional integration	(Böhme et al., 2016; Landry and Philippe, 2004; Parnaby and Towill, 2009)
	Complexity of healthcare systems and healthcare SCs	(Beier, 1995; Böhme et al., 2013; Chircu et al., 2014; Fredendall et al., 2009; Nachtmann and Pohl, 2009; de Vries, 2011)
	Unpredictability and uncertainty (demand, supply, capacity)	(Anand and Wamba, 2013; Bailey et al., 2013; Beier, 1995; Böhme et al., 2013; Fontaine et al., 2009; Gebicki et al., 2014; Jarrett, 1998; Yau et al., 1998)
	Low capacity at bottleneck/lack of personnel	(Elleuch et al., 2014; Fredendall et al., 2009)
	Delays in delivery of (critical) items	(Beier, 1995; Parnaby and Towill, 2009; Thomas et al., 2000)
	Process immaturity	(Anand and Wamba, 2013; Bailey et al., 2013; Böhme et al., 2013, 2016; Fredendall et al., 2009; Kumar and Rahman, 2014; Landry and Philippe, 2004; Nachtmann and Pohl, 2009)
	Inefficient processes	(Anand and Wamba, 2013; Böhme et al., 2016; Nachtmann and Pohl, 2009; Yao et al., 2012; Yau et al., 1998)
	Political agendas, lack of executive commitment, misalignment of incentives within hospitals and across SC	(Böhme et al., 2013, 2016; Callender and Grasman, 2010; McKone-Sweet et al., 2005; de Vries, 2011)
	Wrong people performing tasks	(Bloss, 2011; Landry and Philippe, 2004)
	High SC costs	(Böhme et al., 2016; Romero and Lefebvre, 2015)

(Feibert, 2017)

hospital



1850 suppliers (including TD)
10^6 order lines/year
800 internal customers

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2. Inventory optimization modeling

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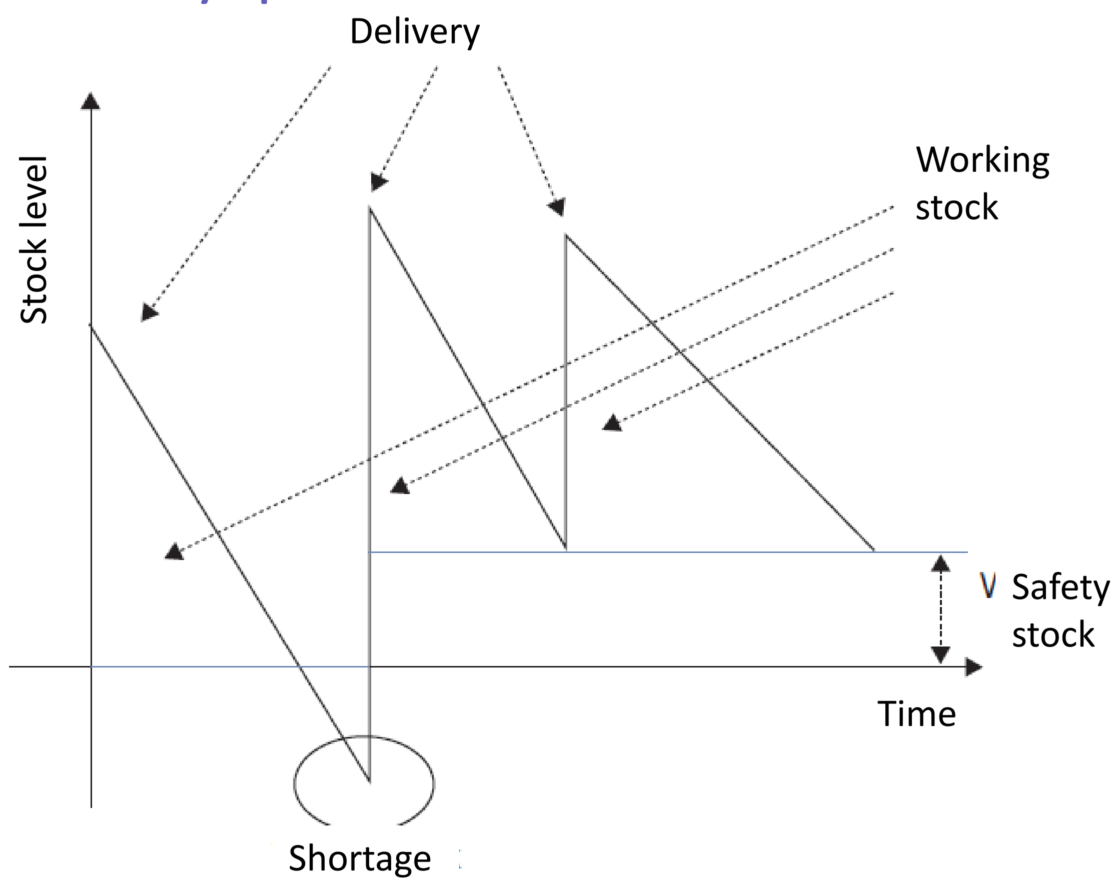
Basic inventory pattern



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Inventory optimization

Objective

answering the questions how much to stock ideally , when to (re)order, how much to (re)order, …

Traditionally

inventory models aim at minimizing cost over time, taking into account inventory holding costs, procurement costs and shortage costs

of course other concerns can be taken into account as well, e.g. item criticality, but also distribution costs (see example in chapter on simulation)

multi-echelon stocks bring in extra complexity

sometimes a MCDM approach is applied

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Item classification

Many, many different items with very different characteristics in terms of demand rate, criticality, … which makes it difficult to have a one-suits-all model

⇨Insight on the item characteristics is needed in order to decide on the most appropriate model

Different classification methods are possible

- Based on cost & usage (annual demand (#/yr) * unit cost (€)): A, B, C
- Based on rotation (turnover=usage/inventory): F (fast), N (normal) , S (slow) movers
- Based on criticality (for care): V (vital), E (essential), D (desirable)
- Based on MCDM approach, e.g. Med-MASTA

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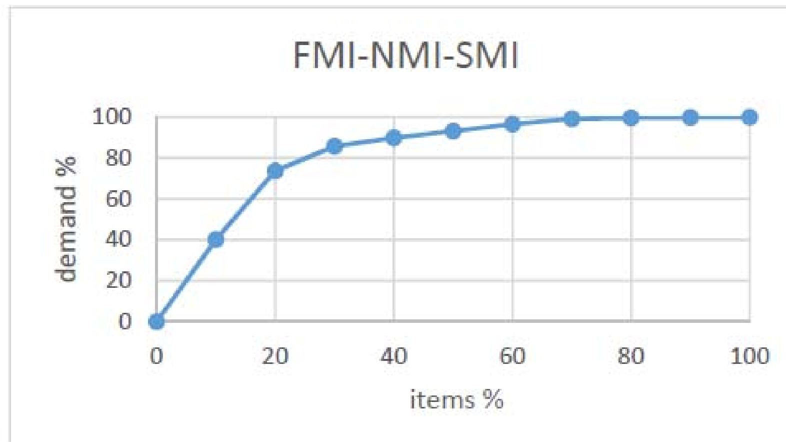
Illustration

data

item code	demand (#/yr)
A	25
B	2
C	90
D	3
E	25
F	20
G	30
H	250
I	300
J	1

step 1 sort		step 2 cumsum	step 3 %
I	300	300	40.2
H	250	550	73.7
C	90	640	85.8
G	30	670	89.8
A	25	695	93.2
E	25	720	96.5
F	20	740	99.2
D	3	743	99.6
B	2	745	99.9
J	1	746	100.0

step 4 analyze



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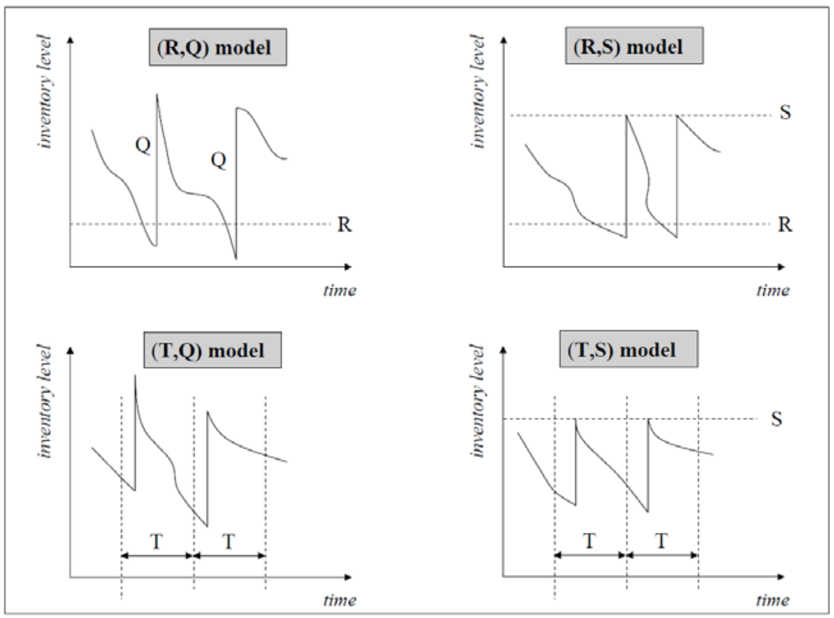
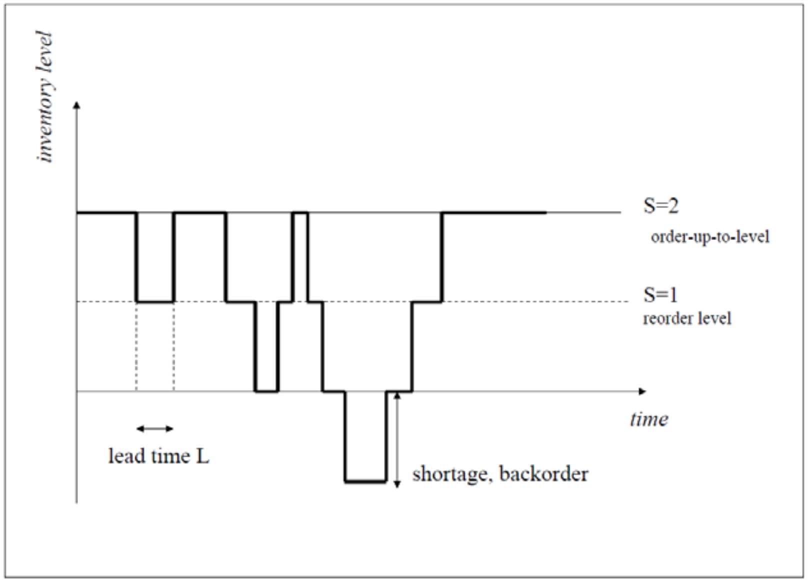
Inventory models (basics)

FMI, NMI



SMI



R=reorder level, S=order-up-to level, T=order period, Q=order size

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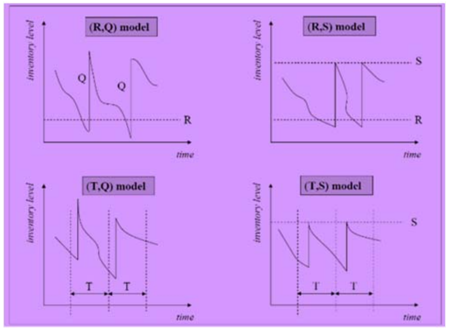
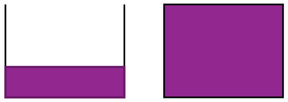
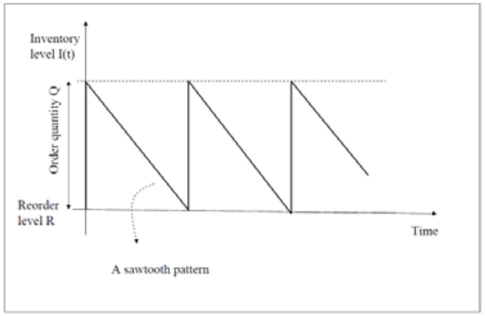


Model examples for FMI & NMI

Two bin system



EOQ model

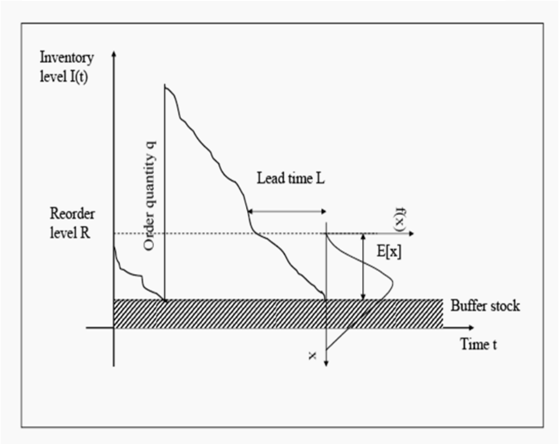


$$Q^* = \sqrt{\frac{2.C_p.r}{C_h}}$$

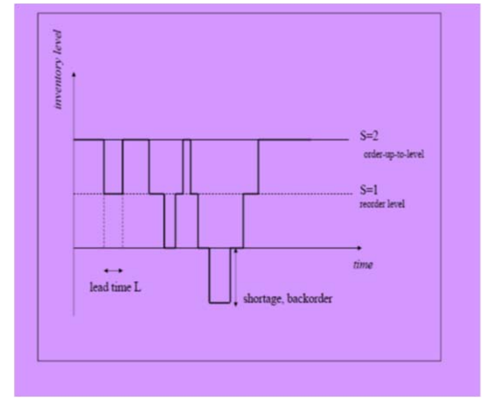
demand

order size

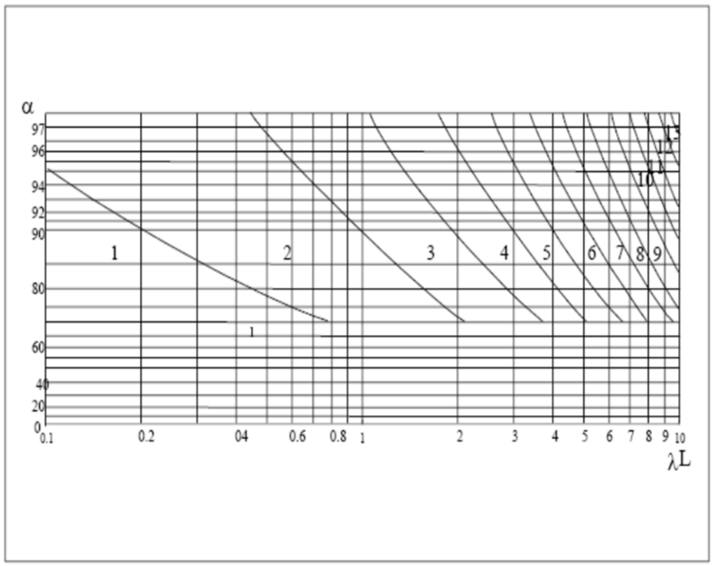
(R,q) model



$$q^* = \sqrt{\frac{2r\left(C_p + C_s E[X-R]^+\right)}{C_h}}$$



Model example for SMI



Service level, e.g.

$$\alpha = \frac{\sum_{i=1}^{S} d.P_d + \sum_{d=S+1}^{\infty} S.P_d}{\sum_{d=0}^{\infty} d.Pd}$$

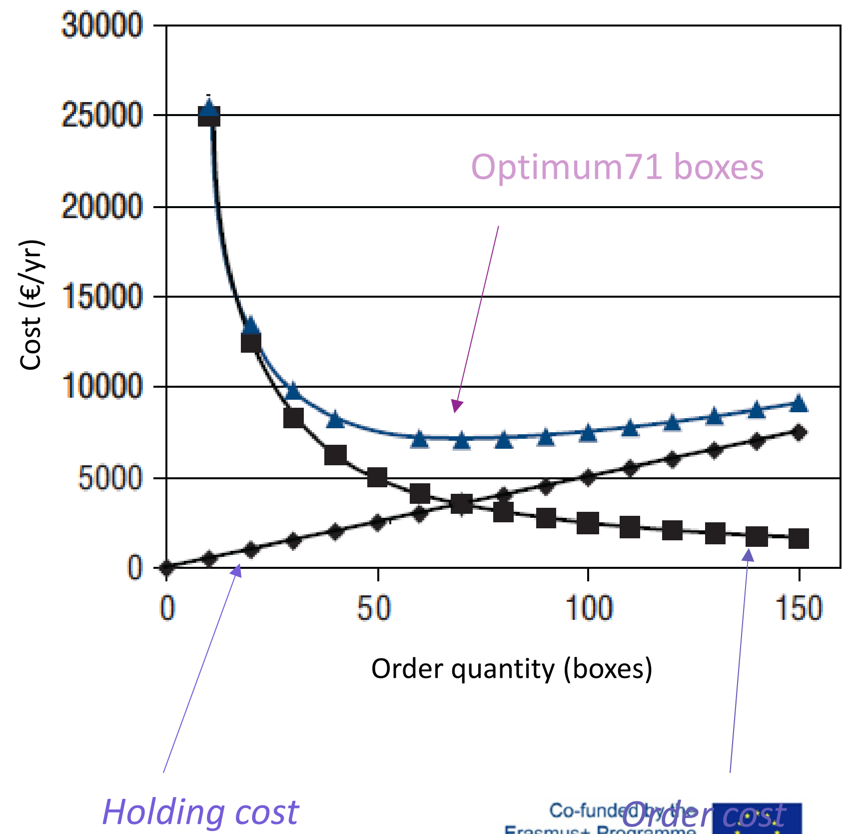
D=demand, Pd=demand probability (demand is assumed to be Poisson distributed)

Exercise EOQ

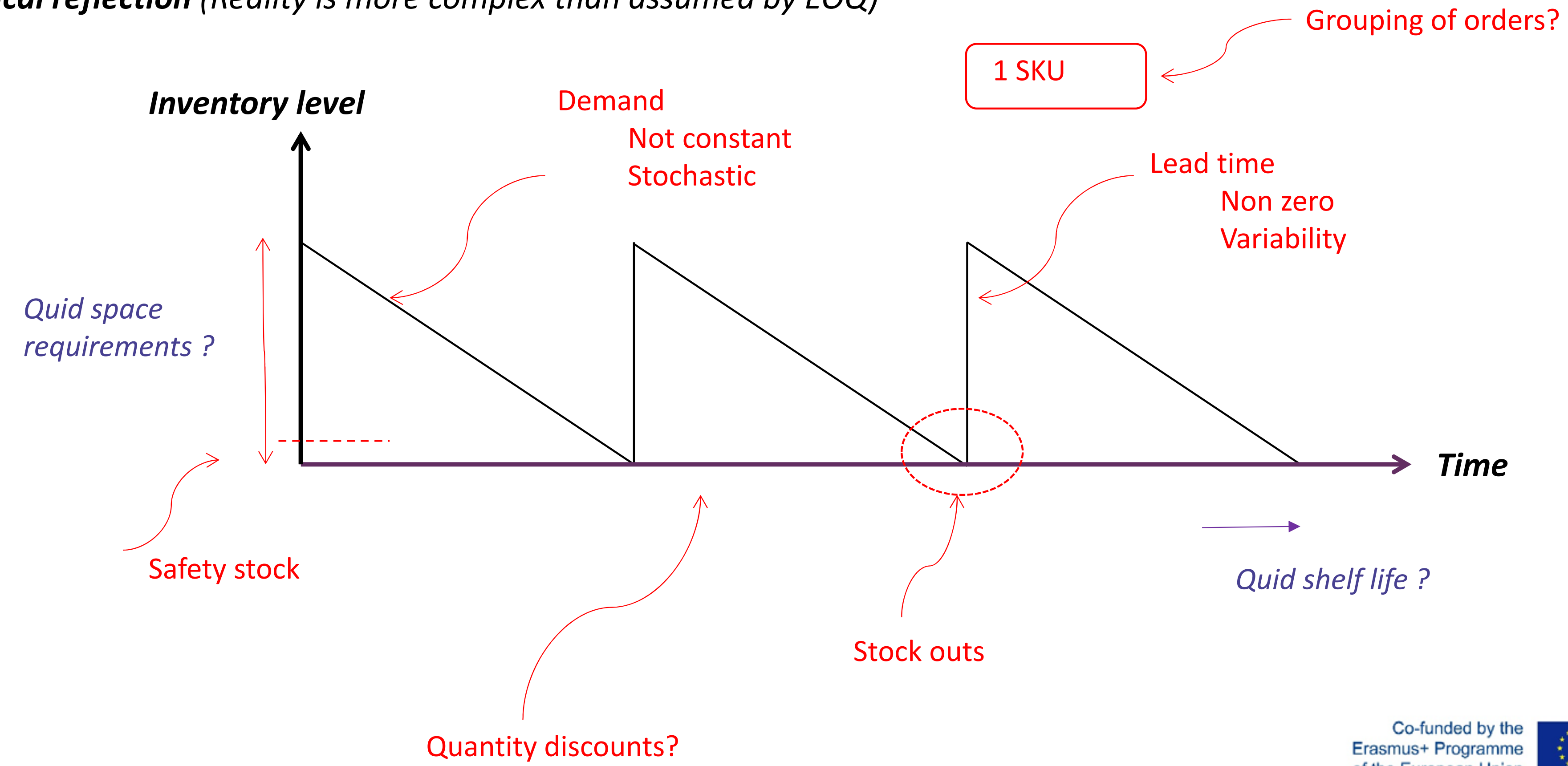
Every year 1000 boxes of filters of type YK37 are used. Fixed order cost is € 250. Inventory holding cost is estimated at 20%. The unit price of a box of filters is € 500.

Filter demand can be considered to be constant over the year. Orders are promptly delivered.

Compute the optimum order lotsize.



Critical reflection *(Reality is more complex than assumed by EOQ)*



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3. Management concepts

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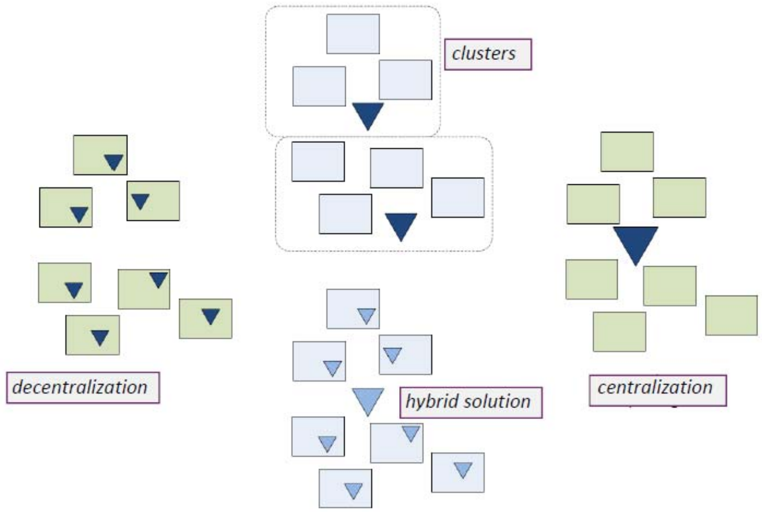
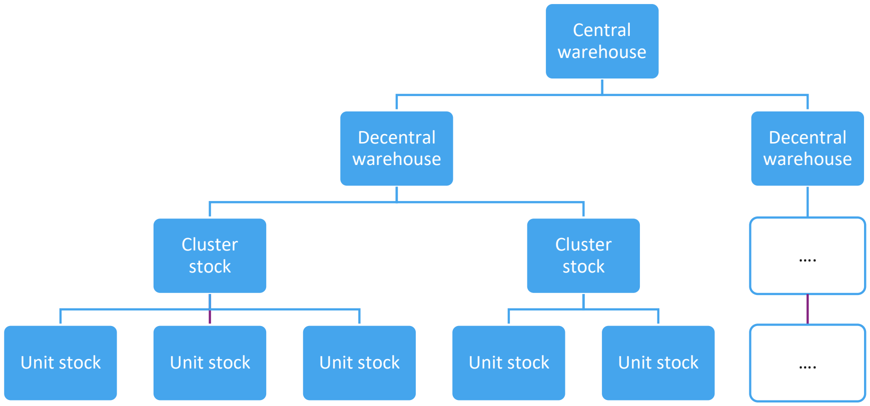
Internal organization

Pooling



Multi-echelon inventory



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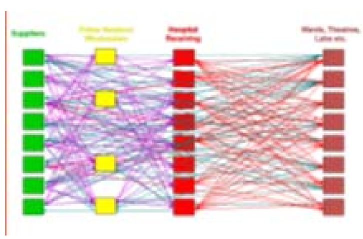
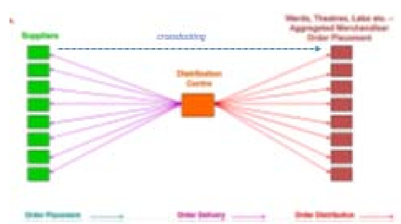
Partnerships

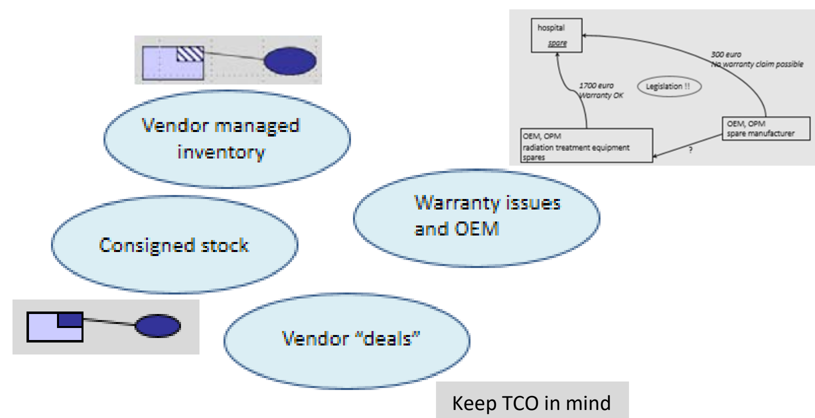
Group purchasing

Logistics provider





Vendors/suppliers



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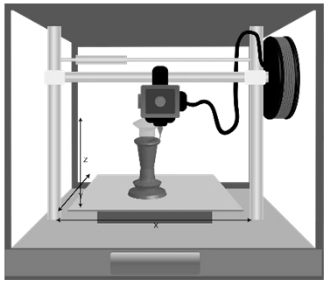
Newer trends

Crossdocking

3D printing



Drone deliveries

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