Aggregate Inventory Policies

References: Arnold et al., *Introduction to Materials Management*, 7th ed., chap. 2, 9; George, *Lean Six Sigma*, chap. 13, 14; Bicheno and Holweg, *The Lean Toolbox*, 4th ed., chap. 9, 17; Simchi-Levy et al., *Designing and Managing the Supply Chain*, chap. 1, 12; Jacobs et al., *Manufacturing Planning and Control for Supply Chain Management*, APICS/CPIM Certification Edition (2011), chap. 5, 16; Garrison et al., *Managerial Accounting*, 12th ed., chap. 3, 4; Williams, "Costing Inventory—Yes It Costs Money," APICS CPIM DSP Reprints, January, 2010; Epstein, *Making Sustainability Work*, chap. 4.

Aggregate Inventory Policies

- Resolving sales and operational conflicts
- Inventory valuation
- Performance metrics

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Emergence of Conflicts

- During the development of business strategy
  - Choice of manufacturing strategy: make-to-stock, make-to-order, assemble-to-order, engineer-to-order
  - Choice of manufacturing process to support strategy: intermittent, repetitive, continuous, project
- During priority and capacity planning
  - Customer service levels
  - Efficient plant operations
  - Backlog and safety stock decisions
- Minimum inventory investment
  - Low inventory levels
  - High inventory turns

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Aggregate Inventory Policies

Introduction

The two types of inventory policies are aggregate and item-level.

- Aggregate-level policies are associated with the impact of inventory management on the overall financial performance of the company.

  > aggregate inventory management—Establishing the overall level (for example, dollar level) of inventory desired and implementing controls to achieve this goal.
  >
  > —*APICS Dictionary*

  - In this section of Session 1, we will cover three topics that relate to aggregate inventory policy:
    - resolving sales and operational conflicts
    - inventory valuation
    - performance metrics
- Item-level policies are associated with materials and operations planning and execution. Later in this section, we will cover two important policies—lot sizing and safety stock, both of which constrain the inventory planning functions addressed in Session 2.

Resolving Sales and Operational Conflicts

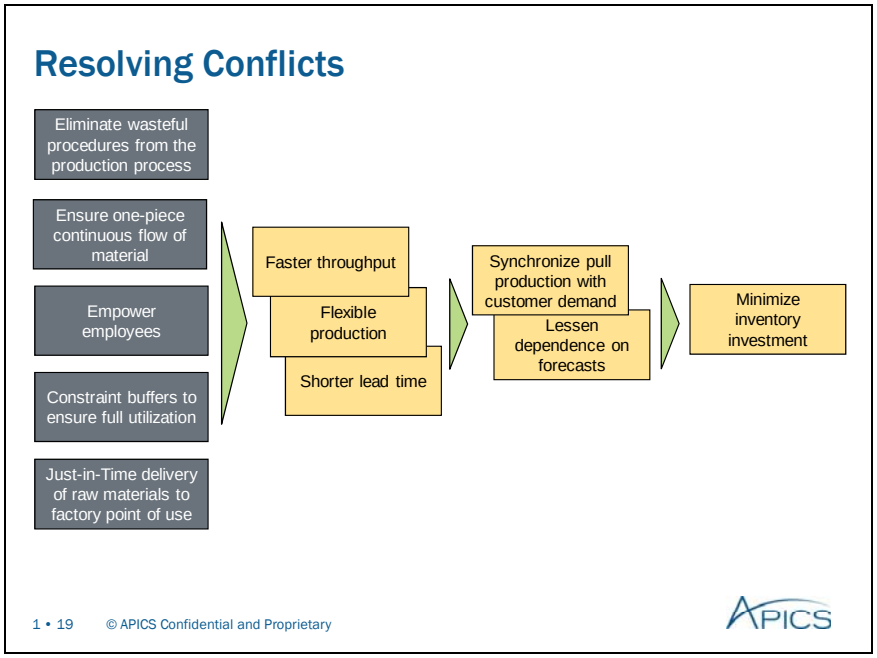
Business Strategy Choices

In any manufacturing organization, different functions have different objectives. These different objectives emerge and are addressed as early as when a manufacturer decides what to make and sell, and how to make it. The manufacturer must make choices relating to

- manufacturing strategy or production environment, such as make-to-stock, make-to-order, assemble-to-order, engineer-to-order, and mass customization
- manufacturing process, such as intermittent, repetitive, continuous, and project.

Decisions on these choices are influenced by product and process design, technology requirements, level of expected demand, product variety and volume, geographic scope of the market, life cycle and environmental cost of purchased materials, and customer expectations about order fulfillment speed and location. Ultimately, these choices and decisions need to balance a set of conflicting objectives:

- high customer service levels—high product variety and quality, and shorter lead times and production flexibility to respond to customer orders
- efficient plant operations—long production runs to minimize changeovers and reduce per-unit production costs; high raw material inventory levels at low costs
- minimum inventory investment—low levels of inventory and high inventory turns, or inventory turnover.
- real cost of materials—lowest purchase price versus total life cycle and environmental costs


Resolving Conflicts
Eliminate wasteful procedures from the production process
Ensure one-piece continuous flow of material
Empower employees
Constraint buffers to ensure full utilization
Just-in-Time delivery of raw materials to factory point of use
Faster throughput
Flexible production
Shorter lead time
Synchronize pull production with customer demand
Lessen dependence on forecasts
Minimize inventory investment
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Priority and Capacity Planning Choices

Ideally, the discussion of tradeoffs should occur often during the priority and capacity planning phases of manufacturing planning control, such as in regularly scheduled sales and operations planning (S&OP) meetings.

Resolving Conflicts

The resolution of conflicting objectives does not always have to be accomplished by tradeoffs. For example, lean and TOC production approaches enable more than one objective to be achieved by increasing supply chain velocity through a number of methods, including

- eliminating wasteful movements and procedures in the production process and fostering a culture of employee empowerment
- ensuring a continuous flow of production from raw materials to finished products by buffering critically constrained resources to maintain full utilization
- establishing supplier relationships and supply management practices that synchronize delivery of raw materials to the point of use at time of production.

Ultimately, these result in faster throughput and shorter manufacturing lead times, which enable the company to lessen its dependence on forecasts and to produce to customer orders. This reduces the amount of inventory needed to support customer service objectives and lowers production costs.

Inventory Valuation

- Inventory is considered a short-term asset because it is expected to be used or sold within a relatively short period.
- Inventory assets include raw materials, WIP, and finished goods owned by the company.
- MRO supplies are not included as an asset; they are considered expenses.

Purpose and Uses of Inventory Valuation

- Determine the cost of raw materials, WIP, and finished goods
- Determine the impact of inventory investment on the financial condition of the business
- Calculate inventory turns and performance metrics; necessary for strategic and policy decisions
- Influence operational decisions about order quantities, safety stock, and replenishment

Cost Systems

- Project costing
- Job order costing
- Process costing

Inventory Valuation

Inventory often is the largest asset on a company's balance sheet. For most companies, inventory is considered a short-term current asset because it is expected to be used or sold within a relatively short period. Inventory includes raw materials, WIP, and finished goods owned by the company. MRO supplies are not included as assets; they are considered expenses.

Purpose and Uses of Inventory Valuation

We mentioned earlier that inventory investment represents costs. Therefore, it is important to know the value of raw materials, WIP, and finished goods inventory.

- This enables you to determine the impact of inventory on the financial condition of the business. It also provides information necessary for strategic and policy decisions, such as inventory turns and performance metrics.
- It also is useful in determining operational approaches to order quantities, safety stock, and replenishment.

Cost Accumulation Methods

Manufacturing and service companies use various cost systems or models to accumulate costs for inventory valuation and decision making. In a manufacturing environment, the three most popular cost systems are project, process, and job order costing. The three types of costs accumulated are labor, material, and factory overhead.

Project costing

Project costing is an accounting method of assigning valuations based on services performed on a project basis. It employs some special rules such as percentage of completion revenue recognition, as many projects—such as shipbuilding, for example—take more than a year to complete.

Job order costing

Custom engineer-to-order and make-to-order job shop manufacturing companies tend to use job cost, because it is important to know the cost accumulation of each different job.

Process costing

Companies with flow production tend to use a process costing system, which enables them to capture the cost to process a batch or group of items.

Note that retail and distribution environments do not need to accumulate cost to manufacture, but do need to track inventory costs as they buy and sell goods.

Types of Inventory Valuation

- Specific identification
- Average cost
- Standard cost
- Actual cost
- Transfer cost
- First in, first out (FIFO)
- Last in, first out (LIFO)

Cost of Goods Sold (Cost of Sales)

Retail stores generally sell goods in the same physical form in which they are acquired. Sometimes the freight costs are added to the acquisition costs to create "landed costs." This occurs when the freight costs can be tracked easily to the item being bought. Landed costs are listed as an asset on the balance sheet until the item is sold. The acquisition costs become the cost of goods sold once the item is sold, thus reducing profit in the period sold.

Service organizations carry material inventories as in the case of plumbers, personal-service organizations, hospitals, hotels, beauty salons, educational organizations, banks, and other financial institutions. Examples of material inventories include the pipes and fittings of a plumbing company, and office supplies used by personal service and financial institutions. These are consumed as operating supplies and are not tracked as cost of goods sold. Other service organizations provide tangible goods in addition to the service, such as automobile repair companies that sell parts with the service. These parts usually are carried in inventory as an asset, issued to the job as required, and tracked as cost of goods sold when the service is provided.

A manufacturing company converts raw material and purchased components into finished goods. Its cost of sales includes the conversion costs, such as labor and overhead, as well as the raw materials and component costs of the goods it sells. A manufacturer has three types of inventory accounts: materials, WIP, and finished goods. After raw materials are transformed into finished products, they remain in inventory until they are sold. In a make-to-order environment, shipment usually is immediate upon completing production. Once sold, the materials are subtracted from inventory and are included in a company's income statement, along with labor and overhead costs, as the cost of goods sold. Note that the terms "cost of goods sold" and "cost of sales" are used interchangeably.

Types of Inventory Valuation

Shown in Visual 1-23 are various types of inventory valuation methods. The different methods are necessary when the cost of an item changes during the accounting period. These methods produce different inventory investment values. Once a company selects its inventory valuation method, it is difficult and time-consuming to change to another method.

Specific identification

The specific identification method keeps track of the units from the beginning inventory and the units purchased, resulting in identification of the purchase cost of each item. Tracking can be done by coding or serial number identification. This method is best used for expensive items, rather than for low or frequently changing unit costs, and can be used to determine actual cost.

Average cost

With the average cost method, the cost of goods sold and ending inventory are based on the average of the actual costs paid for each unit produced or purchased. The average cost applies to all of the items available for sale during the period.

Costing Method Example Data Source

Record of purchases

April	100 units	$10 each
May	100 units	$12 each
June	100 units	$14 each

Ending first quarter inventory: 0 units

Second quarter usage: 210 units

Source: *CPIM Inventory Management Certification Review Course* (APICS 1998).

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Costing Method—FIFO Calculation

Date	Quantity received	Unit cost ($)	Inventory value ($)	Usage quantity	Issue unit cost ($)	Issue value ($)
April	100	10	1,000	100	10	1,000
May	100	12	1,200	100	12	1,200
June	100	14	1,400	10	14	140
				Cost of goods sold = $2,340		
			July starting inventory of 90 at $14 = $1,260			

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Standard cost

With standard cost systems, a single value is selected for an inventory item that is reasonable and often based on historical or anticipated costs. The difference between actual costs incurred and standard costs then is reported in the form of a variance from the standard. This technique consistently reports the inventory asset and the cost of goods sold at the same value. Standard costs typically are reviewed and updated annually.

Actual cost

Actual costs can be used when there is a means of tracking the specific cost of each item, such as some form of lot control, to a specific purchase order or production run. This method is not used often except for custom items or unique items such as expensive jewelry.

Transfer cost and price

Transfer cost and price are important in the transfer of goods between sister companies or divisions. Although management policy can set the transfer price, the net transfer effect is to move the inventory costs from the selling division to the buying division. They do not affect the valuation of assets, as do average, standard, and actual cost.

First in, first out (FIFO)

The FIFO method assumes that the oldest items in inventory are the first ones issued from inventory. In a period of increasing costs, this tends to keep the total inventory value on the balance sheet close to the current market value, but would charge cost of goods sold at the older and lower cost values.

Visual 1-25 shows the FIFO calculation based on the data in Visual 1-24.

Problem 1.2 LIFO

Date	Quantity received	Unit cost ($)	Inventory value ($)	Usage quantity	Issue unit cost ($)	Issue value ($)
April	100	10	1,000	?	?	?
May	100	12	1,200	?	?	?
June	100	14	1,400	?	?	?
				Cost of goods sold		= ?
			July starting inventory of 90 at ____ = ?			

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LIFO (last in, first out)

The LIFO method assumes that the latest items in inventory are the first ones being issued to production or sales. This method assigns cost of goods sold based on the most recent cost incurred. In a period of rising costs, this would tend to understate the total inventory value on the balance sheet. However, it would charge cost of goods sold at values close to the current market value. It should be noted that this is strictly an accounting method for valuing inventory and is not necessarily based on the physical movement of inventory.

Class Problem 1.2: Last In, First Out

Calculate the LIFO valuation for this inventory:

Date	Quantity received	Unit cost ($)	Inventory value ($)	Usage quantity	Issue unit cost ($)	Issue value ($)
April	100	10	1,000			
May	100	12	1,200			
June	100	14	1,400			
				Cost of goods sold		=
			July starting inventory of 90 at ____ =			

Once you have calculated the answer, explain why this would result in a lower total inventory value on the balance sheet than with using FIFO.

_____

_____

Aggregate Inventory Metrics

- Inventory turns
- Days of supply
- Cash-to-cash cycle
- Customer service

Inventory Turns

A measure of how effectively inventory is being used

$$\text{Inventory turns} = \frac{\text{Annual cost of goods sold}}{\text{Average inventory in dollars}}$$

Example:
Annual cost of goods sold = $1,000,000
Average inventory = $500,000

$$\text{Inventory turns} = \frac{\$1,000,000}{\$500,000} = 2$$

Note: “Cost of goods sold” is synonymous with “cost of sales.”

Inventory Performance Metrics

Aggregate Inventory Metrics

Aggregate inventory measures indicate how well inventory is managed from an overall business perspective. Important financial measures include inventory turns, days of supply, and cash-to-cash cycle. Important sources of data for these measures are provided by the costing and inventory valuation activities discussed in the previous section.

Inventory turns

Two performance measures that relate inventory to sales are inventory turns and days of supply. The rule of thumb is that high inventory turns and low days of supply are desirable because they indicate lower levels of inventory relative to sales per period (annual, monthly, and so on).

The inventory turns ratio measures the speed of inventory conversion into sales:

$$\text{Inventory turns} = \frac{\text{annual cost of goods sold}}{\text{average inventory in dollars}}$$

For example, if the annual cost of goods sold is $1,000,000 and the average inventory is $500,000, then:

$$\text{Inventory turns} = \frac{\$1{,}000{,}000}{\$500{,}000} = 2$$

The business is generating annual sales of $1 million in cost of goods sold with an average of $500,000 of inventory, which means it takes about a half a year to recover its cost, or cash. That is, inventory turns two times a year.

What would the inventory turns ratio be in another company that generates the same level of annual sales with an average inventory of $20,000?

_____

How long will it take, on average, to recover the cost of inventory?

_____

Most often used as a comparison from period to period, inventory turnover is an aggregate indicator. It offers insight into the level of inventory investment available to sustain current business levels. An increasing trend in the inventory turns rate over time shows that less inventory is required per dollar of cost of goods sold.

Companies routinely use fiscal or actual month-end inventory levels to determine average inventory. Because this is not really an average level, it can falsely increase or decrease inventory turns. Inventory turns should be based on the company's annual average inventory level.

Days of Supply

$$\text{Days of supply} = \frac{\text{Inventory on hand}}{\text{Average daily usage}} = \frac{6{,}000}{200} = 30 \text{ days}$$

- Days of supply measures the relationship between usage (sales) and inventory.
- In this example, 6,000 units are sold over a period of 30 days at 200 units per day, on average.
- Inventory turns every 30 days, or 12 times a year (inventory turns are 12).

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Cash-to-Cash Cycle

Cash-to-cash cycle =

Days' supply of inventory + accounts receivable days

– accounts payable days

The number of days between paying for the raw materials and getting paid for the product

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Days of supply

Companies also can use days of supply to evaluate sales-to-inventory performance—how many days of inventory are being carried to support annual sales. It measures the ratio of inventory on hand to average daily usage, or sales. Let's assume 6,000 units on hand and annual sales of 73,000 units. The calculation of days of supply takes two steps:

(1) Determine average daily usage.

$$\text{Average daily usage} = \frac{73{,}000}{365} = 200 \text{ units}$$

(2) Calculate days of supply.

$$\text{Days of supply} = \frac{\text{inventory on hand}}{\text{average daily usage}}$$

The days of supply in this example tells us that inventory on hand is 30 days.

It also tells us that if we set a target inventory level of 6,000 units, we would have to replenish it every 30 days at a daily usage rate of 200 units.

What is the inventory turns ratio and how often does inventory turn?

_____

The days of supply concept can be used to set an inventory policy for cycle stock, which is the most active component of inventory. For example, based on an average daily sales or usage of 200 units, the target inventory level for finished goods would be 30 days of supply, or 6,000 units. Materials management personnel then can analyze the tradeoff between (1) lowering the days of supply to 15 days to reduce inventory investment, and (2) the loss of production efficiency in producing in 3,000-unit lot sizes rather than 6,000-unit lot sizes.

Cash-to-cash cycle

Cash-to-cash cycle is yet another measure of an integrated, businesswide supply chain management approach to inventory management. It measures the timespan between paying for raw materials and getting paid for the product.

Cash-to-cash cycle time = days' supply of inventory + accounts receivable days – accounts payable days. It also can be stated as: cash-to-cash cycle time = inventory days of supply + days of sales outstanding – days of payables outstanding.

For example, if a supply chain has 60 days of inventory, 45 days of accounts receivable, and 50 days of accounts payable, its cash-to-cash cycle time is 55 days:

60 + 45 – 50 = 55 days

Companies should use this measurement cautiously and realize that deliberate delay in paying for raw materials can artificially cause the cash-to-cash cycle time to be understated.

Customer Service Metrics

- Total cycle time from order placement to receipt on dock at the customer site
- A focus on the requested receipt date by the customer as opposed to the commitment date
- Cycle time to respond to a customer request such as schedule change or material change
- Total deliveries of units compared to returned materials authorizations (RMAs) due to quality or incorrect shipments
- Metrics that support the total customer experience, including responsiveness, design suggestions for cost reductions or cycle time improvements, service, and warranty

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Customer Service

There are two types of performance metrics for customer service:

- operational metrics—These focus on excellence in meeting customer requirements, such as orders shipped on time, low number of back orders, and ordering periods without a stockout.
- customer satisfaction metrics—These focus on how a supplier supports its customers' business goals and requirements; it can be subjective.

At the aggregate inventory management level, it is important to focus on customer satisfaction metrics. Examples of customer satisfaction metrics include the following:

- total cycle time from order placement to receipt on dock at the customer site
- focus on the requested receipt date by the customer as opposed to the commitment date (The customer might want the product in three weeks versus a commitment of five weeks, giving competitors an opportunity to take customers away by providing faster service.)
- cycle time to respond to a customer request, such as a schedule change or material change
- total deliveries of units compared to returned materials authorizations (RMAs) that have occurred because of quality or business processes, or product that has been incorrectly entered and shipped
- metrics that support the total customer experience, including responsiveness, design suggestions for cost reductions or cycle time improvements, service, and warranty

Some of these metrics may appear to be operational in focus, but they are metrics of the supplier's broader operational performance at the supply chain level. These success factors are critical to achieving customer satisfaction. For example, consider the total cycle time from order placement to receipt on dock. This metric measures the supplier's performance from a cross-functional order fulfillment standpoint. It includes demand and order management, procurement, production lead time, and logistics.

One metric missing from the list is customer loyalty. Some argue that customer loyalty and retention are the key indicators of customer value. Today's customer relationship management software applications can aid in determining customer retention rates.