FIT3158 Note - W7 Inventory Modelling under certainty

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▼ **What are the assumption?**

- Demand occurs at a constant rate of A items per year.
- Ordering Cost is $\$k$ per order.
- Holding Cost is h. This is equivalent to $\$ch$ per item in inventory per year as per previous models.
- Purchase Cost is

  $\$c_1$ per item if the quantity ordered is between 0 and x_1,

  $\$c_2$ if the order quantity is between x_1 and x_2, etc.
- Delivery time (lead time) is constant.
- Planned shortages are not permitted.

1. EOQ

▼ Term

Ordering cost

salaries and expenses of processing an order, regardless of the order quantity

Purchase cost

the actual price of the items

Backorder cost 延期交貨

costs associated with being out of stock when an item is demanded (including lost goodwill or lost sales)

Holding cost 持有成本 aka storage cost

usually a percentage of the value of the item assessed for keeping an item in inventory (including finance costs, insurance, security costs, taxes, warehouse overhead, and other related variable expenses)
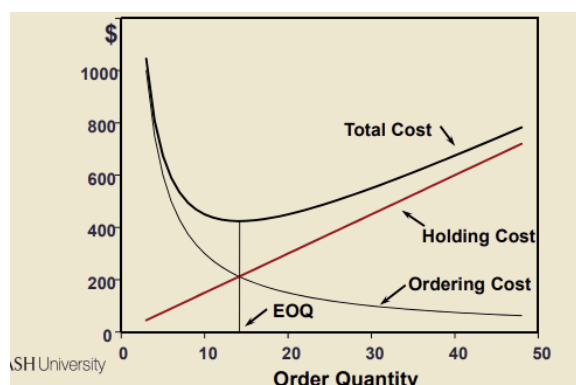
Lead Time 前置時間

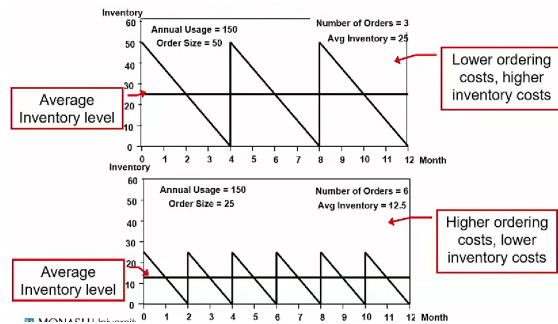- 指的是一個過程從發起到執行完畢之間間隔的時間。
- 比方說，一輛新汽車從下訂單到生產完畢開始運送之間需要花費的前置時間無論如何都大概需要兩周到六個月時間。
- **Here we assumed the lead time is 0.**

Why do we need EOQ?

Problem

問題係大又唔好，小又唔好，所以用EOQ
在cost is minimised 情況下
找optimal Q

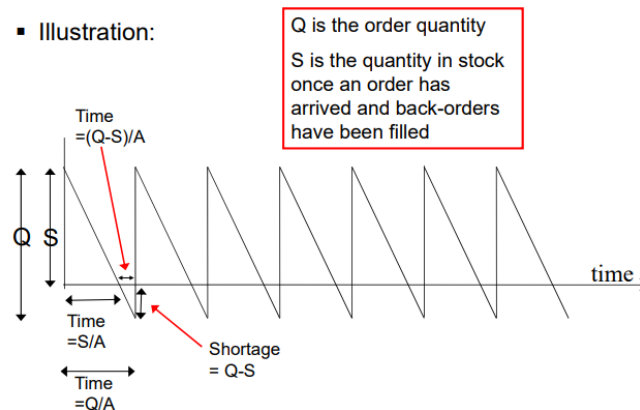|	Small order	Large order
Inventory level	小	大
Holding cost	小	大
Order frequency	常	不常
Ordering cost	大	小

Solution

Using EOQ, we can determine *how much we should order* and *when the order should be placed*.

2. EOQ with Planned Shortages

- Illustration:

Q is the order quantity

S is the quantity in stock once an order has arrived and back-orders have been filled

What does that mean?

A replenishment order (補貨) does not arrive at or before the inventory position drops to zero.

- 允許有缺貨的情形，且顧客同意延期交貨(backorder)

What is backorder？ (Here)

back 可以理解為"未完成、積壓的"。類似的詞彙還有：backlog.

So, **Back order，意思是（由於暫時無貨而）延期交貨。也可以指某商品暫時缺貨，商家允許用戶先下單，等到貨後再發貨。**

Why do we need this model?

想 save holding cost：In many situations, shortages are undesirable and should be avoided if at all possible. However, in other cases it may be desirable—from an economic point of view—to plan for and allow shortages. In practice, these types of situations are most commonly found where the value of the inventory per unit is high and hence the holding cost is high.

- An example of this type of situation is a new car dealer's inventory. Often a specific car that a customer wants is not in stock. However, if the customer is willing to wait a few weeks, the dealer is usually able to order the car.

Why is maximum inventory $Q - S$?

If S backorders exist when a new shipment of size Q arrives, then S backorders are shipped to the appropriate customers, and the remaining Q S units are placed in inventory. Therefore, Q S is the maximum inventory.

如果 **Q** 的貨物到達時，那麼 **S (延期交貨的amount）** 將被運送給適當的客戶，所剩的單位就是 **Q - S，** 亦即 生產的 **(Q) -** 賣走的 **(S)** 會被放置在庫存中。因此，**Q - S** 是最大庫存 （maximum inventory）**.**

▼ What are the assumption?

諗下買車時候：We assume that when a customer places an order and discovers that the supplier is out of stock, the customer waits until the new shipment arrives, and then the order is filled.

- Demand occurs at a constant rate of A items per year.
- Ordering cost: $\$k$ per order.
- Holding cost: $\$ch$ per item in inventory per year.
- Backorder penalty cost: $\$p$ per item back-ordered per year.
- Purchase cost per unit is constant (no quantity discount).
- Set-up time (lead time) is constant.
- Planned shortages are permitted (back-ordered units are withdrawn from a replenishment order when it is delivered).

What are the variable costs?

Annual holding, backorder, and ordering

What are optimal order and back-order quantity combination?

The sum of the annual holding and back-ordering costs equals the annual ordering cost

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3. EOQ with Quantity Discounts

What does that mean?

It is applicable where a supplier offers a lower purchase cost when an item is ordered in larger quantities.

What are the variable costs?

This model's variable costs are annual holding, ordering and purchase costs.

What are optimal order quantity?

The annual holding and ordering costs are not necessarily equal

▼ What are the assumption?

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- Purchase Cost is

    $\$c_1$ per item if the quantity ordered is between 0 and x_1,

    $\$c_2$ if the order quantity is between x_1 and x_2,   etc.
- Delivery time (lead time) is constant.
- Planned shortages are not permitted.

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4. Economic Production Lot Size

This youtube video is extremely useful!

Exercise

Is this similar to EOQ?

Yes, but there is a difference:

- Similar to EOQ model, we are to determine _how much we should order_ and _when the order should be placed;_
- Different from EOQ whereby assuming that the order arrives in a shipment of size Q*, in this model, we assume that units are supplied to inventory at a constant rate over several days or several weeks.

What does that mean?

A replenishment order is not received in one lump sum as it is in the basic EOQ model.

Inventory is replenished gradually as the order is produced (which requires the production rate to be greater than the demand rate).

What are the variable costs?

Annual holding cost and annual set-up cost (equivalent to ordering cost).

What are optimal order quantity?

annual holding and set-up costs are equal.

▼ What are the assumption?

- Demand occurs at a constant rate of *A* items per year.
- Production rate is *B* items per year (and *B > A*).
- Set-up cost: $*k* per run.
- Holding cost: $*ch* per item in inventory per year.
- Manufacturing cost per unit is constant (no quantity discount).
- Set-up time (lead time) is constant.
- Planned shortages are not permitted.

Inventory level / time

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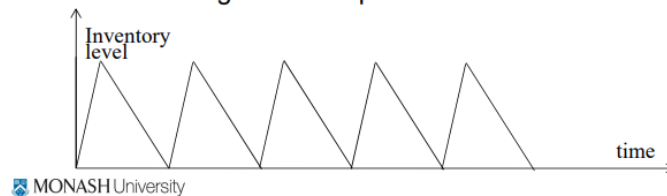
▼ Relevant resources

https://s3-us-west-2.amazonaws.com/secure.notion-static.com/df020ddd-2a73-439d-9e57-fa759add95e2/Inventory_Models.ppt

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Inventory Models: Deterministic Demand

Economic Order Quantity

Optimal order quantity: $Q^* = \sqrt{\dfrac{2Ak}{ch}}$

Number of orders per year $= \dfrac{A}{Q^*}$

Time between orders (cycle time) $= \dfrac{Q^*}{A}$ years

Total annual cost = ordering cost + holding cost $= \dfrac{Ak}{Q} + \dfrac{Qch}{2}$

Economic Production Quantity

Optimal production lot size: $Q^* = \sqrt{\dfrac{2Ak}{ch}}\sqrt{\dfrac{B}{B-A}}$

Number of production runs per year $= \dfrac{A}{Q^*}$

Time between setups (cycle time) $= \dfrac{Q^*}{A}$ years

Total annual cost = setup cost + holding cost $= \dfrac{Ak}{Q} + \dfrac{chQ}{2}\left(\dfrac{B-A}{B}\right)$

Note:
Annual holding cost per item = h
Ordering cost (per order) = k
Item cost = c
Backorder cost (per item) = p
Annual demand = A
Production rate = B

EOQ with back orders

Optimal order quantity, $Q^* = \sqrt{\dfrac{2Ak}{ch}\left(\dfrac{p+ch}{p}\right)}$

Quantity at the beginning of each cycle, $S^* = \sqrt{\dfrac{2Ak}{ch}\left(\dfrac{p}{p+ch}\right)}$

Maximum number of backorders $= Q^* - S^*$

Number of orders per year $= \dfrac{A}{Q^*}$

Time between orders (cycle time) $= \dfrac{Q^*}{A}$ years

Total annual cost = setup + holding + backorder

$= \dfrac{Ak}{Q} + \dfrac{chS^2}{2Q} + \dfrac{p(Q-S)^2}{2Q}$

Formula for total cost using Quantity discounts.

Total annual cost = purchase cost + holding cost + item cost

$= \dfrac{Ak}{Q} + \dfrac{chQ}{2} + Ac$