Operations As a Competitive Weapon
Operations Strategy
Project Management

Process Strategy
Process Analysis
Process Performance and Quality
Constraint Management
Process Layout
Lean Systems

Designing Supply Chain
Integrating the supply chain
Location Facilities
Inventory Management
Forecasting
Sales and Operations Planning
Resource Planning
● **Supply chain**: The network of services, material, and information flows that link a firm’s customer relationship, order fulfillment, and supplier relationship processes to those of its supplier and customers.

● **Supply chain management**: Developing a strategy to organize, control, and motivate the resources involved in the flow of services and materials within the supply chain.

● **Supply chain strategy**: Designing a firm’s supply chain to meet the competitive priorities of the firm’s operations strategy.

*competitive priorities* namely, quality, low cost, flexibility
Supply Chain Design

Figure 9.1 – Supply Chain Efficiency Curve

- Inefficient supply chain operations
- Area of improved operations
- New supply chain efficiency curve with changes in design and execution
- Reduce costs
- Improve performance

Total costs

Supply chain performance
Supply Chain Design

- The goal is to reduce costs as well increase performance.
- Supply chains must be managed to coordinate the inputs with the outputs in a firm to achieve the appropriate competitive priorities of the firm’s enterprise processes.
- The Internet offers firms an alternative to traditional methods for managing the supply chain.
- A supply chain strategy is essential for service as well as manufacturing firms.
Supply Chains

- Every firm or organization is a member of some supply chain

- Services
  - Provide support for the essential elements of various services the firm delivers

- Manufacturing
  - Control inventory by managing the flow of materials
  - Suppliers identified by position in supply chain – “tiers”
  - Suppliers and customers
**Supply Chains**

![Diagram of Supply Chain for a Florist]

Figure 9.2 – Supply Chain for a Florist

Supply Chains

Figure 9.2 – Supply Chain for a Manufacturing Firm
Global Partners Bring the 787 Together

- wing tips: Busan, Korea
- fixed trailing edge: Nagoya, Japan
- moveable trailing edge: Melbourne, Australia
- flap support fairings: Busan, Korea
- tail fin: Frederickson, WA
- tail cone: Auburn, WA
- aft fuselage: Bossier, Korea
- horizontal stabilizer: Foggia, Italy
- passenger entry door: Toulouse, France
- wing: Nagoya, Japan
- nacelles: Chino Vista, CA
- center fuselage: Grottoli, Italy
- mid forward fuselage: Nagoya, Japan
- forward fuselage: Wichita, KS
- cargo access doors: Linkoping, Sweden
- wing/body fairing: Linkoping, Sweden
- landing gear doors: Winnipeg, Canada
- engines: GE - Evendale, Ohio, Rolls Royce - Derby, UK
- main landing gear wheel wall: Nagoya, Japan
- landing gear: Gloucester, UK
- fixed and moveable leading edge: Tuker, OK

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**Creation of Inventory**

**Inventory**: A stock of materials used to satisfy customer demand or to support the production of services or goods.
Types of Inventory

- Three aggregate categories
  - Raw materials
  - Work-in-process
  - Finished goods

- Classified by how it is created
  - Cycle inventory
  - Safety stock inventory
  - Anticipation inventory
  - Pipeline inventory
Supply Chain for Manufacturing

- **Raw materials (RM):** The inventories needed for the production of services or goods.

- **Work-in-process (WIP):** Items, such as components or assemblies, needed to produce a final product in manufacturing.

- **Finished goods (FG):** The items in manufacturing plants, warehouses, and retail outlets that are sold to the firm’s customers.
Inventory at Successive Stocking Points

- Supplier
- Manufacturing plant
- Distribution center
- Retailer

- Raw materials
- Work in process
- Finished goods
Lot sizing principles

1. The lot size, $Q$, varies directly with the elapsed time (or cycle) between orders.

2. The longer the time between orders for a given item, the greater the cycle inventory must be.

Average cycle inventory $= \frac{Q + 0}{2} = \frac{Q}{2}$

This formula is exact only when the demand rate is constant.
Safety Stock and Anticipation Inventory

- Safety Stock inventory
  - Protects against uncertainties in demand, lead time, and supply changes

- Anticipation inventory
  - Used to absorb uneven rates of demand or supply
  - Predictable, seasonal demand patterns lend themselves well to the use of anticipation inventory
Pipeline Inventory

- Pipeline inventory

Average demand during lead time = $\bar{D}_L$
Average demand per period = $\bar{d}$
Number of periods in the item’s lead time = $L$

Pipeline inventory = $\bar{D}_L = \bar{d}L$
EXAMPLE 9.1

A plant makes monthly shipments of electric drills to a wholesaler in average lot sizes of 280 drills. The wholesaler’s average demand is 70 drills a week, and the lead time from the plant is 3 weeks. The wholesaler must pay for the inventory from the moment the plant makes a shipment. If the wholesaler is willing to increase its purchase quantity to 350 units, the plant will give priority to the wholesaler and guarantee a lead time of only 2 weeks. What is the effect on the wholesaler’s cycle and pipeline inventories?
SOLUTION

The wholesaler’s current cycle and pipeline inventories are

Cycle inventory = \( \frac{Q}{2} = 140 \) drills

Pipeline inventory = \( \bar{D}_L = \bar{d}L = (70 \text{ drills/week})(3 \text{ weeks}) = 210 \) drills
**Estimating Inventory Levels**

1. Enter the average lot size, average demand during a period, and the number of periods of lead time:

   | Average lot size | 350 |
   | Average demand   | 70  |
   | Lead time        | 2   |

2. To compute cycle inventory, simply divide average lot size by 2. To compute pipeline inventory, multiply average demand by lead time:

   | Cycle inventory  | 175 |
   | Pipeline inventory | 140 |
Inventory Reduction Tactics

- **Cycle inventory**
  - Reduce the lot size
  - Reduce ordering and setup costs and allow $Q$ to be reduced
  - Increase repeatability to eliminate the need for changeovers

- **Safety stock inventory**
  - Place orders closer to the time when they must be received
  - Improve demand forecasts
  - Cut lead times
  - Reduce supply chain uncertainty
Inventory Reduction Tactics

- **Anticipation inventory**
  - Match demand rate with production rates
  - Add new products with different demand cycles
  - Offer seasonal pricing plans

- **Pipeline inventory**
  - Reduce lead times
  - Change $Q$ in those cases where the lead time depends on the lot size
Inventory Placement

- Where to locate an inventory of finished goods
- Use of distribution centers (DCs)
- Centralized placement
- Inventory pooling
**Measures of Supply Chain Performance (Inventory Measures)**

**Measure of Inventories in 3 basic ways:** 1. Average aggregate inventory value, 2. weeks of supply, 3. inventory turnover

- **Average aggregate inventory value (AGV)** is the total value of all items held in inventory for a firm. (in $)

  \[
  \text{Average aggregate inventory value} = \left( \frac{\text{Value of each unit of item A}}{\text{Number of units of item A typically on hand}} \right) + \left( \frac{\text{Value of each unit of item B}}{\text{Number of units of item B typically on hand}} \right)
  \]

- **Weeks of supply:** The average aggregate inventory value divided by sales per week at cost.

  \[
  \text{Weeks of supply} = \frac{\text{Average aggregate inventory value}}{\text{Weekly sales (at cost)}}
  \]

- **Inventory turnover** is annual sales at cost divided by the average aggregate inventory value maintained for the year.

  \[
  \text{Inventory turnover} = \frac{\text{Annual sales at (cost)}}{\text{Average aggregate inventory value}}
  \]
EXAMPLE 9.2

The Eagle Machine Company averaged $2 million in inventory last year, and the cost of goods sold was $10 million. Figure 9.7 shows the breakout of raw materials, work-in-process, and finished goods inventories. The best inventory turnover in the company’s industry is six turns per year. If the company has 52 business weeks per year, how many weeks of supply were held in inventory? What was the inventory turnover? What should the company do?
Calculating Inventory Measures

<table>
<thead>
<tr>
<th>Item</th>
<th>Average Level</th>
<th>Unit Value</th>
<th>Total Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Materials</td>
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<td>1,400</td>
<td>$50.00</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1,000</td>
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<td>3</td>
<td>400</td>
<td>$60.00</td>
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<td></td>
<td>4</td>
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<td>$10.00</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>800</td>
<td>$15.00</td>
</tr>
<tr>
<td>Work in Process</td>
<td>6</td>
<td>320</td>
<td>$700.00</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>160</td>
<td>$900.00</td>
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<td></td>
<td>8</td>
<td>280</td>
<td>$750.00</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>240</td>
<td>$800.00</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>400</td>
<td>$1,000.00</td>
</tr>
<tr>
<td>Finished Goods</td>
<td>11</td>
<td>60</td>
<td>$2,000.00</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>40</td>
<td>$3,500.00</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>50</td>
<td>$2,800.00</td>
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<tr>
<td></td>
<td>14</td>
<td>20</td>
<td>$5,000.00</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>40</td>
<td>$4,200.00</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average Weekly Sales at Cost: $192,308

Weeks of Supply: 10.4

Inventory Turnover: 5.0

Figure 9.7 – Calculating Inventory Measures Using Inventory Estimator Solver
Calculating Inventory Measures

SOLUTION

The average aggregate inventory value of $2 million translates into 10.4 weeks of supply and 5 turns per year, calculated as follows:

Weeks of supply = \( \frac{\$2\text{ million}}{\$10\text{ million}} \times \frac{52\text{ weeks}}{(52\text{ weeks})} \) = 10.4 weeks

Inventory turns = \( \frac{\$10\text{ million}}{\$2\text{ million}} \) = 5 turns/year
A recent accounting statement showed total inventories (raw materials + WIP + finished goods) to be $6,821,000. This year’s “cost of goods sold” is $19.2 million. The company operates 52 weeks per year. How many weeks of supply are being held? What is the inventory turnover?

Weeks of supply = \[
\frac{\text{Average aggregate inventory value}}{\text{Weekly sales (at cost)}} \]

\[
= \frac{\$6,821,000}{($19,200,000)/(52 \text{ weeks})} = 18.5 \text{ weeks}
\]

Inventory turnover = \[
\frac{\$19,200,000}{\$6,821,000} = 2.8 \text{ turns}
\]
Financial measures

- Total revenue
- Cost of goods sold
- Operating expenses
- Cash flow
- Working capital
- Return on assets ROA
Return on Assets (ROA): is net income divided by total assets.

- Managing the supply chain so as to reduce the aggregate inventory investment will reduce the total assets portion of the firm’s balance sheet.

Working Capital: Money used to finance ongoing operations.

- Weeks of inventory and inventory turns are reflected in working capital.
- Decreasing weeks of supply or increasing inventory turns reduces the working capital.
**Links to Financial Measures**

- **Cost of Goods Sold:** Buying materials at a better price, or transforming them more efficiently, improves a firm’s cost of goods sold measure and ultimately its net income.

- **Total Revenue:** Increasing the percent of on-time deliveries to customers increases total revenue because satisfied customers will buy more services and products.

- **Cash Flow:** *Cash-to-cash* is the time lag between paying for the services and materials needed to produce a service or product and receiving payment for it.
  
  - The shorter the time lag, the better the cash flow position of the firm because it needs less working capital.
Measures of Supply Chain Performance

Figure 9.8 – How Supply Chain Decisions Can Affect ROA

- **Total revenue**
  - Increase sales through better customer service

- **Cost of goods sold**
  - Reduce costs of transportation and purchased materials

- **Operating expenses**
  - Reduce fixed expenses by reducing overhead associated with supply chain operations

- **Net cash flows**
  - Improve positive cash flows by reducing lead times and backlogs

- **Inventory**
  - Increase inventory turnover

- **Working capital**
  - Reduce working capital by reducing inventory investment, lead times, and backlogs

- **Fixed assets**
  - Reduce the number of warehouses through improved supply chain design

- **Total assets**
  - Achieve the same or better performance with fewer assets

- **Net income**
  - Improve profits with greater revenue and lower costs

- **Return on assets (ROA)**
  - Increase ROA with higher net income and fewer total assets
Outsourcing Processes

- Make-or-buy decision

- Outsourcing
  - Benefits to outsourcing
  - Pitfalls to outsourcing
EXAMPLE 9.3

Thompson manufacturing produces industrial scales for the electronics industry. Management is considering outsourcing the shipping operation to a logistics provider experienced in the electronics industry. Thompson’s annual fixed costs of the shipping operation are $1,500,000, which includes costs of the equipment and infrastructure for the operation. The estimated variable cost of shipping the scales with the in-house operation is $4.50 per ton-mile. If Thompson outsourced the operation to Carter Trucking, the annual fixed costs of the infrastructure and management time needed to manage the contract would be $250,000. Carter would charge $8.50 per ton-mile. What is the break-even quantity?
**Using Break-Even Analysis**

**SOLUTION**

From Supplement A, “Decision Making,” the formula for the break-even quantity yields

\[
Q = \frac{F_m - F_b}{c_b - c_m}
\]

\[
= \frac{1,500,000 - 250,000}{8.50 - 4.50}
\]

\[
= 312,500 \text{ ton-miles}
\]

**Decision Point:**

1. How many ton-miles of Product will be shipped now and in the future
2. If that estimate is less than 312,500 ton-miles → outsourcing
A distribution center experiences an average weekly demand of 50 units for one of its items. The product is valued at $650 per unit. Average inbound shipments from the factory warehouse average 350 units. Average lead time (including ordering delays and transit time) is 2 weeks. The distribution center operates 52 weeks per year; it carries a 1-week supply of inventory as safety stock and no anticipation inventory. What is the value of the average aggregate inventory being held by the distribution center?
### Solved Problem 1

**SOLUTION**

<table>
<thead>
<tr>
<th>Type of Inventory</th>
<th>Calculation of Average Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle</td>
<td>( \frac{Q}{2} = \frac{350}{2} = 175 \text{ units} )</td>
</tr>
<tr>
<td>Safety stock</td>
<td>1-week supply = 50 units</td>
</tr>
<tr>
<td>Anticipation</td>
<td>None</td>
</tr>
<tr>
<td>Pipeline</td>
<td>( \bar{d}L = (50 \text{ units/week})(2 \text{ weeks}) = 100 \text{ units} )</td>
</tr>
<tr>
<td></td>
<td><strong>Average aggregate inventory</strong> = 325 units</td>
</tr>
<tr>
<td></td>
<td><strong>Value of aggregate inventory</strong> = $650(325)$</td>
</tr>
<tr>
<td></td>
<td>= $211,250$</td>
</tr>
</tbody>
</table>
Solved Problem 2

A firm’s cost of goods sold last year was $3,410,000, and the firm operates 52 weeks per year. It carries seven items in inventory: three raw materials, two work-in-process items, and two finished goods. The following table contains last year’s average inventory level for each item, along with its value.

a. What is the average aggregate inventory value?

b. How many weeks of supply does the firm maintain?

c. What was the inventory turnover last year?

<table>
<thead>
<tr>
<th>Category</th>
<th>Part Number</th>
<th>Average Level</th>
<th>Unit Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw materials</td>
<td>1</td>
<td>15,000</td>
<td>$3.00</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2,500</td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>3,000</td>
<td>1.00</td>
</tr>
<tr>
<td>Work-in-process</td>
<td>4</td>
<td>5,000</td>
<td>14.00</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>4,000</td>
<td>18.00</td>
</tr>
<tr>
<td>Finished goods</td>
<td>6</td>
<td>2,000</td>
<td>48.00</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>1,000</td>
<td>62.00</td>
</tr>
</tbody>
</table>
## Solved Problem 2

### SOLUTION

a.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Average Level</th>
<th>Unit Value</th>
<th>Total Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15,000</td>
<td>$3.00</td>
<td>=</td>
</tr>
<tr>
<td>2</td>
<td>2,500</td>
<td>5.00</td>
<td>=</td>
</tr>
<tr>
<td>3</td>
<td>3,000</td>
<td>1.00</td>
<td>=</td>
</tr>
<tr>
<td>4</td>
<td>5,000</td>
<td>14.00</td>
<td>=</td>
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<td>5</td>
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<td>18.00</td>
<td>=</td>
</tr>
<tr>
<td>6</td>
<td>2,000</td>
<td>48.00</td>
<td>=</td>
</tr>
<tr>
<td>7</td>
<td>1,000</td>
<td>62.00</td>
<td>=</td>
</tr>
</tbody>
</table>

Average aggregate inventory value =
## Solved Problem 2

### SOLUTION

a.

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Average Level</th>
<th>Unit Value</th>
<th>Total Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>12,500</td>
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<td>3</td>
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<td>1.00</td>
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<tr>
<td>4</td>
<td>5,000</td>
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<td>70,000</td>
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<tr>
<td>5</td>
<td>4,000</td>
<td>18.00</td>
<td>72,000</td>
</tr>
<tr>
<td>6</td>
<td>2,000</td>
<td>48.00</td>
<td>96,000</td>
</tr>
<tr>
<td>7</td>
<td>1,000</td>
<td>62.00</td>
<td>62,000</td>
</tr>
</tbody>
</table>

Average aggregate inventory value = $360,500
Solved Problem 2

b. Average weekly sales at cost = $3,410,000/52 weeks
   = $65,577/week

   Weeks of supply = \[
   \frac{\text{Average aggregate inventory value}}{\text{Weekly sales (at cost)}}
   \]

   = \[
   \frac{$360,500}{\$65,577}
   \]

   = 5.5 weeks

c. Inventory turnover = \[
   \frac{\text{Annual sales (at cost)}}{\text{Average aggregate inventory value}}
   \]

   = \[
   \frac{$3,410,000}{\$360,500}
   \]

   = 9.5 turns
● Case Studies:
  ◆ Volkswagen SCM
  ◆ Ford SCM
  ◆ WAL-MART SCM

● Projects:
  ◆ Comparison and Summary (Project 1: VW+Wal-Mart & Project 2: Ford+Wal-Mart) in respect of the supply chain management over the three large companies philosophy.
  ◆ Implementing green supply chains.
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