Lancaster University
Management School

Introduction to Operations Management

Lecture 1: Inventory Management

2024 – 25

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Inventory Management

- What is inventory?
- Why do we have it?
- Why not have a lot more of it?
- How do we determine how much to have?
- And when do we get it?

Slack et al, chapter 13

All of them are INVENTORY

Raw materials

Work-in-process

Finished goods

What is Inventory?

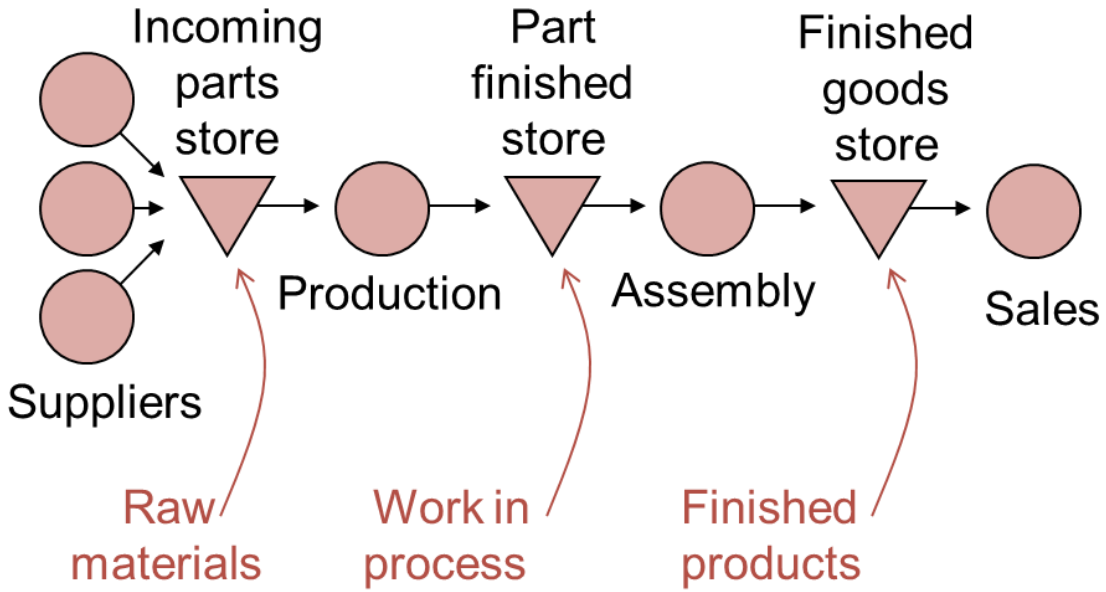
Three types of inventory

Process, operation or supply network	'Inventories'		
	Physical inventories	Queues of customers	Information
Hotel	Food items, drinks, toilet items	At check in and check out	Customer details, loyalty card holders, catering suppliers
Hospital	Dressings, disposable instruments, blood	Patients on a waiting list, patients in bed waiting for surgery, patients in recovery wards	Patient medical records
Credit card application process	Blank cards, form letters	Customers waiting on the phone	Customer's credit and personal information
Computer manufacturer	Components for assembly, packaging materials, finished computers ready for sale	Customers waiting for delivery of their computer	Customers' details, supplier information

Slack et al – Page 444- Example of inventory

Where do you get it?

- At stages in operations processes
- Between unsynchronised activities
- But also supplies – inventory that doesn't enter the operation directly but is necessary for the process – office stationery, cleaning materials *(direct and indirect materials)*



Why do we hold it?

- To meet unexpected supply or demand *(Buffer)*

…e.g. unreliable suppliers

- For batch mfg – usually in large, fixed quantities *(Cycle)*

…e.g. manufacture batches of 100 bread loaves at a time

- Take advantage of short-term opportunities *(Discounts)*

…e.g. Quantity discounts on selected items

- Due to fixed ordering, it is often cheaper to produce in bulk (*Economies of scale*)

…e.g. raw materials

- Transportation *(Pipeline)*

…e.g. Ocean transport takes time to deliver

Why do we hold it?

- 2019 - almost every organisation stockpiled inventory fearing Brexit – from toilet rolls to pharmaceuticals
- 2020 - NHS faced drug shortages as Brexit stockpile used in Covid crisis and as people stockpile commonly used medicines
  - https://www.theguardian.com/society/2020/oct/06/nhs-faces-drug-shortages-as-brexit-stockpile-used-in-covid-crisis
  - 2022 – shortage of chips, Ukraine war leading to shortage of commodities, etc.

Struggle to rebuild 6 weeks' medical stores exacerbated by pandemic's disruption to global production and fears of a 'no-deal' EU exit

Industry has signalled it will be unable to replicate the medicine reserves built last autumn © Matthew Horwood/Getty Images

Why to avoid having physical inventory?

- Holding costs: Insurance, real estate, capital, interest
  - E.g. Brexit stockpiling: £11bn excess inventory in 2019[1]
  - E.g. Brexit/Covid sequel 2020/21: warehouse space running out due to stockpiling[2]
- Shrinkage: Obsolescence, deterioration, theft
  - See the case on blood stocks (p. 433)
  - 5% red blood cells lost from being stored for too long (over about 35 days)
  - Shelf life of platelets is only 5 days
- Obstruction
- Hazards, can cause fire or explosions

- [1] https://cebr.com/reports/cebr-estimates-that-the-brexit-related-inventory-overhang-will-be-11-billion-at-the-end-of-october/
- [2] https://www.thegrocer.co.uk/brexit/food-and-drink-warehouse-space-running-out-for-brexit-stockpiling/648938.article

Hazard: Port Ruihai (Tianjin) (Chemical Warehouse)

2015…Operating licence renewed 2 months before exploding…killing 170…300 buildings, 12,000 cars damaged…$9bn cost to businesses due to insurance and supply chain disruption

Hazard: Beirut Ammonium Nitrate explosion

2020…killed 220…2750 tonnes of ammonium nitrate…stored for 6 six years in the warehouse

So how much should we have?

- Too little inventory is itself a problem - Stock-outs cause walkouts
- Poor customer service
- Dissatisfied customer
- Objective is to identify the "right" level of stock in our supply chain.

But what's the "right" level of stock?

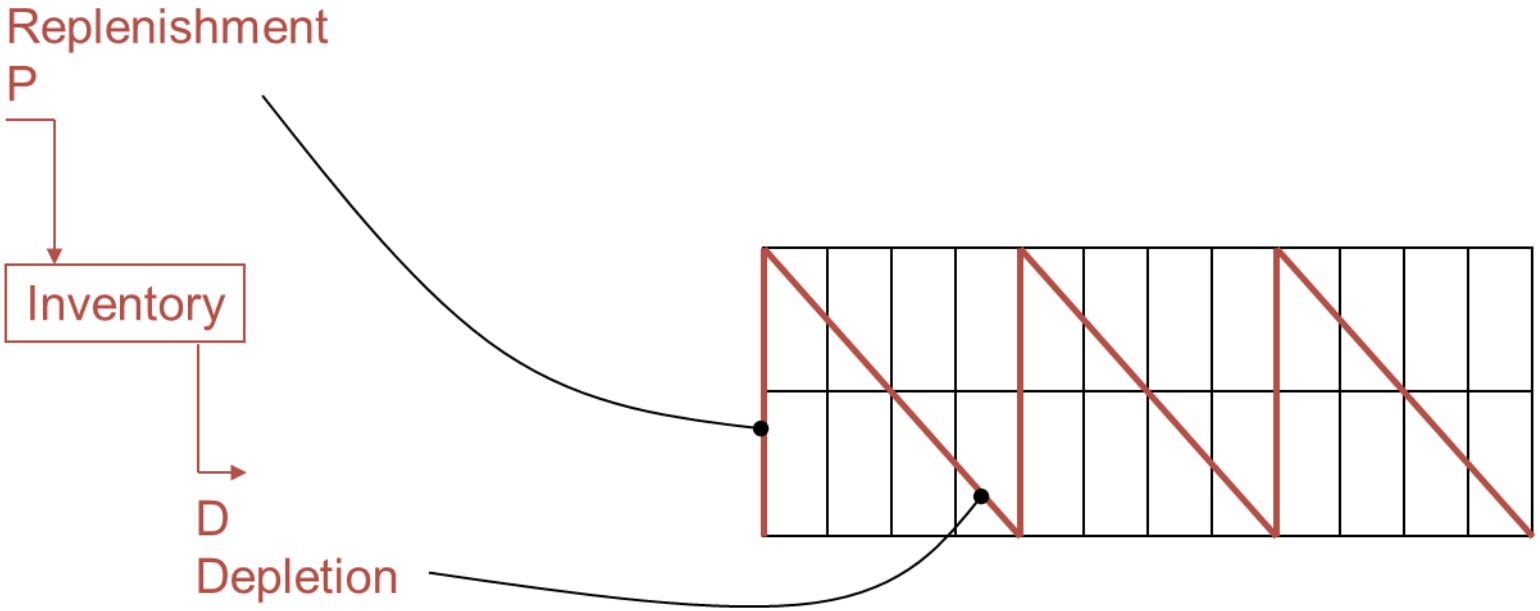
- It's the level that:

1. Guarantee customers' expected demand is satisfied (according to the generated forecasts)…

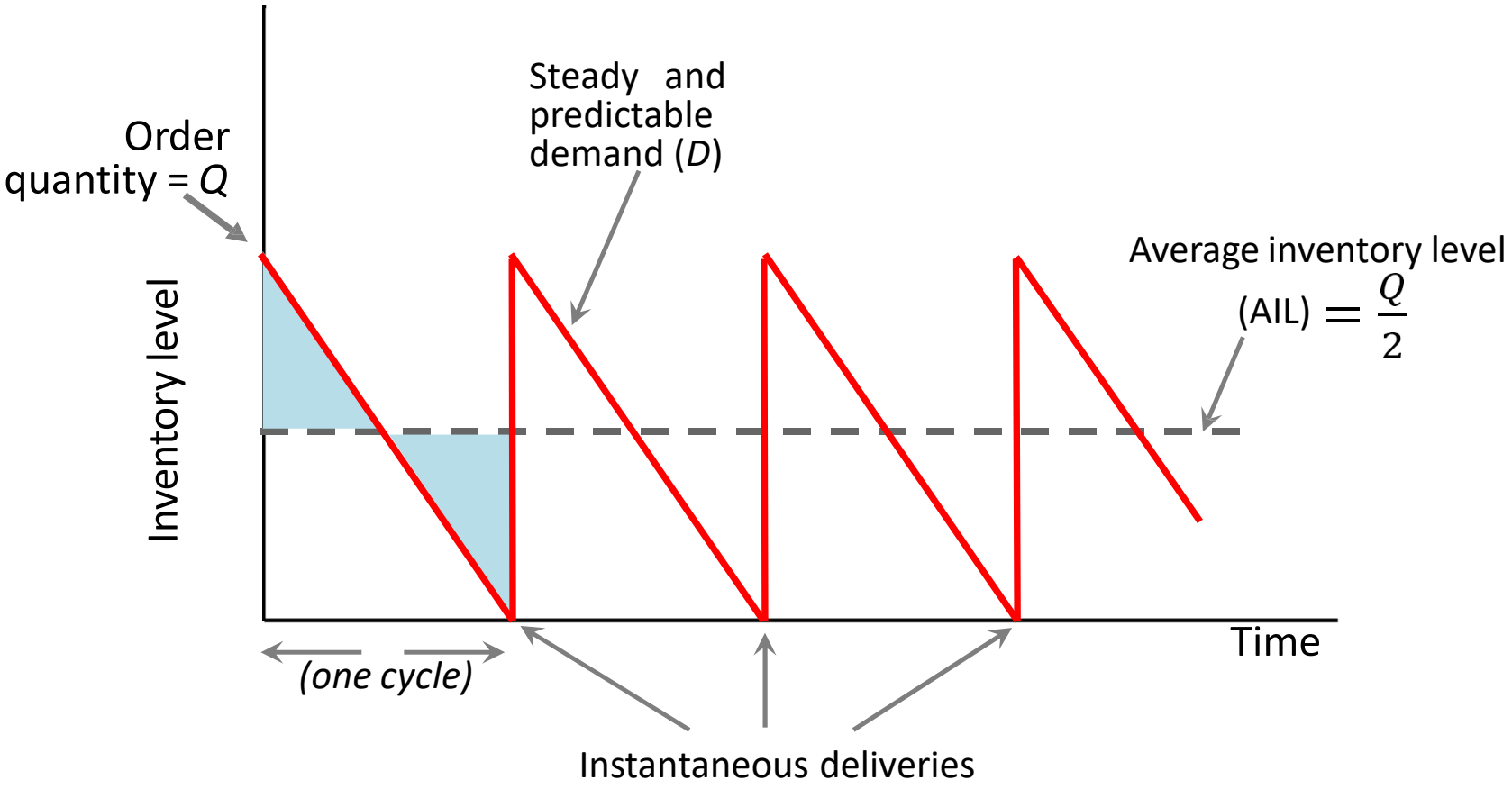
2. …and minimizes the total **cost of ordering** and **carrying the inventory**.

So how much should we have?

- Inventory level follows a specific pattern over time
- Periodically replenished

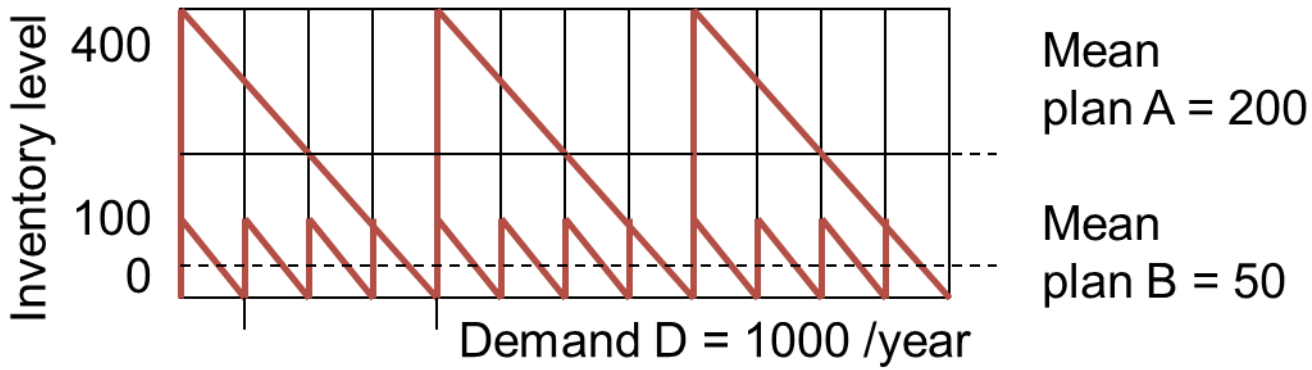


So how much should we have?



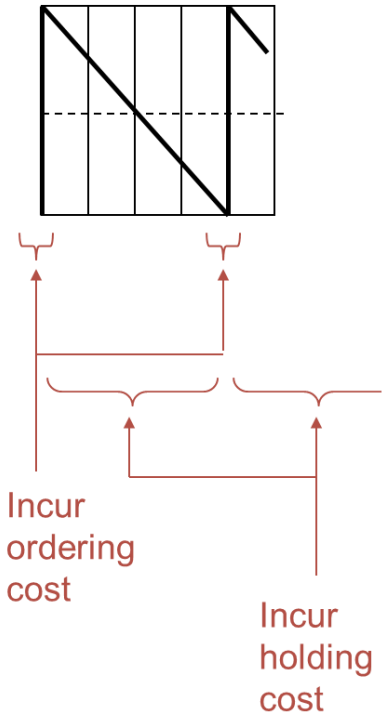
So how much should we have?

- Maximum inventory fixes order quantity & frequency
- Eg if demand 1000 / year
  - Plan A: Max of 400 means order 400, 2.5 times/year
  - Plan B: Max of 100 means order 100, 10 times/year



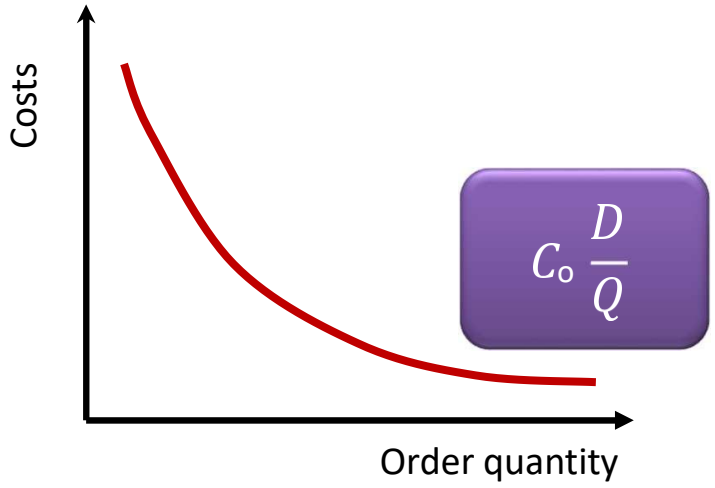
So how much should we have?

- Now determine optimal level by analysing cost
- Add up costs linked to the 2 phases of the process
  - ‘Ordering cost’
    - Placing order, transport, inspection, staff
    - Quantity discounts, supplements
  - ‘Holding cost’
    - Capital cost, interest
    - Storage & insurance
    - Obsolescence, deterioration
    - Handling and staff



So how much should we have?

- 'Ordering cost' assumed same for any size of order
  e.g. £100
- Orders placed in a year = annual demand/order quantity
  e.g. 1) 1000 /100 = 10 orders
  e.g. 2) 1000/80 = 12.5 orders
- Total annual ordering cost (1) = 10 x £100 = £1 000
- Total annual ordering cost (2) = 12.5 x £100 = £1 250
- Or C_oD/Q
  - C_o is cost of each order
  - D is annual demand
  - Q is order quantity



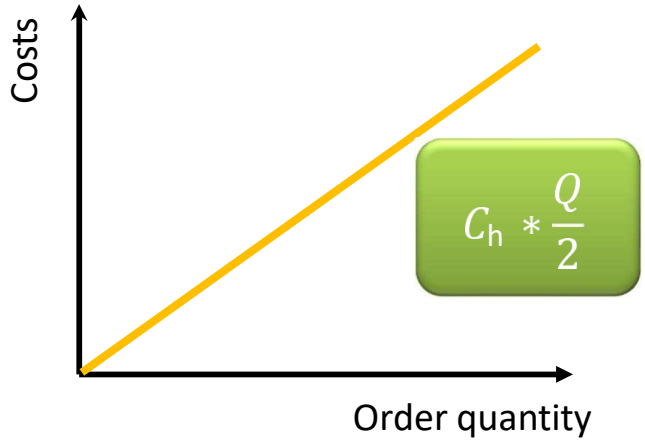
So how much should we have?

- 'Holding cost' a constant per item stored per unit time
  E.g. £10 per unit per year
- Average items stored over a full period = $I_{max}/ 2$
  I.e. order quantity / 2
  E.g. (1) 100 / 2 = 50
  E.g. (2) 200 / 2 = 100
- So total annual holding cost

= £10 x 50 = £500 (1)

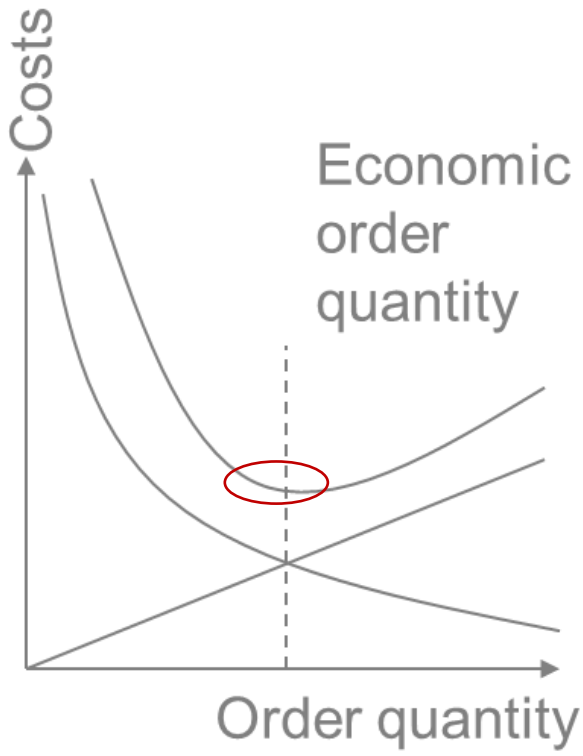
= £10 x 100 = £1000 (2)

- Or $C_hQ/2$
  - C_h is holding cost per unit per unit time
  - Q is order quantity
- This increases with Q



So how much should we have?

- Total cost is the sum of these
- Ie $C_t = C_hQ/2 + C_oD/Q$
- EOQ always has a minimum



EOQ model

Assumptions

1. Uniform demand
2. Constant Lead time (LT)
3. Receipt of inventory is instantaneous and complete *(order date = delivery date)*
4. No quantity discounts
5. No other variable costs considered
6. No stock-out (shortage) cost

$$EOQ = ?\,(units)$$

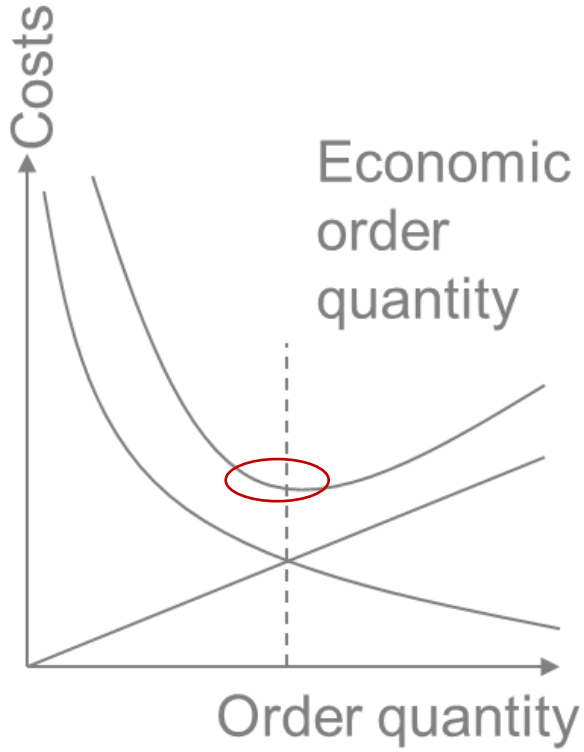
What is the optimal replenishment lot size to minimise the inventory costs?

EOQ formula

- $C_t = C_hQ/2 + C_oD/Q$
- The objective is to minimise the total cost
- Need to find value of Q where this occurs

$$EOQ = \sqrt{\frac{2C_oD}{C_h}}$$

(the *economic order quantity* EOQ)



Slack et al. Chap 13, Pg 452

Exercise

Solved example (Slack & Brandon-Jones, p. 447)

Find the economic order quantity for a building materials firm buying bagged cement. The demand is constant at 2000 tons/year. The ordering cost is £25. The annual holding cost is 20% of the purchase price. The purchase price is £60 / ton.

A) 1 ton

B) 23 ton

C) 47 ton

D) 91 ton

$Q_{min} = \sqrt{(2\ C_o D / C_h)}$

$C_h = 0.2 \times £60/t = £12/t$

$C_o = £25$

$D = 2000\ t$

$= \sqrt{[(2 \times 25 \times 2000)/12]} = 91\ ton$

Exercise

You are the purchase manager of a building materials firm buying bagged cement. The CEO of the firm has asked you to reduce inventory costs. The demand for cement is constant at 2000 t / year. The ordering cost is £25 for each order placed. The annual holding cost is 20% of the purchase price, which includes insurance and warehouse costs. The purchase price for cement is £60 / t. How many orders will you have to place for 91 t of cement to meet the demand?

A) 20

B) 21

C) 22

D) 24

Exercise

Solved example (Slack & Brandon-Jones, p. 447)

But your supplier is refusing to supply less than 100 t of cement in each order. What's the penalty of ordering 100 t at a time as an extra annual cost?

$C_t = C_hQ/2 + C_oD/Q$

A) £1
B) £5
C) £17
D) £81

- **So penalty is negligible**
- **Because minimum is fairly flat**

EOQ - Exercise 2

A company that markets needles to hospitals, would like to reduce its inventory cost by determining the optimal number of needles to obtain per order.

Demand: 1000 units

Ordering cost: £10 per order

Holding cost: £ 0.5 per year

Number of working days per year: 250

$\Rightarrow$ Calculate the optimal number of units per order?

$\Rightarrow$ Calculate the number of orders per year?

$\Rightarrow$ Calculate the expected time between orders?

Any limitations of EOQ?

- Demand (steady/predictable) assumption.
- Does not account for demand fluctuations.
- Unsuitable to use EOQ models for different businesses.
- Instantaneous delivery assumption.
- Supply uncertainty.
- More suitable for small-scale firms.

Next time…

- Economic Batch Quantity
- Re-order levels
- Inventory classification

Questions

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Thank you for attending, email questions to a.Iftikhar@Lancaster.ac.uk