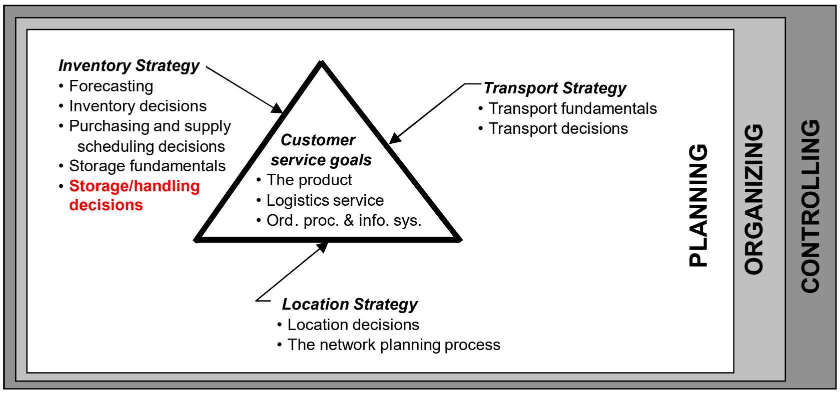
WAREHOUSE LOCATION SELECTION, DESİGN AND MANAGEMENT

Lecture Note #8

Storage/Handling Decisions in Inventory Strategy



Location Selection Methods

- Factor-Rating Method
- Locational Break-Even Analysis
- Center-of-Gravity Method

Factor-Rating Method

- **Popular because a wide variety of factors can be included in the analysis**
- **Six steps in the method**
  1. **Develop a list of relevant factors called key success factors**
  2. **Assign a weight to each factor**
  3. **Develop a scale for each factor**
  4. **Score each location for each factor**
  5. **Multiply score by weights for each factor for each location**
  6. **Recommend the location with the highest point score**

Factor-Rating Example

Key Success Factor	Weight	Scores (out of 100) France	Scores (out of 100) Denmark	Weighted Scores France	Weighted Scores Denmark
Labor availability and attitude	.25	70	60	(.25)(70) = 17.5	(.25)(60) = 15.0
People-to-car ratio	.05	50	60	(.05)(50) = 2.5	(.05)(60) = 3.0
Per capita income	.10	85	80	(.10)(85) = 8.5	(.10)(80) = 8.0
Tax structure	.39	75	70	(.39)(75) = 29.3	(.39)(70) = 27.3
Education and health	.21	60	70	(.21)(60) = 12.6	(.21)(70) = 14.7
Totals	1.00			70.4	68.0

Table 8.4

Locational Break-Even Analysis

- **Method of cost-volume analysis used for industrial locations**
- **Three steps in the method**
  1. Determine fixed and variable costs for each location
  2. Plot the cost for each location
  3. Select location with lowest total cost for expected production volume

Locational Break-Even Analysis Example

Three locations:

Selling price = $120
Expected volume = 2,000 units

City	Fixed Cost	Variable Cost	Total Cost
Akron	$30,000	$75	$180,000
Bowling Green	$60,000	$45	$150,000
Chicago	$110,000	$25	$160,000

Total Cost = Fixed Cost + (Variable Cost x Volume)

Locational Break-Even Analysis Example

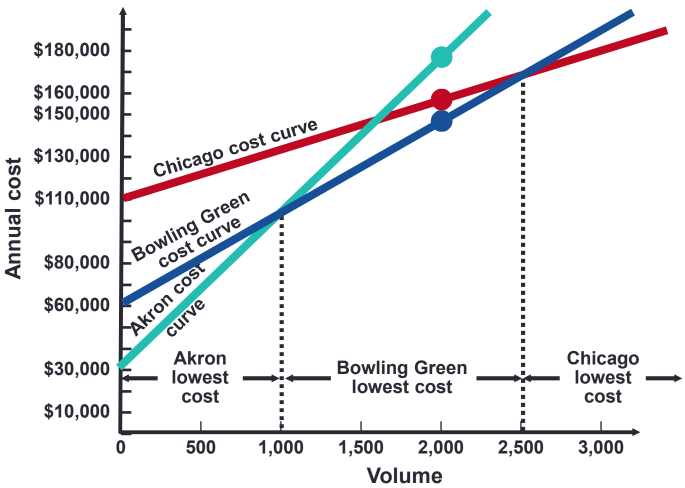


Figure 8.2

Center-of-Gravity Method

- **Finds location of distribution center that minimizes distribution costs**
- **Considers**
  - **Location of markets**
  - **Volume of goods shipped to those markets**
  - **Shipping cost (or distance)**

Center-of-Gravity Method

- **Place existing locations on a coordinate grid**
  - **Grid origin and scale is arbitrary**
  - **Maintain relative distances**
- **Calculate *X* and *Y* coordinates for 'center of gravity'**
  - **Assumes cost is directly proportional to distance and volume shipped**

Center-of-Gravity Method

$$x\text{ - coordinate} = \frac{\sum_i d_{ix} Q_i}{\sum_i Q_i}$$

$$y\text{ - coordinate} = \frac{\sum_i d_{iy} Q_i}{\sum_i Q_i}$$

where d_{ix} = x-coordinate of location i
d_{iy} = y-coordinate of location i
Q_i = Quantity of goods moved to or from location i

Center-of-Gravity Method

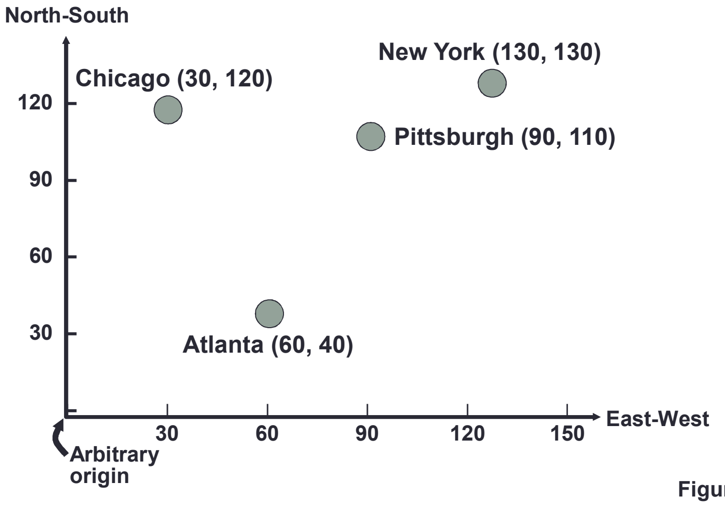


Figure 8.3

Center-of-Gravity Method

Store Location	Number of Containers Shipped per Month
Chicago (30, 120)	2,000
Pittsburgh (90, 110)	1,000
New York (130, 130)	1,000
Atlanta (60, 40)	2,000

$$x\text{-coordinate} = \frac{(30)(2000) + (90)(1000) + (130)(1000) + (60)(2000)}{2000 + 1000 + 1000 + 2000}$$

$$= 66.7$$

$$y\text{-coordinate} = \frac{(120)(2000) + (110)(1000) + (130)(1000) + (40)(2000)}{2000 + 1000 + 1000 + 2000}$$

$$= 93.3$$

Center-of-Gravity Method

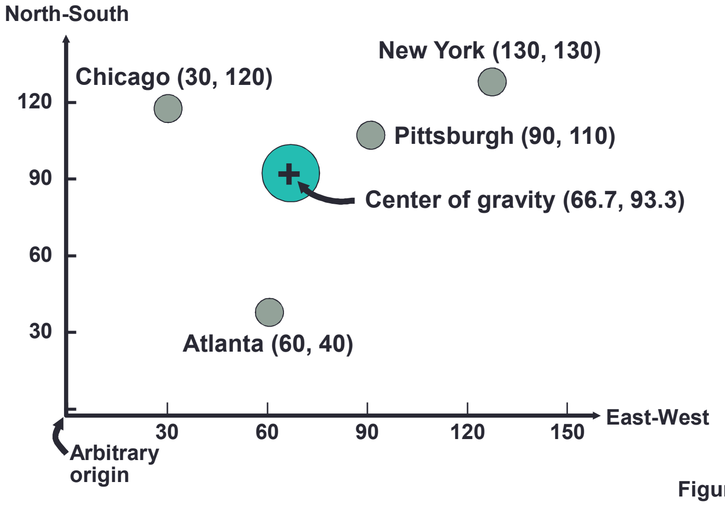


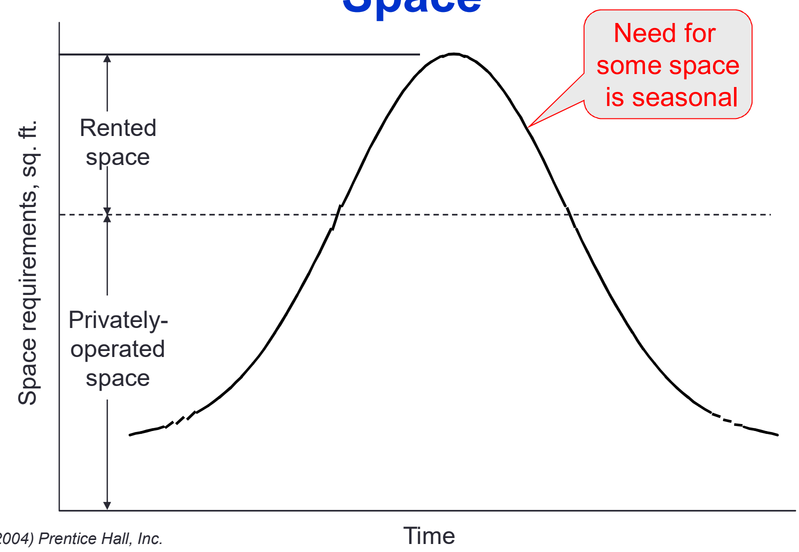
Figure 8.3

Storage Decisions

Sizing the Facility

- From inventory policy, determine the amount of inventory to be stored, that is, space needed
- Determine the facility's seasonal use
- Balance the use of privately-owned space with rented space—a mixed strategy

Mixed Strategy for Warehouse Space



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Storage Decisions

Facility Configuration

- Configuration affects handling costs in a high throughput facility, but less important otherwise
- Square or rectangular shapes are best. L-shaped designs are poor unless conveyors are used.
- Single-story designs are popular for high throughput facilities and land costs are not prohibitively high

Storage Decisions

Space Layout

- Configuration of racks and aisles in the building
- Space layout affects building dimensions and size

Dock Design

- Determined by the number of rail cars along the side of a building or the number of truck stalls needed

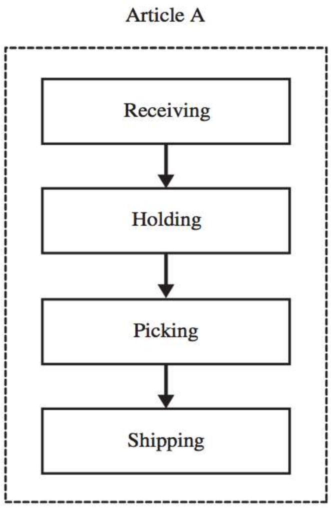
Warehouse Design

- Warehouses are facilities where inventories are sheltered.
- They can be broadly classified into *production warehouses* and DCs.

Flow of items through the warehouse

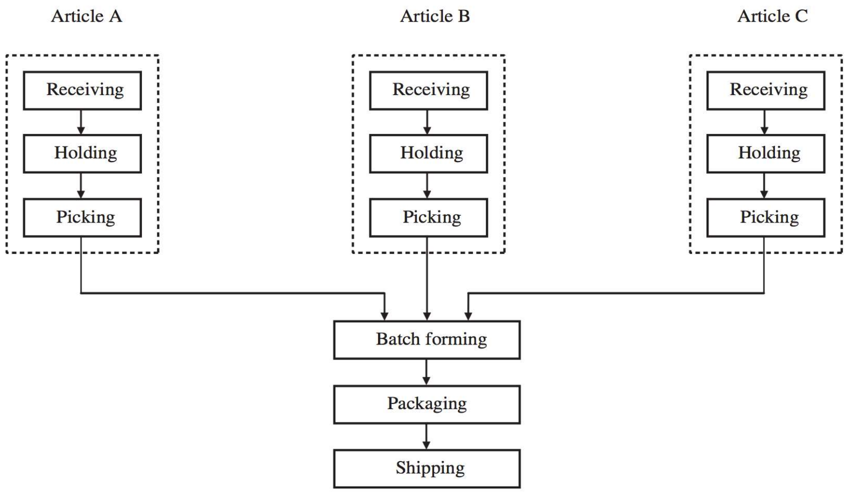
- Warehouses are often used not only to provide inventories a shelter, but also to sort or consolidate goods.
- In a typical DC, the products arriving by truck, rail, or internal transport are unloaded, checked and stocked.
- After a certain time, items are retrieved from their storage locations and transported to an order assembly area.
- In the simplest case, the main activity is the storage of the goods. Here, the merchandise is often received, stored and shipped in full pallets (all one product) and, as a result, material handling is relatively simple.

The flow of items through the warehouse; the goods are received and shipped in full pallets or in full cartons (all one product)



- In the most complex case, large lots of products are received and shipments, containing small quantities of several items, have to be formed and dispatched to customers.
- Consequently, order picking is quite complex, and product sorting and consolidation play a major role in order assemble

The flow of items through the warehouse; the goods are received in full pallets or in full cartons (all one product) and shipped in less than full pallets or cartons



Ownership of the warehouses

- With respect to ownership, there are three main typologies of warehouses.

- *Company-owned warehouses*
- *Public warehouses*
- *Leased warehouse space*

Company-owned warehouses

- *Company-owned warehouses* require a capital investment in the storage space and in the material handling equipment.
- They usually represent the least-expensive solution in the long run in the case of a substantial and constant demand.
- Moreover, they are preferable when a higher degree of control is required to ensure a high level of service, or when specialized personnel and equipment are needed.
- Finally, they can be employed as a depot for the company's vehicles or as a base for a sales office.

Public warehouses

- *Public warehouses* are operated by firms providing services to other companies on a short-term basis.
- As a rule, public warehouses have standardized equipment capable of handling and storing specific types of merchandise (e.g. bulk materials, temperature-controlled goods, etc.).
- Here, all warehousing costs are variable, in direct proportion to the storage space and the services required.
- As a result, it is easy and inexpensive to change warehouse locations as demand varies. For these reasons, public warehouses can suitably accommodate seasonal inventories.

Leased warehouse space

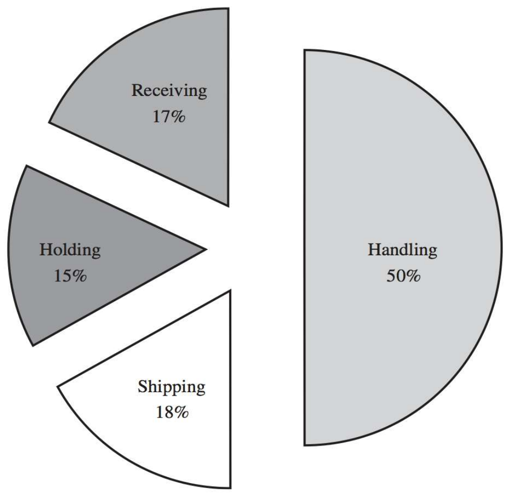
- Finally, *leased warehouse space* is an intermediate choice between short-term space rental and the long-term commitment of a company-owned warehouse.

Warehouse costs

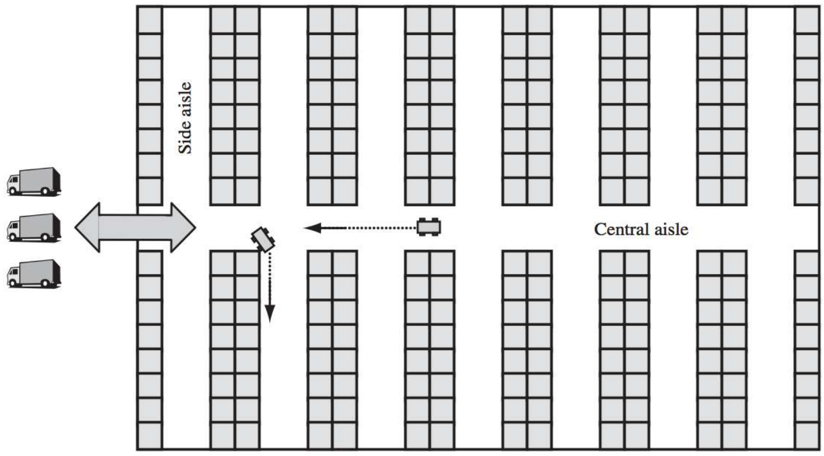
- The total annual cost associated with the operation of a warehouse is the result of four main activities:
  - receiving the products,
  - holding inventories in storage locations,
  - retrieving items from the storage locations,
  - assembling customer orders and shipping.
- These costs depend mainly on the storage medium, the storage/retrieval transport technology and its policies.

- As a rule, receiving the incoming goods and, even more so, forming the outgoing lots, are operations that are difficult to automate and often turn out to be labor-intensive tasks.
- Holding inventories depends mostly on the storage medium, as explained in the following.
- Finally, picking costs depend on the storage/retrieval transport system which can range from a fully manual system (where goods are moved by human pickers travelling on foot or by motorized trolleys) to fully automated systems (where goods are moved by devices under the control of a centralized computer).

Common warehouse costs



Warehouse Design



Warehouse Design

- Designing a warehouse amounts to choosing its building shell, as well as its layout and equipment. In particular, the main design decisions are
  - determining the length, width and height of the building shell;
  - locating and sizing the receiving, shipping and storage zones (e.g. evaluating the number of I/O ports, determining the number, the length and the width of the aisles of the storage zone and the orientation of stacks/racks/drawers);
  - selecting the storage medium;
  - selecting the storage/retrieval transport mechanism.

Determining the number of truck docks

Goods are usually received and shipped by rail or by truck. In the latter case, the number of docks n_D can be estimated through the following formula,

$$n_D = \left\lceil \frac{dt}{qT} \right\rceil,$$

where d is the daily demand from all orders, t is the average time required to load/unload a truck, q is the truck capacity, and T is the daily time available to load/unload trucks.

Determining the capacity of a storage area

The size of a storage area depends on the storage policy. In a *dedicated storage policy*, each product is assigned a pre-established set of positions. This approach is easy to implement but causes an underutilization of the storing space. In fact, the space required is equal to the sum of the maximum inventory of each product in time. Let n be the number of products and let $I_j(t)$, $j = 1, \dots, n$, be the inventory level of item j at time t. The number of required storage locations m_d in a dedicated storage policy is

$$m_d = \sum_{j=1}^{n} \max_t I_j(t). \tag{5.1}$$

In a *random storage policy*, item allocation is decided dynamically on the basis of the current warehouse occupation and on future arrival and request forecast. Therefore, the positions assigned to a product are variable in time. In this case the number of storage locations m_{r} is

$$m_{\mathrm{r}} = \max_t \sum_{j=1}^{n} I_j(t) \leqslant m_{\mathrm{d}}. \tag{5.2}$$