20 Inventory Management, Just-in-Time, and Simplified Costing Methods

Learning Objectives

1. Identify six categories of costs associated with goods for sale
2. Balance ordering costs with carrying costs using the economic-order-quantity (EOQ) decision model
3. Identify the effect of errors that can arise when using the EOQ decision model and ways to reduce conflicts between the EOQ model and models used for performance evaluation
4. Describe why companies are using just-in-time (JIT) purchasing
5. Distinguish materials requirements planning (MRP) systems from just-in-time (JIT) systems for manufacturing
6. Identify the features and benefits of a just-in-time production system
7. Describe different ways backflush costing can simplify traditional inventory-costing systems
8. Understand the principles of lean accounting

Suppose you could receive a large quantity discount for a product that you regularly use, but the discount requires you to buy a year's supply of it and make a large up-front expenditure.

Would you take the quantity discount? Companies face similar decisions because firms pay a price for tying up money in inventory sitting on their shelves or elsewhere. Money tied up in inventory is a particularly serious problem when times are tough. Companies such as Costco work very hard to keep their inventories low.

Costco Aggressively Manages Its Inventory to Thrive in Tough Times[1]

Costco is widely known for its $55-a-year membership fee and its massive, austere warehouses stocked floor to ceiling with large portions of everything from soap to soda. With 627 Costco warehouses around the world, Costco stocks *fewer* items than its competitors and employs innovative inventory management practices that successfully reduce costs throughout its global operations.

The average grocery store carries around 40,000 items, but Costco limits its offerings to about 4,000 products or 90% less, reducing the costs of carrying inventory. Costco also employs a just-in-time inventory management system, which includes sharing data directly with many of its largest suppliers. Companies like PepsiCo and Kraft Foods can track sales performance of items on a warehouse-by-warehouse basis and ship products to replenish Costco's shelves only as needed. These inventory management techniques have allowed Costco to outperform its competitors. Costco turns its inventory more than 12 times a year, far more often than other retailers.

Occasionally, the company leverages its 87 million square feet of warehouse space to reduce its purchasing costs. For example, when Procter & Gamble recently announced a 6% price increase for its paper goods, Costco bought 258 truckloads of paper towels at the old rate and stored them in its distribution centers and warehouses.

Inventory management is important because materials costs often account for more than 40% of total costs of manufacturing companies and more than 70% of total

[1] *Source:* McGregor, Jena. 2008. Costco's artful discounts. *BusinessWeek*, October 20; Brad Stone, "Costco CEO Craig Jelinek Leads the Cheapest, Happiest Company in the World," *Bloomberg Businessweek* (June 6, 2013); Liz Parks, "Sharing the View," NRF Stores (February 2006); and Costco Wholesale Company, 2012 Annual Report (Issaquah, Washington: Costco Wholesale Company, 2012).

costs in merchandising companies. In this chapter, we describe the components of inventory costs, relevant costs for different inventory-related decisions, and how planning and control systems, such as just-in-time systems, can reduce inventory.

Inventory Management in Retail Organizations

Inventory management includes planning, coordinating, and controlling activities related to the flow of inventory into, through, and out of an organization. Consider this breakdown of operations for three major retailers for which cost of goods sold constitutes their largest cost item.

Learning Objective 1

Identify six categories of costs associated with goods for sale

...purchasing, ordering, carrying, stockout, quality, and shrinkage

	Kroger	Costco	Walmart
Revenues	100.0%	100.0%	100.0%
Deduct costs:			
Cost of goods sold	79.4%	87.6%	75.1%
Selling and administration costs	15.4%	9.6%	18.9%
Other costs, interest, and taxes	3.7%	1.1%	2.2%
Total costs	98.5%	98.3%	96.2%
Net income	1.5%	1.7%	3.8%

The low percentages of net income to revenues mean that improving the purchase and management of goods for sale can cause dramatic percentage increases in net income.

Costs Associated with Goods for Sale

There are a number of different types of costs associated with inventory other than the cost of the actual goods purchased. The costs associated with inventory fall into the following six categories:

1. **Purchasing costs** are the cost of goods acquired from suppliers, including incoming freight costs. These costs usually make up the largest cost category of goods in inventory. Discounts for various purchase-order sizes and supplier payment terms affect purchasing costs.
2. **Ordering costs** are the costs of preparing and issuing purchase orders, receiving and inspecting the items included in the orders, and matching invoices received, purchase orders, and delivery records to make payments. Ordering costs include the cost of obtaining purchase approvals, as well as other special processing costs.
3. **Carrying costs** are costs that arise while goods are being held in inventory. Carrying costs include the opportunity cost of the investment tied up in inventory (see Chapter 11, pages 438–440) and the costs associated with storage, such as space rental, insurance, and obsolescence.
4. **Stockout costs** are costs that arise when a company runs out of a particular item for which there is customer demand, a *stockout*. The company must act quickly to

replenish inventory to meet that demand or suffer the costs of not meeting it. A company may respond to a stockout by expediting an order from a supplier, which can be expensive because of additional ordering and manufacturing costs plus any associated transportation costs. Or the company may lose sales due to the stockout. In this case, the opportunity cost of the stockout includes the lost contribution margin on the sale not made plus any contribution margin lost on future sales due to customer ill will.

5. **Costs of quality** are the costs incurred to prevent and appraise, or the costs arising as a result of, quality issues. Quality problems arise, for example, because products get spoiled or broken or are mishandled while products are moved in and out of the warehouse. As discussed earlier in Chapter 19, there are four categories of quality costs: prevention costs, appraisal costs, internal failure costs, and external failure costs.
6. **Shrinkage costs** result from theft by outsiders, embezzlement by employees, misclassifications, and clerical errors. Shrinkage is measured by the difference between (a) the cost of inventory recorded on the books (after correcting errors) and (b) the cost of inventory when physically counted. Shrinkage can often be an important measure of management performance. Consider, for example, the grocery business, where operating income percentages hover around 2%. With such small margins, it is easy to see why one of a store manager's prime responsibilities is controlling inventory shrinkage. A $1,000 increase in shrinkage will erase the operating income from sales of $50,000 (2% × $50,000 = $1,000). Because shrinkage costs generally increase when a firm's inventory increases, most firms try not to hold more inventory than necessary.

Note that not all inventory costs are available in financial accounting systems. For example, opportunity costs are not recorded in these systems but are a significant component in several of these cost categories.

Decision Point

What are the six categories of costs associated with goods for sale?

Information-gathering technology increases the reliability and timeliness of inventory information and reduces the costs related to inventory. For example, barcoding technology allows a scanner to record individual units purchased and sold. As soon as a unit is scanned, a record of its movement is created, which helps a firm better manage its purchasing, carrying, and stockout costs. In the next several sections, we consider how relevant costs are computed for different inventory-related decisions in merchandising companies.

Learning Objective 2

Balance ordering costs with carrying costs using the economic-order-quantity (EOQ) decision model

...choose the inventory quantity per order to minimize these costs

The Economic-Order-Quantity Decision Model

How much should a firm order of a given product? The **economic order quantity** (EOQ) is a decision model that, under a given set of assumptions, calculates the optimal quantity of inventory to order.

- The simplest version of the EOQ model assumes there are only ordering and carrying costs because these are the most common costs of inventory.
- The same quantity is ordered at each reorder point.
- Demand, ordering costs, and carrying costs are known with certainty. The **purchase-order lead time**, the time between placing an order and its delivery, is also known with certainty.
- The purchasing cost per unit is unaffected by the order quantity. This assumption makes purchasing costs irrelevant to determining the EOQ because the purchase price is the same, whatever the order size.
- No stockouts occur. The basis for this assumption is that the costs of stockouts are so high that managers maintain adequate inventory to prevent them.
- When deciding on the size of a purchase order, managers consider the costs of quality and shrinkage costs only to the extent that these costs affect ordering or carrying costs.

Note that EOQ analysis ignores purchasing costs, stockout costs, costs of quality, and shrinkage costs. Also recall from Chapter 11 that managers only consider relevant costs when making decisions. In a later section we will discuss how to identify the relevant

ordering and carrying costs. At this point, we simply note that EOQ is the order quantity that minimizes the sum of a company's relevant ordering and carrying costs. The sum of the costs is the firm's *relevant total ordering and carrying costs* of inventory. The relevant total costs are calculated as follows:

$$\text{Relevant total costs} = \text{Relevant ordering costs} + \text{Relevant carrying costs}$$

We use the following notations:

D = Demand in units for a specified period (one year in this example)

Q = Size of each order (order quantity)

$$\text{Number of purchase orders per period (one year)} = \frac{\text{Demand in units for a period (one year)}}{\text{Size of each order (order quantity)}} = \frac{D}{Q}$$

Average inventory in units $= \frac{Q}{2}$, because each time the inventory goes down to 0, an order for Q units is received. The inventory varies from Q to 0, so the average inventory is $\frac{0 + Q}{2}$.

P = Relevant ordering cost per purchase order

C = Relevant carrying cost of one unit in stock for the time period used for D (one year)

For any order quantity, Q,

$$\text{Annual relevant ordering costs} = \left(\begin{array}{c}\text{Number of}\\ \text{purchase orders}\\ \text{per year}\end{array} \times \begin{array}{c}\text{Relevant ordering}\\ \text{cost per}\\ \text{purchase order}\end{array}\right) = \left(\frac{D}{Q} \times P\right)$$

$$\text{Annual relevant carrying costs} = \left(\begin{array}{c}\text{Average inventory}\\ \text{in units}\end{array} \times \begin{array}{c}\text{Annual}\\ \text{relevant carrying}\\ \text{cost per unit}\end{array}\right) = \left(\frac{Q}{2} \times C\right)$$

$$\text{Annual relevant total costs} = \begin{array}{c}\text{Annual}\\ \text{relevant ordering}\\ \text{costs}\end{array} + \begin{array}{c}\text{Annual}\\ \text{relevant carrying}\\ \text{costs}\end{array} = \left(\frac{D}{Q} \times P\right) + \left(\frac{Q}{2} \times C\right)$$

The order quantity that minimizes annual relevant total costs is

$$EOQ = \sqrt{\frac{2DP}{C}}$$

The EOQ model is solved using calculus, but the key intuition is that relevant total costs are minimized when relevant ordering costs equal relevant carrying costs. If carrying costs are less (greater) than ordering costs, the total costs can be reduced by increasing (decreasing) the order quantity. To solve for EOQ, we set

$$\left(\frac{Q}{2} \times C\right) = \left(\frac{D}{Q} \times P\right)$$

Multiplying both sides by $\frac{2Q}{C}$, we get $Q^2 = \frac{2DP}{C}$

$$Q = \sqrt{\frac{2DP}{C}}$$

The formula indicates that EOQ increases with higher demand and/or higher ordering costs and decreases with higher carrying costs.

Let's see how EOQ analysis works. Glare Shade sells sunglasses. This problem focuses on Glare Shade's basic sunglasses, UX1. Glare Shade purchases the UX1s from

Rytek at $14 a unit. Rytek pays for all incoming freight. No inspection is necessary at Glare Shade because Rytek supplies quality merchandise. Glare Shade's annual demand is 13,000 units of UX1s, at a rate of 250 units per week. Glare Shade requires a 15% annual rate of return on its investment. Relevant ordering cost per purchase order is $200.

The relevant carrying cost per unit per year is as follows:

Required annual return on investment, 0.15 × $14	$2.10
Relevant costs of insurance, materials handling, breakage, shrinkage, and so on, per year	3.10
Total	$5.20

What is the EOQ for ordering UX1 sunglasses?

Substituting $D = 13{,}000$ units per year, $P = \$200$ per order, and $C = \$5.20$ per unit per year, in the EOQ formula, we get

$$EOQ = \sqrt{\frac{2 \times 13{,}000 \times \$200}{\$5.20}} = \sqrt{1{,}000{,}000} = 1{,}000 \text{ units}$$

Purchasing 1,000 units per order minimizes total relevant ordering and carrying costs. Therefore, the number of deliveries each period (1 year in this example) is as follows:

$$\frac{D}{EOQ} = \frac{13{,}000}{1{,}000} = 13 \text{ deliveries}$$

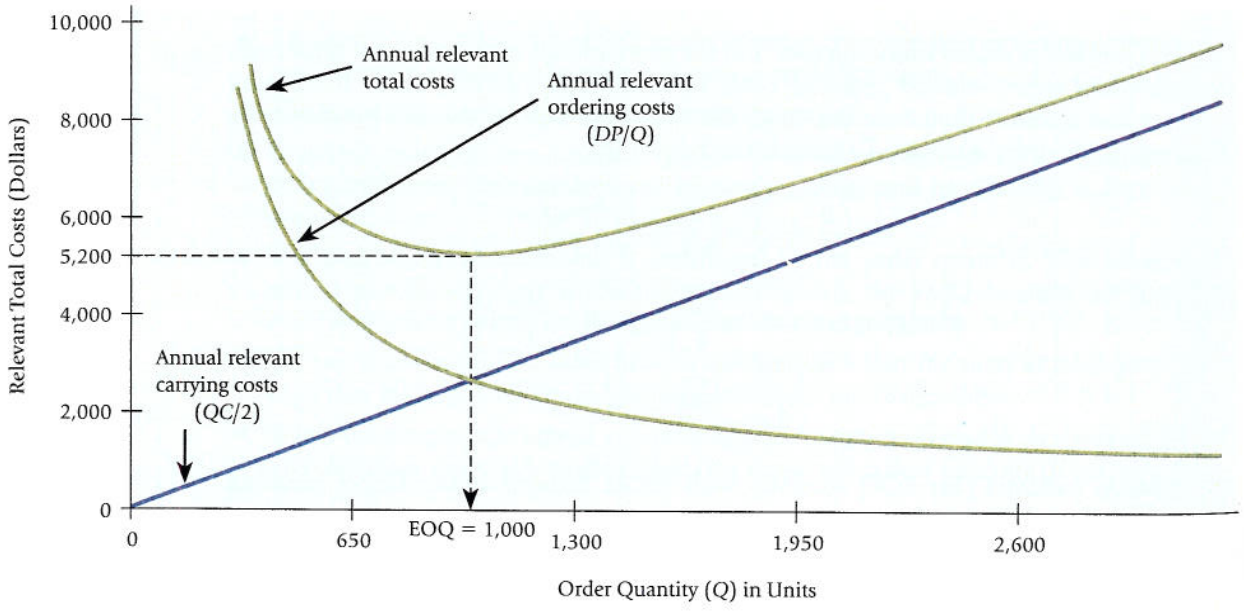
Recall the annual relevant total costs $(\text{RTC}) = \left(\frac{D}{Q} \times P\right) + \left(\frac{Q}{2} \times C\right)$

For $Q = 1{,}000$ units,

$$RTC = \frac{13{,}000 \times \$200}{1{,}000} + \frac{1{,}000 \times \$5.20}{2}$$
$$= \$2{,}600 + \$2{,}600 = \$5{,}200$$

Exhibit 20-1 graphs the annual relevant total costs of ordering (DP/Q) and carrying inventory ($QC/2$) under various order sizes (Q), and it illustrates the tradeoff between these two types of costs. The larger the order quantity, the lower the annual relevant ordering

Exhibit 20-1 Graphic Analysis of Ordering Costs and Carrying Costs for UX1 Sunglasses at Glare Shade



costs, but the higher the annual relevant carrying costs. *The annual relevant total costs are at a minimum at the EOQ at which the relevant ordering and carrying costs are equal.*

When to Order, Assuming Certainty

The second decision Glare Shade's managers face is *when to order* the units. The **reorder point** is the quantity level of inventory on hand that triggers a new purchase order. The reorder point is simplest to compute when both demand and the purchase-order lead time are known with certainty:

$$\text{Reorder point} = \frac{\text{Number of units sold}}{\text{per time period}} \times \frac{\text{Purchase-order}}{\text{lead time}}$$

Suppose the purchase-order lead time for UX1s is 2 weeks:

Economic order quantity	1,000 units
Number of units sold per week	250 units per week (13,000 units ÷ 52 weeks)
Purchase-order lead time	2 weeks

$$\text{Reorder point} = 250 \text{ units per week} \times 2 \text{ weeks} = 500 \text{ units}$$

Glare Shade will order 1,000 units of UX1s each time its inventory falls to 500 units.[2] Exhibit 20-2 shows the behavior of the inventory level of UX1 units, assuming demand occurs uniformly during each week. If the purchase-order lead time is 2 weeks, a new order will be placed when the inventory level falls to 500 units, so the 1,000 units ordered will be received at the precise time that inventory reaches zero.

Safety Stock

If Glare Shade's managers are uncertain about demand or the purchase-order lead time or if they are uncertain about the quantities of UX1s Rytek can provide, they will hold safety stock. **Safety stock** is inventory held at all times regardless of the quantity of inventory ordered using the EOQ model. Companies use safety stock as a buffer against unexpected increases in demand, uncertainty about lead time, and unavailability of stock from

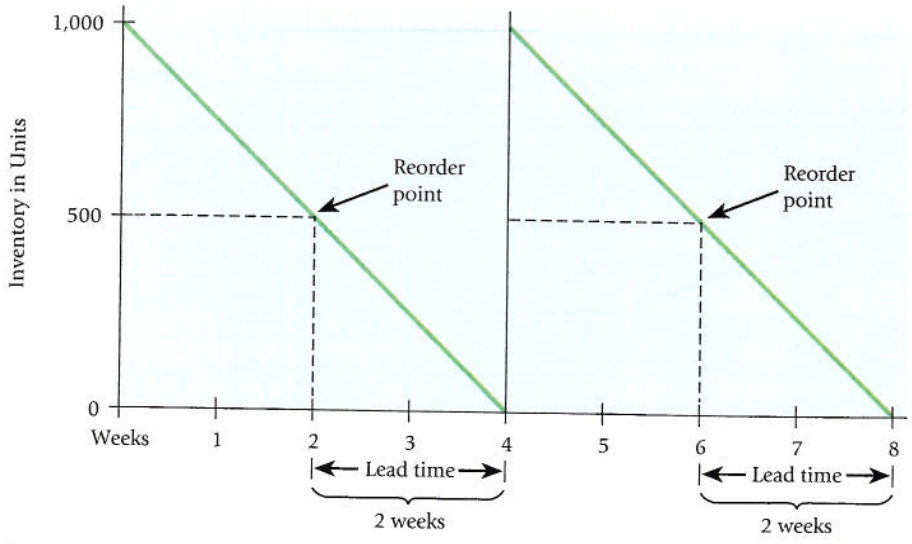


Exhibit 20-2

Inventory Level of UX1 Sunglasses at Glare Shade[a]

[a] This exhibit assumes that demand and purchase-order lead time are certain:
Demand = 250 UX1 sunglasses per week
Purchase-order lead time = 2 weeks

[2] This handy but special formula does not apply when receipt of the order fails to increase inventory to the reorder-point quantity (for example, when lead time is 3 weeks and the order is a 1-week supply). In these cases, orders will overlap.

suppliers. Suppose Glare Shade's managers are uncertain about demand. They expect the demand for UX1s to be 250 units per week, but it could be as high as 400 units per week or as low as 100 units per week. If stockout costs are very high, the managers will want to hold a safety stock of 300 units and incur higher carrying costs. The 300 units equal the maximum excess demand of 150(400 − 250) units per week times the 2 weeks of purchase-order lead time. If stockout costs are minimal, no safety stock will be held to avoid incurring the additional carrying costs.

Managers use a frequency distribution based on prior daily or weekly levels of demand to compute safety-stock levels. Assume that one of the following levels of demand for UX1s will occur over the 2-week purchase-order lead time.

Total Demand for 2 Weeks	200 Units	300 Units	400 Units	500 Units	600 Units	700 Units	800 Units
Probability (sums to 1.00)	0.06	0.09	0.20	0.30	0.20	0.09	0.06

We see that 500 units is the most likely level of demand for 2 weeks because it has the highest probability of occurrence. We see also a 0.35 probability that demand will be 600, 700, or 800 units (0.20 + 0.09 + 0.06 = 0.35).

If a customer wants to buy UX1s and the store has none in stock, Glare Shade can "rush" them to the customer at an additional cost to Glare Shade of $4 per unit. The relevant stockout costs in this case are $4 per unit. The optimal safety-stock level is the quantity of safety stock that minimizes the sum of annual relevant stockout and carrying costs. Note that Glare Shade will place 13 orders per year for UX1s and will incur the same ordering costs whatever level of safety stock it chooses. Therefore, ordering costs are irrelevant for the safety-stock decision. Recall that the relevant carrying cost for UX1s is $5.20 per unit per year.

Exhibit 20-3 tabulates the annual relevant total stockout and carrying costs when the reorder point is 500 units. Over the 2-week purchase-order lead time, stockouts can occur if demand is 600, 700, or 800 units because these levels exceed the 500 units in

Exhibit 20-3 Computation of Safety Stock for Glare Shade When Reorder Point Is 500 Units

Home Insert Page Layout Formulas Data Review View

	A	B	C	D	E	F	G	H	I
1	Safety	Demand							
2	Stock	Levels			Relevant	Number of	Expected	Relevant	Relevant
3	Level	Resulting	Stockout	Probability	Stockout	Orders	Stockout	Carrying	Total
4	in Units	in Stockouts	in Units[a]	of Stockout	Costs[b]	per Year[c]	Costs[d]	Costs[e]	Costs
5	(1)	(2)	(3) = (2) – 500 – (1)	(4)	(5) = (3) × $4	(6)	(7) = (4) × (5) × (6)	(8) = (1) × $5.20	(9) = (7) + (8)
6	0	600	100	0.20	$ 400	13	$1,040		
7		700	200	0.09	800	13	936		
8		800	300	0.06	1,200	13	936		
9							$2,912	$ 0	$2,912
10	100	700	100	0.09	400	13	$ 468		
11		800	200	0.06	800	13	624		
12							$1,092	$ 520	$1,612
13	200	800	100	0.06	400	13	$ 312	$1,040	$1,352
14	300	-	-	-	-	-	$ 0[f]	$1,560	$1,560
15									
16	[a]Demand level resulting in stockouts – Inventory available during lead time (excluding safety stock), 500 units – Safety stock.								
17	[b]Stockout in units × Relevant stockout costs of $4.00 per unit.								
18	[c]Annual demand, 13,000 ÷ 1,000 EOQ = 13 orders per year.								
19	[d]Probability of stockout × Relevant stockout costs × Number of orders per year.								
20	[e]Safety stock × Annual relevant carrying costs of $5.20 per unit (assumes that safety stock is on hand at all times and that there is no overstocking								
21	caused by decreases in expected usage).								
22	[f]At a safety stock level of 300 units, no stockout will occur and, hence, expected stockout costs = $0.								

stock at the time Glare Shade places the purchase orders. Consequently, Glare Shade only evaluates safety stock levels of 0, 100, 200, and 300 units of UX1s. If the safety stock is 0 units, Glare Shade will incur stockout costs if demand is 600, 700, or 800 units but will have no additional carrying costs. At the other extreme, if the safety stock is 300 units, Glare Shade will never incur stockout costs but will have higher carrying costs. As Exhibit 20-3 shows, the firm's annual relevant total stockout and carrying costs are lowest ($1,352) when a safety stock of 200 units of UX1s is maintained. Therefore, 200 units is the optimal safety-stock level. The 200 units of safety stock is the extra stock that Glare Shade always maintains. For example, Glare Shade's total inventory of UX1s at the time of reordering its EOQ of 1,000 units would be 700 units (the reorder point of 500 units plus safety stock of 200 units).

Decision Point

What does the EOQ decision model help managers do, and how do managers decide on the safety-stock levels?

Estimating Inventory-Related Relevant Costs and Their Effects

Learning Objective 3

Identify the effect of errors that can arise when using the EOQ decision model

...errors in predicting parameters have a small effect on costs

and ways to reduce conflicts between the EOQ model and models used for performance evaluation

...by making the two models congruent

How do Glare Shade's managers calculate the annual relevant inventory-related costs, such as the relevant carrying, stockout, and ordering costs?

We start by discussing the relevant inventory carrying costs of $5.20 per unit per year, which consist of the *relevant incremental costs* plus the *relevant opportunity cost of capital*. What are the *relevant incremental costs* of carrying inventory? Only those costs, such as warehouse rent, warehouse workers' salaries, costs of obsolescence, costs of shrinkage, costs of breakage, and costs of insurance, that change with the quantity of inventory held. The salaries paid to clerks, stock keepers, and materials handlers are irrelevant if they are unaffected by changes in inventory levels. Suppose, however, that as inventories increase (decrease), total salary costs increase (decrease) as clerks, stock keepers, and materials handlers are added (transferred to other activities or laid off). In this case, the salaries paid are relevant costs of carrying inventory. Similarly, costs of storage space owned that cannot be used for other profitable purposes when inventories decrease are irrelevant. But if the space has other profitable uses or if total rental cost is tied to the amount of space occupied, storage costs are relevant costs of carrying inventory.

What is the *relevant opportunity cost of capital*? It is the return forgone by investing capital in inventory rather than elsewhere. It is calculated as the required rate of return multiplied by the per-unit costs of acquiring inventory, such as the purchase price of units, incoming freight, and incoming inspection. Opportunity costs are also computed on investments (say, in equipment) if these investments are affected by changes in inventory levels.

In the case of stockouts, the relevant incremental cost is the cost of expediting an order from a supplier. The relevant opportunity cost is (1) the lost contribution margin on sales forgone because of the stockout and (2) the lost contribution margin on future sales forgone as a result of customer ill will.

The relevant ordering costs are only those ordering costs that change with the number of orders placed (for example, the costs of preparing and issuing purchase orders and receiving and inspecting materials).

Cost of a Prediction Error

Predicting relevant costs is difficult and seldom flawless, which raises the question, "What is the cost when actual relevant costs differ from the estimated relevant costs used for decision making?"

Suppose Glare Shade's relevant ordering costs per purchase order for UX1s are $100, but the manager predicts them to be $200 when calculating the order quantity. We can calculate the cost of this "prediction" error using a three-step approach.

Step 1: Compute the Monetary Outcome from the Best Action That Could Be Taken, Given the *Actual* Amount of the Cost Input (Cost per Purchase Order). This is the benchmark—that is, the decision the manager would have made if the manager had

known the correct ordering cost against which actual performance can be measured. Using $D = 13{,}000$ units of UX1 per year, $P = \$100$, and $C = \$5.20$ per unit per year,

$$EOQ = \sqrt{\frac{2DP}{C}}$$

$$= \sqrt{\frac{2 \times 13{,}000 \times \$100}{\$5.20}} = \sqrt{500{,}000}$$

$$= 707 \text{ units (rounded)}$$

Glare Shade's annual relevant total costs when the $EOQ = 707$ units are as follows:

$$RTC = \frac{DP}{Q} + \frac{QC}{2}$$

$$= \frac{13{,}000 \times \$100}{707} + \frac{707 \times \$5.20}{2}$$

$$= \$1{,}839 + \$1{,}838 = \$3{,}677$$

Step 2: Compute the Monetary Outcome from the Best Action Based on the Incorrect *Predicted* Amount of the Cost Input (Cost per Purchase Order). In this step, the manager calculates the order quantity based on the prediction (that later proves to be wrong) that the ordering cost is \$200. When this is the case, the best action is to purchase 1,000 units in each order (page 768). However, the actual cost of the purchase order is only \$100. Consequently, the actual annual relevant total costs when $D = 13{,}000$ units per year, $Q = 1{,}000$ units, $P = \$100$, and $C = \$5.20$ per unit per year are as follows:

$$RTC = \frac{13{,}000 \times \$100}{1{,}000} + \frac{1{,}000 \times \$5.20}{2}$$

$$= \$1{,}300 + \$2{,}600 = \$3{,}900$$

Step 3: Compute the Difference Between the Monetary Outcomes from Step 1 and Step 2.

	Monetary Outcome
Step 1	\$3,677
Step 2	3,900
Difference	\$ (223)

The cost of the prediction error, \$223, is less than 7% of the relevant total costs of \$3,677. Note that the annual relevant-total-costs curve in Exhibit 20-1 is somewhat flat over the range of order quantities from 700 to 1,300 units. That is, the annual relevant cost is roughly the same even if misestimating the relevant carrying and ordering costs results in an EOQ quantity of 1,000 plus 30% (1,300) or 1,000 minus 30% (700). *The square root in the EOQ model diminishes the effect of estimation errors because it results in the effects of the incorrect numbers becoming smaller.*

In the next section, we consider a planning-and-control and performance-evaluation issue that frequently arises when managing inventory.

Conflicts Between the EOQ Decision Model and Managers' Performance Evaluation

What happens if the order quantity based on the EOQ decision model differs from the order quantity managers would choose to make their own performance look best? Consider, for example, opportunity costs. As we have seen, the EOQ model takes into account opportunity costs because these costs are relevant costs when calculating inventory carrying costs. However, managers evaluated on financial accounting numbers, which is often the case, will ignore opportunity costs. Why? Because financial accounting only records actual transactions, not the costs of opportunities forgone (see Chapter 11). Managers

interested in making their own performance look better will only focus on measures used to evaluate their performance. Conflicts will then arise between the EOQ model's optimal order quantity and the order quantity that managers regard as optimal.

As a result of ignoring some of the carrying costs (the opportunity costs), managers will be inclined to purchase larger lot sizes of materials than the lot sizes calculated according to the EOQ model, particularly if larger lot sizes result in lower purchase prices. As we discussed in the previous section, the cost of these suboptimal choices is small if the quantities purchased are close to the EOQ. However, if the lot sizes become much greater, the cost to the company can be quite large. Moreover, if we consider other costs, such as costs of quality and shrinkage of holding large inventories, the cost to the company of purchasing in large lot sizes is even greater. To achieve congruence between the EOQ decision model and managers' performance evaluations, companies such as Walmart design performance-evaluation systems that charge managers responsible for managing inventory levels with carrying costs that include a required return on investment.

Decision Point

How do errors in predicting the parameters of the EOQ model affect costs? How can companies reduce the conflict between the EOQ decision model and models used for performance evaluation?

Just-in-Time Purchasing

Learning Objective 4

Describe why companies are using just-in-time (JIT) purchasing

...high carrying costs, costs of quality, and shrinkage costs, low ordering costs, high-quality suppliers, and reliable supply chains

Just-in-time (JIT) purchasing is the purchase of materials (or goods) so that they are delivered just as needed for production (or sales). Consider Hewlett-Packard's (HP's) JIT purchasing: HP has long-term agreements with suppliers of the major components of its printers. Each supplier is required to make frequent deliveries of small orders directly to the production floor, based on the production schedules HP provides them. The suppliers work hard to keep their commitments because any failure on their part will result in HP's assembly plant not meeting its scheduled deliveries of printers.

JIT Purchasing and EOQ Model Parameters

Suppose Glare Shade's managers believe that the current purchasing policies might result in the carrying costs of the firm's inventories (parameter C in the EOQ model) being much greater than what they had estimated because of higher warehousing, handling, insurance, and equipment costs. Suppose they also believe that the cost of placing a purchase order (parameter P in the EOQ model) is likely to decrease because of the following:

- Glare Shade is establishing long-term purchasing agreements that define the price and quality terms it has with its suppliers over an extended period. No additional negotiations need to take place before supplies can be ordered.
- New electronic systems allow Glare Shade to place purchase orders, tally delivery records, and make payments to suppliers more cost effectively.
- Glare Shade is using purchase-order cards (similar to consumer credit cards such as VISA and MasterCard). As long as purchasing personnel stay within preset total and individual-transaction dollar limits, traditional labor-intensive procurement-approval procedures are not required.

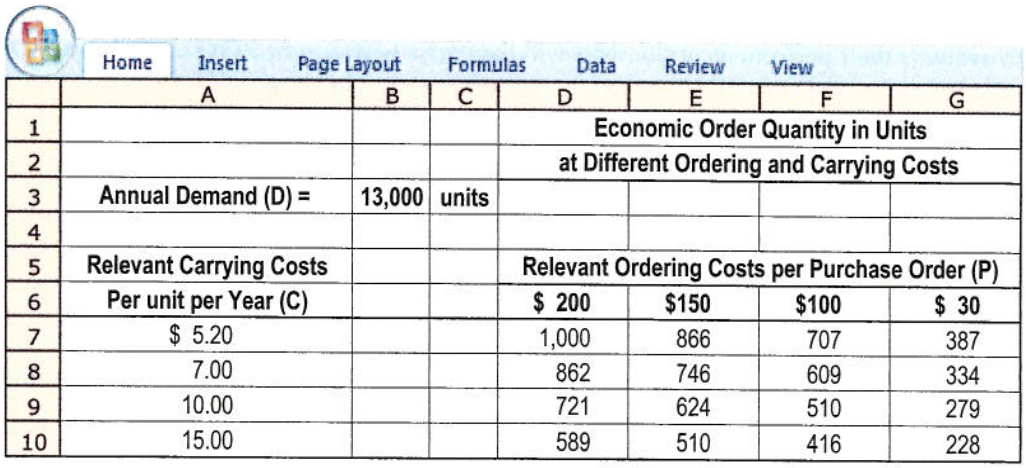
Exhibit 20-4 tabulates the sensitivity of the EOQ (page 768) to changes in carrying and ordering costs of UX1s. Exhibit 20-4 supports moving toward JIT purchasing because, as the company's relevant carrying costs increase and relevant ordering costs per purchase order decrease, the EOQ decreases and ordering frequency increases.

Relevant Costs of JIT Purchasing

JIT purchasing is not guided solely by the EOQ model because that model only emphasizes the tradeoff between relevant carrying and ordering costs. Inventory management, however, also includes accounting for a company's purchasing costs, stockout costs, costs of quality, and shrinkage costs. Glare Shade's managers are concerned that ordering and storing large quantities of UX1 units have contributed to defective and broken units and shrinkage. So, the company begins implementing JIT purchasing by asking the

Exhibit 20-4

Sensitivity of EOQ to Variations in Relevant Ordering and Carrying Costs for UX1 Sunglasses



Home Insert Page Layout Formulas Data Review View

	A	B	C	D	E	F	G
1				Economic Order Quantity in Units			
2				at Different Ordering and Carrying Costs			
3	Annual Demand (D) =	13,000	units				
4							
5	Relevant Carrying Costs			Relevant Ordering Costs per Purchase Order (P)			
6	Per unit per Year (C)			$ 200	$150	$100	$ 30
7	$ 5.20			1,000	866	707	387
8	7.00			862	746	609	334
9	10.00			721	624	510	279
10	15.00			589	510	416	228

supplier of UX1 units to make more frequent deliveries of smaller sizes. Glare Shade has recently established an Internet business-to-business purchase-order link with its supplier, Rytek. Glare Shade triggers a purchase order for UX1s by a single computer entry. Payments are made electronically for batches of deliveries, rather than for each individual delivery. These changes reduce the company's ordering costs from $200 to only $2 per purchase order! Glare Shade will use the Internet purchase-order link whether or not it shifts to JIT purchasing. We next evaluate the effect JIT purchasing has on quality and costs.

Description of Item	Current Purchasing Practice	JIT Purchasing Practice
Deliveries	1,000 units purchased 13 times per year	100 units purchased 130 times per year (5 times every 2 weeks)
Purchasing costs	$14 per unit	$14.02 per unit (Note: Many companies do not pay a higher price for more frequent deliveries.)
Inspection of units	Units inspected at the time of receipt at a cost of $0.05 per unit to identify units that need to be returned	Units not inspected because Rytek ensures that quality UX1 sunglasses are delivered to support Glare Shade's JIT purchasing.
Required rate of return on investment	15%	15%
Relevant carrying cost of insurance, materials handling, storage, etc.	$3.10 per unit of average inventory per year	$3.00 per unit of average inventory per year (lower insurance, materials handling, and storage rates)
Customer return costs	$10 for shipping and processing a defective unit returned by a customer. The high quality of units supplied by Rytek and Glare Shade's inspection procedures will result in no units being returned by customers.	$10 for shipping and processing a defective unit returned by a customer. The high quality of units supplied by Rytek will result in no units being returned by customers.
Stockout costs	No stockout costs because demand and purchase-order lead times during each 4-week period (52 weeks ÷ 13 deliveries) are known with certainty.	More stockouts because demand variations and delays in supplying units are more likely in the short time intervals between orders under JIT purchasing. Glare Shade expects to incur stockout costs on 150 units of UX1 per year under the JIT purchasing policy. When a stockout occurs, Glare Shade must rush-order units at an additional cost of $4 per unit.

Exhibit 20-5 Annual Relevant Costs of Current Purchasing Policy and JIT Purchasing Policy for UX1 Sunglasses

	A	B	C	D	E	F	G	H	I	J
1		Relevant Costs Under								
2		Current Purchasing Policy					JIT Purchasing Policy			
3	Relevant Items	Relevant Cost per Unit		Quantity per Year	Total Costs		Relevant Cost per Unit		Quantity per Year	Total Costs
4	(1)	(2)		(3)	(4) = (2) × (3)		(5)		(6)	(7) = (5) × (6)
5	Purchasing costs	$14.00	per unit	13,000	$182,000		$14.02	per unit	13,000	$182,260
6	Ordering costs	$ 2.00	per order	13	26		$ 2.00	per order	130	260
7	Inspection costs	$ 0.05	per unit	13,000	650		$ -	per unit	-	-
8	Opportunity carrying costs	$ 2.10[a]	per unit of average inventory per year	500[b]	1,050		$ 2.10[a]	per unit of average inventory per year	50[c]	105
9	Other carrying costs (insurance, materials handling, etc.)	$ 3.10	per unit of average inventory per year	500[b]	1,550		$ 3.00	per unit of average inventory per year	50[c]	150
10	Customer return costs	$10.00	per unit returned	0	0		$10.00	per unit returned	0	0
11	Stockout costs	$ 4.00	per unit	0	0		$ 4.00	per unit	150	600
12	Total annual relevant costs				$185,276					$183,375
13	Annual difference in favor of JIT Purchasing					$1,901				
14										
15	[a]Purchasing cost per unit × 0.15 per year									
16	[b]Order quantity/2 = 1,000/2 = 500 units									
17	[c]Order quantity/2 = 100/2 = 50 units									

Should Glare Shade implement the JIT purchasing option of 130 deliveries of UX1 per year? Exhibit 20-5 compares Glare Shade's relevant total costs under the current purchasing policy and the JIT policy. It shows net cost savings of $1,901 per year by shifting to a JIT purchasing policy. The benefits of JIT purchasing arise from lower carrying and inspection costs as a result of better quality. JIT purchasing gives Glare Shade's managers immediate feedback about quality problems by reducing the "safety net" large quantities of inventory afford.

Supplier Evaluation and Relevant Costs of Quality and Timely Deliveries

Companies that implement JIT purchasing choose their suppliers carefully and develop long-term supplier relationships. Some suppliers are better positioned than others to support JIT purchasing. For example, the corporate strategy of Frito-Lay, a supplier of potato chips and other snack foods, emphasizes service, consistency, freshness, and the quality of the products the company delivers. As a result, Frito-Lay makes deliveries to retail outlets more frequently than many of its competitors.

What are the relevant total costs when choosing suppliers? Consider again the UX1 units purchased by Glare Shade. Denton Corporation, another supplier of UX1 sunglasses, offers to supply all the units that Glare Shade needs. Glare Shade requires the supplier to deliver 100 units 130 times per year (5 times every 2 weeks). Glare Shade will establish an Internet-based purchase-order link with whichever supplier it chooses, trigger a purchase order for UX1 units by a single computer entry, and make payments electronically for batches of deliveries, rather than for each individual delivery. As discussed earlier, the company's ordering costs will be only $2 per purchase order. The following table provides information about Denton versus Rytek. Rytek charges a higher price than Denton but also supplies higher-quality UX1s. The information about Rytek is the same as that presented earlier under JIT purchasing in Exhibit 20-5.

Description of Item	Purchasing Terms from Rytek	Purchasing Terms from Denton
Purchasing costs	$14.02 per unit	$13.80 per unit
Inspection of UX1s	Glare Shade has bought UX1s from Rytek in the past and knows that it will deliver quality UX1s on time. UX1s supplied by Rytek require no inspection.	Denton does not enjoy a sterling reputation for quality, so Glare Shade plans to inspect UX1s at a cost of $0.05 per UX1.
Required rate of return on investment	15%	15%
Relevant carrying cost of insurance, materials handling, storage, etc.	$3.00 per unit per year	$2.90 per unit per year because of lower purchasing costs
Customer return costs	Glare Shade estimates $10 for shipping and processing a defective UX1 unit returned by a customer. Fortunately, the high quality of units supplied by Rytek will result in no units being returned by customers.	Glare Shade estimates $10 for shipping and processing a defective UX1 unit returned by a customer and product returns of 2.5% of all units sold.
Stockout costs	Glare Shade expects to incur stockout costs on 150 UX1 units each time resulting in a rush-order at a cost of $4 per unit.	Denton has less control over its processes, so Glare Shade expects to incur stockout costs on 360 UX1 units each time initiating rush orders at a cost of $4 per unit

Exhibit 20-6 shows the relevant total costs of purchasing from Rytek and Denton. Even though Denton is offering a lower price per unit, there is a net cost savings of $1,873 per year by purchasing UX1s from Rytek because of lower inspection, customer returns, and stockout costs. The benefit of purchasing from Rytek could be even greater if purchasing high-quality UX1s from Rytek enhances Glare Shade's reputation and increases customer goodwill, leading to higher sales and profitability in the future.

Exhibit 20-6 Annual Relevant Costs of JIT Purchasing for UX1 Sunglasses from Rytek and Denton

Home Insert Page Layout Formulas Data Review View

	A	B	C	D	E	F	G	H	I	J
1		Relevant Cost of JIT Purchasing From								
2		Rytek					Denton			
3	Relevant Items	Relevant Cost per Unit		Quantity per Year	Total Costs		Relevant Cost per Unit		Quantity per Year	Total Costs
4	(1)	(2)		(3)	(4) = (2) × (3)		(5)		(6)	(7) = (5) × (6)
5	Purchasing costs	$14.02	per unit	13,000	$182,260		$13.80	per unit	13,000	$179,400
6		$ 2.00	per order	130	260		2.00	per order	130	260
7	Inspection costs	-	per unit	-	-		0.05	per unit	13,000	650
8	Opportunity carrying costs	$ 2.10[a]	per unit of average inventory per year	50[b]	105		2.07[a]	per unit of average inventory per year	50[b]	103
9	Other carrying costs (insurance, materials handling, etc.)	$ 3.00	per unit of average inventory per year	50[b]	150		2.90	per unit of average inventory per year	50[b]	145
10	Customer return costs	$10.00	per unit returned	0	0		10.00	per unit returned	325[c]	3,250
11	Stockout costs	$ 4.00	per unit	150	600		4.00	per unit	360	1,440
12	Total annual relevant costs				$183,375					$185,248
13	Annual difference in favor of Rytek					$1,873				
14										
15	[a]Purchasing cost per unit × 0.15 per year									
16	[b]Order quantity ÷ 2 = 100 ÷ 2 = 50 units									
17	[c]2.5% of units returned × 13,000 units									

JIT Purchasing, Planning and Control, and Supply-Chain Analysis

Retailers' inventory levels depend on the demand patterns of their customers and supply relationships with their distributors and manufacturers, the suppliers to their manufacturers, and so on. The *supply chain* describes the flow of goods, services, and information from the initial sources of materials and services to the delivery of products to consumers, regardless of whether those activities occur in the same company or in other companies. Retailers can purchase inventories on a JIT basis only if activities throughout the supply chain are properly planned, coordinated, and controlled.

Procter and Gamble's (P&G's) experience with its Pampers product illustrates the gains from supply-chain coordination. Retailers selling Pampers found that the weekly demand for the product varied because families purchased disposable diapers randomly. Anticipating even more demand variability and lacking information about available inventory with P&G, retailers' orders to P&G became more variable. This, in turn, increased variability of orders at P&G's suppliers, resulting in high levels of inventory at all stages in the supply chain.

How did P&G respond to these problems? By sharing information and planning and coordinating activities throughout the supply chain among retailers, P&G, and P&G's suppliers. Sharing sales information reduced the level of uncertainty that P&G and its suppliers had about retail demand for the product and led to (1) fewer stockouts at the retail level, (2) reduced manufacturing of Pampers not immediately needed by retailers, (3) fewer manufacturing orders that had to be "rushed" or "expedited," and (4) lower inventories held by each company in the supply chain. The benefits of supply chain coordination at P&G have been so great that retailers such as Walmart have contracted with P&G to manage their inventories on a just-in-time basis. This practice is called *supplier- or vendor-managed inventory*. Coordinating supply chains, however, can be difficult because supply-chain partners don't always share accurate and timely information about their sales, inventory levels, and sales forecasts with one another. Some of the reasons for these challenges are communication problems, trust issues between the companies, incompatible information systems, and limited people and financial resources.

Decision Point

Why are companies using just-in-time (JIT) purchasing?

Inventory Management, MRP, and JIT Production

Learning Objective 5

Distinguish materials requirements planning (MRP) systems

...manufacturing products based on demand forecasts

from just-in-time (JIT) systems for manufacturing

...manufacturing products only upon receiving customer orders

We now turn our attention from purchasing to managing the production inventories of manufacturing companies. Two of the most widely used systems to plan and implement inventory activities within plants are materials requirements planning (MRP) and just-in-time (JIT) production.

Materials Requirements Planning

A **materials requirements planning (MRP) system** is a "push-through" system that manufactures finished goods for inventory on the basis of demand forecasts. Companies such as Guidant, which manufactures medical devices, and Philips, which makes consumer electronic products, use MRP systems. To determine outputs at each stage of production, MRP uses (1) the demand forecasts for final products; (2) a bill of materials detailing the materials, components, and subassemblies for each final product; and (3) information about a company's inventories of materials, components, and products. Taking into account the lead time required to purchase materials and to manufacture components and finished products, a master production schedule specifies the quantity and timing of each item to be produced. Once production starts as scheduled, the output of each department is pushed through the production line.

Maintaining accurate inventory records and costs is critical in an MRP system. For example, after becoming aware of the full costs of carrying finished goods inventory in its MRP system, National Semiconductor contracted with FedEx to airfreight its microchips

from a central location in Singapore to customer sites worldwide instead of storing the chips at geographically dispersed warehouses.

Just-in-Time (JIT) Production

Decision Point

How do materials requirements planning (MRP) systems differ from just-in-time (JIT) production systems?

In contrast, JIT production is a "demand-pull" approach, which is used by companies such as Toyota in the automobile industry, Dell in the computer industry, and Braun in the appliance industry. **Just-in-time (JIT) production,** which is also called **lean production,** is a "demand-pull" manufacturing system that manufactures each component in a production line as soon as, and only when, needed by the next step in the production line. Demand triggers each step of the production process, starting with customer demand for a finished product at the end of the process and working all the way back to the demand for direct materials at the beginning of the process. In this way, demand pulls an order through the production line. The demand-pull feature of JIT production systems results in close coordination among workstations and smooths the flow of goods, despite low quantities of inventory. JIT production systems help companies meet the demand for high-quality products on time and at the lowest possible cost.

Learning Objective 6

Identify the features and benefits of a just-in-time production system

...for example, organizing work in manufacturing cells, improving quality, and reducing manufacturing lead time to reduce costs and earn higher margins

Features of JIT Production Systems

A JIT production system has these features:

- Production is organized in **manufacturing cells,** which are work areas with different types of equipment grouped together to make related products. Materials move from one machine to another, and various operations are performed in sequence, minimizing materials-handling costs.
- Workers are hired and trained to be multiskilled and capable of performing a variety of operations and tasks, including minor repairs and routine equipment maintenance.
- Defects are aggressively eliminated. Because of the tight links between workstations and the minimal inventories at each workstation, defects arising at one workstation quickly affect other workstations in the line. JIT creates an urgency for solving problems immediately and eliminating the root causes of defects as quickly as possible. Low levels of inventories allow workers to trace problems to and solve problems at earlier workstations in the production process, where the problems likely originated.
- The *setup time*, the time required to get equipment, tools, and materials ready to start the production of a component or product, and the *manufacturing cycle time*, the time from when an order is received by manufacturing until it becomes a finished good, are reduced. Setup costs correspond to the ordering costs P in the EOQ model. Reducing the setup time and its costs makes production in smaller batches economical, which in turn reduces inventory levels. Reducing the manufacturing cycle time enables a company to respond faster to changes in customer demand (see also Concepts in Action: After the Encore: Just-in-Time Live Concert Recordings).
- Suppliers are selected on the basis of their ability to deliver quality materials in a timely manner. Most companies implementing *JIT production* also implement *JIT purchasing*. JIT plants expect JIT suppliers to make timely deliveries of high-quality goods directly to the production floor.

We next present a relevant-cost analysis for deciding whether to implement a JIT production system.

Costs and Benefits of JIT Production

As we have seen, JIT production clearly lowers a company's carrying costs of inventory. But there are other benefits of lower inventories: heightened emphasis on improving quality by eliminating the specific causes of rework, scrap, and waste, and lower manufacturing cycle times. It is important, therefore, when computing the relevant benefits and costs of reducing inventories in JIT production systems for managers to take into account all benefits and all costs.

Consider Hudson Corporation, a manufacturer of brass fittings. Hudson is considering implementing a JIT production system. To implement JIT production, Hudson must incur $100,000 in annual tooling costs to reduce setup times. Hudson expects that JIT production will reduce its average inventory by $500,000 and that the relevant costs of insurance, storage, materials handling, and setups will decline by $30,000 per year. The company's required rate of return on its inventory investments is 10% per year. Should Hudson implement a JIT production system? On the basis of the information provided, we would be tempted to say "no" because the annual relevant total cost savings amount to $80,000 [(10% of $500,000) + $30,000)], which is less than the additional annual tooling costs of $100,000.

Our analysis, however, is incomplete. We have not considered the other benefits of lower inventories associated with JIT production. Hudson estimates that implementing JIT will improve quality and reduce rework on 500 units each year, resulting in savings of $50 per unit. Also, better quality and faster delivery will allow Hudson to charge $2 more per unit on the 20,000 units that it sells each year.

The annual relevant benefits and costs from implementing JIT equal the following:

Incremental savings in insurance, storage, materials handling, and set up	$ 30,000
Incremental savings in inventory carrying costs (10% × $500,000)	50,000
Incremental savings from reduced rework ($50 per unit × 500 units)	25,000
Additional contribution margin from better quality and faster delivery ($2 per unit × 20,000 units)	40,000
Incremental annual tooling costs	(100,000)
Net incremental benefit	$ 45,000

Therefore, Hudson *should* implement a JIT production system.

JIT in Service Industries

JIT purchasing and production methods can be used in service industries as well. For example, inventories and supplies, and the associated labor costs to manage them, represent more than a third of the costs in most hospitals. By implementing a JIT purchasing and distribution system, Eisenhower Memorial Hospital in Palm Springs, California, reduced its inventories and supplies by 90% in 18 months. McDonald's has adapted JIT production practices to making hamburgers.[3] Before, McDonald's precooked a batch of hamburgers that were placed under heat lamps to stay warm until ordered. If the hamburgers didn't sell within a specified period of time, they were discarded, resulting in high inventory holding costs and spoilage costs. Moreover, the quality of hamburgers deteriorated the longer they sat under the heat lamps. A customer placing a special order for a hamburger (such as a hamburger with no cheese) had to wait for it to be cooked. Now McDonald's cooks hamburgers only when they are ordered. By increasing the quality of hamburgers and reducing the time needed for special orders, JIT has led to greater customer satisfaction.

We next turn our attention to planning and control of production systems.

Enterprise Resource Planning (ERP) Systems[4]

Enterprise resource planning systems are frequently used in conjunction with JIT production. An **enterprise resource planning (ERP) system** is an integrated set of software modules covering a company's accounting, distribution, manufacturing, purchasing, human resources, and other functions. Real-time information is collected in a single database and simultaneously fed into all of the software applications, giving personnel greater visibility into the company's end-to-end business processes. For example, using an ERP system,

[3] Charles Atkinson, "McDonald's, A Guide to the Benefits of JIT," *Inventory Management Review* (November 8, 2005). http://www.inventorymanagementreview.org/2005/11/mcdonalds_a_gui.html.

[4] For an excellent discussion, see Thomas H. Davenport, "Putting the Enterprise into the Enterprise System," *Harvard Business Review* (July–August 1998); also see A. Cagilo, "Enterprise Resource Planning Systems and Accountants: Towards Hybridization?" *European Accounting Review* (May 2003).

Concepts in Action

After the Encore: Just-in-Time Live Concert Recordings

Each year, millions of music fans flock to concerts to see artists ranging from Pearl Jam to the Dave Matthews Band. When fans stop by the merchandise stand to pick up a T-shirt or poster after the show ends, they often have another option: buying a professional recording of the concert they just saw! Just-in-time production, enabled by advances in technology, now allows fans to relive the live concert experience just a few minutes after the final chord is played.

Live concert recordings have long been hampered by production and distribution difficulties. Live albums typically sold few copies, and retail outlets that profit from volume-driven merchandise turnover, like Best Buy, were somewhat reluctant to carry them.

Several companies, including Live Nation and Nugs.net, now employ microphones, recording and audio mixing hardware and software, and an army of high-speed computers to produce concert recordings during the show. As soon as each song is complete, engineers burn that track onto hundreds of CDs or USB drives. At the end of the show, they have to burn only one last song. Once completed, the recordings are packaged and rushed to merchandise stands throughout the venue for instant sale.

Sources: Sabra Chartrand, "How to Take the Concert Home." *New York Times* (May 3, 2004); Stephen Humphries, "Get Your Official 'Bootleg' Here," *Christian Science Monitor* (November 21, 2003); Eliot Van Buskirk, "Apple Unveils 'Live Music' in iTunes," *Wired Business* (blog), November 24, 2009, http://www.wired.com/business/, accessed July 2013; and Clyde Smith, "Nugs.net Appetizer Puts Direct-to-Fan Download Sales In Facebook Newsfeed," Hypebot.com (blog), August 12, 2011, http://www.hypebot.com/, accessed July 2013.

a salesperson can generate a contract for a customer in Germany, verify the customer's credit limits, and place a production order. The system will then use this same information to schedule manufacturing in, say, Brazil, requisition materials from inventory, order components from suppliers, and schedule shipments. Simultaneously the system credits the salesperson with his or her commission and records all the costing and financial accounting information. An ERP system also allows a company to shift its manufacturing and distribution plans rapidly in response to changes in supply and demand.

Companies believe that an ERP system is essential to support JIT initiatives because of the effect it has on lead times. For example, using an ERP system, Autodesk, a maker of computer-aided design software, reduced order lead time from 2 weeks to 1 day. Fujitsu, an information technology company, reduced its lead time from 18 days to 1.5 days.

ERP systems are large and unwieldy. Because of their complexity, the suppliers of ERP systems such as SAP and Oracle provide software units that are standard but that can be customized at significant cost. Without some customization, unique and distinctive features that confer strategic advantage will not be available. The challenge when implementing ERP systems is to strike the proper balance between the lower cost and reliability of standardized systems and the strategic benefits that accrue from customization. Companies such as Netsuite are developing ERP systems for small and medium-sized enterprises that are easier to customize using cloud-based computing and providing the software as a service.

Performance Measures and Control in JIT Production

In addition to their personal observations, managers use financial and nonfinancial measures to evaluate and control JIT production. We now describe these measures and indicate the effect JIT systems are expected to have on these measures.

1. Financial performance measures, such as the inventory turnover ratio (cost of goods sold ÷ average inventory), which is expected to increase

2. Nonfinancial performance measures of inventory, quality, and time such as the following:
   - Number of days of inventory on hand, expected to decrease
   - Units produced per hour, expected to increase
   - $\frac{\text{Number of units scrapped or requiring rework}}{\text{Total number of units started and completed}}$, expected to decrease
   - Manufacturing cycle time, expected to decrease
   - $\frac{\text{Total setup time for machines}}{\text{Total manufacturing time}}$, expected to decrease

Personal observation and nonfinancial performance measures provide the most timely, intuitive, and easy-to-understand measures of manufacturing performance. Rapid, meaningful feedback is critical because the lack of inventories in a demand-pull system makes it urgent for managers to detect and solve problems quickly.

Effect of JIT Systems on Product Costing

By reducing materials handling, warehousing, and inspection, JIT systems reduce overhead costs. JIT systems also aid in the direct tracing of some costs usually classified as indirect. For example, the use of manufacturing cells makes it cost-effective to trace materials handling, machine operating, and inspection costs to specific products or product families made in these cells. These costs then become direct costs of those products. Also, the use of multiskilled workers in these cells allows the costs of setup, maintenance, and quality inspection to be traced as direct costs. These changes have prompted some companies using JIT to adopt simplified product-costing methods that dovetail with JIT production and that are less costly to operate than the traditional costing systems described in Chapters 4, 7, 8, and 17. We examine two of these methods next: backflush costing and lean accounting.

Decision Point

What are the features and benefits of a just-in-time (JIT) production system?

Backflush Costing

Learning Objective 7

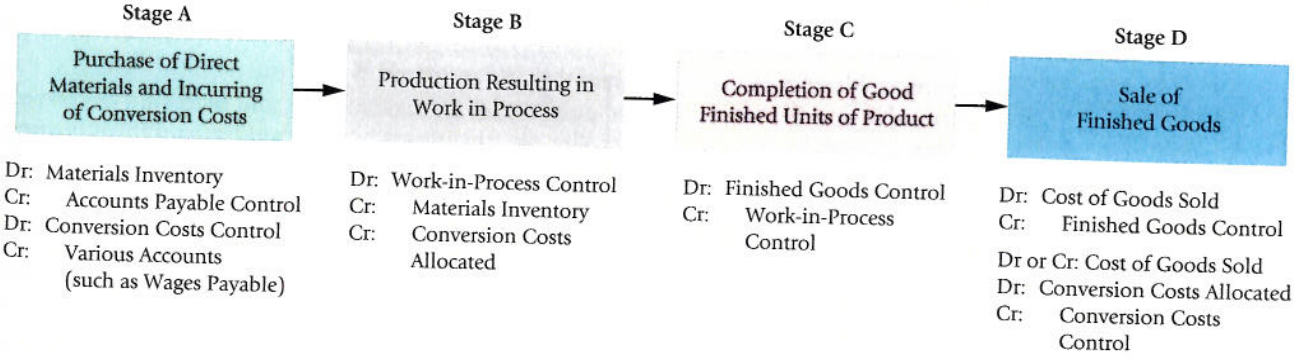
Describe different ways backflush costing can simplify traditional inventory-costing systems

...for example, by not recording journal entries for work in process, purchase of materials, or production of finished goods

Organizing manufacturing in cells, reducing defects and manufacturing cycle times, and ensuring the timely delivery of materials enable a company's purchasing, production, and sales to occur in quick succession with minimal inventories. The absence of inventories makes choices about cost-flow assumptions (such as weighted average or first-in, first-out) or inventory-costing methods (such as absorption or variable costing) unimportant: All manufacturing costs of the accounting period flow directly into cost of goods sold. The rapid conversion of direct materials into finished goods that are immediately sold greatly simplifies the costing system.

Simplified Normal or Standard Costing Systems

Traditional normal or standard-costing systems (Chapters 4, 7, 8, and 17) use **sequential tracking**, which is a costing system in which the recording of the journal entries occurs in the same order as actual purchases and progress in production. Costs are tracked sequentially as products pass through each of the following four stages:



A sequential-tracking costing system has four *trigger points*, corresponding to Stages A, B, C, and D. A **trigger point** is a stage in the cycle, from the purchase of direct materials and incurring of conversion costs (Stage A) to the sale of finished goods (Stage D), at which journal entries are made in the accounting system. The journal entries (with Dr. representing debits and Cr. representing credits) for each stage are displayed below the box for that stage (as described in Chapter 4).

An alternative approach to sequential tracking is backflush costing. **Backflush costing** is a costing system that omits recording some of the journal entries relating to the stages from the purchase of direct materials to the sale of finished goods. When journal entries for one or more stages are omitted, the journal entries for a subsequent stage use normal or standard costs to work backward to "flush out" the costs in the cycle for which journal entries were *not* made. When inventories are minimal, as in JIT production systems, backflush costing simplifies costing systems without losing much information.

Consider the following data for the month of April for Silicon Valley Computer (SVC), which produces keyboards for personal computers.

- There are no beginning inventories of direct materials and no beginning or ending work-in-process inventories.
- SVC has only one direct manufacturing cost category (direct materials) and one indirect manufacturing cost category (conversion costs). All manufacturing labor costs are included in conversion costs.
- From its bill of materials and an operations list (description of operations to be undergone), SVC determines that the standard direct materials cost per keyboard unit is $19 and the standard conversion cost is $12.
- SVC purchases $1,950,000 of direct materials. To focus on the basic concepts, we assume SVC has no direct materials variances. Actual conversion costs equal $1,260,000. SVC produces 100,000 good keyboard units and sells 99,000 units.
- Any underallocated or overallocated conversion costs are written off to cost of goods sold at the end of April.

We use three examples to illustrate backflush costing. *They differ in the number and placement of trigger points.*

Example 1: The three trigger points for journal entries are Purchase of direct materials and incurring of conversion costs (Stage A), Completion of good finished units of product (Stage C), and Sale of finished goods (Stage D).

Note that there is no journal entry for Production resulting in work in process (Stage B) because this method is used when work-in-process inventory is minimal (units started are quickly converted to finished goods).

SVC records two inventory accounts:

Type	Account Title
Combined materials inventory and materials in work in process	Materials and In-Process Inventory Control
Finished goods	Finished Goods Control

Exhibit 20-7, Panel A, summarizes the journal entries for Example 1 with three trigger points: Purchase of direct materials and incurring of conversion costs, Completion of good finished units of product, and Sale of finished goods (and recognizing under- or overallocated costs). For each stage, the backflush costing entries for SVC are shown on the left. The comparable entries under sequential tracking (costing) are shown on the right.

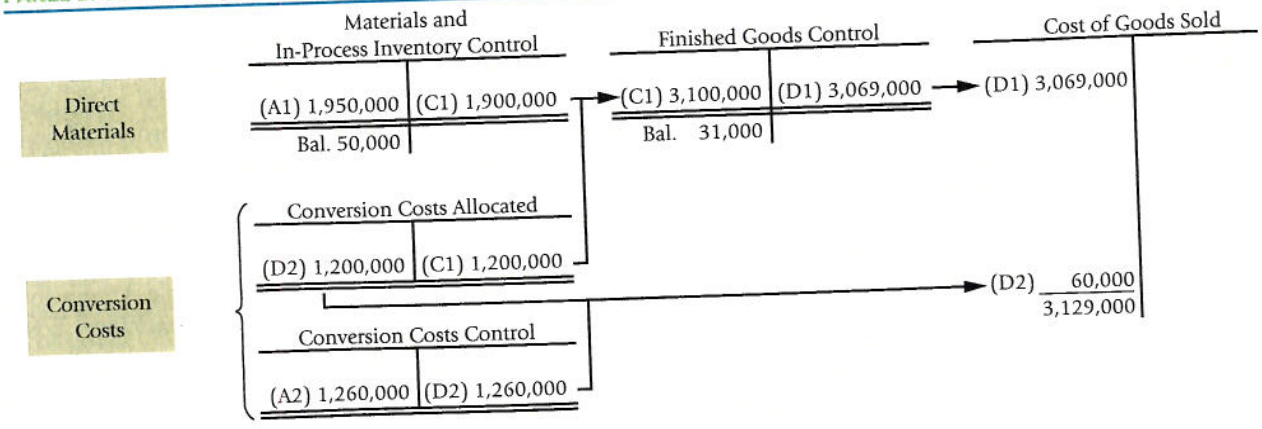
Consider first the entries for the purchase of direct materials and incurring of conversion costs (Stage A). As described earlier, the inventory account under backflush costing combines direct materials and work in process. When materials are purchased, these costs increase (are debited to) the Materials and In-Process Inventory Control account. Under the sequential tracking approach, the direct materials and work-in-process accounts are separate, so the purchase of direct materials is debited to Materials Inventory Control. Actual conversion costs are recorded as incurred under backflush costing, just as in sequential tracking, and they increase (are debited to) Conversion Costs Control.

Exhibit 20-7 Journal Entries and General Ledger Overview for Backflush Costing and Journal Entries for Sequential Tracking with Three Trigger Points: Purchase of Direct Materials and Incurring of Conversion Costs, Completion of Good Finished Units of Product, and Sale of Finished Goods

PANEL A: Journal Entries

	Backflush Costing			Sequential Tracking		
Stage A: Record Purchase of Direct Materials and Incurring of Conversion Costs						
1. Record Direct Materials Purchased.						
Entry (A1)	Materials and In-Process Inventory Control	1,950,000		Materials Inventory Control	1,950,000	
	Accounts Payable Control		1,950,000	Accounts Payable Control		1,950,000
2. Record Conversion Costs Incurred.						
Entry (A2)	Conversion Costs Control	1,260,000		Conversion Costs Control	1,260,000	
	Various accounts (such as Wages Payable Control)		1,260,000	Various accounts (such as Wages Payable Control)		1,260,000
Stage B: Record Production Resulting in Work in Process.						
Entry (B1)	No Entry Recorded			Work-in-Process Control	3,100,000	
				Materials Inventory Control		1,900,000
				Conversion Costs Allocated		1,200,000
Stage C: Record Cost of Good Finished Units Completed.						
Entry (C1)	Finished Goods Control	3,100,000		Finished Goods Control	3,100,000	
	Materials and In-Process Inventory Control		1,900,000	Work-in-Process Control		3,100,000
	Conversion Costs Allocated		1,200,000			
Stage D: Record Cost of Finished Goods Sold (and Under- or Overallocated Conversion Costs).						
1. Record Cost of Finished Goods Sold.						
Entry (D1)	Cost of Goods Sold	3,069,000		Cost of Goods Sold	3,069,000	
	Finished Goods Control		3,069,000	Finished Goods Control		3,069,000
2. Record Underallocated or Overallocated Conversion Costs.						
Entry (D2)	Conversion Costs Allocated	1,200,000		Conversion Costs Allocated	1,200,000	
	Cost of Goods Sold	60,000		Cost of Goods Sold	60,000	
	Conversion Costs Control		1,260,000	Conversion Costs Control		1,260,000

PANEL B: General Ledger Overview for Backflush Costing



The coding that appears in parentheses for each entry indicates the stage in the production process that the entry relates to as presented in the text.

Next consider the entries for production resulting in work in process (Stage B). Recall that 100,000 units were started into production in April and that the standard cost for the units produced is \$31 (\$19 direct materials + \$12 conversion costs) per unit. Under backflush costing, no entry is recorded in Stage B because work-in-process inventory is minimal and all units are quickly converted to finished goods. Under sequential tracking, work-in-process inventory is increased as manufacturing occurs and later decreased as manufacturing is completed and the product becomes a finished good.

The entries to record the completion of good finished units (Stage C) give backflush costing its name. The costs have not been recorded sequentially with the flow of the product along its production route through work in process and finished goods. Instead, the output trigger point reaches *back* and pulls ("*flushes*") the standard direct material costs from Materials and In-Process Inventory Control and the standard conversion costs for manufacturing the finished goods. Under the sequential tracking approach, Finished Goods Control is debited (increased) and Work-in-Process Control is credited (decreased) as manufacturing is completed and finished goods are produced. The net effect of Stages B and C under sequential tracking is the same as the effect under backflush costing (except for the name of the inventory account).

Finally consider the entries to record the sale of finished goods (and under- or over-allocated conversion costs) (Stage D). The standard cost of 99,000 units sold in April equals \$3,069,000 (99,000 units × \$31 per unit). The entries to record the cost of finished goods sold are exactly the same under backflush costing and sequential tracking.

Actual conversion costs may be underallocated or overallocated in an accounting period. Chapter 4 (pages 127–132) discussed various ways to dispose of underallocated or overallocated manufacturing overhead costs. Companies that use backflush costing typically have low inventories, so prorating underallocated or overallocated conversion costs between work in process, finished goods, and cost of goods sold is seldom necessary. Generally, companies write off underallocated or overallocated conversion costs to cost of goods sold only at the end of the fiscal year. Other companies, like SVC, record the write-off monthly. The journal entry to dispose of the difference between actual conversion costs incurred and standard conversion costs allocated is exactly the same under backflush costing and sequential tracking.

The April 30 ending inventory balances under backflush costing are as follows:

Materials and In-Process Inventory Control (\$1,950,000 − \$1,900,000)	\$50,000
Finished Goods Control, 1,000 units × \$31/unit (or \$3,100,000 − \$3,069,000)	31,000
Total	\$81,000

The April 30 ending inventory balances under sequential tracking would be exactly the same except that the inventory account would be Materials Inventory Control. Exhibit 20-7, Panel B (page 783), provides a general-ledger overview of this version of backflush costing.

The elimination of the typical Work-in-Process Control account reduces the amount of detail in the accounting system. Units on the production line may still be tracked in physical terms, but there is "no assignment of costs" to specific work orders while they are in the production cycle. In fact, there are no work orders or labor-time records in the accounting system.

The three trigger points to make journal entries in Example 1 will lead SVC's backflush costing system to report costs that are similar to the costs reported under sequential tracking when SVC has minimal work-in-process inventory. In Example 1, any inventories of direct materials or finished goods are recognized in SVC's backflush costing system when they are acquired or produced (as would be done in a costing system using sequential tracking). International Paper Company uses a method similar to Example 1 in its specialty papers plant.

Accounting for Variances

Accounting for variances between actual and standard costs is basically the same under all standard-costing systems. The procedures are described in Chapters 7 and 8. Suppose

that in Example 1, SVC had an unfavorable direct materials price variance of $42,000. Then the journal entry would be as follows:

Materials and In-Process Inventory Control	1,950,000	
Direct Materials Price Variance	42,000	
Accounts Payable Control		1,992,000

Direct materials costs are often a large proportion of total manufacturing costs, sometimes as much as 60%. Consequently, many companies measure the direct materials efficiency variance in total by physically comparing what remains in direct materials inventory against what should remain based on the output of finished goods for the accounting period. In our example, suppose that such a comparison showed an unfavorable materials efficiency variance of $30,000. The journal entry would be as follows:

Direct Materials Efficiency Variance	30,000	
Materials and In-Process Inventory Control		30,000

The underallocated or overallocated conversion costs are split into various overhead variances (spending variance, efficiency variance, and production-volume variance), as explained in Chapter 8. Each variance is closed to the Cost of Goods Sold account, if it is immaterial in amount.

Example 2: The two trigger points are Purchase of direct materials and incurring of conversion costs (Stage A) and Sale of finished goods (Stage D).

This example uses the SVC data to illustrate a backflush costing that differs more from sequential tracking than the backflush costing in Example 1. This example and Example 1 have the same first trigger point, purchase of direct materials and incurring of conversion costs. But the second trigger point in Example 2 is the sale, not the completion, of finished goods. *Note that there is no journal entry for Production resulting in work in process (Stage B) and Completion of good finished units of product (Stage C) because this method is used when there are minimal work-in-process and finished goods inventories (units started are quickly converted into finished goods that are immediately sold).* In this example, there is only one inventory account: direct materials, whether the materials are in storerooms, in process, or in finished goods.

Type	Account Title
Combines direct materials inventory and any direct materials in work-in-process and finished goods inventories	Inventory Control

Exhibit 20-8, Panel A, summarizes the journal entries for Example 2 with two trigger points: Purchase of direct materials and incurring of conversion costs and Sale of finished goods (and recognizing under- or overallocated costs). As in Example 1, for each stage, the backflush costing entries for SVC are shown on the left. The comparable entries under sequential tracking are shown on the right.

The entries for direct materials purchased and conversion costs incurred (Stage A) are the same as in Example 1, except that the inventory account is called Inventory Control. As in Example 1, no entry is made to record the production of work-in-process inventory (Stage B) because the work-in-process inventory is minimal. When finished goods are completed (Stage C), no entry is recorded because the completed units are expected to be sold quickly and the finished goods inventory is expected to be minimal. As finished goods are sold (Stage D), the cost of goods sold is calculated as 99,000 units sold × $31 per unit = $3,069,000, which is composed of direct materials costs (99,000 units × $19 per unit = $1,881,000) and conversion costs allocated (99,000 units × $12 per unit = $1,188,000). This is the same Cost of Goods Sold calculated under sequential tracking as described in Example 1.

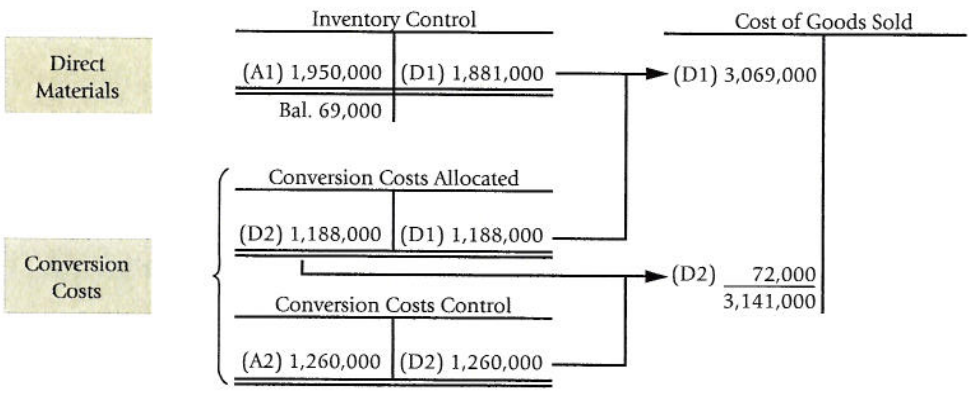
Under this method of backflush costing, conversion costs are not inventoried because no entries are recorded when finished goods are produced in Stage C. That is, compared with sequential tracking, Example 2 does not assign $12,000($12 per unit × 1,000 units) of conversion costs to finished goods inventory produced but not sold. Of the $1,260,000 in conversion

Exhibit 20-8 Journal Entries and General Ledger Overview for Backflush Costing and Journal Entries for Sequential Tracking with Two Trigger Points: Purchase of Direct Materials and Incurring of Conversion Costs and Sale of Finished Goods

PANEL A: Journal Entries

	Backflush Costing			Sequential Tracking		
Stage A: Record Purchase of Direct Materials and Incurring of Conversion Costs						
1. Record Direct Materials Purchased.						
Entry (A1)	Inventory: Control	1,950,000		Materials Inventory Control	1,950,000	
	Accounts Payable Control		1,950,000	Accounts Payable Control		1,950,000
2. Record Conversion Costs Incurred.						
Entry (A2)	Conversion Costs Control	1,260,000		Conversion Costs Control	1,260,000	
	Various accounts (such as Wages Payable Control)		1,260,000	Various accounts (such as Wages Payable Control)		1,260,000
Stage B: Record Production Resulting in Work in Process.						
Entry (B1)	No Entry Recorded			Work-in-Process Control	3,100,000	
				Materials Inventory Control		1,900,000
				Conversion Costs Allocated		1,200,000
Stage C: Record Cost of Good Finished Units Completed.						
Entry (C1)	No Entry Recorded			Finished Goods Control	3,100,000	
				Work-in-Process Control		3,100,000
Stage D: Record Cost of Finished Goods Sold (and Under- or Overallocated Conversion Costs).						
1. Record Cost of Finished Goods Sold.						
Entry (D1)	Cost of Goods Sold	3,069,000		Cost of Goods Sold	3,069,000	
	Inventory Control		1,881,000	Finished Goods Control		3,069,000
	Conversion Costs Allocated		1,188,000			
2. Record Underallocated or Overallocated Conversion Costs.						
Entry (D2)	Conversion Costs Allocated	1,188,000		Conversion Costs Allocated	1,200,000	
	Cost of Goods Sold	72,000		Cost of Goods Sold	60,000	
	Conversion Costs Control		1,260,000	Conversion Costs Control		1,260,000

PANEL B: General Ledger Overview for Backflush Costing



The coding that appears in parentheses for each entry indicates the stage in the production process that the entry relates to as presented in the text.

costs, $1,188,000 is allocated at standard cost to the units sold. The remaining $72,000 ($1,260,000 − $1,188,000) of conversion costs is underallocated compared to $60,000 under sequential tracking. Entry (D2) presents the journal entry if SVC, like many companies, writes off these underallocated costs monthly as additions to the Cost of Goods Sold account.

The April 30 ending balance of the Inventory Control account is $69,000 ($1,950,000 − $1,881,000). This balance represents the $50,000 direct materials still on hand + $19,000 direct materials embodied in the 1,000 finished units manufactured but not sold during the period. Finished goods inventory under sequential tracking is: direct materials, $19,000 + conversion costs, $12,000 for a total of $31,000. Exhibit 20-8, Panel B, provides a general-ledger overview of Example 2. The approach described in Example 2 closely approximates the costs computed using sequential tracking when a company holds minimal work-in-process and finished goods inventories.

Toyota's cost accounting system at its Kentucky plant is similar to this example. Two advantages of this system are (1) it removes the incentive for managers to produce for inventory because conversion costs are recorded as period costs instead of inventoriable costs and (2) it focuses managers on sales.

Example 3: The two trigger points are Completion of good finished units of product (Stage C) and Sale of finished goods (Stage D).

This example has two trigger points. In contrast to Example 2, the first trigger point in Example 3 is delayed until Stage C, SVC's completion of good finished units of product. *Note that there are no journal entries for Purchase of direct materials and incurring of conversion costs (Stage A) and Production resulting in work in process (Stage B) because this method is used when there are minimal direct materials and work-in-process inventories (direct materials purchased are quickly placed into production and then quickly converted into finished goods).* Exhibit 20-9, Panel A, summarizes the journal entries for Example 3 with two trigger points: Completion of good finished units of product and Sale of finished goods (and recognizing under- or overallocated costs). As in Examples 1 and 2, for each stage, the backflush costing entries for SVC are shown on the left. The comparable entries under sequential tracking are shown on the right.

No entry is made for direct materials purchases of $1,950,000 (Stage A) because the acquisition of direct materials is not a trigger point in this form of backflush costing. As in Examples 1 and 2, actual conversion costs are recorded as incurred and no entry is made to record production resulting in work-in-process inventory (Stage B). The cost of 100,000 good finished units completed (Stage C) is recorded at standard cost of $31 ($19 direct materials + $12 conversion costs) per unit as in Example 1 except that Accounts Payable Control is credited (instead of Materials and In-Process Inventory Control) because no entry had been made when direct materials were purchased in Stage A. Note that at the end of April, $50,000 of direct materials purchased have not yet been placed into production ($1,950,000 − $1,900,000 = $50,000), nor have the cost of those direct materials been entered into the inventory-costing system. The Example 3 version of backflush costing is suitable for a JIT production system in which both direct materials inventory and work-in-process inventory are minimal. As finished goods are sold (Stage D), the cost of goods sold is calculated as 99,000 units sold × $31 per unit = $3,069,000. This is the same Cost of Goods sold calculated under sequential tracking. The Finished Goods Control account has a balance of $31,000 under both this form of backflush costing and sequential tracking. The journal entry to dispose of the difference between the actual conversion costs incurred and standard conversion costs allocated is the same under backflush costing and sequential tracking. The only difference between this form of backflush costing and sequential tracking is that direct materials inventory of $50,000 (and the corresponding Accounts Payable Control) is not recorded, which is no problem if direct materials inventories are minimal. Exhibit 20-9, Panel B, provides a general-ledger overview of Example 3.

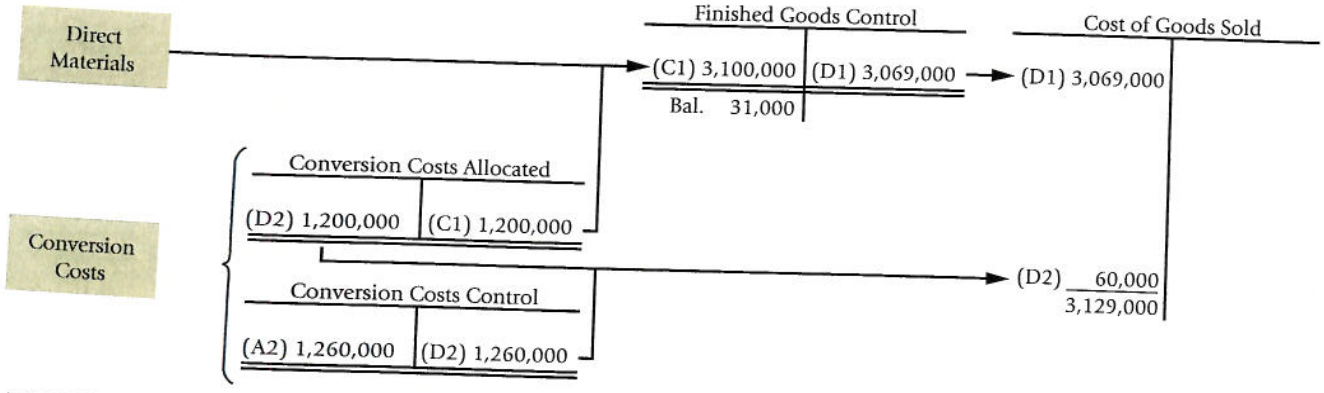
Extending Example 3, backflush costing systems could use the sale of finished goods as the only trigger point. This version of backflush costing is most suitable for a JIT production system with minimal direct materials, work-in-process, and finished goods inventories. That's because this backflush costing system maintains no inventory accounts.

Exhibit 20-9 Journal Entries and General Ledger Overview for Backflush Costing and Journal Entries for Sequential Tracking with Two Trigger Points: Completion of Good Finished Units of Product and Sale of Finished Goods

PANEL A: Journal Entries

	Backflush Costing			Sequential Tracking		
Stage A: Record Purchase of Direct Materials and Incurring of Conversion Costs.						
1. Record Direct Materials Purchased.						
Entry (A1)	No Entry Recorded			Materials Inventory Control	1,950,000	
				Accounts Payable Control		1,950,000
2. Record Conversion Costs Incurred.						
Entry (A2)	Conversion Costs Control	1,260,000		Conversion Costs Control	1,260,000	
	Various accounts (such as Wages Payable Control)		1,260,000	Various accounts (such as Wages Payable Control)		1,260,000
Stage B: Record Production Resulting in Work in Process.						
Entry (B1)	No Entry Recorded			Work-in-Process Control	3,100,000	
				Materials Inventory Control		1,900,000
				Conversion Costs Allocated		1,200,000
Stage C: Record Cost of Good Finished Units Completed.						
Entry (C1)	Finished Goods Control	3,100,000		Finished Goods Control	3,100,000	
	Accounts Payable Control		1,900,000	Work-in-Process Control		3,100,000
	Conversion Costs Allocated		1,200,000			
Stage D: Record Cost of Finished Goods Sold (and Under- or Overallocated Conversion Costs).						
1. Record Cost of Finished Goods Sold.						
Entry (D1)	Cost of Goods Sold	3,069,000		Cost of Goods Sold	3,069,000	
	Finished Goods Control		3,069,000	Finished Goods Control		3,069,000
2. Record Underallocated or Overallocated Conversion Costs.						
Entry (D2)	Conversion Costs Allocated	1,200,000		Conversion Costs Allocated	1,200,000	
	Cost of Goods Sold	60,000		Cost of Goods Sold	60,000	
	Conversion Costs Control		1,260,000	Conversion Costs Control		1,260,000

PANEL B: General Ledger Overview for Backflush Costing



The coding that appears in parentheses for each entry indicates the stage in the production process that the entry relates to as presented in the text.

Special Considerations in Backflush Costing

The accounting procedures illustrated in Examples 1, 2, and 3 do not strictly adhere to Generally Accepted Accounting Principles (GAAP). For example, work-in-process inventory, which is an asset, exists but is not recognized in the financial accounting system. Advocates of backflush costing, however, cite the generally accepted accounting principle of materiality in support of the various versions of backflush costing. As the three examples illustrate, backflush costing can approximate the costs that would be reported under sequential tracking by varying the number of trigger points and where they are located. If significant amounts of direct materials inventory or finished goods inventory exist, adjusting entries can be incorporated (as explained next).

Suppose there are material differences in a company's operating income and inventories based on a backflush costing system and a conventional standard-costing system. A journal entry can be recorded to adjust the backflush number to comply with GAAP. For example, the backflush entries in Example 2 would result in expensing all conversion costs to the Cost of Goods Sold account ($1,188,000 at standard costs + $72,000 write-off of underallocated conversion costs = $1,260,000). But suppose conversion costs were regarded as sufficiently material in amount to be included in the Inventory Control account. Then entry (D2) in Example 2, closing the Conversion Costs accounts, would change as follows:

Original entry (D2)	Conversion Costs Allocated	1,188,000	
	Cost of Goods Sold	72,000	
	Conversion Costs Control		1,260,000
Revised entry (D2)	Conversion Costs Allocated	1,188,000	
	Inventory Control (1,000 units × $12)	12,000	
	Cost of Goods Sold	60,000	
	Conversion Costs Control		1,260,000

Critics say backflush costing leaves no audit trails—the ability of the accounting system to pinpoint the uses of resources at each step in the production process. However, the absence of sizable amounts of materials inventory, work-in-process inventory, and finished goods inventory means managers can keep track of operations by personal observations, computer monitoring, and nonfinancial measures.

What are the implications of JIT and backflush costing systems for activity-based costing (ABC) systems? Simplifying the production process, as a JIT system does, makes more of the costs direct and reduces the extent of overhead cost allocations. Simple ABC systems are often adequate for companies implementing JIT. These simple ABC systems work well with backflush costing. Costs from ABC systems yield a more accurate budgeted conversion cost per unit for different products in the backflush costing system. The activity-based cost information is also useful for product costing, decision making, and cost management.

Decision Point

How does backflush costing simplify traditional inventory costing?

Lean Accounting

Learning Objective 8

Understand the principles of lean accounting

...focus on costing value streams rather than products and limit arbitrary allocations

Another simplified product costing system that can be used with JIT (or lean production) systems is *lean accounting*. When a company utilizes JIT production, it has to focus on the entire value chain of business functions (from suppliers to manufacturing to customers) in order to reduce inventories, lead times, and waste. The improvements throughout the value chain that result have led some companies with JIT systems to develop organizational structures and costing systems that focus on **value streams,** which are all the value-added activities needed to design, manufacture, and deliver a given product or product line to customers. For example, a value stream can include the activities needed to develop and engineer products, advertise and market those products, process orders, purchase and receive materials, manufacture and ship orders, bill customers, and collect

payments. The use of manufacturing cells in JIT systems helps keep a company focused on its value streams.

Lean accounting is a costing method that focuses on value streams, as distinguished from individual products or departments, thereby eliminating waste in the accounting process.[5] If a company makes multiple, related products in a single value stream, it does not compute product costs for the individual products. Instead, it traces many actual costs directly to the value stream. Tracing more costs as direct costs to value streams is possible because companies using lean accounting often dedicate resources to individual value streams. We now illustrate lean accounting for Manuela Corporation.

Manuela Corporation manufactures toner cartridges and ink cartridges for use with its printers. It makes two models of toner cartridges in one manufacturing cell and two models of ink cartridges in another manufacturing cell. The following table lists revenues, operating costs, operating income, and other information for the different products.

	Toner Cartridges		Ink Cartridges	
	Model A	**Model B**	**Model C**	**Model D**
Revenues	$600,000	$700,000	$800,000	$550,000
Direct materials	340,000	400,000	410,000	270,000
Direct manufacturing labor	70,000	78,000	105,000	82,000
Manufacturing overhead costs (e.g., equipment lease, supervision, and unused facility costs)	112,000	130,000	128,000	103,000
Rework costs	15,000	17,000	14,000	10,000
Design costs	20,000	21,000	24,000	18,000
Marketing and sales costs	30,000	33,000	40,000	28,000
Total costs	587,000	679,000	721,000	511,000
Operating income	$ 13,000	$ 21,000	$ 79,000	$ 39,000
Direct materials purchased	$350,000	$420,000	$430,000	$285,000
Unused facility costs	$ 22,000	$ 38,000	$ 18,000	$ 15,000

Using lean accounting principles, Manuela's managers calculate the value-stream operating costs and operating income for toner cartridges and ink cartridges, not individual models, as follows:

	Toner Cartridges	Ink Cartridges
Revenues ($600,000 + $700,000; $800,000 + $550,000)	$1,300,000	$1,350,000
Direct materials used ($340,000 + $400,000; $410,000 + $270,000)	740,000	680,000
Direct manufacturing labor ($70,000 + $78,000; $105,000 + $82,000)	148,000	187,000
Manufacturing overhead (after deducting unused facility costs) ($112,000 − $22,000) + ($130,000 − $38,000); ($128,000 − $18,000) + ($103,000 − $15,000)	182,000	198,000
Design costs ($20,000 + $21,000; $24,000 + $18,000)	41,000	42,000
Marketing and sales costs ($30,000 + $33,000; $40,000 + $28,000)	63,000	68,000
Total value stream operating costs	1,174,000	1,175,000
Value-stream operating income	$ 126,000	$ 175,000

[5] See Bruce L. Baggaley, "Costing by Value Stream," *Journal of Cost Management* (May–June 2003).

To gain insights, Manuela's lean accounting system, like many lean accounting systems, compares value-stream costs against costs that include costs of all purchased materials. Doing so keeps the company focused on reducing its direct materials and work-in-process inventory. In our example, the cost of direct material purchases exceeds the cost of direct materials used.

Manuela allocates its facility costs (such as depreciation, property taxes, and leases) to value streams based on the square footage each value stream uses. This encourages managers to use less space for production and for holding and moving inventory. Note that Manuela does not consider unused facility costs when calculating its manufacturing overhead costs of value streams. Instead, it treats these costs as plant or business unit expenses. Manuela excludes unused facility costs because it only includes in its value-stream costs those costs that add value. Increasing the visibility of unused capacity costs creates incentives to reduce these costs or to find alternative uses for the company's capacity. Manuela also excludes rework costs when calculating its value-stream costs and operating income because these costs are non-value-added costs. Companies also exclude from value-stream costs common costs such as corporate or support-department costs that cannot reasonably be assigned to value streams.

The analysis shows that although the total cost of the toner cartridges based on direct materials purchases rather than direct materials used is $1,296,000 [$587,000 + $679,000 + ($350,000 − $340,000) + ($420,000 − $400,000)], the value-stream cost using lean accounting is $1,174,000(90.6% × $1,296,000). The difference between the two indicates that there are opportunities for improving the company's profitability by reducing unused facility and rework costs and by purchasing direct materials only as needed for production. Making improvements is particularly important because Manuela's value-stream operating income is only 9.7%($126,000 ÷ $1,300,000) of its revenues. Manuela's ink cartridges portray a different picture. The total cost for ink cartridges based on direct materials purchases rather than direct materials used is $1,267,000 [$721,000 + $511,000 + ($430,000 − $410,000) + ($285,000 − $270,000)], whereas the value-stream cost using lean accounting is $1,175,000(92.7% × $1,267,000). The ink cartridges value stream has low unused facility and rework costs and is more efficient. Moreover, the ink cartridges also have higher value-stream operating income profitability of 13%($175,000 ÷ $1,350,000).

Lean accounting is much simpler than traditional product costing. Why? Because calculating actual product costs by value streams requires less overhead allocation. Consistent with JIT and lean production, lean accounting emphasizes improvements in the value chain from suppliers to customers. Lean accounting encourages practices—such as reducing direct materials and work-in-process inventories, improving quality, using less space, and eliminating unused capacity—that reflect the goals of JIT production.

Critics of lean accounting charge that it does not compute the costs of individual products, which makes it less useful for making decisions. Proponents of lean accounting argue that the lack of individual product costs is not a problem because most decisions are made at the product line level rather than the individual product level and that pricing decisions are based on the value created for the customer (market prices) and not product costs.

Another criticism of lean accounting is that it excludes certain support costs and unused capacity costs. As a result, the decisions based on only value-stream costs will look profitable because they do not consider all costs. Proponents of lean accounting argue that the method overcomes this problem by adding a larger markup on value-stream costs to compensate for some of these excluded costs. Moreover, in a competitive market, prices will eventually settle at a level that represents a reasonable markup above a product's value-stream costs because customers will be unwilling to pay for non-value-added costs. The goal must therefore be to eliminate non-value-added costs.

A final criticism of lean accounting is that, like backflush costing, it does not correctly account for inventories under Generally Accepted Accounting Principles (GAAP). However, the method's proponents are quick to point out that in lean accounting environments, work-in-process and finished goods inventories are immaterial from an accounting perspective.

Decision Point

How is lean accounting different from traditional costing systems?

Problems for Self-Study

Problem 1

Lee Company has a Singapore plant that manufactures MP3 players. One component is an XT chip. Expected demand is for 5,200 of these chips in March 2013. Lee estimates the ordering cost per purchase order to be $250. The monthly carrying cost for one unit of XT in stock is $5.

Required

1. Compute the EOQ for the XT chip.
2. Compute the number of deliveries of XT in March 2013.

Solution

$$EOQ = \sqrt{\frac{2 \times 5{,}200 \times \$250}{\$5}}$$

$$= 721 \text{ chips (rounded)}$$

$$\text{Number of deliveries} = \frac{5{,}200}{721}$$

$$= 8 \text{ (rounded)}$$

Problem 2

Littlefield Company uses a backflush costing system with three trigger points:

- Purchase of direct materials
- Completion of good finished units of product
- Sale of finished goods

There are no beginning inventories. Information for April 2013 is as follows:

Direct materials purchased	$880,000	Conversion costs allocated	$ 400,000
Direct materials used	$850,000	Costs transferred to finished goods	$1,250,000
Conversion costs incurred	$422,000	Cost of goods sold	$1,190,000

Required

1. Prepare journal entries for April (without disposing of underallocated or overallocated conversion costs). Assume there are no direct materials variances.
2. Under an ideal JIT production system, how would the amounts in your journal entries differ from the journal entries in requirement 1?

Solution

1. Journal entries for April are as follows:

Entry (A1)	Materials and In-Process Inventory Control	880,000	
	Accounts Payable Control		880,000
	(direct materials purchased)		
Entry (A2)	Conversion Costs Control	422,000	
	Various accounts (such as Wages Payable Control)		422,000
	(conversion costs incurred)		
Entry (C1)	Finished Goods Control	1,250,000	
	Materials and In-Process Inventory Control		850,000
	Conversion Costs Allocated		400,000
	(standard cost of finished goods completed)		
Entry (D1)	Cost of Goods Sold	1,190,000	
	Finished Goods Control		1,190,000
	(standard costs of finished goods sold)		

2. Under an ideal JIT production system, if the manufacturing lead time per unit is very short, there would be zero inventories at the end of each day. Entry (C1) would be $1,190,000 finished goods production [to match finished goods sold in entry (D1)], not $1,250,000. If the marketing department could only sell goods costing $1,190,000, the JIT production system would call for direct materials purchases and conversion costs of lower than $880,000 and $422,000, respectively, in entries (A1) and (A2).

Decision Points

The following question-and-answer format summarizes the chapter's learning objectives. Each decision presents a key question related to a learning objective. The guidelines are the answer to that question.

Decision	Guidelines
1. What are the six categories of costs associated with goods for sale?	The six categories are purchasing costs (costs of goods acquired from suppliers), ordering costs (costs of preparing a purchase order and receiving goods), carrying costs (costs of holding inventory of goods for sale), stockout costs (costs arising when a customer demands a unit of product and that unit is not on hand), costs of quality (prevention, appraisal, internal failure, and external failure costs), and shrinkage costs (the costs resulting from theft by outsiders, embezzlement by employees, misclassifications, and clerical errors).
2. What does the EOQ decision model help managers do, and how do managers decide on the safety-stock levels?	The economic-order-quantity (EOQ) decision model helps managers to calculate the optimal quantity of inventory to order by balancing ordering costs and carrying costs. The larger the order quantity, the higher are the annual carrying costs and the lower the annual ordering costs. The EOQ model includes costs recorded in the financial accounting system as well as opportunity costs of carrying inventory that are not recorded in the financial accounting system. Managers choose a level of safety stock to minimize the stockout costs and the carrying costs of holding more inventory.
3. How do errors in predicting the parameters of the EOQ model affect costs? How can companies reduce the conflict between the EOQ decision model and models used for performance evaluation?	The cost of prediction errors when using the EOQ model is small. To reduce the conflict between the EOQ decision model and the performance evaluation model, companies should include the opportunity cost of investment in inventory when evaluating managers. The opportunity cost of investment tied up in inventory is a key input in the EOQ decision model that is often ignored in the performance-evaluation model.
4. Why are companies using just-in-time (JIT) purchasing?	Just-in-time (JIT) purchasing is making purchases in small order quantities just as needed for production (or sales). JIT purchasing is a response to high carrying costs and low ordering costs. JIT purchasing increases the focus of companies and suppliers on quality and timely deliveries. Companies coordinate their activities and reduce inventories throughout the supply chain, from the initial sources of materials and services to the delivery of products to consumers.
5. How do materials requirements planning (MRP) systems differ from just-in-time (JIT) production systems?	Materials requirements planning (MRP) systems use a "push-through" approach whereby finished goods are manufactured on the basis of demand forecasts. Just-in-time (JIT) production systems use a "demand-pull" approach in which goods are manufactured only after receiving customer orders.

Decision	Guidelines
6. What are the features and benefits of a just-in-time (JIT) production system?	JIT production systems (a) organize production in manufacturing cells, (b) hire and train multiskilled workers, (c) emphasize total quality management, (d) reduce manufacturing lead time and setup time, and (e) build strong supplier relationships. The benefits of JIT production include lower costs and higher margins from better flow of information, higher quality, and faster delivery as well as simpler accounting systems.
7. How does backflush costing simplify traditional inventory costing?	Traditional inventory-costing systems use sequential tracking, in which recording of the journal entries occurs in the same order as actual purchases and progress in production. Most backflush costing systems do not record journal entries for the work-in-process stage of production. Some backflush costing systems also do not record entries for either the purchase of direct materials or the completion of finished goods.
8. How is lean accounting different from traditional costing systems?	Lean accounting assigns costs to value streams rather than to products. Non-value-added costs, unused capacity costs, and costs that cannot be easily traced to value streams are not allocated but instead expensed.

Terms to Learn

This chapter and the Glossary at the end of the book contain definitions of the following important terms:

backflush costing **(p. 782)**
carrying costs **(p. 765)**
economic order quantity (EOQ) **(p. 766)**
enterprise resource planning (ERP) system **(p. 779)**
inventory management **(p. 765)**
just-in-time (JIT) production **(p. 778)**
just-in-time (JIT) purchasing **(p. 773)**
lean accounting **(p. 790)**
lean production **(p. 778)**
manufacturing cells **(p. 778)**
materials requirements planning (MRP) system **(p. 777)**
ordering costs **(p. 765)**
purchase-order lead time **(p. 766)**
purchasing costs **(p. 765)**
reorder point **(p. 769)**
safety stock **(p. 769)**
sequential tracking **(p. 781)**
shrinkage costs **(p. 766)**
stockout costs **(p. 765)**
trigger point **(p. 782)**
value streams **(p. 789)**

Assignment Material

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Questions

20-1 Why do better decisions regarding the purchasing and managing of goods for sale frequently cause dramatic percentage increases in net income?
20-2 Name six cost categories that are important in managing goods for sale in a retail company.
20-3 What assumptions are made when using the simplest version of the economic-order-quantity (EOQ) decision model?
20-4 Give examples of costs included in annual carrying costs of inventory when using the EOQ decision model.
20-5 Give three examples of opportunity costs that typically are not recorded in accounting systems, although they are relevant when using the EOQ model in the presence of demand uncertainty.
20-6 What are the steps in computing the cost of a prediction error when using the EOQ decision model?
20-7 Why might goal-congruence issues arise when managers use an EOQ model to guide decisions on how much to order?
20-8 "JIT purchasing has many benefits but also some risks." Do you agree? Explain briefly.
20-9 What are three factors causing reductions in the cost to place purchase orders for materials?
20-10 "You should always choose the supplier who offers the lowest price per unit." Do you agree? Explain.

20-11 What is supply-chain analysis, and how can it benefit manufacturers and retailers?
20-12 What are the main features of JIT production, and what are its benefits and costs?
20-13 Distinguish inventory-costing systems using sequential tracking from those using backflush costing.
20-14 Describe three different versions of backflush costing.
20-15 Discuss the differences between lean accounting and traditional cost accounting.

Exercises

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20-16 Economic order quantity for retailer. Fan Base (FB) operates a megastore featuring sports merchandise. It uses an EOQ decision model to make inventory decisions. It is now considering inventory decisions for its Los Angeles Galaxy soccer jerseys product line. This is a highly popular item. Data for 2013 are as follows:

Expected annual demand for Galaxy jerseys	10,000
Ordering cost per purchase order	$200
Carrying cost per year	$7 per jersey

Each jersey costs FB $40 and sells for $80. The $7 carrying cost per jersey per year consists of the required return on investment of $4.80 (12% × $40 purchase price) plus $2.20 in relevant insurance, handling, and storage costs. The purchasing lead time is 7 days. FB is open 365 days a year.

Required

1. Calculate the EOQ.
2. Calculate the number of orders that will be placed each year.
3. Calculate the reorder point.

20-17 Economic order quantity, effect of parameter changes (continuation of 20-16). Athletic Textiles (AT) manufactures the Galaxy jerseys that Fan Base (FB) sells to its customers. AT has recently installed computer software that enables its customers to conduct "one-stop" purchasing using state-of-the-art Web site technology. FB's ordering cost per purchase order will be $30 using this new technology.

Required

1. Calculate the EOQ for the Galaxy jerseys using the revised ordering cost of $30 per purchase order. Assume all other data from Exercise 20-16 are the same. Comment on the result.
2. Suppose AT proposes to "assist" FB. AT will allow FB customers to order directly from the AT Web site. AT would ship directly to these customers. AT would pay $10 to FB for every Galaxy jersey purchased by one of FB's customers. Comment qualitatively on how this offer would affect inventory management at FB. What factors should FB consider in deciding whether to accept AT's proposal?

20-18 EOQ for a retailer. The Denim World sells fabrics to a wide range of industrial and consumer users. One of the products it carries is denim cloth, used in the manufacture of jeans and carrying bags. The supplier for the denim cloth pays all incoming freight. No incoming inspection of the denim is necessary because the supplier has a track record of delivering high-quality merchandise. The purchasing officer of the Denim World has collected the following information:

Annual demand for denim cloth	26,400 yards
Ordering cost per purchase order	$165
Carrying cost per year	20% of purchase costs
Safety-stock requirements	None
Cost of denim cloth	$9 per yard

The purchasing lead time is 2 weeks. The Denim World is open 250 days a year (50 weeks for 5 days a week).

Required

1. Calculate the EOQ for denim cloth.
2. Calculate the number of orders that will be placed each year.
3. Calculate the reorder point for denim cloth.

20-19 EOQ for manufacturer. Turfpro Company produces lawn mowers and purchases 4,500 units of a rotor blade part each year at a cost of $30 per unit. Turfpro requires a 15% annual rate of return on investment. In addition, the relevant carrying cost (for insurance, materials handling, breakage, etc.) is $3 per unit per year. The relevant ordering cost per purchase order is $75.

Required

1. Calculate Turfpro's EOQ for the rotor blade part.
2. Calculate Turfpro's annual relevant ordering costs for the EOQ calculated in requirement 1.
3. Calculate Turfpro's annual relevant carrying costs for the EOQ calculated in requirement 1.
4. Assume that demand is uniform throughout the year and known with certainty so there is no need for safety stocks. The purchase-order lead time is half a month. Calculate Turfpro's reorder point for the rotor blade part.

20-20 Sensitivity of EOQ to changes in relevant ordering and carrying costs, cost of prediction error. Alpha Company's annual demand for its only product, XT-590, is 10,000 units. Alpha is currently analyzing possible combinations of relevant carrying cost per unit per year and relevant ordering cost per purchase order, depending on the company's choice of supplier and average levels of inventory. This table presents three possible combinations of carrying and ordering costs.

Relevant Carrying Cost per Unit per Year	Relevant Ordering Cost per Purchase Order
$10	$400
$20	$200
$40	$100

Required

1. For each of the relevant ordering and carrying-cost alternatives, determine (a) EOQ and (b) annual relevant total costs.
2. How does your answer to requirement 1 give insight into the impact of changes in relevant ordering and carrying costs on EOQ and annual relevant total costs? Explain briefly.
3. Suppose the relevant carrying cost per unit per year was $20 and the relevant ordering cost per purchase order was $200. Suppose further that Alpha calculates EOQ after incorrectly estimating relevant carrying cost per unit per year to be $10 and relevant ordering cost per purchase order to be $400. Calculate the actual annual relevant total costs of Alpha's EOQ decision. Compare this cost to the annual relevant total costs that Alpha would have incurred if it had correctly estimated the relevant carrying cost per unit per year of $20 and the relevant ordering cost per purchase order of $200 that you have already calculated in requirement 1. Calculate and comment on the cost of the prediction error.

20-21 JIT production, relevant benefits, relevant costs. The Colonial Hardware Company manufactures specialty brass door handles at its Lynchburg plant. Colonial is considering implementing a JIT production system. The following are the estimated costs and benefits of JIT production:

a. Annual additional tooling costs would be $200,000.
b. Average inventory would decline by 80% from the current level of $2,000,000.
c. Insurance, space, materials-handling, and setup costs, which currently total $600,000 annually, would decline by 25%.
d. The emphasis on quality inherent in JIT production would reduce rework costs by 30%. Colonial currently incurs $400,000 in annual rework costs.
e. Improved product quality under JIT production would enable Colonial to raise the price of its product by $8 per unit. Colonial sells 40,000 units each year.

Colonial's required rate of return on inventory investment is 15% per year.

Required

1. Calculate the net benefit or cost to Colonial if it adopts JIT production at the Lynchburg plant.
2. What nonfinancial and qualitative factors should Colonial consider when making the decision to adopt JIT production?
3. Suppose Colonial implements JIT production at its Lynchburg plant. Give examples of performance measures Colonial could use to evaluate and control JIT production. What would be the benefit of Colonial implementing an enterprise resource planning (ERP) system?

20-22 Backflush costing and JIT production. Grand Devices Corporation assembles handheld computers that have scaled-down capabilities of laptop computers. Each handheld computer takes 6 hours to assemble. Grand Devices uses a JIT production system and a backflush costing system with three trigger points:

- Purchase of direct materials and incurring of conversion costs
- Completion of good finished units of product
- Sale of finished goods

There are no beginning inventories of materials or finished goods and no beginning or ending work-in-process inventories. The following data are for August 2013:

Direct materials purchased	$2,958,000	Conversion costs incurred	$777,600
Direct materials used	$2,937,600	Conversion costs allocated	$806,400

Grand Devices records direct materials purchased and conversion costs incurred at actual costs. It has no direct materials variances. When finished goods are sold, the backflush costing system "pulls through" standard direct material cost ($102 per unit) and standard conversion cost ($28 per unit). Grand Devices produced 28,800 finished units in August 2013 and sold 28,400 units. The actual direct material cost per unit in August 2013 was $102, and the actual conversion cost per unit was $27.

Required

1. Prepare summary journal entries for August 2013 (without disposing of under- or overallocated conversion costs).
2. Post the entries in requirement 1 to T-accounts for applicable Materials and In-Process Inventory Control, Finished Goods Control, Conversion Costs Control, Conversion Costs Allocated, and Cost of Goods Sold.
3. Under an ideal JIT production system, how would the amounts in your journal entries differ from those in requirement 1?

20-23 Backflush costing, two trigger points, materials purchase and sale (continuation of 20-22). Assume the same facts as in Exercise 20-22, except that Grand Devices now uses a backflush costing system with the following two trigger points:

- Purchase of direct materials and incurring of conversion costs
- Sale of finished goods

The Inventory Control account will include direct materials purchased but not yet in production, materials in work in process, and materials in finished goods but not sold. No conversion costs are inventoried. Any under- or overallocated conversion costs are written off monthly to Cost of Goods Sold.

Required

1. Prepare summary journal entries for August, including the disposition of under- or overallocated conversion costs.
2. Post the entries in requirement 1 to T-accounts for Inventory Control, Conversion Costs Control, Conversion Costs Allocated, and Cost of Goods Sold.

20-24 Backflush costing, two trigger points, completion of production and sale (continuation of 20-22). Assume the same facts as in Exercise 20-22, except now Grand Devices uses only two trigger points, Completion of good finished units of product and Sale of finished goods. Any under- or overallocated conversion costs are written off monthly to Cost of Goods Sold.

Required

1. Prepare summary journal entries for August, including the disposition of under- or overallocated conversion costs.
2. Post the entries in requirement 1 to T-accounts for Finished Goods Control, Conversion Costs Control, Conversion Costs Allocated, and Cost of Goods Sold.

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Problems

20-25 EOQ, uncertainty, safety stock, reorder point. Chadwick Shoe Co. produces and sells an excellent-quality walking shoe. After production, the shoes are distributed to 20 warehouses around the country. Each warehouse services approximately 100 stores in its region. Chadwick uses an EOQ model to determine the number of pairs of shoes to order for each warehouse from the factory. Annual demand for Warehouse OR2 is approximately 120,000 pairs of shoes. The ordering cost is $250 per order. The annual carrying cost of a pair of shoes is $2.40 per pair.

Required

1. Use the EOQ model to determine the optimal number of pairs of shoes per order.
2. Assume each month consists of approximately 4 weeks. If it takes 1 week to receive an order, at what point should warehouse OR2 reorder shoes?
3. Although OR2's average weekly demand is 2,500 pairs of shoes (120,000 ÷ 12 months ÷ 4 weeks), demand each week may vary with the following probability distribution:

Total demand for 1 week	2,000 pairs	2,250 pairs	2,500 pairs	2,750 pairs	3,000 pairs
Probability (sums to 1.00)	0.04	0.20	0.52	0.20	0.04

If a store wants shoes and OR2 has none in stock, OR2 can "rush" them to the store at an additional cost of $2 per pair. How much safety stock should Warehouse OR2 hold? How will this affect the reorder point and reorder quantity?

20-26 EOQ, uncertainty, safety stock, reorder point. Stewart Corporation is a major automobile manufacturer. It purchases steering wheels from Coase Corporation. Annual demand is 10,400 steering wheels per year or 200 steering wheels per week. The ordering cost is $100 per order. The annual carrying cost is $13 per steering wheel. It currently takes 1.5 weeks to supply an order to the assembly plant.

Required

1. What is the optimal number of steering wheels that Stewart's managers should order according to the EOQ model?
2. At what point should managers reorder the steering wheels, assuming that both demand and purchase-order lead time are known with certainty?

3. Now assume that demand can vary during the 1.5-week purchase-order lead time. The following table shows the probability distribution of various demand levels:

Total Demand for Steering Wheels for 1.5 Weeks	Probability of Demand (sums to 1)
100	0.15
200	0.20
300	0.40
400	0.20
500	0.05

If Stewart runs out of stock, it would have to rush order the steering wheels at an additional cost of $9 per steering wheel. How much safety stock should the assembly plant hold? How will this affect the reorder point and reorder quantity.

20-27 MRP, EOQ, and JIT. Tech Works Corp. produces J-Pods, music players that can download thousands of songs. Tech Works forecasts that demand in 2014 will be 48,000 J-Pods. The variable production cost of each J-Pod is $54. In its MRP system, due to the large $10,000 cost per setup, Tech Works plans to produce J-Pods once a month in batches of 4,000 each. The carrying cost of a unit in inventory is $17 per year.

Required

1. Using the MRP system, what is the annual cost of producing and carrying J-Pods in inventory? (Assume that, on average, half of the units produced in a month are in inventory.)
2. A new manager at Tech Works has suggested that the company use the EOQ model to determine the optimal batch size to produce. (To use the EOQ model, Tech Works needs to treat the setup cost in the same way it would treat ordering cost in a traditional EOQ model.) Determine the optimal batch size and number of batches. Round up the number of batches to the nearest whole number. What would be the annual cost of producing and carrying J-Pods in inventory if it uses the optimal batch size? Compare this cost to the cost calculated in requirement 1. Comment briefly.
3. Tech Works is also considering switching from its MRP system to a JIT system. This will result in producing J-Pods in batch sizes of 600 J-Pods and will reduce obsolescence, improve quality, and result in a higher selling price. The frequency of production batches will force Tech Works to reduce setup time and will result in a reduction in setup cost. The new setup cost will be $500 per setup. What is the annual cost of producing and carrying J-Pods in inventory under the JIT system?
4. Compare the models analyzed in the previous parts of the problem. What are the advantages and disadvantages of each?

20-28 Effect of management evaluation criteria on EOQ model. Computer Depot purchases one model of computer at a wholesale cost of $300 per unit and resells it to end consumers. The annual demand for the company's product is 600,000 units. Ordering costs are $1,200 per order and carrying costs are $75 per computer, including $30 in the opportunity cost of holding inventory.

Required

1. Compute the optimal order quantity using the EOQ model.
2. Compute (a) the number of orders per year and (b) the annual relevant total cost of ordering and carrying inventory.
3. Assume that when evaluating the manager, the company excludes the opportunity cost of carrying inventory. If the manager makes the EOQ decision excluding the opportunity cost of carrying inventory, the relevant carrying cost would be $45, not $75. How would this affect the EOQ amount and the actual annual relevant cost of ordering and carrying inventory?
4. What is the cost impact on the company of excluding the opportunity cost of carrying inventory when making EOQ decisions? Why do you think the company currently excludes the opportunity costs of carrying inventory when evaluating the manager's performance? What could the company do to encourage the manager to make decisions more congruent with the goal of reducing total inventory costs?

20-29 JIT purchasing, relevant benefits, relevant costs. (CMA, adapted) The Greene Corporation is an automotive supplier that uses automatic turning machines to manufacture precision parts from steel bars. Greene's inventory of raw steel averages $300,000. John Oates, president of Greene, and Helen Gorman, Greene's controller, are concerned about the costs of carrying inventory. The steel supplier is willing to supply steel in smaller lots at no additional charge. Gorman identifies the following effects of adopting a JIT inventory program to virtually eliminate steel inventory:

- Without scheduling any overtime, lost sales due to stockouts would increase by 35,000 units per year. However, by incurring overtime premiums of $20,000 per year, the increase in lost sales could be reduced to 20,000 units per year. This would be the maximum amount of overtime that would be feasible for Greene.
- Two warehouses currently used for steel bar storage would no longer be needed. Greene rents one warehouse from another company under a cancelable leasing arrangement at an annual cost of

$45,000. The other warehouse is owned by Greene and contains 12,000 square feet. Three-fourths of the space in the owned warehouse could be rented for $1.25 per square foot per year. Insurance and property tax costs totaling $7,000 per year would be eliminated.

Greene's required rate of return on investment is 20% per year. Greene's budgeted income statement for the year ending December 31, 2014, (in thousands) is:

Revenues (900,000 units)		$ 5,400
Cost of goods sold		
Variable costs	$2,025	
Fixed costs	725	
Total costs of goods sold		2,750
Gross margin		2,650
Marketing and distribution costs		
Variable costs	$ 450	
Fixed costs	750	
Total marketing and distribution costs		1,200
Operating income		$ 1,450

Required

1. Calculate the estimated dollar savings (loss) for the Greene Corporation that would result in 2014 from the adoption of JIT purchasing.
2. Identify and explain other factors that Greene should consider before deciding whether to adopt JIT purchasing.

20-30 Supply chain effects on total relevant inventory cost. Peach Computer Co. outsources the production of motherboards for its computers. It is currently deciding which of two suppliers to use: Alpha or Beta. Due to differences in the product failure rates in the two companies, 5% of motherboards purchased from Alpha will be inspected and 25% of motherboards purchased from Beta will be inspected. The following data refer to costs associated with Alpha and Beta:

	Alpha	Beta
Number of orders per year	50	50
Annual motherboards demanded	10,000	10,000
Price per motherboard	$108	$105
Ordering cost per order	$13	$10
Inspection cost per unit	$6	$6
Average inventory level	100 units	100 units
Expected number of stockouts	100	300
Stockout cost (cost of rush order) per stockout	$4	$6
Units returned by customers for replacing motherboards	50	500
Cost of replacing each motherboard	$30	$30
Required annual return on investment	10%	10%
Other carrying cost per unit per year	$3.50	$3.50

Required

1. What is the relevant cost of purchasing from Alpha and Beta?
2. What factors other than cost should Peach consider?

20-31 Supply chain effects on total relevant inventory cost. Joe's Deli orders specially-made sandwich buns from two different suppliers: Gold Star Breads and Grandma's Bakery. Joe's Deli would like to use only one of the suppliers in the future. Due to variations in quality, Joe's would need to inspect 30% of Gold Star's buns and 60% of Grandma's. The following data refer to costs associated with the two suppliers.

	Gold Star	Grandma's
Number of orders per year	100	100
Annual buns demanded	2,400	2,400
Price per bun	$ 2.50	$ 2.00
Ordering cost per order	$ 10.00	$ 12.00
Inspection cost per bun	$ 0.50	$ 0.50
Average inventory level	200	200

	Gold Star	Grandma's
Expected number of stockouts	10	10
Stockout cost of rush order	$ 10.00	$ 3.00
Estimated sandwiches returned by customers because of defective buns	60	100
Cost of fixing sandwiches returned by customers because of defective buns	$ 1.50	$ 1.50
Opportunity cost of investment	12%	12%
Other carrying costs per bun per year	$ 0.50	$ 0.50

Required

1. What is the relevant cost of purchasing from Gold Star and Grandma's?
2. What factors other than cost should Joe's Deli consider?

20-32 Backflush costing and JIT production. The Grand Meter Corporation manufactures electrical meters. For August, there were no beginning inventories of direct materials and no beginning or ending work in process. Grand Meter uses a JIT production system and backflush costing with three trigger points for making entries in the accounting system:

- Purchase of direct materials and incurring of conversion costs
- Completion of good finished units of product
- Sale of finished goods

Grand Meter's August standard cost per meter is direct materials, $25, and conversion cost, $20. Grand Meter has no direct materials variances. The following data apply to August manufacturing:

Direct materials purchased	$550,000	Number of finished units manufactured	21,000
Conversion costs incurred	$440,000	Number of finished units sold	20,000

Required

1. Prepare summary journal entries for August (without disposing of under- or overallocated conversion costs). Assume no direct materials variances.
2. Post the entries in requirement 1 to T-accounts for Materials and In-Process Inventory Control, Finished Goods Control, Conversion Costs Control, Conversion Costs Allocated, and Cost of Goods Sold.

20-33 Backflush, two trigger points, materials purchase and sale (continuation of 20-32). Assume that the second trigger point for Grand Meter Corporation is the sale—rather than the completion—of finished goods. Also, the inventory account is confined solely to direct materials, whether these materials are in a storeroom, in work in process, or in finished goods. No conversion costs are inventoried. They are allocated to the units sold at standard costs. Any under- or overallocated conversion costs are written off monthly to Cost of Goods Sold.

Required

1. Prepare summary journal entries for August, including the disposition of under- or overallocated conversion costs. Assume no direct materials variances.
2. Post the entries in requirement 1 to T-accounts for Inventory Control, Conversion Costs Control, Conversion Costs Allocated, and Cost of Goods Sold.

20-34 Backflush, two trigger points, completion of production and sale (continuation of 20-32). Assume the same facts as in Problem 20-33 except now there are only two trigger points: Completion of good finished units of product and Sale of finished goods.

Required

1. Prepare summary journal entries for August, including the disposition of under- or overallocated conversion costs. Assume no direct materials variances.
2. Post the entries in requirement 1 to T-accounts for Finished Goods Control, Conversion Costs Control, Conversion Costs Allocated, and Cost of Goods Sold.

20-35 Lean accounting. Reliable Security Devices (RSD) has introduced a just-in-time production process and is considering the adoption of lean accounting principles to support its new production philosophy. The company has two product lines: Mechanical Devices and Electronic Devices. Two individual products are made in each line. Product-line manufacturing overhead costs are traced directly to product lines and then allocated to the two individual products in each line. The company's traditional cost-accounting system allocates all plant-level facility costs and some corporate overhead costs to individual

products. The latest accounting report using traditional cost accounting methods included the following information (in thousands of dollars):

	Mechanical Devices		Electronic Devices	
	Product A	Product B	Product C	Product D
Sales	$1,400	$1,000	$1,800	$900
Direct material (based on quantity used)	400	200	500	150
Direct manufacturing labor	300	150	400	120
Manufacturing overhead (equipment lease, supervision, production control)	180	240	400	190
Allocated plant-level facility costs	100	80	160	60
Design and marketing costs	190	100	210	84
Allocated corporate overhead costs	30	20	40	16
Operating income	$200	$210	$90	$280

RSD has determined that each of the two product lines represents a distinct value stream. It has also determined that out of the $400,000 ($100,000 + $80,000 + $160,000 + $60,000) plant-level facility costs, product A occupies 22% of the plant's square footage, product B occupies 18%, product C occupies 36%, and product D occupies 14%. The remaining 10% of square footage is not being used. Finally, RSD has decided that in order to identify inefficiencies, direct material should be expensed in the period it is purchased, rather than when the material is used. According to purchasing records, direct material purchase costs during the period were as follows:

	Mechanical Devices		Electronic Devices	
	Product A	Product B	Product C	Product D
Direct material (purchases)	$420	$240	$500	$180

Required

1. What are the cost objects in RSD's lean accounting system?
2. Compute operating income for the cost objects identified in requirement 1 using lean accounting principles. What would you compare this operating income against? Comment on your results.

20-36 JIT production, relevant benefits, relevant costs, ethics. Perez Container Corporation is considering implementing a JIT production system. The new system would reduce current average inventory levels of $4,000,000 by 75%, but it would require a much greater dependency on the company's core suppliers for on-time deliveries and high-quality inputs. The company's operations manager, Jim Ingram, is opposed to the idea of a new JIT system because he is concerned that the new system (a) will be too costly to manage; (b) will result in too many stockouts; and (c) will lead to the layoff of his employees, several of whom are currently managing inventory. He believes that these layoffs will affect the morale of his entire production department. The management accountant, Sue Winston, is in favor of the new system because of its likely cost savings. Jim wants Sue to rework the numbers because he is concerned that top management will give more weight to financial factors and not give due consideration to nonfinancial factors such as employee morale. In addition to the reduction in inventory described previously, Sue has gathered the following information for the upcoming year regarding the JIT system:

- Annual insurance and warehousing costs for inventory would be reduced by 60% of current budgeted level of $700,000.
- Payroll expenses for current inventory management staff would be reduced by 15% of the budgeted total of $1,200,000.
- Additional annual costs for JIT system implementation and management, including personnel costs, would equal $440,000.
- The additional number of stockouts under the new JIT system is estimated to be 5% of the total number of shipments annually. Ten thousand shipments are budgeted for the upcoming year. Each stockout would result in an average additional cost of $500.
- Perez's required rate of return on inventory investment is 10% per year.

Required

1. From a financial perspective, should Perez adopt the new JIT system?
2. Should Sue Winston rework the numbers?
3. How should she manage Jim Ingram's concerns?