COORDINATED INVENTORY MANAGEMENT

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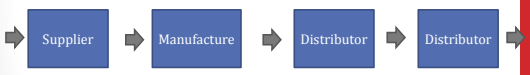
Inventory Exists In Many Places Throughout The Supply Chain



There are a number of reasons why inventory exists:

- To obtain economies of scale
- To prevent for uncertainty / to achieve higher service level

FUNGSI PERSEDIAAN :

- Mengurangi ketergantungan antar tahap dalam mata rantai sistem produksi – distribusi.
- Mempertahankan stabilitas penggunaan tenaga kerja karena fluktuasi *demand*.
- Mengantisipasi kemungkinan terjadinya gangguan yang berupa keterlambatan pasokan atau berhentinya aktivitas dalam sistem produksi.
- Mengambil keuntungan dng memanfaatkan potongan harga untuk pembelian dlm jumlah besar.
- Mengantisipasi tejadinya kenaikan harga barang karena inflasi.
- Mengantisipasi terjadinya *stock out* karena permintaan melebihi perkiraan.

Types of Inventory

- Based on their status:
  - *Raw Material*
  - *Finished Part*
  - *Component Part*
  - *Subassembly Material*
  - *Work In-Process* (*WIP*)
  - *Finished Goods*
- Based on their functions:
  - Pipeline / in-transit inventory
  - Cycle stock
  - Safety stock
  - Anticipation stock

Types of Inventory (2)

- Berdasarkan Sifat Ketergantungan Kebutuhan
  - Independent Demand → kebutuhan akan suatu item barang tidak tergantung item yang lain.
    Misalnya kebutuhan barang untuk memenuhi permintaan pembeli di sebuah toko, kebutuhan bahan baku utama dari produk yang kebutuhannya ditentukan berdasarkan demand forecasting.
  - Dependent Demand → kebutuhan akan item tertentu tergantung/terkait pada kebutuhan terhadap item yang lain. Ketergantungan antar item bisa berbentuk :
    - ketergantungan vertikal : mis. kebutuhan dari komponen penyusun subrakitan/ produk jadi.
    - ketergantungan horizontal : mis. kebutuhan dr komponen pelengkap (bahan pembantu) yang menyertai produk.

People often behave conservatively when making inventory decision.

This is due to, as stated by Ballou (1999, pp. 310), criticism for being overstocked is much more defensible than being short of supply.

The major portion of inventory holding costs is of an opportunity cost nature and therefore goes unidentified in normal accounting system.

Inventory Models For Items With Stable Demand

Models without coordination

Models with coordination between buyer and supplier

Finding Optimal Order Quantity

- When a type of item is consumed quite continuously in almost a constant rate, there is a simple model to apply to determine the optimal order quantity such that the total inventory cost is minimum. Total inventory costs consist of ordering cost and inventory holding cost.
- If ordering cost is high, people tend to order less frequently to reduce total order cost. If inventory holding cost is high, order smaller quantity so that lower average inventory is held.

How Large Should Your Orders Be?

- If your orders are too large, you'll have excess inventory and high holding costs
- If your orders are too small, you will have to place more orders to meet demand, leading to high ordering costs

Order Size	Holding Costs	Ordering Costs
Too LARGE	High	Low
Too SMALL	Low	High

- *Ordering cost* perperioda = frekuensi pemesanan dalam 1 perioda x C = $\frac{D}{Q}C$
- *Purchase cost* perperioda = jumlah kebutuhan perperioda x P = DP
- *Holding cost* perperioda = rata-rata banyaknya barang yang disimpan perperioda x H = $\frac{Q}{2}H$
- ***Total cost inventory*** : TC = $\frac{D}{Q}C$ + DP + $\frac{Q}{2}H$
- TC akan minimum jika : = $\frac{dTC}{dQ} = 0$ dan $\frac{d^2TC}{d^2Q} > 0$

The model:
Total cost = Order cost + Holding cost

$$TC(Q) = \frac{D}{Q}Co + \frac{Q}{2}h$$

$$Q^* = \sqrt{\frac{2CoD}{h}}$$

Where D = annual demand
Co = order cost
h = inventory holding cost

An Example

A baking company produces bread using flour as main raw material. The company on average uses 200 kg flours a day (1 year = 365 days). Costs for placing an order is about Rp. 100.000. The price for 10 kg flour is Rp. 25.000,- Annual inventory holding cost is about 25% of the inventory value. Determine optimal order quantity.

Reorder Point

- When there is a lead time, EOQ should be applied under a reorder point scheme. Reorder point is an inventory position where a company should place an order. When lead time is l periods and demand per period is d then the reorder point is demand during lead time, that is:

$$d \times l$$

- For example, if lead time for ordering flour is one week, determine reorder point.

Dealing with Demand Uncertainty

- When demand and or lead time is uncertain, extra inventory is usually provided to cope with demand uncertainty. Thus, reorder point should include safety stock as follows:

$$ROP = dxl + s$$

Safety Stock

- If demand variability follows a normal distribution around the average level, demand uncertainty is represented by the standard deviation of demand. Furthermore, safety stock affects the service level. Thus, when setting a safety stock level, a service level target should be determined. Safety stock is the determined by the following formula:

$$s = k(SL)x\sigma$$

- where k (SL) is a number in a standard normal distribution representing that there is a probability of SL that demand is less than or equal to k, while σ is the standard deviation of demand. The values of k for different SL can be obtained in a normal inverse table. For example, if k = 1.645, SL = 95%.

- Lead Time Pengiriman berdistribusi normal dengan rata-rata 5 hari dan standard deviasi 0,5 hari dan permintaan per hari rata2 1 ton dengan standard deviasi 0,1 ton. Manajemen menetapkan service level 95%.Hitung safety stock dan nilai ROP nya..

EOQ WITH COORDINATION

- The weakness of the traditional EOQ is that it views cost from the perspective of the buyer only.
- If there is cost incurred to the supplier associated with each order placed by the buyer, an integrated model can be developed.

The Model

Optimal order quantity from both sides is:

$$Q = \sqrt{\frac{2(A_s + A_b)D}{(h_s + h_b)}}$$

Where:

A_s = fixed order processing cost incurred to the supplier

A_b = fixed order cost incurred to the buyer

D = annual demand

h_s = inventory holding cost to the supplier

h_b = inventory holding cost to the buyer

Joint Ordering Policies: An Example For Products With Stable Demand

Demand in a year = 10000
(Buyer) Order cost = 200
(Buyer) Inventory holding cost = 4
(Supplier) Order processing cost = 800
(Supplier) Inventory holding cost = 3

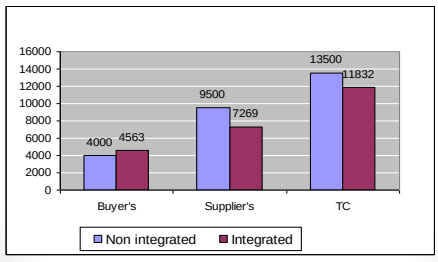
Tentukan berapa optimal order quantity dan ongkos-ongkos yang ditanggung oleh buyer, supplier, maupun total keduanya bila:

1. **Tidak ada integrasi**
2. **Ada integrasi antara buyer dan supplier**

Solution

TRADITIONAL MODEL
EOQ = 1000

INTEGRATED MODEL
EOQ = 1690



INVENTORY MODELS FOR ITEMS WITH SEASONAL DEMAND AND/OR LIMITED LIFE

- **Model without coordination**
- **Model with coordination between buyer and supplier**

Examples of Inventory with Seasonal Demand or Inventory with Limited Lifetime

- Newspapers and Magazines
- Vegetables, fresh milk, fresh foods, etc.
- Fashion products
- Innovative high tech products: digital camera, mobile phone, computers

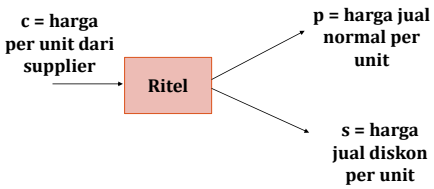
Tradeoff

- Here, unlike for products with stable demand, the tradeoff is not between ordering and inventory holding costs, but between: overstocking and shortage costs.
  - Overstocking → products sold with markdown costs or even disposed
  - Shortage → lost of opportunity and lost of future customers

BASIC MODEL: NEWSBOY INVENTORY PROBLEM

- For items with limited life, in determining purchasing or production decisions, we balance the overstocking and understocking costs. Overstocking cost is not just inventory holding cost, but could also be costs due to very low or zero selling price for the products. Understocking cost is cost associated with the lost of selling opportunity.

Newsboy Model



If the overstocking cost is Co and understocking cost is Cu then the optimal service level is:

Co = c-s dan Cu = p-c

Kentungan perusahaan

- Q < D → *(p-c) Q atau Cu*Q*
- Q > D → *(p-c) D - (c-s) (Q-D)*
- Secara umum :

P(b)=Cu Min (Q,D) – max (0, [Q-D] Co)

Optimal Order Quantity

- If demand is normally distributed with mean and standard deviation then the optimal order or production quantity is: $Q^* = \mu + k(SL^*)\sigma$
- If the overstocking cost is Co and understocking cost is Cu then the optimal service level is: $SL^* = \frac{Cu}{Cu + Co}$
- Where k(SL*) is the inverse normal distribution, can be found in normal table.

Joint Ordering Policies

Principle:

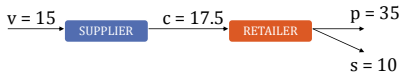
- Consider costs more broadly. The overstocking cost is the real cost incurred, from the supply chain perspective, for stocking one unit of extra inventory.
- The understocking cost is the opportunity cost incurred for one unit shortage from the perspective of the supply chain.

Example

- Garment distributor in USA is determining how many shirts are to be ordered from Indonesia for a selling season in Summer 2002. The selling price for a shirt is $35 if sold during the summer. If not, the shirts have to be sold in a discount price of $10. The distributor has to pay $17.5 for one shirt to the manufacturer. The cost already includes delivery. Demand for the shirts is estimated to follow a normal distribution with mean 1000 and standard deviation 300.
- Determine:
  - The optimal service level for the distributor
  - The optimal number of shirts to be ordered.

MODEL FOR JOINT ORDERING POLICIES

Suppose that the costs associated with producing one unit of item at the manufacturer is $15.



For Retailer:
Co = c-s = 7.5
Cu = p-c = 17.5

For Supply Chain:
Co = v-s = 5
Cu = p-v = 20

Optimal service level = Cu/(Co+Cu)

For retailer alone, SL*= 17.5/25 = 70%
For supply chain, SL* = 20/25 = 80%

Optimal Order for Different Situation

	Tanpa Koordinasi	Dengan Koordinasi	Perubahan
SL*	70%	80%	10%
Q	1157	1253	96
Keuntungan Ritel (Ekspektasi)	14858	14758	-101
Keuntungan pabrik	2893	3133	240
Keuntungan Total	17751	17890	139

Steps Dalam Melakukan Simulasi (Silakan dicoba)

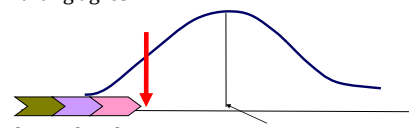
- Generate demand (D) yang berdistribusi normal dengan mean 1000 dan standar deviasi 200. Pada Excell ini bisa dilakukan dengan perintah:
  =Round(NORMINV(Rand(), 1000, 200),0).
- Profit supplier (SP) yang besarnya = Q * 2 dimana Q adalah order quantity dari buyer.
- Profit untuk buyer (BP) adalah Q * 5 kalau Q kurang dari permintaan dan D * 5 – (Q-D)*3 kalau Q lebih dari D. Pada EXCELL formulasinya adalah:
  =Min(Q,D)*5 – Max(0,(Q-D))*3
- Hitung total profit = BP + SP.
- Lakukan untuk Q = 1066 maupun 1235.

What is required to make the models work?

- ❑Willingness to share costs data
- ❑Willingness to work together to establish joint plan

Quick Response: Reducing inventory mismatch

Zara menghentikan produksi kalau signal awal menunjukkan Pasar kurang agresif



Ukuran batch kecil

Ekspektasi awal

Vendor Managed Inventory (VMI)

Suppliers are given more roles.
They make decisions on delivery schedule.

Informasi POS dan data persediaan secara real time

Membuat keputusan pengiriman ke Cortese

Results :
-Pengurangan stockout dari 6-7 % menjadi hampir 0%
- Persediaan berkurang sekitar 46%
- Pengiriman menjadi lebih konsisten

- Demand for Deskpro computer at Best Buy 1000 unit per month. Best Buy incurs a fixed order placement, transportation, and receiving cost of $4000 each time an order is placed. Each computer cost Best Buy $500 and the retailer has a holding cost of 20 percent . Evaluate the number of computer that the store manager should order in each replenishment lot