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Chapter 2 Supply-Chain Management

PROBLEMS

1. EBI Solar
   a. Inventory turnover = (Annual sales at cost)/(Average aggregate inventory value)
      Thus, 4.50 = 2 500 000 / Average aggregate inventory value
      Average aggregate inventory value = $555 556
      Weekly sales = Cost of goods sold / 52 = $2 500 000 / 52 = $48 077
      Weeks of supply = Average aggregate inventory value / weekly sales
      = $555 556 / 48 077 = 11.56 weeks of supply
   b. Average aggregate inventory value = raw material + work-in-process + finished goods
      = $100 500 + $25 800 + $16 200 = $142 500
      Inventory turnover = (Annual sales at cost)/(Average aggregate inventory value)
      = $2 500 000 / $142 500 = 17.54
      Weeks of supply = Average aggregate inventory value / weekly sales
      = $142 500 / 48 077 = 2.96 weeks of supply

2. Roll-away Corporation. Average aggregate inventory value can be calculated as:

Average aggregate inventory value	= Raw materials + WIP + Finished goods = $2 470 000 + $1 566 000 + $1 200 000 = $5 236 000
a. Sales per week	= Cost of goods sold / 52 weeks per year = $48 000 000 / 52 = $923 077
Weeks of supply	= Average aggregate inventory value / Weekly sales (at cost) = $5 236 000 / $923 077 = 5.7 weeks
b. Inventory turnover	= (Annual sales at cost) / (Average aggregate inventory value) = $48 000 000 / $5 236 000 = 9.17 turns/year

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3. Sterling Inc.

a.

Part Number	Average Inventory (units)	Value ($/unit)	Total Value ($)
RM-1	20 000	1.00	20 000
RM-2	5 000	5.00	25 000
RM-3	3 000	6.00	18 000
RM-4	1 000	8.00	8 000
WIP-1	6 000	10.00	60 000
WIP-2	8 000	12.00	96 000
FG-1	1 000	65.00	65 000
FG-2	500	88.00	44 000
	44 500		336 000

Average aggregate inventory value: $336 000

b. Average weekly sales at cost = $6 500 000 / 52
= $125 000

Weeks of supply = $336 000 / $125 000
= 2.688 weeks.

c. Inventory turnover = Annual sales (at cost) / Average aggregate inventory value
= $6 500 000 / $336 000
= 19.34 turns.

4. One product line

Inventory turnover = (Annual sales at cost)/(Average aggregate inventory value)
10.0 = $985 000 / Average aggregate inventory value
Average aggregate inventory value = $985 000 / 10 = $98 500

5. A retailer

a.

Sales per week = Cost of goods sold / 52 weeks per year
= $3 500 000 / 52
= $67 308

Weeks of supply = Average aggregate inventory value / Weekly sales (at cost)
= $1 200 000 / $67 308
= 17.8 wk

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b.

Inventory turnover = (Annual sales at cost) /
(Average aggregate inventory value)
= $3 500 000 / $1 200 000
= 2.9 turns/year

6. Large global automobile manufacturer

a. We must use the break-even equation for evaluating processes:

$$Q = \frac{F_m - F_b}{c_b - c_m}$$

Q = ($6 million - $4 million) / ($8.00 - $5.00) = 666 667 solenoids. Consequently, the automobile manufacturer would need to use 666 667 or more solenoids to make a financial case to retain manufacture of them in-house.

b. If the projection is for less than 666 667 solenoids, the use of the subcontractor becomes a possibility. However, in doing so, the manufacturer loses some control over the production of that part. If that part is critical to the end product, relinquishing direct oversight may not be a good idea. The ability of the subcontractor to deliver on time and with high quality are also factors to consider. Also, once out of the manufacturing of that part, it typically will take quite a while to start it back up again, raising issues of labor skills and equipment. Ethical issues, such as the potential layoffs and the effect on the community, should also be considered.

7. BlueFin Bank

We use the break-even equation for evaluating two processes:

$$Q = \frac{F_m - F_b}{c_b - c_m}$$

The key is to solve for the fixed costs of the "make" option,

$$F_m = F_b + (c_b - c_m)Q$$

F_m = $12 million + 0.02(20 million) = $12 400 000. Consequently, if the fixed annual costs to do the transactions in-house exceed, $12 400 000, BlueFin would be better off using DataEase.

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8. Bennet Company
   a. Each supplier's performance can be calculated as:

Performance Criterion	Weight	Weighted Rating Supplier A	Supplier B	Supplier C
1. Price	0.2	0.6(0.2) = 0.12	0.5(0.2) = 0.10	0.9(0.2) = 0.18
2. Quality	0.2	0.6(0.2) = 0.12	0.4(0.2) = 0.08	0.8(0.2) = 0.16
3. Delivery	0.3	0.6(0.3) = 0.18	0.3(0.3) = 0.09	0.8(0.3) = 0.24
4. Production facilities & capacity	0.1	0.5(0.1) = 0.05	0.9(0.1) = 0.09	0.6(0.1) = 0.06
5. Environmental protection	0.1	0.7(0.1) = 0.07	0.8(0.1) = 0.08	0.6(0.1) = 0.06
6. Financial position	0.1	0.9(0.1) = 0.09	0.9(0.1) = 0.09	0.7(0.1) = 0.07
Total weighted score		0.63	0.53	0.77

   b. Suppliers A and C survived the hurdle. Supplier A would receive 45% of the orders and Supplier C would receive 55% of the orders.
   c. Ben's system provides some assurance that orders are placed with qualified suppliers. The orders are divided between two suppliers, so there is a ready alternative if a strike, fire, or other problem prevents one supplier from performing. The system also rewards suppliers with more orders if they improve performance.

9. Beagle Clothiers. The weights for the four criteria—price, quality, delivery, and flexibility—should be 0.2, 0.2, 0.2, and 0.4, respectively. The weighted scores are:

	Supplier A	Supplier B	Supplier C
Price	8 × 0.2 = 1.6	6 × 0.2 = 1.2	6 × 0.2 = 1.2
Quality	9 × 0.2 = 1.8	7 × 0.2 = 1.4	7 × 0.2 = 1.4
Delivery	7 × 0.2 = 1.4	9 × 0.2 = 1.8	6 × 0.2 = 1.2
Flexibility	5 × 0.4 = 2.0	8 × 0.4 = 3.2	9 × 0.4 = 3.6
Total weighted score	6.8	7.6	7.4

   Supplier B should be selected.

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DISCUSSION QUESTIONS

1. Wal-Mart's approach is to generate a competitive situation between suppliers and to drive down prices. One of the major competitive priorities in Wal-Mart's business is low cost, thereby keeping retail prices to a minimum. Wal-Mart is dealing with standardized goods in high volumes, and consequently uses an efficient supply chain.

   Benetton deals with fashion goods that have shorter life cycles. Therefore, Benetton needs a more flexible supply chain and also more control over the supply channels. In-house manufacturing operations combined with rapid response suppliers provides the capability to produce fashion goods quickly.

2. Many of the key suppliers for Autoshare are service-based, including information technology that track cars, property management firms that own the parking lots, auto mechanics for preventive maintenance and repairs, and suppliers of fuel. Of course, automobile manufacturers are critical suppliers to provide new vehicles to replace older cars, ideally with a more fuel efficient design. In contrast, Boeing has a network of very sophisticated suppliers that manufacture parts and subsystems, in addition to its own plant network.

   Autoshare is working with partners to expand the number of locations to expand customer service and the value of membership. Thus, its primary focus is on downstream linkages with property owners to increase access. In parallel, AutoShare's service suppliers also need to expand their ability to serve a growing number of locations. In contrast, Boeing is working to develop upstream linkages with its suppliers—to the point where much the of the technology development work is their responsibility. As an aircraft designer and integrator, web-based technologies can improve collaboration during design, the speed of information exchange, and scheduling once production begins. This is particularly important as the extent of design and manufacturing work by suppliers continues to expand.

   AutoShare is heavily using the web to interact with customers and track usage. In addition, web-based data exchange also might be used to schedule maintenance and other background services. Similar to AutoShare, Boeing could include customers in the web-based system, once a new aircraft is launched into production. Here, customized options or changes could be readily captured into scheduling, and customers could monitor their orders as they move through the system. The web may also facilitate the more timely collection of operating performance data for its aircraft in service. Thus, the web can offer a new option for Boeing to develop closer relationships with its customers.

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CASE: WOLF MOTORS *

A. Synopsis

Wolf Motors has just expanded its network of auto dealerships to include its first auto supermarket where three different makes of cars are sold at the same facility. John Wolf, the president and owner of the dealership, has identified three factors that have contributed to the success of the dealerships: volume, "one price-lowest price" concept of pricing, and after-the-sale service to the cars sold. Focusing on the service aspect, three components are critical to providing quality after-the-sale service: well-trained technicians, the latest equipment technologies, and an adequate supply of service parts and materials. Presently each dealership is responsible for ordering and managing its inventory of parts and service materials. The recent growth has brought with it both space and financial resource constraints. John is now wondering what, if anything, can be done with respect to the purchasing of service parts and materials that would help address some of these concerns.

B. Purpose

This case provides students with the opportunity to investigate the purchasing function of an organization in the service sector. Students begin to see that the effective management of materials is not only essential in manufacturing environments but is also critical in supporting the delivery of quality services.

Students are confronted by a number of issues as they are asked to recommend a suitable structure for the purchasing function. Included among them are the following:

1. Given the growth in the number of dealerships in the network, should the purchasing function be centralized to take advantage of certain economics of scale, or should it remain decentralized in each separate dealership?

2. Given the different categories of service parts that are purchased, supplier management issues are raised. Some parts may be more appropriately purchased through single-source contracting, whereas others may be competitively bid on by multiple suppliers. Bid awards don't necessarily have to be awarded on the basis of low cost alone. Also some items may be grouped and purchased from the same supplier using blanket orders.

3. Limited space for inventory storage and limited investment dollars complicate the issues. Fast, reliable service in repairing and servicing cars is a key factor in the success of the dealership, but space and dollars limit service part availability to some extent.

4. Finally, students have the opportunity to bring into play basic inventory management concepts such as an ABC analysis to help determine appropriate levels of inventory investment and inventory stocking policies. This case can also be used as a lead-in to Chapter 10, Inventory Management.

* This case was prepared by Dr. Brooke Saladin, Wake Forest University, as a basis for classroom discussion.

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C. Analysis

The analysis of this case can be accomplished in three logical steps. Students should first address the issue of restructuring the purchasing function. Then the inherent policies and procedures to carry out the purchasing processes can be addressed, followed by an analysis of specific inventory management issues that help lead into Chapter 10, Inventory Management.

Major factors to consider in addressing these steps include:

- Presently each individual dealership handles its own purchase and management of service parts and materials.
- The new dealership is an auto supermarket with three different makes of cars sold at the same location. The purchase of this dealership has led to a tightening of financial resources. Having three different makes of cars to service has also created a space constraint in stocking service parts.
- Wolf Motors is trying to reduce the total operating costs in order to compete effectively in a very price competitive market with its "one price-lowest price" strategy, while at the same time it needs to maintain a high level of service. High service levels have traditionally been linked to high levels of inventory of spare parts.
- There is a need to maintain timely delivery of service parts due to the limited space available.
- There are various categories of parts and materials. One key distinction is that some parts are available only from the auto manufacturer or its certified dealer/wholesaler. Other parts and materials (i.e., oil, lubricants, fan belts, and so on) are more generic and can be purchased from a number of sources, including local vendors.
- Parts are not only used to service and repair cars but are also sold over-the-counter to the do-it-yourself mechanic or other repair garages. Therefore, the overall levels of demand and supporting inventory must be coordinated among service needs, sales, and special promotions such as free brake inspections or discounts on oil changes and air-conditioner service. Weather also plays a role in the demand for parts: extreme cold affects the electrical/ignition systems, heat affects the air-conditioning, and rain affects the wipers.

1. *Structural Issues:* Students should first address the structural issues that face Wolf Motors pertaining to the purchase of parts and materials. These issues include two categories of decisions: (1) centralized purchasing versus continuing a decentralized model of letting each dealership purchase and manage its own inventories and (2) the responsibility relationships purchasing should maintain with inventory management and control, to include the distribution of parts for service and over-the-counter sales.

   Although there is some advantage to be gained by maintaining a decentralized, local purchasing function, it appears that Wolf Motors has grown to the point where a more formal central purchasing function is warranted. Wolf's size should give it some economy of scale leverage to help maintain low costs and timely deliveries.

   Within the purchasing function, personnel could be assigned specific responsibilities or vendors such as:

   - Specific auto manufacturers or their certified distributors
   - Wholesale distributors of generic parts such as alternators, carburetors, or brake pads
   - Wholesale distributors of consumable materials such as oils, lubricants, or filters

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The second structural issue pertains to the level of integration that needs to be structured and maintained between purchasing, inventory stocking and control, and parts distribution. Should these be separate functions that "hand off" the responsibility for materials as they flow through the system, or should an integrated supply chain be implemented? The issue is one of being able to balance the purchasing costs, inventory carrying costs, distribution/logistics costs, and target service levels.

2. *Policies and Procedures:* After the structural issues have been discussed, students should consider alternative purchasing options that are available for procuring parts. Given that the parts and materials being purchased differ quite a bit with respect to availability, usage, costs, and delivery lead time, the policies and procedures used to order various parts may be different. Alternative policies that may be used include:
   - ❑ Competitive bidding
   - ❑ Single-source contracting
   - ❑ Blanket orders
   - ❑ Open-ended orders

   Of course, these approaches are not mutually exclusive and may be combined for certain categories of parts. Students should discuss how each of these alternatives may be used for different groups of parts and materials. Going out for competitive bids would be most appropriate for "commodity" type items that are readily available from a number of vendors. Given that other aspects of the service, such as reliability and dependability, are comparable, then a competitive bid will help reduce purchase costs. Where the quality of the parts and/or service provided differs, then a single-source contract may be warranted. This should lead to a partnership arrangement that is beneficial to both parties.

   Blanket orders are used when a number of parts are to be purchased from a single supplier. Blanket orders help reduce the overall ordering and distribution costs by grouping items under a single order. This may be an appropriate procedure for purchasing oils and lubricants from a local supplier or for ordering "factory certified" parts from a manufacturer or its designated distributor.

   Open-ended orders provide flexibility in allowing items to be added or deleted from an order or for the time period of the order to be extended, such as in a blanket order of oil. Through this discussion students will begin to see that all items should not be ordered by the same procedure. Factors such as the item's availability, relative importance, usage levels, and costs will have a significant impact on the way the item should be procured. This has implications also in determining how the purchasing function's performance should be measured and evaluated. Just getting the lowest price is no longer good enough. Other measures of performance, such as product quality, reliable on-time delivery, and ordering flexibility with respect to the size and timing of the order, may be more important than price. This is an important lesson the students should understand.

3. *Inventory Management Issues:* The financial resource and space constraint issues brought out in the case provide the opportunity to discuss the close relationship and necessary integration that purchasing must have with inventory management. Suggested inventory management policies that can be discussed include the three important factors in making inventory stocking-level decisions. These include costs, delivery lead time, and space

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required/available. Students should see that each of these factors can be used to prioritize the different parts and materials to be inventoried.

- ❑ You can discuss the different costs incurred in ordering and carrying inventory to set students up for the trade-offs to be discussed in the Inventory Management chapter.
- ❑ You can bring out the issue of total investment in inventory over time to open the door for a discussion of the ABC analysis in the Inventory Management chapter.
- ❑ There is the issue of where to stock different parts in the storeroom or warehouse. Frequently used material should be stored in easily accessed locations, and a random location system will minimize space requirements.
- ❑ You could also introduce how inventories can be categorized, such as building anticipation stocks for promotions and seasonal use.
- ❑ Finally, perhaps implementing an effective EDI link between locations and suppliers would reduce delivery lead time.

The amount of time and depth of analysis pertaining to the discussion of inventory management issues will depend on how you wish to lead into the chapter on inventory management. You should at least make sure the students see the necessary integration between purchasing and inventory management policies.

D. Recommendations

How the case is used will determine the level of detail you should expect with respect to any recommendations students may make. When used as an in-class exercise without any prior preparation by the students, the focus of the case should be on discussing the issues and recognizing the trade-offs that need to be made in the decisions. If given more time to read and analyze the case, typical recommendations to expect include:

1. Some form of centralization of the purchasing function

2. Development of partnership agreements for "key" parts that perhaps may lead to single sourcing

3. The use of blanket orders to reduce ordering costs and to limit the number of suppliers

4. Open-ended ordering agreements, especially in the "commodity" type materials that can be sourced locally to reduce lead times and minimize inventory investment

5. Perhaps the establishment of a central warehouse facility to reduce overall space requirements while maintaining parts availability in a timely manner

6. Conducting an analysis of inventory cost trade-offs to minimize total costs of inventory policies

E. Teaching Suggestions

This case can be used as either an in-class "cold-call" exercise or an overnight reading and analysis exercise. In either case the class discussion flows well when the instructor follows the order of the discussion questions at the end of the case. The level of detail necessary to make this a good decision case is not present. The case was designed to act as a vehicle to introduce the issues that pertain to purchasing and to show students that the issues are similar

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in both services and manufacturing. Therefore, it is best to begin the discussion by first focusing on how the purchasing function should be organized. Then focus the students on specific policies and procedures that Wolf may implement for different categories of parts. Finally, if time permits, you can begin to introduce some inventory management issues and show how the inventory function interacts with purchasing.

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CASE: BRUNSWICK DISTRIBUTORS

There are two options that need to be considered in the analysis of Brunswick Distribution, Inc. (BDI). The accompanying spreadsheet program, Brunswick Financial Analyzer, can be used to explore various areas where operations can help firms to become more profitable. The program can take any data as a starting point and show how various changes (or shocks) to the status quo will affect the financial measures. It uses the well-known DuPont analysis as a basis for its calculations.

This Instructor's Manual contains full financial statements to accompany the Dupont analysis using the spreadsheet program. The student should use the Financial Analyzer spreadsheet to do a DuPont analysis for Brunswick.

A summary of the conclusions from the analysis of the two options posed in the case follow.

Option 1: Invest in new warehouse facilities

- Inventory turnover improves marginally with this option. (See the DuPont analysis ratios).
- Net income goes up but not enough to make the new investment attractive.
- Declining returns ⇒ The DuPont analysis indicates worsening ratios if this option is adopted. (See the DuPont analysis ratios).
- The investment would put Brunswick in a precarious debt to equity situation.

Option 2: Streamlining the order fulfillment system.

- The *basic* system results in lower profits than the status quo and poor financial ratios. It is clearly not the better of the two alternatives in this option. This alternative can be discarded in favor of the *fully integrated* alternative.
- In this case of the fully integrated system, the DuPont analysis shows improving results in all the ratios with the exception of the sales to total assets ratio.
- Operational measures are mixed. Note that the inventory turns measure actually go down. While inventory valuation goes down (because of the reductions in direct labor costs), the cost of good sold goes down further (because of reductions in shipping costs as well). This points out the weakness in the inventory turns measure when looking at an aggregate inventory. Operationally, it is better to " measure each item's inventory in terms of physical "units" and its demands also in "units." The problem, of course, is getting to an aggregate measure of inventory turns because of the conflicts in units of measure.
- The cash cycle has deteriorated largely because of the decrease in accounts payable. Brunswick needs to work on getting it's A/R days and inventories down.
- The fully integrated option increases the leverage ratios but not as substantially as in Option 1.

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- Another reason why Option 2 is the better than Option 1 is its impact on the stock market performance measures.

While Option 2 – fully integrated system – dominates Option 1, it does not improve the inventory problems at Brunswick. "Inventory days" goes up and "inventory turns" go down. Brunswick may decide to take Option 2 for other reasons. This option may improve customer service and drive increases in customer demands in the future. The analysis of these two options shows the tradeoff in attempting to build market share (Option 1) and becoming more efficient (Option 2). It should be pointed out to the students that the Dupont analysis is a short-term analysis. It is debatable which of the two options may have more long-term benefits.

Educational objectives

- To critically examine the inter-related activities of marketing, finance and operations.
- To study how seemingly small changes in various aspects of the business affect return on equity and financial measures.
- To emphasize that operational changes that affect the cost of goods sold (such as direct materials costs or labor costs) can have an effect on the firm's inventory measures because of the way inventory is valued, even if the actual stock of inventory remains unchanged.

DISCUSSION

Option 1

Income statement

- This option increases annual revenue by $3.6 million.
- This option would increase costs by a total of $1,717,000, split up between shipping ($955 thousand), direct material ($358 thousand), and direct labor cost ($404 thousand).
- Annual depreciation works out to be $500,000, which is computed as straight-line depreciation of the $10 million investment for 20 years. ($10 million/20)
- Annual interest is computed at the rate of 11%. (11%*$12 million = $1,320,000)

Balance sheet

- $1.5 million in accounts receivable.
- $10 million investment in plant and equipment.
- $2 million in property.
- The Financial Analyzer assumes that the new level of inventory investment is equal to the old level, plus direct changes (plus or minus) in the shock column, plus one-half the total

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of the changes to the direct materials on the Income Statement (plus or minus) and the changes to the direct labor on the Income Statement (plus or minus). The Financial Analyzer will automatically do this computation, given the inputs on the Income Statement and the direct inventory shock. Here we have assumed that direct materials changes and the labor changes take place gradually over the course of the year so that the average level is one half of the total.

- On the liability side accounts payable is increased by the amount of the interest from the new loan, adjusted downward for savings in materials and labor, and adjusted for any net changes in taxes. Once the annual interest is entered in the "shock" column, the Financial Analyzer does the computation for you.

- The entire $12 million is assumed to be a long-term loan agreement.

See the complete spreadsheet analysis for Option 1.

Option 2

This option would contribute 16% in direct cost savings for the fully integrated system which is computed as 16% * Cost of sales (16%*$21,620,000). This works out to be $3,460,000 in annual savings split up equally for direct material and direct labor cost – ($1,730,000).

Income Statement

- Annual depreciation works out to be $1,600,000, which is computed as straight-line depreciation of the $8 million investment for five years. ($8M/5)

- Annual interest is computed at the rate of 10%. 10%*$8 million = $800,000.

Balance Sheet

- $8 million investment in plant and equipment.

- On the liability side, accounts payable is computed as being made up of direct material costs net of savings and the additional amount payable on the higher taxes resulting from the savings.

- The entire $8 million is assumed to be a long-term loan agreement.

See the complete spreadsheet analysis for the two alternatives of Option 2.

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Other Issues to Discuss

One of the biggest issues facing BDI is the predictability of sales. Since orders do not come in from retailers in a timely fashion, considerable emphasis is placed on forecasting sales for manufacturers. This forecasting is largely historical and therefore does not reflect the changes that have occurred over the past two years. In order to better determine levels of safety stock, a better integration of the supply chain is required. Getting the end customer involved by showcasing the product in a kitchen-like setting and acquiring forward-looking information from the end user might help Brunswick in determining demand. Perhaps a better approach, however, is to implement vendor managed inventory programs with retailers and using their forecasts of sales in various product lines. This could somewhat alleviate the delayed ordering from the retailer and allow more accurate 60/90/120 ordering to the manufacturer.

With the additional business, and the extra product lines, BDI has acquired some deadweight. The company already supplies the majority of high-end appliances and the new lines have cut in to the profit margins that the company has historically observed. Other financial concerns, such as the poor cash cycle, can be looked at in one of two ways: either bring accounts receivable and accounts payables closer in line by delaying payables whenever possible and placing tighter controls on receivables, or, increase liquidity by obtaining a larger operating loan.

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TN1. Invest in New Warehouse Facilities

Inc. Stmt.		Without Shock $ 000's	Without Shock $ 000's	Shock $ 000's	With Shock	With Shock
Revenue			$33,074	$3,600		$36,674
Cost of Goods Sold						
Shipping costs		$8,931		$955	$9,886	
Direct materials		$5,963		$358	$6,321	
Direct Labor & other		$6,726		$404	$7,130	
Total		$21,620			$23,337	
Gross Profit			$11,454			$13,337
Operating Expenses						
Selling Expenses		$3,820			$3,820	
Fixed Expenses		$4,229			$4,229	
Depreciation		$1,794		$500	$2,294	
Total		$9,843			$10,343	
Earnings Before Interest and Taxes			$1,611			$2,994
Interest Expense		$631		$1,320	$1,951	
Earnings Before Taxes			$980			$1,043
Taxes @	40%	$392			$417	
Net Income			$588			$626
Dividends		$0			$0	
Contribution to Retained Earnings			$588			$626
# of Shares Outstanding		350			350	
Stock Price as of	1/31/1997	$5.00			$5.00	

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TN1 (continued)

Balance Sheet

Assets	Without Shock		Shock	With Shock	
Current Assets					
Inventory	$6,789			$7,170	
Total Inventory		$6,789			$7,170
Cash	$3,223			$3,223	
Accounts Receivable	$5,603		$1,500	$7,103	
Other Current Assets	$1,381			$1,381	
Total CA		$16,996			$18,877
Long-term Assets					
Property	$3,179		$2,000	$5,179	
Plant and Equipment, net	$8,995		$10,000	$18,995	
Long-term Investments	$1,000			$1,000	
Total LTA		$13,174			$25,174
Total Assets		$30,170			$44,051

Liabilities	Without Shock		Shock	With Shock	
Current Liabilities					
Accounts Payable	$1,282		$1,320	$3,389	
Short-term Liabilities				$0	
Notes Payable	$1,099			$1,099	
Short-term Debt	$4,159			$4,159	
Total STL		$6,540			8647.2
Long-term Liabilities					
Long-term Loans	$7,523		$12,000	$19,523	
Bonds				$0	
Other Liabilities				$0	
Total LTL		$7,523			$19,523
Total Debt		$14,063			$28,170
Equity	$1,750			$1,750	
Common Stock				$0	
Paid-in-excess	$428			$428	
Retained Earnings	$13,929			$13,703	
Total Equity		$16,107			$15,881
Total Debt & Equity		$30,170			$44,051

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TN1 (continued)

DuPont Analysis	Without Shock	With Shock	Change	
ROE	3.7%	**3.9%**	**UP**	= Net Income / Equity
ROA	3.2%	**2.4%**	**DOWN**	= EBIT / Total Assets
NPM	1.8%	**1.7%**	**DOWN**	= Net Income / Sales
TATO	109.6%	**83.3%**	**DOWN**	= Sales / Total Assets
Operational Measures				
Current ratio	2.60	**2.18**	**DOWN**	= Current Assets / Current Operating Liabilities
Inventory Turns	3.2	**3.3**	**UP**	= COGS / Inventory
WC to Sales	31.6%	**27.9%**	**DOWN**	= Operating WC / Sales
Fixed Asset Turnover	111.8%	**103.6%**	**DOWN**	= Net Property, Plant, Equipment / COGS
Liquidity				
A/R Days	61.8	**55.8**	**DOWN**	= Accounts Rec. / (Sales / 365) = # of days to collect credit charges
A/P Days	78.5	**195.7**	**UP**	= Accounts Pay. / (Direct Materials / 365)
Inventory Days	114.6	**112.1**	**DOWN**	= Inventory / (COGS / 365)
Cash Cycle	98.0	**(27.8)**	**DOWN**	= A/R Days - A/P Days + Inventory Days
Financial Performance				
Debt- Asset Ratio	46.6%	**63.9%**	**UP**	= Debt / Total Assets
Debt-Equity Ratio	87.3%	**177.4%**	**UP**	= Debt / Equity
Times Interest Earned	2.55	**1.53**	**DOWN**	= EBIT / Interest
Gross Profit Margin	34.6%	**36.4%**	**UP**	= Gross Profit / Sales
Materials %	18.0%	**17.2%**	**DOWN**	= Direct Materials / COGS
Labor %	20.3%	**19.4%**	**DOWN**	= Direct Labor / COGS
Stock Market Performance				
EPS	1.68	**1.79**	**UP**	= Earnings / # of shares outstanding
Earnings / Price	0.34	**0.36**	**UP**	= EPS / Market Price
Market Value/ Book V	0.11	**0.11**	**UP**	= Market Value / Book Value of Equity

Many of the financial and performance ratios degrade relative to the current status. Troubling, however is the debt-equity increase to 177.4%. This is an unreasonably high leverage and may pose difficulties for Brunswick to obtain financing. Inventory turns essentialy do not improve,

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TN2. Streamlining the Order Fulfillment System – Basic

Inc. Stmt.		Without Shock $ 000's	$ 000's	Shock $ 000's	With Shock	
Revenue			$33,074			$33,074
Cost of Goods Sold						
Shipping costs		$8,931		($1,081)	$7,850	
Direct materials		$5,963			$5,963	
Direct Labor & other		$6,726		($1,081)	$5,645	
Total		$21,620			$19,458	
Gross Profit			$11,454			$13,616
Operating Expenses						
Selling Expenses		$3,820			$3,820	
Fixed Expenses		$4,229		$800	$5,029	
Depreciation		$1,794		$1,160	$2,954	
Total		$9,843			$11,803	
Earnings Before Interest and Taxes			$1,611			$1,813
Interest Expense		$631		$530	$1,161	
Earnings Before Taxes			$980			$652
Taxes @	40%	$392			$261	
Net Income			$588			$391
Dividends		$0			$0	
Contribution to Retained Earnings			$588			$391
# of Shares Outstanding		350			350	
Stock Price as of	1/31/1997	$5.00			$5.00	

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TN2 (continued)

Balance Sheet

Assets	Without Shock		Shock	With Shock	
Current Assets					
Inventory	$6,789			$6,249	
Total Inventory		$6,789			$6,249
Cash	$3,223			$3,223	
Accounts Receivable	$5,603			$5,603	
Other Current Assets	$1,381			$1,381	
Total CA		$16,996			$16,456
Long-term Assets					
Property	$3,179			$3,179	
Plant and Equipment, net	$8,995		$5,300	$14,295	
Long-term Investments	$1,000			$1,000	
Total LTA		$13,174			$18,474
Total Assets		$30,170			$34,930

Liabilities	Without Shock		Shock	With Shock	
Current Liabilities					
Accounts Payable	$1,282		$530	$600	
Short-term Liabilities				$0	
Notes Payable	$1,099			$1,099	
Short-term Debt	$4,159			$4,159	
Total STL		$6,540			5857.8
Long-term Liabilities					
Long-term Loans	$7,523		$5,300	$12,823	
Bonds				$0	
Other Liabilities				$0	
Total LTL		$7,523			$12,823
Total Debt		$14,063			$18,681
Equity	$1,750			$1,750	
Common Stock				$0	
Paid-in-excess	$428			$428	
Retained Earnings	$13,929			$14,071	
Total Equity		$16,107			$16,249
Total Debt & Equity		$30,170			$34,930

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TN2 (continued)

DuPont Analysis	Without Shock	With Shock	Change	
ROE	3.7%	**2.4%**	**DOWN**	= Net Income / Equity
ROA	3.2%	**1.9%**	**DOWN**	= EBIT / Total Assets
NPM	1.8%	**1.2%**	**DOWN**	= Net Income / Sales
TATO	109.6%	**94.7%**	**DOWN**	= Sales / Total Assets
Operational Measures				
Current ratio	2.60	**2.81**	**UP**	= Current Assets / Current Operating Liabilities
Inventory Turns	3.2	**3.1**	**DOWN**	= COGS / Inventory
WC to Sales	31.6%	**32.0%**	**UP**	= Operating WC / Sales
Fixed Asset Turnover	80.8%	**89.8%**	**UP**	= Net Property, Plant, Equipment / COGS
Liquidity				
A/R Days	61.8			= Accounts Rec. / (Sales / 365) = # of days to collect credit charges
A/P Days	78.5	**36.7**	**DOWN**	= Accounts Pay. / (Direct Materials / 365)
Inventory Days	114.6	**117.2**	**UP**	= Inventory / (COGS / 365)
Cash Cycle	98.0	**142.3**	**UP**	= A/R Days - A/P Days + Inventory Days
Financial Performance				
Debt- Asset Ratio	46.6%	**53.5%**	**UP**	= Debt / Total Assets
Debt-Equity Ratio	87.3%	**115.0%**	**UP**	= Debt / Equity
Times Interest Earned	2.55	**1.56**	**DOWN**	= EBIT / Interest
Gross Profit Margin	34.6%	**41.2%**	**UP**	= Gross Profit / Sales
Materials %	18.0%			= Direct Materials / COGS
Labor %	20.3%	**17.1%**	**DOWN**	= Direct Labor / COGS
Stock Market Performance				
EPS	1.68	**1.12**	**DOWN**	= Earnings / # of shares outstanding
Earnings / Price	0.34	**0.22**	**DOWN**	= EPS / Market Price
Market Value/ Book V	0.11	**0.11**	**DOWN**	= Market Value / Book Value of Equity

The basic level option results in less profit per year and worsening financial ratios. Average inventories increase and inventory turns decrease.

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TN3. Streamlining the Order Fulfillment System – Full System

Inc. Stmt.		Without Shock $ 000's	$ 000's	Shock $ 000's	With Shock	
Revenue			$33,074			$33,074
Cost of Goods Sold						
Shipping costs		$8,931		($1,730)	$7,201	
Direct materials		$5,963			$5,963	
Direct Labor & other		$6,726		($1,730)	$4,996	
Total		$21,620			$18,160	
Gross Profit			$11,454			$14,914
Operating Expenses						
Selling Expenses		$3,820			$3,820	
Fixed Expenses		$4,229		$800	$5,029	
Depreciation		$1,794		$1,600	$3,394	
Total		$9,843			$12,243	
Earnings Before Interest and Taxes			$1,611			$2,671
Interest Expense		$631		$800	$1,431	
Earnings Before Taxes			$980			$1,240
Taxes @	40%	$392			$496	
Net Income			$588			$744
Dividends		$0			$0	
Contribution to Retained Earnings			$588			$744
# of Shares Outstanding		350			350	
Stock Price as of	1/31/1997	$5.00			$5.00	

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TN3 (continued)

Balance Sheet

Assets	Without Shock		Shock	With Shock	
Current Assets					
Inventory	$6,789			$5,924	
Total Inventory		$6,789			$5,924
Cash	$3,223			$3,223	
Accounts Receivable	$5,603			$5,603	
Other Current Assets	$1,381			$1,381	
Total CA		$16,996			$16,131
Long-term Assets					
Property	$3,179			$3,179	
Plant and Equipment, net	$8,995		$8,000	$16,995	
Long-term Investments	$1,000			$1,000	
Total LTA		$13,174			$21,174
Total Assets		$30,170			$37,305

Liabilities	Without Shock		Shock	With Shock	
Current Liabilities					
Accounts Payable	$1,282		$800	$456	
Short-term Liabilities				$0	
Notes Payable	$1,099			$1,099	
Short-term Debt	$4,159			$4,159	
Total STL		$6,540			5714
Long-term Liabilities					
Long-term Loans	$7,523		$8,000	$15,523	
Bonds				$0	
Other Liabilities				$0	
Total LTL		$7,523			$15,523
Total Debt		$14,063			$21,237
Equity	$1,750			$1,750	
Common Stock				$0	
Paid-in-excess	$428			$428	
Retained Earnings	$13,929			$13,890	
Total Equity		$16,107			$16,068
Total Debt & Equity		$30,170			$37,305

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TN3 (continued)

DuPont Analysis	Without Shock	With Shock	Change	
ROE	3.7%	**4.6%**	**UP**	= Net Income / Equity
ROA	3.2%	**3.3%**	**UP**	= EBIT / Total Assets
NPM	1.8%	**2.2%**	**UP**	= Net Income / Sales
TATO	109.6%	**88.7%**	**DOWN**	= Sales / Total Assets

Operational Measures				
Current ratio	2.60	**2.82**	**UP**	= Current Assets / Current Operating Liabilities
Inventory Turns	3.2	**3.1**	**DOWN**	= COGS / Inventory
WC to Sales	31.6%	**31.5%**	**DOWN**	= Operating WC / Sales
Fixed Asset Turnover	93.3%	**111.1%**	**UP**	= Net Property, Plant, Equipment / COGS

Liquidity				
A/R Days	61.8			= Accounts Rec. / (Sales / 365) = # of days to collect credit charges
A/P Days	78.5	**27.9**	**DOWN**	= Accounts Pay. / (Direct Materials / 365)
Inventory Days	114.6	**119.1**	**UP**	= Inventory / (COGS / 365)
Cash Cycle	98.0	**153.0**	**UP**	= A/R Days - A/P Days + Inventory Days

Financial Performance				
Debt- Asset Ratio	46.6%	**56.9%**	**UP**	= Debt / Total Assets
Debt-Equity Ratio	87.3%	**132.2%**	**UP**	= Debt / Equity
Times Interest Earned	2.55	**1.87**	**DOWN**	= EBIT / Interest
Gross Profit Margin	34.6%	**45.1%**	**UP**	= Gross Profit / Sales
Materials %	18.0%			= Direct Materials / COGS
Labor %	20.3%	**15.1%**	**DOWN**	= Direct Labor / COGS

Stock Market Performance				
EPS	1.68	**2.13**	**UP**	= Earnings / # of shares outstanding
Earnings / Price	0.34	**0.43**	**UP**	= EPS / Market Price
Market Value/ Book V	0.11	**0.11**	**UP**	= Market Value / Book Value of Equity

The fully integrated option dominates the basic option as well as Option 1. The financial ratios are beter, however none of the options addresses the issue of inventory turns. Brunswick may decide on Option 2: Full Implementation for otjher reasons, primarily customer service that may pay off in more customers in the future.

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EXPERIENTIAL EXERCISE: SONIC DISTRIBUTORS

A. Synopsis

The purpose of this exercise is to provide a situation in which students can observe how supply-chain management affects the efficiency and effectiveness of a distribution network. It is designed to be quite flexible. In its simplest form it can be a "quick hit" to give the students an initial exposure to supply chains and thus set them up for a more productive lecture and discussion of the chapter. Alternatively complexity can be added so the efficient and the responsive distribution chains can be compared or more freedom can be allowed making it an analytical simulation to observe and measure the effects of changes to the system. In this last format, students can configure the supply chain for efficiency or responsiveness (or anywhere in between) and then operate it while measuring its supply-chain performance.

Many lessons can be brought out from a discussion of the results of this exercise. It demonstrates the complexities of managing an enterprise where there are multiple parties and information requirements involved. It brings forth the trade-offs that must be made when conflicting goals exist with different costs or benefits. It shows the cost implications of managerial decisions such as establishing safety stock policies and setting production lot sizes. And, it shows the role of time delay on the overall system performance.

The results of this exercise can also lead to further discussions: The distribution of demand for the distribution centers (and thus for the factory) depends not only on the nature of the demand at the retail stores but also on the ordering policies of the retailer and the distribution center. This can lead to a discussion of dependent demand, which sets the stage for the next chapter's material. As a tie-in to applied statistics, the smoothing effect of grouping several independent demands, and perhaps, even the central limit theorem can be teased out of the results. An outline of some of the topics from Chapter 8 that spring from this exercise can be found at the end of this teaching note.

B. Preparation Materials

- Retail and Distributor Purchase Order Forms (one set for each retail store and one set for each of the two distribution centers). A set is made up of one form for each simulated day the game is to be played.
- Manufacturing Work Order Sheet (one set for the factory). The set for the factory contains as many forms as the proposed length of the simulation times the number of distributors it serves.
- Factory and Distributor Material Delivery Forms (one set for the factory and one set for each distribution center that the factory supplies). The size of the set for a distributor is the proposed number of days times the number of retail stores each is to serve.
- Inventory Position Worksheets (one for each retail store, each distribution center, and the factory)
- A random demand generator such as a pair of dice, a deck of playing cards for each team (with all face cards removed) or slips of paper with the numbers 1 to 10 written on them, random number table, a simple computer program, etc.

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Preparation Time Required

Instructor: It will take a couple of hours to read through the material and fully understand the procedure that the students will enact. It is suggested that the instructor personally play several rounds before presenting it in class to the students. The instructor should play the part of all participants (retail stores, distribution centers, and the factory) to best grasp each student's role. Although it appears complex at first, the procedure is fairly simple.

Preclass preparation consists of devising the random demand generators, one for each company (team). If only one type of CD is to be produced (Quick-Hit version), a pair of dice works well (one pair for each retail store is best but a pair can be shared by the stores in a team). If the demonstration is to include all four types of CD demands, an easy demand generator is a shuffled deck of playing cards with all the face cards and jokers removed.

Inventory position and cost calculation worksheets need to be photocopied, one for each retail outlet, distributor, and factory. Likewise, sets of Retail Store and Distribution Center Purchase Order Forms, Factory Work Order Forms, and Factory and Distribution Center Material Delivery Forms need to be photocopied.

Students: Prereading the exercise is suggested; it reduces the startup time. It should take the students only 15 minutes or so to read and understand the instructions. Indicate to the students how the exercise will be run (the "Quick Hit" version in the text or the "Efficient versus Responsive Comparison" or the "Analytical Simulation" versions in this teaching note).

Class Time Required

As with any business simulation, there is a trade-off between realism and feasibility. More detail can yield a more realistic estimate of what true distribution chain costs are. This realism comes at the cost of more effort on the part of the student to perform the exercise. It also can cause more confusion when trying to explain the rationale behind each cost and how to account for it when calculating total cost. Therefore, three versions of the exercise are suggested to allow whatever level of realism the instructor chooses; other configurations are easily devised, depending on the objectives the instructor.

In its simplest form, the "Quick Hit" version can take as little as 45 minutes to run. This has enough detail for the students to observe the dynamics of a supply chain. The "Efficient versus Responsive Comparison" version takes about 75 minutes. The "Analytical Simulation" version generates the most realistic total costs and allows the students try several configurations. Therefore, it can take two hours or more plus additional time for postexercise debriefing and discussion. This longer configuration works best for a one-night-per-week class or if the debriefing and discussion session can take place during the following class. It could also be given as a multiple session exercise if the goal of the instructor is to cover distribution chain performance in depth.

Setting Up

This exercise works well when two or more companies are formed. In any case, companies should be configured with no fewer than two retail outlets drawing from each of the two distributors. Although this is the minimum, more than two retail outlets to each distributor are better because they more clearly demonstrate the effect of averaging stochastic demand at the distributors. If teams of less than 14 must be formed, first assign only one person to the retail stores; next assign only one person to the factory; finally, assign only one to each of the distribution centers. Play will progress a little more slowly because the students working alone will have more to do (both undertake the transactions and record them).

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The following parameters need to be established for each team:

1. Starting conditions:
   Initial inventory of each of the four artist's CDs at the:
   Retail stores—the text suggests 15
   Distribution centers—the text suggests 25
   Factory—the text suggests 100
   Outstanding orders (or backorders—if any) for each of the four CDs at the:
   Distribution centers—the text suggests none
   Factory—the text suggests none
   Note: There will be no backorders at the Retail Stores because any stockout results in a lost sale.

2. Operating considerations:
   Demand patterns—will a quantity of only one artist's CD be sold at a given retail store each day (i.e., each retailer will generate only one random number for demand per round—as for the Quick Hit version) or will several artist's CDs be sold (i.e., each retailer will generate several different random numbers to determine demand)?

3. Costs
   Transportation costs and holding costs in the inventory pipeline are expressly ignored in the Quick Hit version for simplicity.
   Holding cost per unit per day—may be different for each of the stages in the distribution chain.[1] The text suggests:
   Retail outlets—$1.00/day
   Distribution center—$0.50/day
   Factory—$0.25/day
   Ordering/setup cost—may be different for each of the stages in the distribution chain. The text suggests:
   Retail outlets—$20.00/order
   Distribution center—$20.00/order
   Factory setup—$50 per order. For other versions with a capacity limited factory, the setup cost does not recur in subsequent days of production until another order is called for.
   Stockout cost (may be different for each stage—will be equivalent to the contribution margin of a lost sale for the retail stores) the text suggests $8.00 for each CD short in a period.
   Expediting cost (for example, shipping an order by UPS instead of normal freight). The text doesn't suggest a cost for the Quick Hit version.

[1] These holding costs differentials are designed to dissuade students from positioning too much forward inventory at the retail outlets. See a discussion of other possibilities in the parameter list for the Efficient vs. Responsive version, later on.

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4. Delays
   Ordering delay—time from when a purchase order (PO) is issued until it is received. The text suggests one day.
   Delivery delay—time required to assemble, pack, and transport an order once the PO is received. The text suggests one day.
   Production time—time from receiving an order until it is ready for shipment (may be determined by factory production lot sizes). The text suggests one day. If the factory is capacity limited, the delivery delay will be as long as it takes to run the entire order. Partial production runs are not shipped.

5. Lot sizing restrictions—may be EOQ, lot-for-lot, minimum order quantity, or fixed lot size:
   Retail Store orders—the text indicates there are none.
   Distribution Center orders—the text indicates there are none.
   Factory production lot sizes and capacity. Also, the factory may be able to produce multiple types simultaneously or be restricted to producing only one type of CD at a time. For the Quick Hit version, the text suggests a minimum lot size of 20 and an upper limit of 200, which is well above any required production. For the Quick Hit version, this large capacity eliminates the complexity needing to extend a production run over several days.

6. Storage capacity restrictions—the text does not mention any for the Quick Hit version.

All of these parameters will be preset by the instructor for the "Quick Hit" and the "Efficient versus Responsive Comparison" versions. The "Analytical Simulation" version allows students to adjust many of the operating considerations by making lot sizing and cost/performance trade-off decisions.

C. Conducting the Exercise

Break the class into teams and have them sit together so that communication among the team members will be convenient. They can be seated in an area of the classroom or around a large table. Let them arrange themselves to establish effective and efficient transmission chains for the required information (POs and material delivery forms). To include delays in the transmission of POs to suppliers or in the delivery of goods from suppliers, provide a place where the POs and delivery forms can be placed for the required delay periods. If the team is seated at a table, 8 ½ × 11 pieces of paper (one for each source and sink pair) can be fastened on the table and marked as delay stations. If the students are sitting in chairs, an empty chair between the various pairs within the team can serve as a delay station.

Specify the values for the parameters (listed previously) that will be followed for the exercise. Review the sequence of play. If a deck of cards or slips of paper are used to determine demand, specify that at the end of each round (day) the cards or slips that were drawn should be returned to the deck and the deck reshuffled. Go over the items that are to be recorded on the worksheets. Start off with a few practice rounds to be sure each student understands his or her task, how the data are gathered, and how play progresses.

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To simplify record keeping, have the students adopt an MRP "midpoint convention" for recording transactions. This assumes all transactions occur simultaneously in the middle of the day—scheduled receipts arrive, demand is determined and met, and any shortages occur, all at noon. Inventory recorded in the inventory position worksheet is the ending inventory after all these transactions occur.

Regardless of the version, for each simulated day the sequence of play goes as follows:

Retailer:

a. Each retailer receives any shipment due in from their distributor (one day after shipment) and places it into sales inventory (adds the quantity indicated on any incoming Material Delivery Form from the distributor—after its one-day delay—to the current inventory level on the Retailer's Inventory Position Worksheet). Note: for the first day of the exercise no order will be coming in.
b. The retailers each determine the day's retail demand (the quantity of CDs requested) by rolling a pair of dice. The roll determines the number demanded.
c. Retailers fill demand from available stock if possible. Demand is filled by subtracting it from the current inventory level indicated on the worksheet. If demand exceeds supply, sales are lost. Record all lost sales on the worksheet.
d. Retailers determine whether an order should be placed. If an order is required, the desired quantity of CDs is written on a Retail Store Purchase Order, which is forwarded to the distributor (who receives it after a one-day delay). If an order is made, it should be noted on the worksheet. Retailers may also desire to keep track of outstanding orders separately.

Distributor:

a. The distributor receives any shipment due in from the factory and places the CDs in available inventory (adds the quantity indicated on any incoming Material Delivery Form from the factory—after its one-day delay—to the current inventory level on the distributor's Inventory Position Worksheet).
b. All outstanding back orders are filled (the quantity is subtracted from the current inventory level indicated on the worksheet) and prepared for shipment. CDs are shipped by filling out a Distribution Center Material Delivery Form indicating the quantity of CDs to be delivered.
c. The distributor uses the purchase orders received from the retail stores (after the designated one-day delay) to prepare shipments for delivery from available inventory. Quantities shipped are subtracted from the current inventory level on the worksheet. If insufficient supply exists, back orders are generated.
d. The distributor determines whether a replenishment order should be placed. If an order is required, the quantity of CDs is written on a Distribution Center Purchase Order, which is forwarded to the factory (after a one-day delay). If an order is made, it should be noted on the worksheet. The distributor may also desire to keep track of outstanding orders separately.

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Factory:

a. The factory places any available new production into inventory (adds the items produced the previous day to the current inventory level on the Factory Inventory Position Worksheet).
b. All outstanding back orders are filled (the quantity is subtracted from the current inventory level indicated on the worksheet) and prepared for shipment. CDs are shipped by filling out a Factory Material Delivery Form, indicating the quantity of CDs to be delivered.
c. The factory obtains the incoming distributor's purchase orders (after the designated one-day delay) and ships them from stock if it can. These amounts are subtracted from the current values on the inventory worksheet. Any unfilled orders become back orders for the next day.
d. The factory decides whether to issue a work order to produce CDs either to stock or to order. If production is required, a Factory Work Order is issued and the order is noted on the inventory worksheet. Remember that the setup cost is for each *production* order. It is important to keep careful track of all production in process.

When all parties have completed and recorded their day's transactions, go back to Retailer Step a and repeat. Make the students aware that, once an order is placed, it cannot be changed (unless, of course, you wish to simulate the ability to amend orders).

The exercise must be run long enough in order for the interactions within the system to be revealed. The number of rounds required will depend on the parameters that are selected. In general, if feedback is sluggish (the time between issuing a PO and the receipt of inventory is two or more days), as many as 40 simulated days may be required to see the effects of the system dynamics. If feedback time is short, the number of required rounds may be reduced at the expense of fully developing the dynamic characteristics in the system.

When the exercise is concluded, have each entity (retailer(s), distributor, and the factory) calculate the total cost of operation.

For retail stores, find the total of:

1. The cumulative amount of inventory of each type of CD (there will be only one type of CD if the Quick Hit version is run). Add the inventory position numbers in each of the two columns on the worksheet for each type of CD and then multiply the total by the holding cost per CD per day.

2. The total ordering cost. Count the number of times an order was placed and multiply by the ordering cost.

3. The total stockout cost. Add the numbers in each of the two columns on the worksheet for stockouts and multiply the total by the cost per lost sale.

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For distribution centers, find the total of:

1. The cumulative amount of inventory of each type of CD (only one type if Quick Hit version). Add the numbers in each of the two columns on the worksheet for each type of CD and then multiply the total by the holding cost per CD per day.

2. The total ordering cost. Count the number of times an order was placed and multiply by the ordering cost.

For the factory, find the total of:

1. The cumulative amount of inventory of each type of CD (only one type if Quick Hit version). Add the numbers in each of the two columns on the worksheet for each type of CD and then multiply the total by the holding cost per CD per day.

2. The total setup cost. Count the number of times a production order was placed and multiply by the setup cost.

Then add up the costs of all the entities. The lower the total cost, the better the team operated the distribution chain.

D. "Quick Hit" Version (the version in the text)

In this version, only one type of CD is produced and there is only one Distribution Center. The team breakout, procedures, costs, and conditions for this version are given in the text. Distribute the materials to each team (the worksheets, order and delivery forms, and the random demand generator). Assuming that they have already read the exercise description and instructions, briefly review the sequence of steps they will follow in each round (simulated day). Remind them of the values they need to use for each of the operating parameters (costs and conditions).

Allow the students to complete a couple of practice rounds so that each person knows his or her task. Then have them reset to the starting conditions (no pipeline inventory and the initial quantities in stock) and begin the exercise. Let them go until most teams have at least 25 rounds completed, more if you have time.

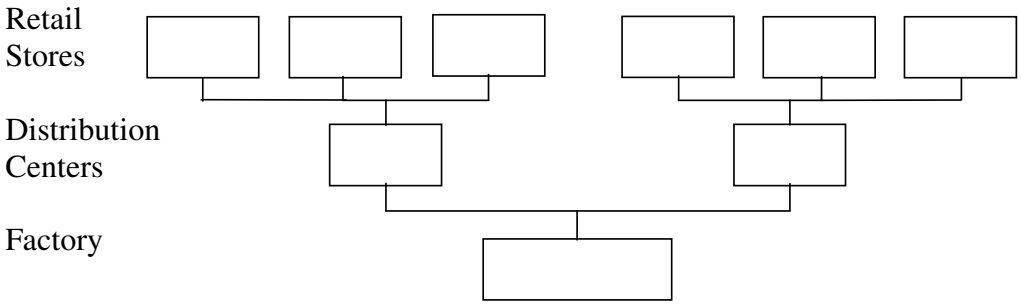
When completed, have them determine the total cost of their operation. Discussion can then begin.

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E. Efficient Versus Responsive Comparison

Divide the class into two companies (teams) of 16 to 26 or so, although, if necessary, as few as 7 can form a team:

2 people schedule production at the factory
2 people operate each of the two distribution centers
The remaining pairs of people operate the retail stores



At each of the distribution centers and retail stores, one person determines demand and fills the orders while the other records and graphs inventory levels as play progresses. Both help decide when and how much to order. The goal is to achieve the lowest total operating costs for the entire distribution chain.

In these expanded versions **four** groups currently have top-10 recordings being sold. They are: Jake Spade and the Diggers, The Heartmenders, Diamonds in the Ruff, and Kulture Klub. Consequently, playing cards make a convenient way of determining demand. When using cards, the daily retail demand for a given group's recording at a given retail outlet is determined by drawing a playing card. The suit determines which group's CDs sold that day and the pip (the number) indicates how many were sold.

Briefly review the sequence of steps they will follow in each round. Then give the students the following parameters for their production:

Starting conditions for both teams:

Initial inventory of each of the four artist's CDs at the:

Retail stores—15 CDs of each artist
Distribution centers—25 CDs of each artist
Factory—50 CDs of each artist

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Team 1—Efficient Supply Chain

Costs:

Holding cost per unit per day:[2]

Retail outlets: $1.00/CD/day

Distribution centers: $0.50/CD/day

Factory: $0.25/CD/day

Pipeline inventory cost: These costs can be ignored or added in depending on the level of realism desired (because they are linear, they don't affect the best decisions to make, only the total cost that is generated). If you choose to include them, add another column to the inventory position worksheets for the DCs and the factory next to the inventory column. Explain that the DC pays inventory holding costs on open orders (inventory shipped to the retailers but not yet received), and the factory pays inventory costs for open orders sent to the DCs.

Ordering cost (retailers and distributors): $20/order for single or mixed types.

Factory setup cost (to run an order): $50 (unless the subsequent order is for the same type CD as the preceding order).

Stockout (lost margin) cost for retail stores: $8 per CD sale lost in a period.

Back orders: There is no cost for back orders due to shortages from the factory or the distribution centers, although all back orders must be filled first before shipping new orders.

Shipping cost: One alternative is to ignore this cost by using the rationale that, as other products are already being distributed through this chain and CDs are light and take up little volume, the cost is essentially zero. If you desire more realism, a per shipment (or per unit) shipping cost can be included.

Expediting cost (for example, shipping an order by UPS instead of normal freight): $1 per CD.

Outstanding orders:

Retail outlets and distribution centers: no orders.

Existing factory order: 200 Kulture Klub CDs in production, the first 50 to be delivered next period.

Lot sizing restrictions:

Retail store orders—minimum order: 20 of each artist. More may be ordered if desired.

Distribution center orders—minimum order: 100 of each artist. More may be ordered if desired.

Factory production lot sizes and capacity: Limited to only one type CD at a time. Produce in lots of 200 at the rate of 50 per day (i.e., an order takes four days to complete but 50 units are available the day after production starts).[3]

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[2] As with the Quick Hit version, these cost differentials are designed to prevent too much forward placement of inventory. One possibility is to make the costs more equal, but impose capacity limits on how much a retailer is willing to hold. Another possibility is to make the lead time from the factory longer than from the DC to the retailers.

[3] The factory capacities should be adjusted upward if there are more than six retail stores drawing off a single factory's production. Using playing cards, the average demand is 5.5 CDs per store per day. With four retail stores the factory will experience a mean demand of 22 CDs per day, and the peak demand can occasionally approach 40. Having a production capacity of 50/day makes meeting demand without a lot of forward placed inventory a challenge. With more than four retail outlets, the capacity cushion becomes very thin. Six retail outlets give a mean demand of 33 with a peak of 60. Although the increased number of retail outlets reduces the variability of

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Delays

Ordering delay: 1 day transit time for orders between retail stores and distributors and between distributors and the factory. Note: As an alternative, you may wish to allow this "efficient" firm to employ electronic data interchange (EDI) and allow the team to electronically forward orders with no delay. This capability is provided to the other "responsive" firm.

It takes one day to start up production (i.e., a one-day delay) if the factory has not been producing anything the previous day. There is no delay if immediately starting a second order of an existing CD or switching to a new type CD.

Delivery delay: 1-day delivery time between distributors and retail stores and between the factory and the distributors.

Team 2—Responsive Supply Chain

Costs:

Holding cost per unit per day (see footnote 2 above):

Retail outlets: $2.00/CD/day

Distribution Centers: $1.00/CD/day

Factory: $0.50/CD/day

Pipeline inventory cost: These costs can be ignored or added in depending on the level of realism desired (as they are linear, they don't affect the best decisions to make, only the total cost that is generated). If you choose to include them, add another column to the inventory position worksheets for the DCs and the factory next to the inventory column. Explain that the DC pays inventory holding costs on open orders (inventory shipped to the retailers but not yet received), and the factory pays inventory costs for open orders sent to the DCs.

Ordering cost (retailers and distributors): $20/order for single or mixed types

Factory setup cost (to run an order): $25 (unless the subsequent order is for the same type CD as the preceding order).

Stockout (lost margin) cost—retail store: $16 per CD sale lost in a period.

There is no cost for back orders for shortages from the factory or the distribution centers, although all back orders must be filled first before shipping new orders.

Expediting cost (for example, shipping an order by UPS instead of normal freight): $.50 per CD. (This is suggested to be lower than for the efficient chain using the rationale this is planned for and, thus, can be contracted at a lower cost.)

Lot sizing restrictions—none: all orders may be made lot-for-lot including factory production lot sizes.

Factory capacity: 50 units/day, may be of mixed types (see footnote 3).

Outstanding orders: no orders for retail outlets, distribution centers, or the factory.

Delays

Ordering delay: none. Using EDI, orders placed in one period can be acted on the following period. This includes the factory. Furthermore, the factory should be informed about all retail store purchase orders at the time they are made, although they do not ship to the distribution centers until a request for inventory has been issued.

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the demand experienced by the factory, it becomes very hard to avoid stockouts. More than six retail outlets require increased capacity at the factory.

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Delivery delay: orders received are shipped the same day. They are available for use the following day. Note: As an alternative, you may wish to maintain a delivery delay, say, of one day.

Have the two teams run 30 to 40 rounds and then allow the students to compare the performance of the two different types of supply chains using the data gathered on their worksheets. To focus the discussion, suggest to the students that they use Tables 11.2 and 11.3 found in the text as a guide for comparison.

F. "Analytical Simulation" Version

This version allows the students to see how the various distribution chain parameters (see the list under "Setting Up" in Section B) affect performance. It can be run by forming two or more teams, each designing a distribution system by selecting values for their distribution system's parameters based on their understanding of the chapter material. The teams run their various systems simultaneously (like in the "Efficient Versus Responsive Comparison" version). After sufficient periods have been simulated, the teams come together to discuss and compare the effectiveness of their distribution system designs.

Alternatively, it can be run with the class operating as one team. Have them select the way they want to design the distribution system and then run it for a while to establish how well it performs. They can then discuss the results, adjust various parameters, and rerun the exercise to see if performance has been improved. This alternative works best for smaller sized classes.

In either case, the instructor will need to establish values for the various operating costs and set limits over which the other parameters can reasonably range. Other variations can be included as well. For instance, it could be permissible to allow the factory or DCs to position inventory forward (as anticipation inventory) rather than waiting for a purchase order to better synchronize the entire distribution chain. It is also possible to allow for partial shipments to better allocate scarce resources.

G. Debriefing/Discussion

When any of the versions of the game have been completed, there will be an opportunity to discuss many of the topics that are covered in Chapter 11 of the text. Some of the more relevant of these topics are outlined below. Furthermore, any of these topics can become issues to include for investigation when playing the analytical version of the game.

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Possible disruptions to model:
- External supply chain causes
  - Volume changes
  - Product mix changes
  - Delivery delays
  - Partial shipments
- Internal supply chain causes
  - Production failure
  - Product modifications
  - New products
  - Promotional demand peaks
  - Information
- Value analysis
- Where to stock
  - Forward placement
  - Backward placement (Even out variations in demand—inventory pooling. This could be simulated by developing a bimodal demand generator—include face cards and have them worth 25 CDs.)
- Supply-chain performance measures
  - Holding costs (Table 11.1)
    - Aggregate inventory value (the different types of CDs could be valued differently)
    - Week's supply
    - Inventory turns
  - Production costs:
    - Setups
    - Lot sizes
    - Material purchases (quantity and supplier lead-time)
    - Defects—yield (relate to required speed of delivery and length of run)
  - Transport (shipping) costs
    - Truckload vs. LTL common carrier vs. UPS
  - Tardiness costs
    - Time delay
    - Lost sales, back orders (measured as percent on-time delivery)

Students can also be shown the imbalance that exists between a flow shop production and a product that needs to be flexible by decreeing that the factory only produce in large, multiday runs.

It may also be instructive to have the students graph their inventory positions over the duration of the exercise to better display the supply chain dynamics. It will become evident that the greater the delays in the delivery of the POs and the shipment of the CDs, the more wild the resulting inventory level excursions.

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Some students may wish to write a computer simulation to replicate this exercise. By doing so and then experimenting with the model, they will develop a deeper appreciation for the system dynamics that evolve from adjusting various parameters. Although a simulation is an interesting tool, most students will not gain much by playing with a model created by someone else. The inner workings are not clear enough to develop a full understanding of the interactions that take place. However by participating in the in-class exercise, these interactions become more evident and can be better appreciated.

H. Worksheets

Two sets are provided; one for the single product version ("Quick Hit"), and one for the other two multiple product versions. Duplicate as many of these as needed (see "Materials" section of the instructions).

One thing expressly left out of the worksheets is a column for keeping track of what has been ordered but not yet delivered. This is to allow the students to discover, on their own, the importance of keeping track of outstanding orders so that double ordering does not occur. If you do not wish this to be a self-discovery exercise, you can add a column to the Inventory Position Worksheets for this information to be recorded.

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Forms for Single Product (Quick Hit) Version:

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
Quantity:		

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Forms for Single Product (Quick Hit) Version:

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

DISTRIBUTION CENTER P. 0.	
Day Sent:	Day Rec'd.:
Quantity:	

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Forms for Single Product (Quick Hit) Version:

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
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FACTORY WORK ORDER	
Day Placed:	Day Complete:
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FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
Quantity:	

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Forms for Single Product (Quick Hit) Version:

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

FACTORY MATL. DELIVERY FORM	
Day Shipped:	Day Rec'd.:
Quantity:	

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Forms for Single Product (Quick Hit) Version:

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

DIST. CNTR. MATL. DELIV. FORM		
To Store:	Day Ship:	Day Rec.:
Quantity:		

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Retailer Inventory Position Worksheet—One for each Retail Store

INVENTORY POSITION				**RETAIL STORE #**			
Day	Ending Inven-tory	Stock-outs	Quantity Ordered	Day	Ending Inven-tory	Stock-outs	Quantity Ordered
1				21			
2				22			
3				23			
4				24			
5				25			
6				26			
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			
Cumulative sum of both columns for each category Total number of check marks for orders							
Holding cost/day/unit in first column, stockout cost (lost sale per unit) in second column, ordering cost/order in last column							
Cumulative holding, ordering, and stockout costs							
Total operating cost (sum of all costs)							

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Distributor Inventory Position Worksheet—One for each Distribution Center

DISTRIBUTION CENTER INVENTORY POSITION							
Day	Ending Inven-tory	Back Orders	Quantity Ordered	Day	Ending Inven-tory	Back Orders	Quantity Ordered
1				21			
2				22			
3				23			
4				24			
5				25			
6				26			
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			
Cumulative sum of both columns for each category Total number of check marks for orders							
Holding cost/day/unit in first column, ordering cost/order in last column						0	
Resulting cumulative holding and ordering costs							
Total operating cost (sum of both costs)							

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Factory Inventory Position Worksheet

FACTORY INVENTORY POSITION							
Day	Ending Inventory	Back Orders	Production Order	Day	Ending Inventory	Back Orders	Production Order
1				21			
2				22			
3				23			
4				24			
5				25			
6				26			
7				27			
8				28			
9				29			
10				30			
11				31			
12				32			
13				33			
14				34			
15				35			
16				36			
17				37			
18				38			
19				39			
20				40			
Cumulative sum of both columns for each category Total number of check marks for orders							
Holding cost/day/unit in first column, production order cost/order in last column						0	
Resulting cumulative holding and ordering costs							
Total operating cost (sum of both costs)							

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Forms for Multiple Product Versions:

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

RETAIL STORE PURCHASE ORDER		
Retailer:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

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Forms for Multiple Product Versions:

DISTRIBUTION CENTER P. 0.		
Center:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

DISTRIBUTION CENTER P. 0.		
Center:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

DISTRIBUTION CENTER P. 0.		
Center:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

DISTRIBUTION CENTER P. 0.		
Center:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

DISTRIBUTION CENTER P. 0.		
Center:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

DISTRIBUTION CENTER P. 0.		
Center:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

DISTRIBUTION CENTER P. 0.		
Center:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

DISTRIBUTION CENTER P. 0.		
Center:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

DISTRIBUTION CENTER P. 0.		
Center:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

DISTRIBUTION CENTER P. 0.		
Center:	Day Sent:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

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Forms for Multiple Product Versions:

FACTORY WORK ORDER	
Day Placed:	Day Complete:
CD Artist—Check One:	Quantity:
Jake Spade and the Diggers	
The Heartmenders	
Diamonds in the Ruff	
Kulture Klub	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
CD Artist—Check One:	Quantity:
Jake Spade and the Diggers	
The Heartmenders	
Diamonds in the Ruff	
Kulture Klub	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
CD Artist—Check One:	Quantity:
Jake Spade and the Diggers	
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Kulture Klub	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
CD Artist—Check One:	Quantity:
Jake Spade and the Diggers	
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Day Placed:	Day Complete:
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CD Artist—Check One:	Quantity:
Jake Spade and the Diggers	
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Kulture Klub	

FACTORY WORK ORDER	
Day Placed:	Day Complete:
CD Artist—Check One:	Quantity:
Jake Spade and the Diggers	
The Heartmenders	
Diamonds in the Ruff	
Kulture Klub	

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Forms for Multiple Product Versions:

FACTORY MATL. DELIVERY FORM		
To Cntr:	Day Ship:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

FACTORY MATL. DELIVERY FORM		
To Cntr:	Day Ship:	Day Rec.:
CD Artist:		Quantity:
Jake Spade and the Diggers		
The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

FACTORY MATL. DELIVERY FORM		
To Cntr:	Day Ship:	Day Rec.:
CD Artist:		Quantity:
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The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

FACTORY MATL. DELIVERY FORM		
To Cntr:	Day Ship:	Day Rec.:
CD Artist:		Quantity:
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The Heartmenders		
Diamonds in the Ruff		
Kulture Klub		

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To Cntr:	Day Ship:	Day Rec.:
CD Artist:		Quantity:
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CD Artist:		Quantity:
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Jake Spade and the Diggers		
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Diamonds in the Ruff		
Kulture Klub		

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Retailer Inventory Position Worksheet—One for each Retail Store

RETAIL STORE INVENTORY POSITION WORKSHEET							RETAIL STORE #						
	Ending Inventory				Stock-outs	Order Quantity		Ending Inventory				Stock-outs	Order Quantity
Day	«	a	©	••			Day	«	a	©	••		
1							21						
2							22						
3							23						
4							24						
5							25						
6							26						
7							27						
8							28						
9							29						
10							30						
11							31						
12							32						
13							33						
14							34						
15							35						
16							36						
17							37						
18							38						
19							39						
20							40						
Cumulative sum of both columns for each category Total number of check marks for orders													
Cost/unit (supplied by instructor). Holding cost/day/unit in first four columns, stockout cost (lost sale per unit) in fifth column, ordering cost/order in last column													
Cumulative holding, ordering, and stockout costs													
Total operating cost (sum of all costs)													

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Distributor Inventory Position Worksheet—One for each Distribution Center

DISTRIBUTION CENTER INVENTORY POSITION WORKSHEET							CENTER #						
	Ending Inventory				Back Orders	Order Quantity	Ending Inventory					Back Orders	Order Quantity
Day	«	a	©	••			Day	«	a	©	••		
1							21						
2							22						
3							23						
4							24						
5							25						
6							26						
7							27						
8							28						
9							29						
10							30						
11							31						
12							32						
13							33						
14							34						
15							35						
16							36						
17							37						
18							38						
19							39						
20							40						
Cumulative sum of both columns for each category Total number of check marks for orders													
Cost/unit (supplied by instructor) Holding cost/day/unit in first four columns, ordering cost/order in last column.													
Resulting cumulative holding and ordering costs													
Total operating cost (sum of all costs)													

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Factory Inventory Position Worksheet

FACTORY INVENTORY POSITION WORKSHEET													
	Ending Inventory				Back Orders	Production Order						Back Orders	Production Order
Day	«	a	©	••			Day	«	a	©	••		
1							21						
2							22						
3							23						
4							24						
5							25						
6							26						
7							27						
8							28						
9							29						
10							30						
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13							33						
14							34						
15							35						
16							36						
17							37						
18							38						
19							39						
20							40						
Cumulative sum of both columns for each category Total number of check marks for orders													
Cost/unit (supplied by instructor) Holding cost/day/unit in first four columns, production order cost/order in last column													
Resulting cumulative holding and production costs													
Total operating cost (sum of all costs)													

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Chapter 2 Supply Chain Management

Supply-chain management seeks to synchronize a firm's functions and those of its suppliers to match the flow of materials, services, and information with customer demand. SCM has tremendous strategic implications, as it can be used to achieve important competitive priorities.

TEACHING TIP
Discuss how Nikon achieved significant results by redesigned supply chain. .

Note: Figure 2.1 Supply Chain Efficiency is the motivation for this chapter. The blue line is an efficiency curve which shows the trade-offs between costs and performance for the current supply chain design. It illustrates the best possible performance when the best in the industry are considered. The red dot indicates inefficient supply chain operations. The challenge is to move operations into the tinted area close to the curve. If new competitive innovations are developed the firm might be able to push the entire performance frontier outward as shown by the dashed red line.

A. Supply Chain Strategies

For a products or services to maximize its potential in the marketplace, managers must match supply chain design to the operational strategy of the firm and the characteristics of the product or service.

TEACHING TIP
It is important to discuss the theory that supply chains can be designed to achieve certain competitive priorities.

1. Linking firms to deliver value

- All the suppliers in a firm's supply chain play an integral role in its ability to meet its competitive priorities for the customer benefit bundle
- Tier 1 suppliers provide materials or services that are used directly by the firm, tier 2 suppliers supply tier 1 suppliers, and so on
- The performance of one firm determines the flow of services or products downstream to the next stage of the supply chain

2. Efficient versus responsive supply chains
   a. Efficient supply chains
      - Work best in environments where demand is highly predictable
      - The focus of the supply chain is on efficient flows of services and materials keeping inventories to a minimum

- The firm's competitive priorities are low-cost operations, consistent quality, and on-time delivery

b. Responsive supply chains
   - Designed to react quickly in order to hedge against uncertainties in demand
   - Work best when firms offer a great variety of services or products and demand predictability is low
   - New-service/product introduction is frequent
   - Typical competitive priorities are development speed, fast delivery times, customization, variety, volume flexibility, and top quality

3. Implementing the right design
   - The alignment with operational strategy and implementation for efficient and responsive supply chains is summarized in **Table 2.2**.

Table 2.2: Design Features of Efficient and Responsive Supply Chains

Factor	Efficient supply chains	Responsive supply chains
Operations strategy	Make-to-stock or standardized services or products; emphasize high volumes	Assemble-to-order, make-to-order, or customized services or products; emphasize variety
Inventory investment	Low; enable high inventory turns	As needed to enable fast delivery time, use modular components
Lead time	Shorten, but do not increase costs	Shorten aggressively
Supplier selection	Emphasize low prices, consistent quality, on-time delivery	Emphasize fast delivery time, customization, variety, volume flexibility, high performance design quality

4. Outsourcing processes

a. Break-even analysis for make-or-buy decisions
   - Break even quantity

$$Q = \frac{F_m - F_b}{c_b - c_m}$$

b. Outsourcing
   - Outsourcing is the act of a firm's paying suppliers and distributors to perform the required processes and provide needed services and materials
   - Advantages of outsourcing
     - Better quality and cost savings
     - Attractive if low volumes or specialized expertise is required
   - Offshoring Involves moving processes to another country
   - Pitfalls of outsourcing and offshoring
     - Overlooking major opportunities to fix existing processes

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- Technology transfer
- Process integration

c. Vertical integration
   - Backward integration—toward the sources of raw materials, parts, and services through acquisitions
   - Forward integration—acquires more channels of distribution
   - Advantages of vertical integration
     - If a firm has the right skills, volume, and resources, then vertical integration allows the firm to perform processes at lower cost and higher quality than outsiders

TEACHING TIP
Discuss Example 2.1 the break-even analysis for the outsourcing decisions

B. Measures of Supply Chain Performance

Supply chain management involves managing the flow of materials that create inventories in the supply chain.

1. Forms of inventory
   - The three categories of inventories are:
     - raw materials (RM)
     - work-in-process (WIP)
     - finished goods (FG)
   - Manufacturers spend 60% of sales on purchased materials and services, and service providers spend as much as 40% so the management of materials flows is therefore important from a cost perspective alone

2. Inventory placement
   - Fundamental supply decision is where to keep inventories
   - Inventory pooling: keeping all finished goods inventory at the manufacturing plant and shipping directly to customer, reducing inventory and safety stock through the merging of variable demands from customers
   - Forward placement: putting the inventory close to the customer and enhancing fast delivery times and reducing transportation costs, may require duplicating stocking of the same item in several locations

3. Inventory measures
   - Average aggregate inventory value

     Average aggregate inventory value = $(N_a c_a) + (N_b c_b) +_ \ldots _+ (N_n c_n)$

     where:

N_a =_ Average quantity of materials, part, component, of product *a*
ca =_ Average cost per unit of materials, part, component, of product *a*
n _= Total number of materials, parts, components, and products

- Total value of all items held in inventory by a firm
- Expressed in dollar values because the sum of individual items in raw materials, work-in-process, and finished goods values can be determined
- It is an average because it usually represents the inventory investment over some period of time
- This tells managers how much of a firm's assets are tied up in inventory

- Weeks of supply
  - Measure obtained by dividing the average aggregate inventory value by sales by sales per week at cost
  - Formula expressed

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

  - In some low-inventory operations, days or even hours are a better unit of time
- Inventory turnover

$$\textit{Inventory turnover} = \frac{\text{Annual Sales (at cost)}}{\text{Average aggregate inventory value}}$$

  - Measure obtained by dividing annual sales at cost by the average aggregate inventory level maintained during the year

TEACHING TIP
See solved problem at the end of the chapter for a detailed example of the three inventory measures

4. Process measures
   a. Four core processes discussed in Chapter 1 are translated into specific operating measures in Table 2.3

TEACHING TIP
Students do not have a difficult time with the weeks of supply or the inventory turns calculations, but they have a lot of difficulty understanding how these measures relate to typical financial measures they discuss in accounting or finance classes. Reserve some time to discuss the following measures and how they relate to the inventory measures. Review Figure 2.4 Inventory at successive stacking points.

5. Financial measures

a. Total revenue

- Increasing the percent of on-time deliveries to customers will increase total revenue because satisfied customers will buy more services and products

b. Cost of goods sold

- Being able to buy materials at a better price and process, or transform them more efficiently, will improve the firm's cost of goods sold, and ultimately net income

c. Selling, general, and administrative expenses

- Designing a supply chain with minimal capital investment can reduce overhead and depreciation charges

d. Cash flow

- The difference between flow of funds into and out of an organization
- Cash-to-Cash is the time lag between paying for services and materials needed to produce a service or product and receiving payment for it
- The shorter the time lag, the better the cash flow position of the firm because it needs less working capital
- The goal is to have a negative cash-to-cash situation, which is possible when the customer pays for service or product before the firm has to pay for the resources and material needed to produce it

e. Working capital

- Money used to finance ongoing operations
- Decreasing weeks of supply or increasing inventory turns reduces the working capital needed to finance inventories

f. Return on assets

- Can be increased by reducing costs of fixed investments such as warehouses and aggregate inventory investment
- Techniques for reducing inventory, transportation, and operating costs related to resource usage and scheduling are discusses in the chapter to follow

TEACHING TIP

Discuss Figure 2.5: How supply chain decisions can affect financial performance

C. Supplier Relationship Process

The supplier relationship focuses on the interaction of the firm and upstream suppliers and there are several important decision areas that can affect this relationship.

1. Sourcing

- Purchasing is in a good position to select suppliers for the supply chain

a. Selection

- Price
- Quality
- Delivery
- Green purchasing
  - Supplier with strong environmental impact

b. Supplier certification
- Verify that potential suppliers have the capability to provide the materials or services the buying firm requires
- Typically involves visits by cross-functional teams to do an in-depth evaluation of the supplier's processes

2. Design collaboration
- Designing new services or products with key supplier's
- Facilitates concurrent engineering, eliminating costly delays and mistakes
- Early supplier involvement
  - Includes suppliers in the design phase
- Pre-sourcing
  - Suppliers given significant, if not total, responsibility for the design of components or systems
- Value analysis
  - Systematic effort to reduce the cost or improve the performance of products or services

3. Negotiation

a. Competitive orientation
- A zero-sum game
- The purpose is to drive costs down to the minimum level
- Power in the supply chain relates to the purchasing clout a firm has

b. Cooperative orientation
- A partnership between buyers and sellers
- This orientation implies long-term commitments, joint work on quality, and buyer support of infrastructure
- Typically, fewer suppliers are needed in this arrangement, e.g. sole sourcing

TEACHING TIP
Use the example of Sharp discussed in the beginning of Chapter 8.

- Some firms use mixed strategy. Key is to use the approach that service the firm's competitive priorities best

4. Buying

- Discuss four approaches to e-purchasing
  a. Electronic data interchange (EDI)
     - A technology that enables the transmission of routine business documents over a computer network
  b. Catalogue hubs
     - Posting of a centralized online catalogue for pre-approved items
  c. Exchanges
     - An electronic marketplace where buying firms and selling firms come together
  d. Auctions
     - An exchange where firms place competitive bids for items
  e. Centralized versus localized buying
     - Centralized
       ⇒ Advantage of increases purchasing clout
       ⇒ Disadvantage is loss of control at the local level
     - Localized
       ⇒ Desirable for items unique to a particular facility
       ⇒ For purchases that must be closely meshed with production schedules
       ⇒ Advantage when the firm has major facilities in foreign countries because the managers there, often foreign nationals, have a much better understanding of the local culture than staff members at the home office

5. Information exchange

a. Radio frequency identification
   - A method for identifying items through the use of radio signals from a tag attached to an item (RFID)
   - Data from the tags can be transmitted wirelessly from one place to another through electronic product code (EPC) networks and the Internet, making it theoretically possible to uniquely identify every item a company produces and track it until the tag is destroyed

b. Vendor-managed inventories
   - An extreme application of the forward placement tactic where supplier locates inventories at the customer's facility
     - Inventories are on consignment and are paid for only when used
     - Key elements:
       - Collaborative effort
       - Cost savings
       - Customer service

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        - Written agreement
    - Continuous replenishment, a VMI method in which the supplier monitors inventory at the customer and replenishes the stock as needed

D. Order Fulfillment Process

The order fulfillment process produces and delivers the product or service to the firm's customers.

1. Customer demand planning
    - CDP is a business-planning process that enables sales teams (and customers) to develop demand forecasts as input to service-planning processes, production and inventory planning, and revenue planning
2. Supply planning
    - The supply planning process takes the demand forecasts produced by CDP and the capacity available to generate a plan to meet the demand
3. Internal operations activities
    - Encompasses all of the tasks required to deliver a product or service to a customer.
    - These activities might be focused on addressing any of the competitive priorities, and might be done by either employees or customers
4. Logistics
    - A key aspect of order fulfillment is the logistics process, which delivers the product or service to the customer

    a. Ownership
        - The firm has the most control over the logistics process if it operates as a private carrier

    b. Facility location
        - Locating facilities in close proximity to suppliers and customers

    c. Shipment mode
        - The drivers for the selection of the mode of transportation should be the firm's competitive priorities

    d. Capacity
        - The performance of a logistics process is directly linked to its capacity and variability of demand

    e. Cross-docking
        - The packing of products on incoming shipments so that they can be easily sorted at intermediate warehouses and immediately transferred for outgoing shipment

E. Customer Relationship Process

1. Order placement process
   - Activities required to register the need for a product or service and to confirm the acceptance of the order
   - It is advantageous to make this process simple and fast
   - The internet assists firms with
     - Cost reduction
     - Revenue flow increase
     - Global access
     - Pricing flexibility
2. Customer service
   - Customers judge the firm on the basis of their experience with this process
   - Many firms have replaced humans with automated systems or outsourced service in an effort to reduce costs

F. Supply Chain Dynamics

Each firm is the supply chain depends on other firms for service, materials or information. So the actions of downstream supply chain members can indirectly affect the operations of upstream members, even several tiers away.

- Bullwhip effect: the phenomenon in supply chains whereby ordering patterns experience increasing variance as you proceed upstream in the chain

TEACHING TIP
Discuss supply chain tiers from Fig. 2.3.

- Upstream members (toward the lowest tier in the supply chain) must react to the demands placed on them by downstream members of the chain
- The slightest change in customer demand can ripple through the entire chain, each member receiving more variability in demands from the member immediately downstream

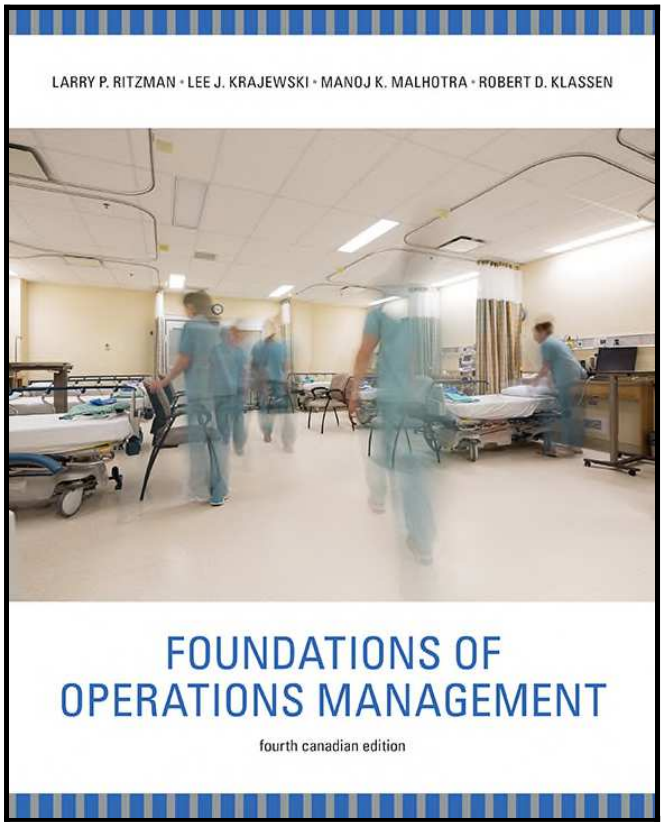
1. External causes
   - Volume changes
   - Service and product mix changes
   - Late deliveries
   - Underfilled shipments
2. Internal causes
   - Internally generated shortages
   - Order batching

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- Engineering changes
- New service or product introductions
- Service or product promotions
- Information errors

3. Levers for improved supply chain performance
   - Problems caused by supply chain dynamics and options to improve
     - Sharing data: to facilitate planning at all levels in the supply chain share POS data and RFID tracking of inventory
     - Collaborative activities
     - Reduce replenishment lead times
     - Reduce order lot sizes
     - Ration short supplies
     - Use everyday low pricing (EDLP)
     - Be cooperative and trustworthy (to a point)

2 SUPPLY CHAIN MANAGEMENT



PowerPoint Slides by
Julius Bankole

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Supply Chain Management

- Synchronize a firm's processes with those of its suppliers
- Coordination of key processes:
  - Order placement
  - Order fulfillment
  - Purchasing
- The goal is to match the flow of:
  - Material
  - Services
  - Information

  To Customer Demand

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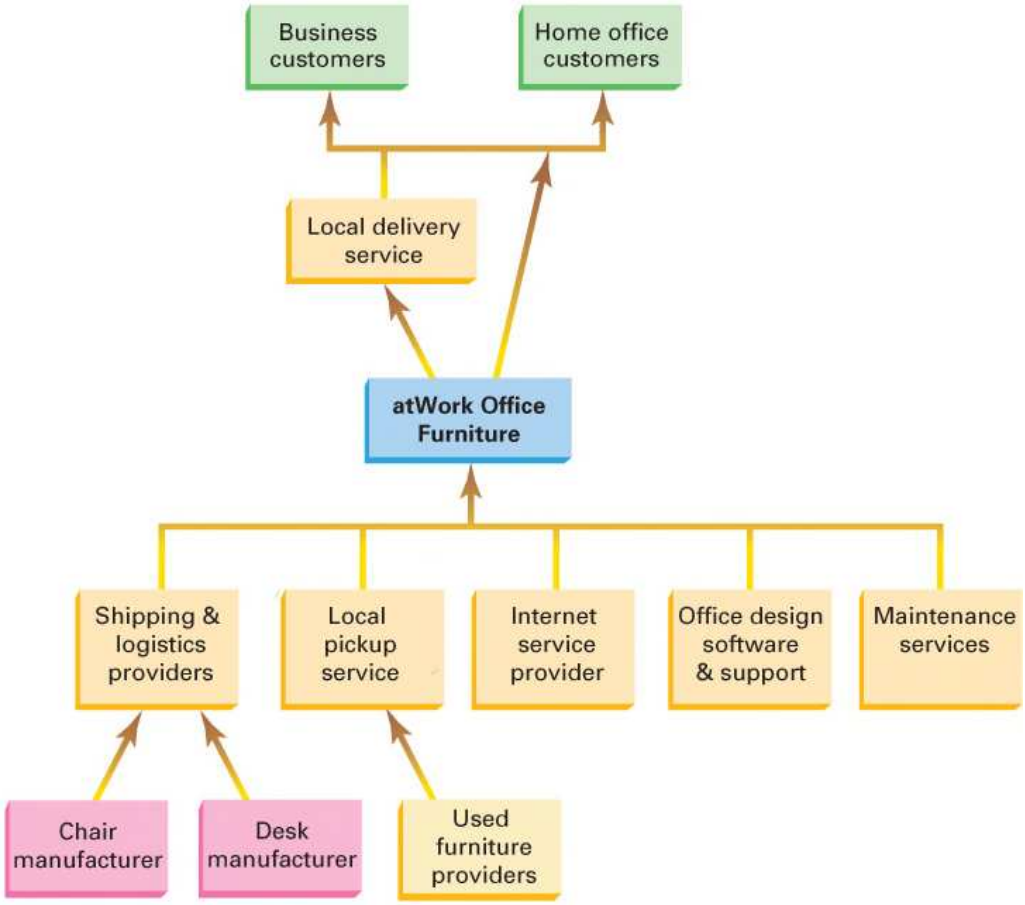
Supply Chain Management

- The design of supply chain is driven by the need to support for the essential elements of the various service packages it delivers
- A customer benefit bundle consists of a core service or product along with a set of peripheral products and services
- Management must design and leverage the firm's supply chain both to acquire supporting goods and services and to reach the customer

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Supply Chain for an Office Furniture Retailer

FIGURE 2.2 *Supply Chain for an Office Furniture Retailer*

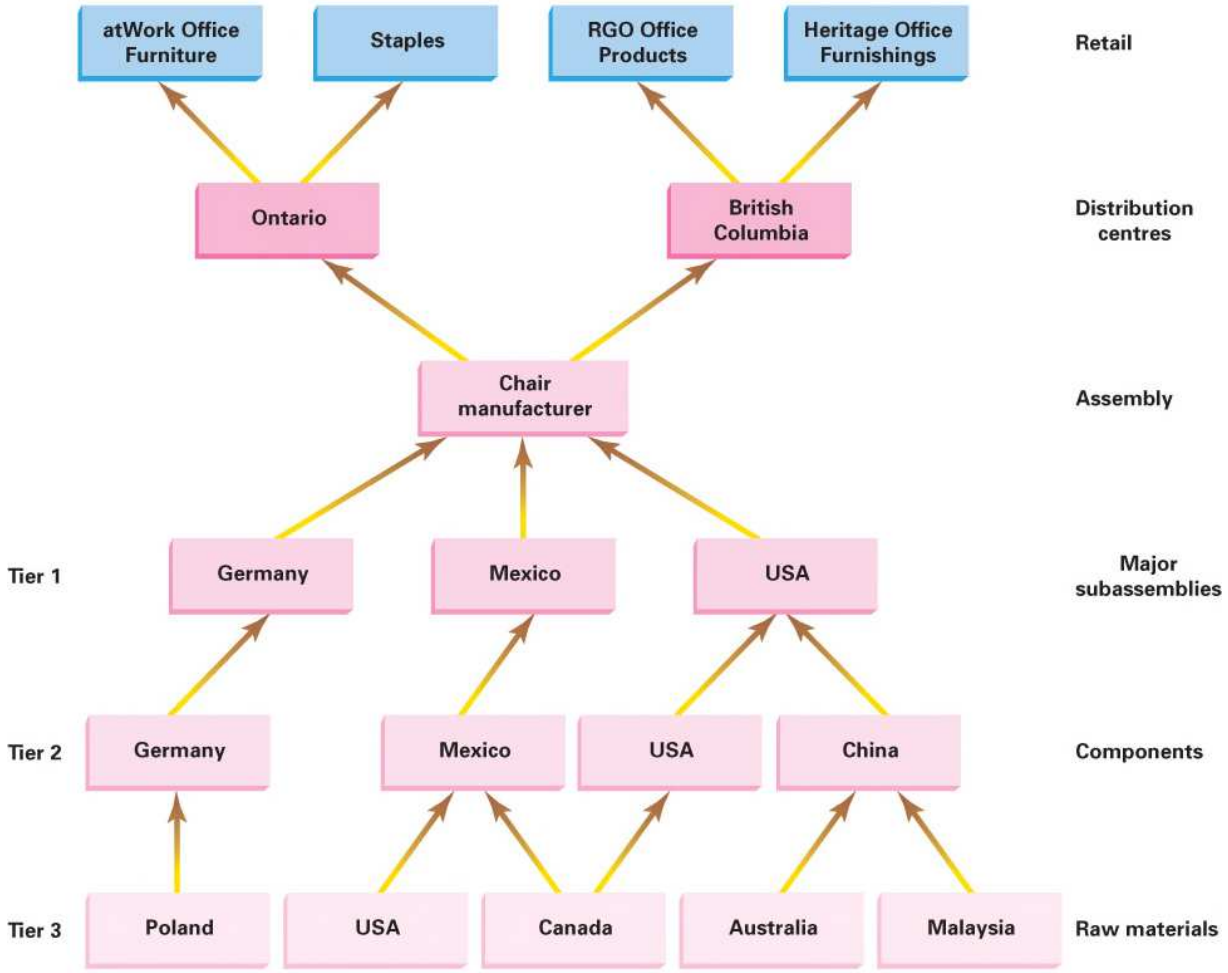


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Illustrative Supply Chain for a Manufacturing Firm

FIGURE 2.3 *Supply Chain for a Manufacturing Firm*



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Supply Chain Strategies

- **Two supply chain designs:**
  - **Efficient versus responsive supply chains**
    - **Efficient supply chains coordinate the flow of materials and services so as to minimize inventories and maximize the efficiency of the chain**
    - **Responsive supply chains react quickly to market demands by positioning inventories and capacities in order to hedge against variation and uncertainties in demand**
- **Implementing the right design**
  - **Effective alignment of operations and its competitive priorities**

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Outsourcing

- Paying suppliers and distributors to perform processes and provide needed services and materials
- Make-or-buy decision
  - A managerial choice between whether to outsource a process or do it in-house
- Backward integration
  - A firm's movement upstream toward the sources of raw materials and parts
- Forward integration
  - A firm's movement downstream such as acquiring new channels of distribution, warehouses and retail stores

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Offshoring

- A supply chain strategy that involves moving internal processes to another country, often in a joint venture partnership
- In a joint venture, the two firms agree to cooperatively produce a service or product together
- Pitfalls of offshoring include:
  - Short-term savings might overlook major opportunities to fix existing processes
  - Technology transfer
  - Difficulties integrating processes

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Inventory

- A stock of items, including materials, orders, information, and people, that flow through or are used in a process to satisfy customer demand
- A traditional accounting definition limits inventory to materials, components, and products

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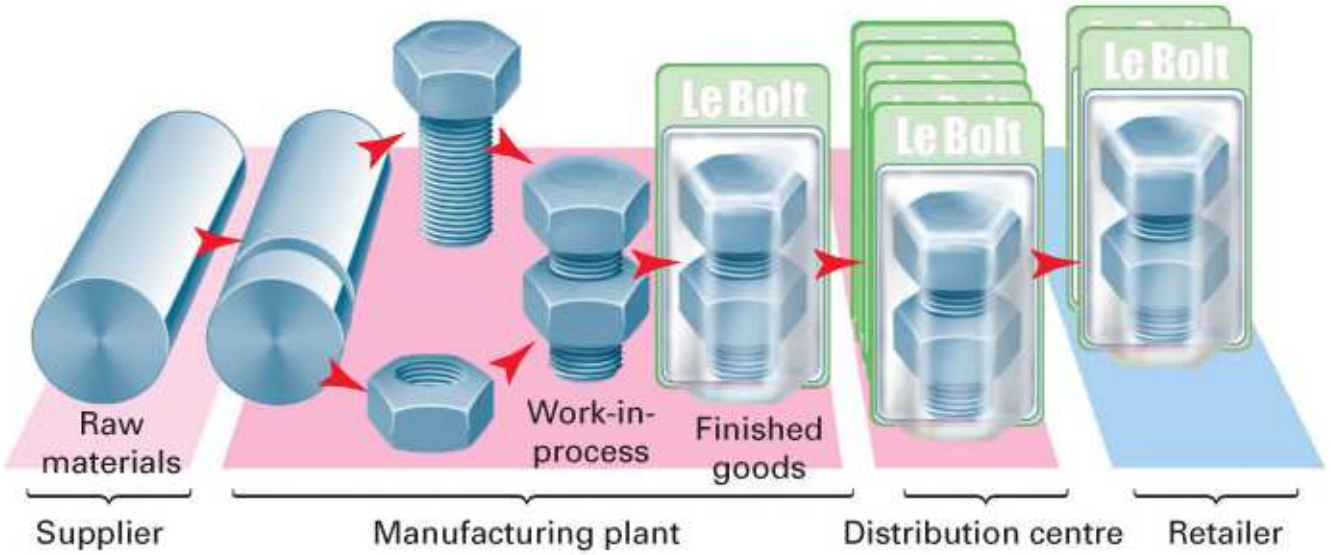
Forms of Inventory

- **Raw Materials**
  - Required inputs to produce a good or service
- **Work-In-Process (WIP)**
  - Items partially through a process that are needed for a final product or service
- **Finished Goods**
  - Items that have completed the manufacturing or service transformation process

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Inventory at Successive Stocking Points

FIGURE 2.4 *Inventory at Successive Stocking Points*



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Inventory Placement

- **Fundamental decision is where to keep various inventories**
- **Centralized inventory**
  - **Keeping all the inventory at one location such as a firm's manufacturing plant or a warehouse and shipping directly to customers is one extreme**
- **Inventory pooling**
  - **A reduction in inventory and safety stock because of the merging of variable demands from customers**
    - **A higher than expected demand from one customer can be offset by a lower-than-expected demand from another**
- **Forward placement**
  - **Locating stock closer to customers at a warehouse, distribution centre, wholesaler, or retailer**

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Inventory Measures

- All methods of inventory begin with a physical count of units, volume or weight
- Reports in three basic ways
  - Average aggregate inventory value
  - Weeks of supply
  - Inventory turnover

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Average Aggregate Inventory

- **The total value of all items held in the firm's inventory**

$$AAIV = (N_a c_a) + (N_b c_b) + \ldots + (N_n c_n)$$

AAIV = Average aggregate inventory value

N_a = Average quantity of materials, part, component, or product *a*

c_a = Average cost per unit of materials, part, component, or product *a*

n = Total number of materials, parts, components, or products

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Weeks of Supply

- **An inventory measure obtained by dividing the average aggregate inventory value by sales per week at cost**

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

Numerator includes value of all inventories, RM, WIP, FG

Denominator represents value of finished goods sold at cost

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Inventory Turnover

- **A measure of the rate at which inventory is consumed, derived by dividing the annual sales at cost by the average aggregate inventory value maintained during the year**

$$\text{Inventory turnover} = \frac{\text{Annual sales (at cost)}}{\text{Average aggregate inventory value}}$$

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Inventory Measures: an Example

A recent accounting statement showed total inventories (raw materials + WIP + finished goods) to be $6,821,000. This year's "cost of goods sold" is $19.2 million. The company operates 52 weeks per year.

How many weeks of supply are being held?

What is the inventory turnover?

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

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

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

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Supply-Chain Process Measures

TABLE 2.3 *Supply Chain Process Measures*

SUPPLIER RELATIONSHIP	ORDER FULFILLMENT	CUSTOMER RELATIONSHIP
• Percentage of suppliers' deliveries on time • Suppliers' lead times • Percentage of defects in purchased materials and services • Cost of purchased materials and services	• Percentage of incomplete orders shipped • Percentage of orders shipped on time • Time to fulfill the orders • Percentage of returned items or botched services • Cost to produce the item or service • Customer satisfaction with the order-fulfillment process	• Percentage of orders taken accurately • Time to complete the order placement process • Customer satisfaction with the order placement process • Availability of services • Customer's evaluation of firm's sustainability

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Financial Measures

- **Total Revenue**
  - Increasing the percent of on-time deliveries to customers increases total revenue because satisfied customers will buy more services and products
- **Cost of Goods Sold**
  - Buying materials at a better price, or transforming them more efficiently, improves a firm's cost of goods sold measure and ultimately its net income
- **Selling, General, and Administrative Expenses**
  - Administration, distribution, and capital costs related to supply chains are often fixed costs

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Financial Measures

- **Cash Flow**
  - ***Cash-to-cash*** **is the time lag between paying for the services and materials needed to produce a service or product and receiving payment for it**
    - **The shorter the time lag, the better the cash flow position of the firm because it needs less working capital**
- **Working Capital**
  - **Money used to finance ongoing operations**
    - **Increasing inventory turns reduces the working capital needed to finance inventories**
    - **Reducing working capital is done by improving customer relationship, order fulfillment, or supplier relationship process**

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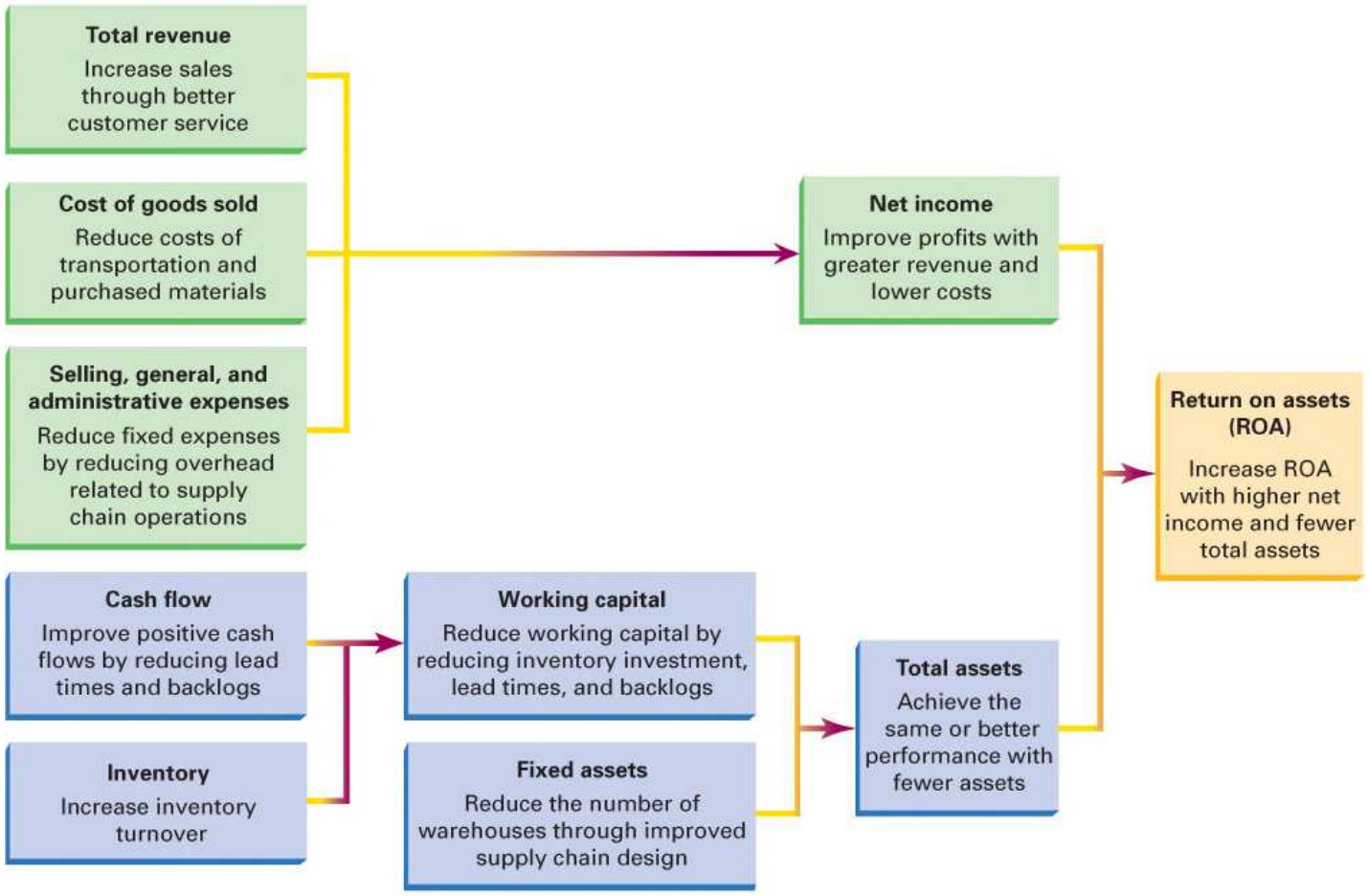
Financial Measures

- **Return on Assets (ROA)**
  - **Is net income divided by total assets**
    - **Reducing investments or increasing net income through better cost management increases ROA**

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Financial Measures

FIGURE 2.5 *How Supply Chain Decisions Can Affect Financial Performance*



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Supplier Relationship Process

- Focuses on the interaction of the firm and upstream suppliers
- Important decision areas (also called nested processes) that affect the design of the supplier relationship process are:
  - Sourcing
  - Design collaboration
  - Negotiation
  - Buying
  - Information exchange

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Nested Processes

- **Sourcing**
  - The purchasing function is the eyes and ears of the organization in the supplier marketplace
  - Continuously seeking better value from suppliers
  - Purchasing is in good position to select suppliers for the supply chain and to conduct certification programs
    - Selection
    - Supplier Certification
    - Competitive Orientation
    - Cooperative Orientation

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Five Nested Processes

- **Design collaboration**
  - Focuses on jointly designing new services or products with key suppliers
  - Facilitates concurrent engineering by drawing key suppliers into the new service or product development process
  - Early supplier involvement
    - Refers to a program that includes suppliers in the design phase of a service or product
  - Presourcing
    - A level of supplier involvement in which suppliers are selected early in a product's concept development stage and are given significant, if not total, responsibility for the design of certain components or systems of the product

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Five Nested Processes

- **Value Analysis**
  - **A systematic effort to reduce the cost or improve performance of services or products, either purchased or produced**

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Five Nested Processes

- **Negotiation**
  - **Focuses on obtaining an effective contract that meets price, quality and other requirements from suppliers**

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Five Nested Processes

- **Buying**
  - Relates to the actual procurement of the service or material from the supplier
  - Process includes creation, management, and approval of purchase orders and determines the locus of control for purchasing decisions
  - Four approaches to e-purchasing
    - Electronic Data Interchange (EDI)
    - Catalogue hubs
    - Exchanges
    - Auctions
  - Centralized versus localized buying decision

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Electronic Purchasing

- **Electronic Data Interchange (EDI)**
  - Enables the transmission of routine, standardized business documents from computer to computer
- **Catalog hubs**
  - A system whereby suppliers post their catalog of items on the Internet and buyers select what they need and purchase them electronically
- **Exchange**
  - An electronic marketplace where buying firms and selling firms come together to do business
- **Auction**
  - A marketplace where firms place competitive bids to buy something

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Centralized versus Localized Buying

- **Centralized buying** increases purchasing clout. Savings can be significant, often 10% or more
- Increased buying power can mean getting better service, ensuring long-term supply availability, or developing new supplier capability
- The biggest disadvantage is loss of local control
- Centralized buying is undesirable for items unique to a particular facility
- The best solution may be one where both local autonomy and centralized buying are possible

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Five Nested Processes

- **Information Exchange**
  - Facilitates the exchange of pertinent operating information, such as forecasts, schedules, and inventory levels between the firm and its suppliers
  - Radio Frequency Identification (RFID)
  - Vendor-managed inventories (VMI)

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Radio Frequency Identification (RFID)

- A method for identifying items through the use of radio signals from a tag attached to an item using an Electronic Product Code (EPC)
  - Wal-Mart and Gillette are among a number of large retailers, manufacturers, government agencies, and suppliers currently implementing RFID in their supply chains

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Vendor-Managed Inventories (VMI)

- An extreme application of forward placement involving locating inventories at the customer's facilities
- Key ingredients are:
  - Collaborative effort requires trust & accountability
  - Cost savings is realized by eliminating excess inventory
  - Customer service: The supplier is frequently on site for improved response times and reducing stockouts
  - Written agreement on procedures, methods, and schedules are clearly specified

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Continuous Replenishment Program (CRP)

- A VMI method in which the supplier monitors the customer's inventory levels and replenishes stock as needed to avoid shortages
  - Collaborative planning, forecasting, and replenishment (CPFR)

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Order Fulfillment Process

- Produces and delivers the service or product to the firm's customers
- There are four key nested processes:
  - Customer demand planning
  - Supply planning
  - Internal operations activities
  - Logistics

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Customer Demand Planning (CDP)

- Facilitates the collaboration of a supplier and its customers to more accurately forecast customer requirements for a service or product
- A business-planning process that enables sales teams (and customers) to develop demand forecasts as input to service-planning processes, production and inventory planning, and revenue planning

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Supply planning

- The supply planning process takes the demand forecasts produced by CDP and the capacity available to generate a plan to meet the demand
- This process is both critical for effective execution in the supply chain and very complex

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Internal operations activities

- **Encompasses all of the tasks required to deliver a product or service to a customer**
- **Might be focused on addressing any of the competitive priorities, and might be done by either employees or customers**

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Logistics

- Deliver the product or service to the customers
- Five important decisions that determine the design and implementation of logistics processes:
  - Degree of ownership
  - Facility location
  - Shipment mode
  - Level of capacity
  - Amount of cross docking

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Customer Relationship Process

- Addresses the interface between the firm and its customers downstream in the supply chain
- Order Placement Process
  - The activities required to register the need for a product or service and to confirm the acceptance of the order
- Customer Service
  - This process helps customers with answers to questions regarding the service or product, resolves problems, and in general, provides information to assist customers

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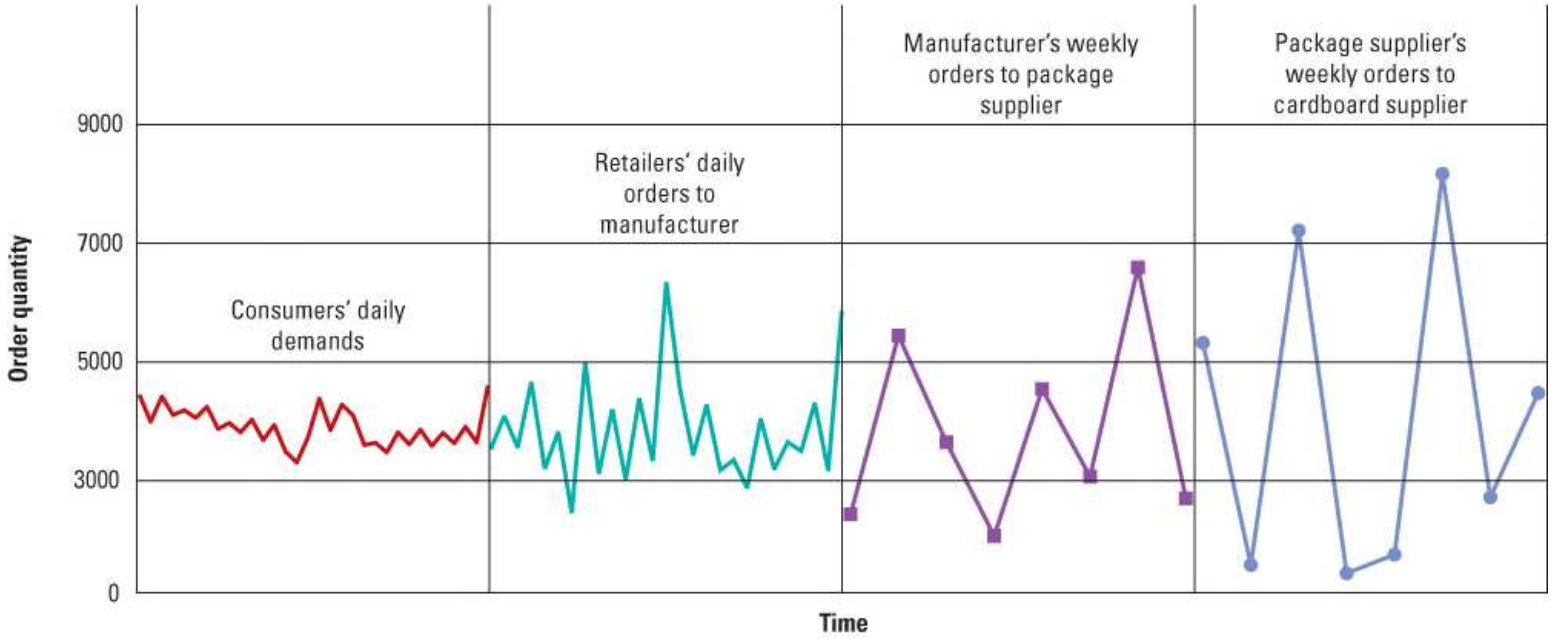
Supply Chain Dynamics

- **Supply chain dynamics can wreak havoc on supply chain performance measures**
  - **Actions of downstream supply chain members can affect the operations of upstream members**
- **Bullwhip effect**
  - **The phenomenon in supply chains whereby ordering patterns experience increasing variance as you proceed upstream in the chain**

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Supply Chain Dynamics for Facial Tissue

FIGURE 2.6 *Supply Chain Dynamics for Facial Tissue*



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External Causes of Supply Chain Disruption

- **Volume changes**
  - Customers may change ordered quantity or delivery date
- **Service and product mix changes**
  - Customers may change the mix of ordered items
- **Late deliveries**
  - Late deliveries can force a switch in production schedules
- **Underfilled shipments**
  - Partial shipments can cause a switch in production schedule or quantity produced

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Internal Causes of Supply Chain Disruption

- **Internally generated shortages of parts**
- **Order batching**
- **Engineering changes**
  - **To the design of services or products are disruptive**
- **New service or product introductions**
  - **Disrupt the supply chain and may require a new supply chain**
- **Service or product promotions**
  - **May create a demand spike**
- **Information errors**
  - **Such as demand forecast errors, faulty inventory counts, or miscommunication with suppliers**

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Levers for Improved Supply Chain Performance

- Options include
  - Sharing data
  - Collaborative activities
  - Reduce replenishment lead times
  - Reduce order lot sizes
  - Ration short supplies
  - Use everyday low pricing
  - Be cooperative and trustworthy (to a point)

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Supply Chains and Sustainability

- Ways to increase efficiency and reduce the impact of their actions on the environment
- Basic process concerns
  - Environmental stewardship and social responsibility
  - Actively work toward designing and delivering services, products, and processes that take into account both the environment and other people (beyond customers) throughout the supply chain
  - First step – better communication across the supply chain
  - Second step – any material used or produced must be tracked from cradle to the grave or better yet, to cradle (recycle or reuse)

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Addressing these areas:

- **Environmental protection**
- **Productivity improvement**
- **Social responsibilities**
- **Risk minimization**
- **Innovation**

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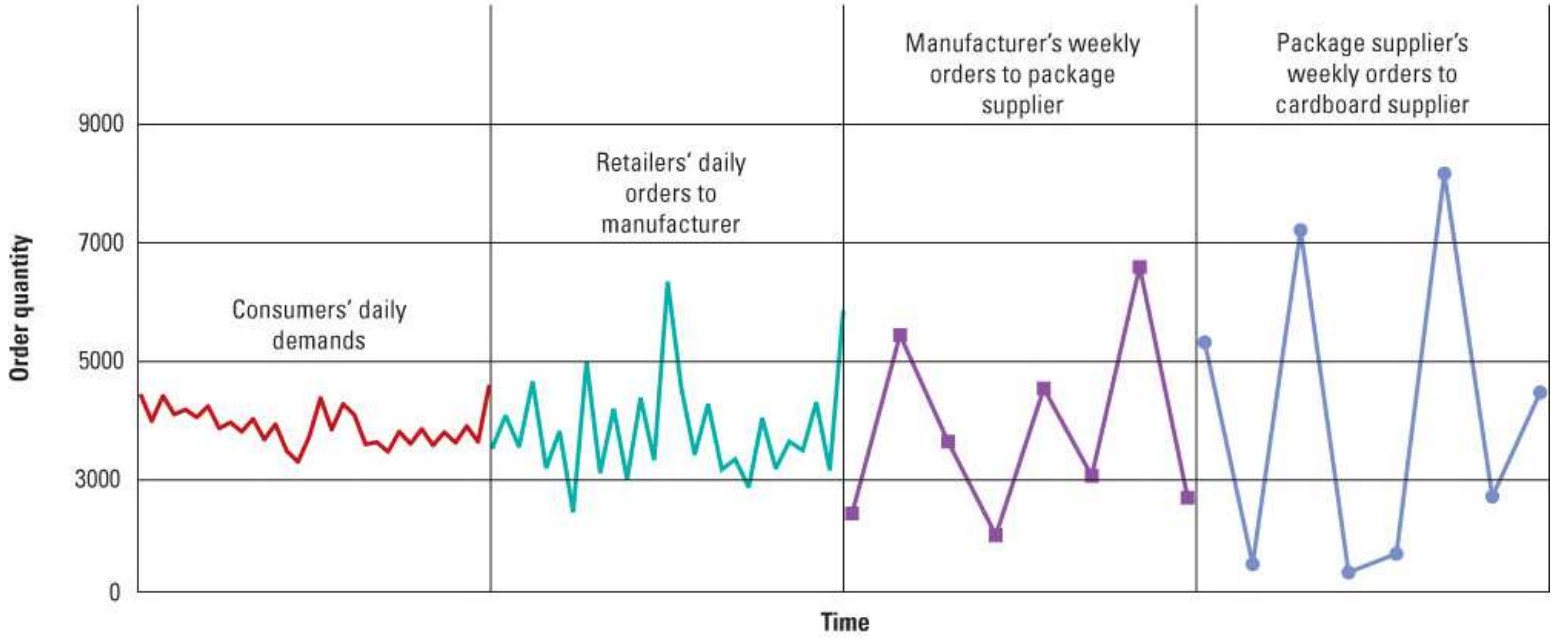
Reverse Supply Chain

- The process of planning for, collecting, and controlling flow of new, used, or end-of-life products from customers to supply chain partners for reuse, repair, remanufacturing, or recycling
- A closed-loop supply chain is a supply chain that integrates forward flow with reverse flows
  - It focuses on the complete chain of operations from cradle to cradle (producing a new product)
- Products flow to and from consumers, offering multiple points to benefit from consumed materials

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Closing the loop in the Supply Chain

FIGURE 2.6 *Supply Chain Dynamics for Facial Tissue*



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Three Aspects of Waste in the Supply Chain

- Services often generate large amounts of waste, and the reverse supply chain is frequently overlooked
- Reverse supply chains can be particularly important in the industries with short-lived products, such as electronics
- Information about a product or service's sustainability performance across the supply chain, if measured, can be sent back to the new service/product development process to introduce improvements in future generations and new services

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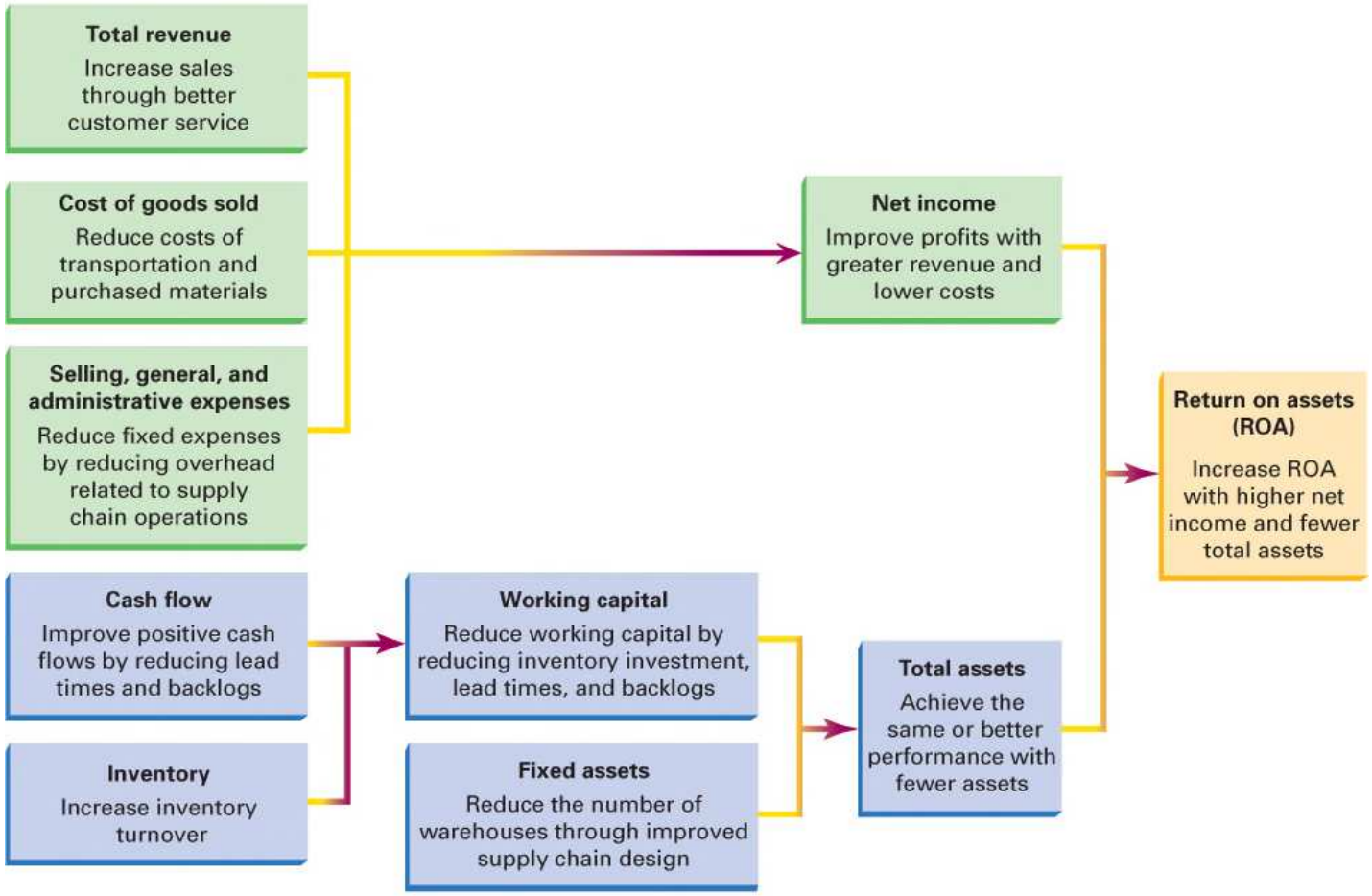
New Service or Product Development Process

- A core process that fundamentally shapes the supply chain
- Times change, people change, technologies change, and so services or products change
- The new service/product development process begins with design and ends with the launch of the new offering

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New service and Product Development Process

FIGURE 2.5 *How Supply Chain Decisions Can Affect Financial Performance*



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Four Stages of Development Process

- **Design**
  - Links the creation of new services or products to the corporate strategy of the firm
- **Analysis**
  - Involves a critical review of the new offering and how it will be produced to make sure that it fits the corporate strategy, is compatible with regulatory standards, presents an acceptable market risk, and satisfies the needs of the intended customers

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Four Stages of Development Process

- **Development**
  - Brings more specificity to the new offering
  - The required competitive priorities are used as inputs to the design (or redesign)of the processes that will be involved in delivering the new offering
- **Full launch**
  - Involves the coordination of many processes
  - Promotions for the new offering must be initiated, sales personnel briefed, distribution processes activated, and old services or products that the new offering is to replace withdrawn

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Supply Chain Environments

TABLE 2.2 *Design Features for Efficient and Responsive Supply Chains*

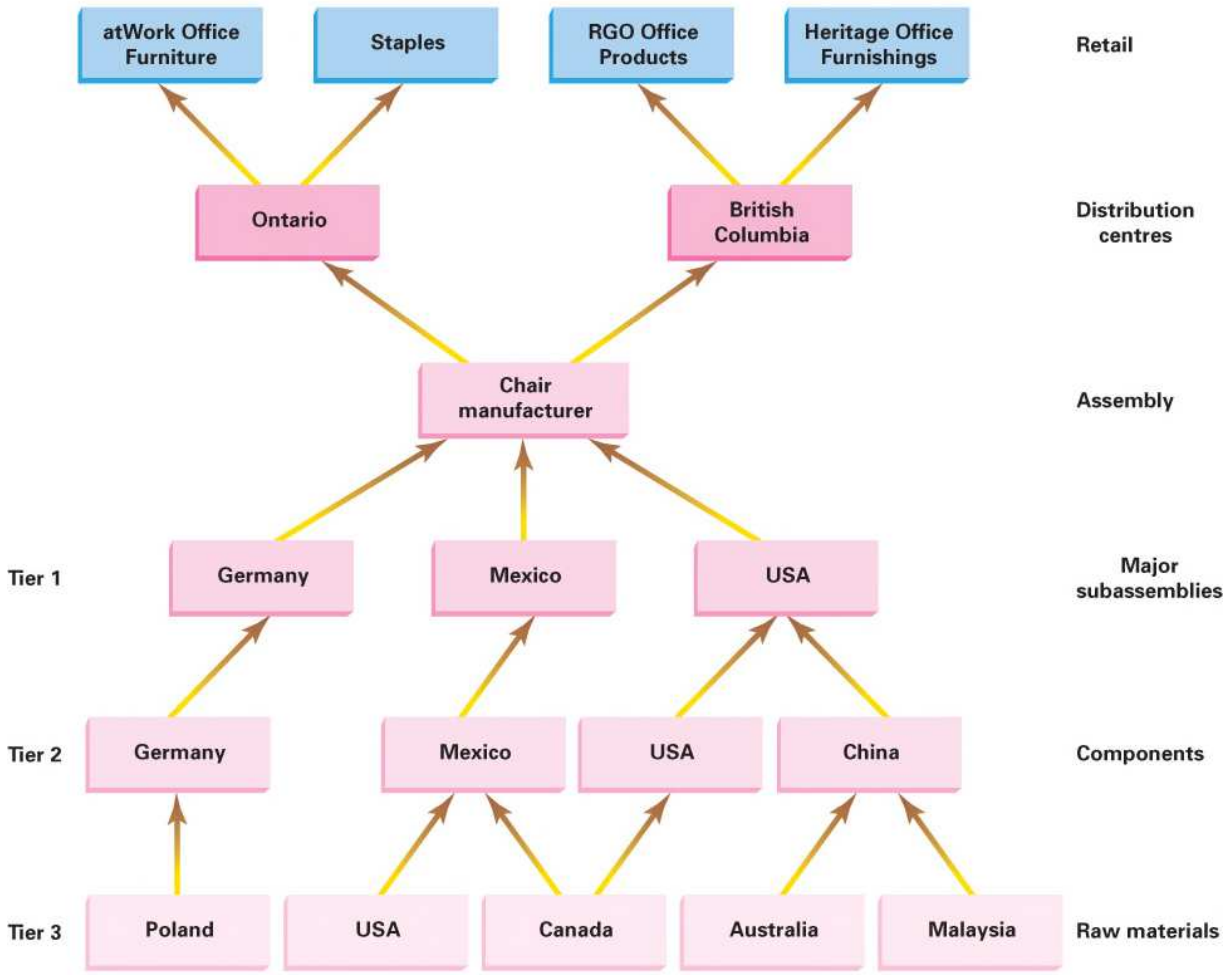
FACTOR	EFFICIENT SUPPLY CHAINS	RESPONSIVE SUPPLY CHAINS
Operations strategy	Emphasize high-volume, standardized products or services, such as make-to-stock	Emphasize product or service variety, including assemble-to-order, make-to-order, or customization
Inventory investment	Low; focus on high inventory turnover	Higher at critical points in supply chain to enable fast delivery time; use modular components
Lead time	Shorten, if possible without driving up cost	Shorten aggressively
Supplier selection	Emphasize low prices, consistent quality, on-time delivery	Emphasize fast delivery time, customization, volume flexibility, high-performance design quality

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Supply Chain Design

FIGURE 2.3 *Supply Chain for a Manufacturing Firm*



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