GLOBAL EDITION

Introduction to Materials Management

EIGHTH EDITION

Stephen N. Chapman • J. R. Tony Arnold • Ann K. Gatewood • Lloyd M. Clive

ALWAYS LEARNING

PEARSON

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PREFACE

Introduction to Materials Management is an introductory text written for students in community colleges and universities. It is used in technical programs, such as industrial engineering and manufacturing engineering; in business, operations and supply chain management programs; and by those already in industry, whether or not they are working in materials management.

This text has been widely adopted by colleges and universities not only in North America but also in many other parts of the world. The APICS organization recommends this text as a key reference for certification preparation for various CPIM examinations. In addition, the text is used by production and inventory control societies around the world, including South Africa, Australia, New Zealand, Germany, France, and Brazil, and by consultants who present in-house courses to their customers.

Introduction to Materials Management covers all the basics of supply chain management, manufacturing planning and control systems, purchasing, physical distribution, lean and quality management. The material, examples, questions, and problems lead the student logically through the text. The writing style is simple and user-friendly—both instructors and students who have used the book attest to this.

NEW TO THIS EDITION

- All chapters have been updated to reflect new techniques and technology
- Nine additional case studies have been added
- Several special topic boxes have been added relating chapter topics to nonmanufacturing settings such as service industries
- End-of-chapter problems have been revised, and some new ones added throughout the text
- Expansion of purpose and impact of strategic planning, including environmental and sustainability issues. Allows students to understand the importance of the field at a higher level, including impacts and benefits to society as a whole
- Additional information included on demand management
- Additional information included on lean production concepts and Theory of Constraints. Theory of Constraint provides an interesting and potentially effective alternative method to think about several of the concepts in the book, and can help students compare and contrast Theory of Constraint with non-Theory of Constraint approaches. (See Ch. 6)
- A brief introduction to Project Management has been added to Ch. 6 to provide students initial exposure to a skill today's employers are looking for

In addition, we have retained several features from previous editions.

- Margin icons to note key concepts
- Key terms listed at the end of each chapter
- Example problems within the chapters
- Chapter summaries
- Questions and problems at the end of each chapter
- Full supplements package including Instructor's Manual, Computerized Test Bank, PowerPoint, and Image Bank available for download

APPROACH AND ORGANIZATION

Materials management means different things to different people. In this textbook, materials management includes all activities in the flow of materials from the supplier to the consumer. Such activities include physical supply, operations planning and control, and physical distribution. Other terms sometimes used in this area are *business logistics* and *supply chain management*. Often, the emphasis in business logistics is on transportation and distribution systems with little concern for what occurs in the factory. Whereas some chapters in this text are devoted to transportation and distribution, emphasis is placed on operations planning and control.

Distribution and operations are managed by planning and controlling the flow of materials through them and by using the system's resources to achieve a desired customer service level. These activities are the responsibility of materials management and affect every department in a manufacturing business. If the materials management system is not well designed and managed, the distribution and manufacturing system will be less effective and more costly. Anyone working in manufacturing or distribution should have a good basic understanding of the factors influencing materials flow. This text aims to provide that understanding and also includes chapters on quality management and lean production.

APICS defines the body of knowledge, concepts, and vocabulary used in production and inventory control. Establishing standard knowledge, concepts, and vocabulary is essential both for developing an understanding of production and inventory control and for making clear communication possible. Where applicable, the definitions and concepts in this text subscribe to APICS vocabulary and concepts.

The first six chapters of *Introduction to Materials Management* cover the basics of production planning and control. Chapter 7 discusses important factors in purchasing and supply chain; Chapter 8 discusses forecasting. Chapters 9, 10, and 11 look at the fundamentals of inventory management. Chapter 12 discusses physical inventory and warehouse management, and Chapter 13 examines the elements of distribution systems, including transportation, packaging, and material handling. Chapter 14 covers factors influencing product and process design. Chapter 15 looks at the philosophy and environment of lean production and explains how operations planning and control systems relate to lean production. Chapter 16 examines the elements of total quality management and six sigma quality approaches.

ONLINE INSTRUCTOR RESOURCES

At the Instructor Resource Center, **www.pearsonglobaleditions.com/Chapman**, instructors can easily register to gain access to a variety of instructor resources available with this text in downloadable format. If assistance is needed, our dedicated technical support team is ready to help with the media supplements that accompany this text. Visit http://247.pearsoned.com for answers to frequently asked questions and toll-free user support phone numbers.

List of Supplements

- Instructor's Manual
- Computerized Test Bank
- PowerPoint
- Image Bank

ACKNOWLEDGMENTS

The period of time since the seventh edition of this book was published included the very unfortunate passing of two of the authors of the seventh edition—Tony Arnold and Lloyd Clive. Tony Arnold was responsible for the original vision and creation of the book many

years ago, and Lloyd Clive brought significant additional insights and knowledge in the creation of the last two revisions. Both of these gentlemen were well known and highly respected both by students and colleagues, and will be greatly missed.

The addition of Ann Gatewood as a new coauthor brings her extensive experience, knowledge, and insight to this eighth edition. However, this eighth edition continues to reflect the original vision of providing a clear and understandable introductory look at the field of Materials Management.

Help and encouragement have come from a number of valued sources, among them friends, colleagues, and students. We thank the many readers of the book who have provided comments and suggestions. We especially wish to thank members of the various APICS CPIM Committees who have provided specific guidance for the revision. Specifically, we would like to thank Andrea Prud'homme (The Ohio State University), Jim Caruso (Covidien), Frank Montabon (Iowa State University), and Mark Hardison (SIGA Technologies) for their significant insights and suggestions. In addition, we received several worthwhile suggestions from John Kanet (The University of Dayton) and Keith Launchbury (Keith Launchbury and Associates). Other academic reviewers include Vahid H Khiabani (Minnesota State University—Moorhead), Michael Gallaway (North Lake College), John Kros (East Carolina University), and Sunderesh Heragu (Oklahoma State University—Stillwater). Steve Chapman would also like to thank his wife Jeannine for her continued support and encouragement during the revision process.

Overall, this book is dedicated to those who have taught us the most—our colleagues and our students.

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CHAPTER ONE

INTRODUCTION TO MATERIALS MANAGEMENT

INTRODUCTION

The wealth of a country is measured by its gross national product—the output of goods and services produced by the nation in a given time. Goods are physical objects, something one can touch, feel, or see. Services are the performance of some useful function such as banking, medical care, restaurants, clothing stores, or social services.

But what is the source of wealth? Wealth is measured by the amount of goods and services produced, but where does it come from? Although rich natural resources may exist in an economy, such as mineral deposits, farmland, and forests, these are only potential sources of wealth. A production function is needed to transform these resources into useful goods. The transformation process begins with extracting minerals from the earth, farming, lumbering, or fishing, and then using these resources to manufacture useful products.

There are many stages between the extraction of resource material and the final consumer product. At each stage in the development of the final product, value is added, thus creating more wealth. If ore is extracted from the earth and sold, wealth is gained from the efforts, but those who continue to transform the raw material will gain more and usually far greater wealth. Japan is a prime example of this. It has very few natural resources and imports most of the raw materials it needs. However, the Japanese have developed one of the wealthiest economies in the world by transforming the raw materials they purchase and adding value to them through manufacturing.

Manufacturing companies are in the business of converting raw materials to a form that is of far more value and use to the consumer than the original raw materials. Logs are converted into tables and chairs, iron ore into steel, and steel into cars and refrigerators. This conversion process, called *manufacturing* or *production*, makes a society wealthier and creates a better standard of living.

To get the most value out of resources, production processes must be so designed that they make products most efficiently. Once the processes exist, operations are managed so they produce goods most economically. Managing the operation means planning for and controlling the resources used in the process: labor, capital, and material. All are important, but the major way in which management plans and controls operations is through the flow of materials. The flow of materials in turn controls the performance of the process. If the right materials in the right quantities are not available at the right time, the process cannot produce what it should. Labor and machinery will be poorly utilized. The profitability, and even the existence, of the company will be threatened.

OPERATING ENVIRONMENT

Operations management works in a complex environment affected by many factors. Among the most important are government regulation, the economy, competition, customer expectations, and quality.

Government. Regulation of business by the various levels of government is extensive. Regulation applies to such areas as the environment, safety, product liability, and taxation. Government, or the lack of it, affects the way business is conducted.

Economy. General economic conditions influence the demand for a company's products or services and the availability of inputs. During economic recession, the demand for some products may decrease while demand for others may increase. Materials and labor shortages or surpluses influence the decisions management makes. Shifts in the age of the population, needs of ethnic groups, low population growth, increased free trade between countries, and increased global competition all contribute to changes in the marketplace.

Competition. Competition is more severe today than ever before.

- Manufacturing companies face competition from throughout the world. They find foreign competitors selling in their markets even though they themselves may not be selling in foreign markets.
- Transportation and the movement of materials are relatively more efficient and less costly than they used to be.
- Worldwide communications are fast, effective, and cheap. Information and data can be moved almost instantly around the globe. The internet allows buyers to search out new sources of supply from anywhere in the world as easily as they can from local sources.

Customers. Both consumers and industrial customers have become much more demanding, and suppliers have responded by improving the range of characteristics they offer. Some of the characteristics and selection customers expect in the products and services they buy are:

- A fair price.
- Higher (exact) quality products and services.
- Delivery lead time.
- Better presale and after-sale service.
- Product and volume flexibility.

Quality. Since competition is international and aggressive, successful companies provide quality that not only meets customers' high expectations but also exceeds them.

Order Qualifiers and Order Winners

Generally, a supplier must meet set minimum requirements to be considered a viable competitor in the marketplace. Customer requirements may be based on price, quality, delivery, and so forth and are called **order qualifiers**. For example, the price for a certain type of product must fall within a range for the supplier to be considered by potential customers. But being considered does not mean winning the order. To win orders, a supplier must have characteristics that encourage customers to choose its products and services over competitors'. Those competitive characteristics, or combination of characteristics, that persuade a company's customers to choose its products or services are called **order winners**. They provide a competitive advantage for the firm. Order winners change over time and may well be different for different markets. For example, fast delivery may be vital in one market but not in another. Characteristics that are order winners today probably will not remain so, because competition will try to copy winning characteristics, and the needs of customers will change.

It is very important that a firm understands the order winners and order qualifiers for each of its products or services and in each of its markets because they should drive the manufacturing and corporate strategy. Since it is virtually impossible to be the best in every dimension of competition, firms should in general strive to provide at least a minimal level of acceptance for each of the order qualifiers but should try to be the *best* in the market for the order winner(s).

One also should recognize that the order winners and qualifiers for any product/market combination are not static. Not only will customers change perspectives as competitors jockey for position, but the order winners and qualifiers will also often change based on the concepts of the product life cycle. Most products go through a life cycle,

including introduction, growth, maturity, and decline. For example, in the introduction phase, design and availability are often much more important than price. Quality and delivery tend to have increased importance during growth, while price and delivery are often the order winners for mature products. This life cycle approach is complicated in that the duration of the life cycle will be very different for different products. Although some products have life cycles many years long, the life cycle of other products (certain toys or electronics, for example) can be measured in months or even weeks.

Manufacturing Strategy

A highly market-oriented company will focus on meeting or exceeding customer expectations and on order winners. In such a company, all functions must contribute toward a winning strategy. Thus, operations must have a strategy that allows it to supply the needs of the marketplace and provide fast on-time delivery.

Delivery lead time From the supplier's perspective, delivery lead time is the time from receipt of an order to the delivery of the product. From the customer's perspective, it may also include time for order preparation and transmittal. Most customers want delivery lead time to be as short as possible, and manufacturing must determine a process strategy to achieve this. There are five basic process strategy choices: engineer-to-order, make-to-order, configure-to-order, assemble-to-order, and make-to-stock. Customer involvement in the product design, delivery lead time, and inventory state are influenced by each strategy. Based on the type of products a company makes, and their customer base, a company may determine that more than one process strategy is required. Figure 1.1 shows the effect of each process strategy on lead time.

Engineer-to-order means that the customer's specifications require unique engineering design or significant customization. Usually the customer is highly involved in the product design. Inventory will not normally be purchased until needed by manufacturing. Delivery lead time is long because it includes not only purchase lead time but also design lead time.

Make-to-order means that the manufacturer does not start to make the product until a customer's order is received. The final product is usually made from standard items but may include custom-designed components as well. Delivery lead time is reduced because there is little design time required and inventory is held as raw material.

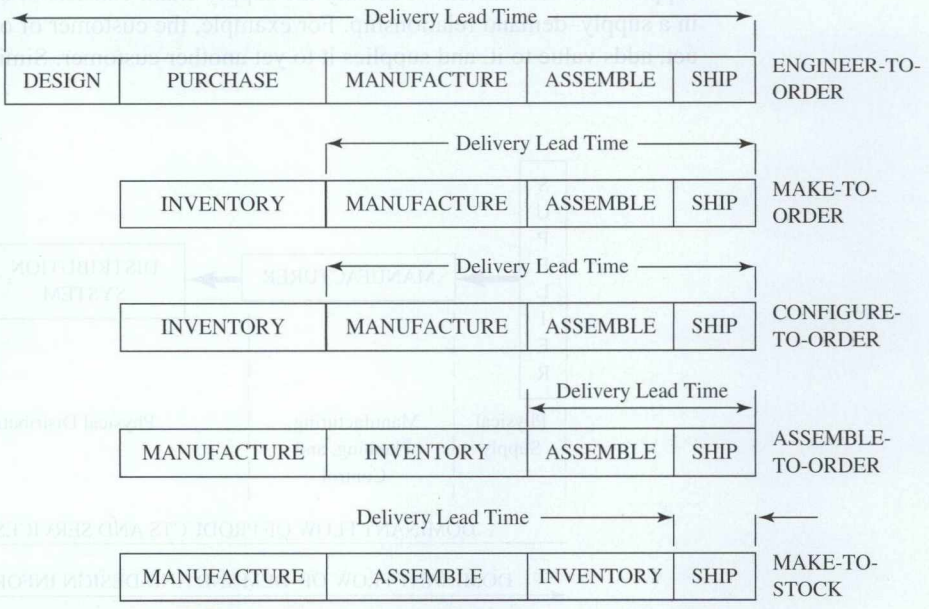

FIGURE 1.1 Manufacturing strategy and lead time.

Configure-to-order means that the customer is allowed to configure a product based on various features and options. Each customer, and order, may be an entirely unique configuration that has never been done before, and the configuration often occurs at the beginning of the process. Delivery lead time is reduced because there is no design time required and the different features and options may already be available. Customer involvement includes selecting the features and options desired.

Assemble-to-order means that the product is made from standard components or options that the manufacturer can inventory and assemble according to a customer order. This is usually done at a later stage in the process than configure-to-order. Delivery lead time is reduced further because there is no design time needed and inventory is held ready for assembly. Customer involvement in the design of the product is limited to selecting the assembly options needed.

Make-to-stock means that the supplier manufactures the goods and sells from a finished goods inventory. Delivery lead time is shortest as manufacturing and assembly have already been completed. The customer has little direct involvement in the product design.

Postponement is another application of assemble-to-order, described in *APICS Dictionary,* 14th edition as "a product design strategy that shifts product differentiation closer to the consumer by postponing identity change to the last possible supply chain location." This strategy reduces the number of different items in the supply chain, lowering the amount of in-process inventory.

An example of postponement would be computer printers for a global market that use universal power supplies that can be switched to different voltages. Upon receipt of a customer's order, they are packaged with the appropriate cords, instructions, and labeling. This avoids filling an entire supply chain with expensive printers destined for many different countries. Some basic postponement can be done in a distribution center and often by third party logistics (3PL) providers. Foreign suppliers of appliances, such as vacuum cleaners destined for multiple customers, postpone the packaging of their products, applying customer-specific labels, bar codes, boxes, instructions, and so forth until after receipt of the customer order.

THE SUPPLY CHAIN CONCEPT

There are three phases to the flow of materials. Raw materials flow into a manufacturing company from a physical supply system, they are processed by manufacturing, and finally, finished goods are distributed to end consumers through a physical distribution system. Figure 1.2 shows this system graphically. Although this figure shows only one supplier and one customer, usually the supply chain consists of several companies linked in a supply–demand relationship. For example, the customer of one supplier buys a product, adds value to it, and supplies it to yet another customer. Similarly, one customer may

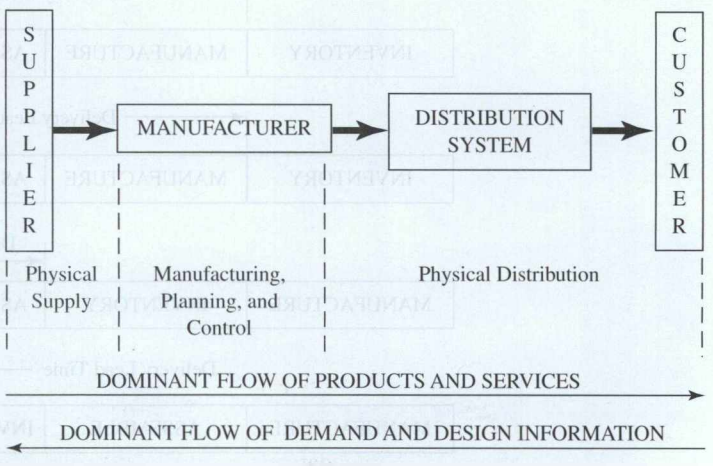

FIGURE 1.2 Supply–production–distribution system.

have several suppliers and may in turn supply several customers. As long as there is a chain of supplier–customer relationships, they are all members of the same supply chain.

There are a number of important factors in supply chains:

- The supply chain includes all activities and processes to supply a product or service to a final customer.
- Any number of companies can be linked in the supply chain.
- A customer can be a supplier to another customer, so the total chain can have a number of supplier–customer relationships.
- Although the distribution system can be direct from supplier to customer, depending on the products and markets, it can contain a number of intermediaries (distributors) such as wholesalers, warehouses, and retailers.
- Product or services usually flow from supplier to customer; design, demand information, and cash usually flow from customer to supplier.

Although these systems vary from industry to industry and company to company, the basic elements are the same: supply, production, and distribution. The relative importance of each depends on the costs of the three elements.

Supply Chain Concepts

In recent years there has been a great deal of attention given to the concept of **supply chain management (SCM)**. It is important to understand fundamental concepts of supply chain management and its impact on materials management.

Historical perspective In the past, many company managers placed most of their attention on the issues that were internal to their companies. Of course, they were aware of the impact of suppliers, customers, and distributors, but those entities were often viewed as business entities only. Specialists in purchasing, sales, and logistics were assigned to deal with those outside entities, often through formal legal contracts that were negotiated regularly and represented short term agreements. For example, suppliers were often viewed as business adversaries. A key responsibility of a purchasing agent was to negotiate the best financial and delivery conditions from a supplier, whose job was to maximize company profit.

The first major change in that perspective for most companies can be traced to the explosive growth in just-in-time (JIT) concepts, originally developed by Toyota and other Japanese companies in the 1970s. Supplier partnerships were felt to be a major aspect of successful JIT. With that concept, suppliers were viewed as partners as opposed to adversaries, meaning the supplier and the customer had mutually linked destinies, and each was linked to the success of the other. Great emphasis was put on trust between the partners, and many of the formal boundary mechanisms, such as the receiving/inspection activity of incoming parts, were changed or eliminated altogether. As the partnership concept grew, there were many other changes in the relationship, including:

- **Mutual analysis for cost reduction.** Both parties examined the process used to transmit information and deliver parts, with the idea that cost reductions would be shared between the two parties.
- **Mutual product design.** In the past, the customer often submitted complete designs to the supplier, who was obligated to produce according to design. With partnering, both companies worked together. Often the supplier would know more about how to make a specific product, whereas the customer would know more about the application for which the design was intended. Together, they could produce a superior design compared to what either could do alone.
- **Enhanced information flow.** JIT incorporated the concept of greatly reduced inventory in the process and the need for rapid delivery according to need; therefore, the speed of accurate information flow became critical. Formal paper-based systems gave way to electronic data interchange (EDI) and more informal communication methods between individuals at the supplier and customer.

The growth of the supply chain concept As the world continues to change, additional modifications are being added to the trend:

- There has been explosive growth in computer capability and associated software applications. Highly effective and integrated systems such as **enterprise resource planning** (**ERP**) and the ability to link companies electronically (through the internet, for example) have allowed companies to share large amounts of information quickly and easily. The ability to have information rapidly has become a competitive necessity for many companies.
- There has been a large growth in global competition. Very few companies can still say they have only local competition, and many of the global competitors are forcing existing companies to find new ways to be successful in the marketplace.
- There has been a growth in technological capabilities for products and processes. Product life cycles for many products are shrinking rapidly, forcing companies to not only become more flexible in design but also to communicate changes and needs to suppliers and distributors.
- The changes prompted by JIT in the 1980s have continued to mature and become more accurately defined as lean production. Now many companies have new approaches to inter-organizational relationships as a normal form of business.
- Partially in response to the preceding conditions, more and more companies are subcontracting more of their work to suppliers, keeping only their most important core competencies as internal activities.

What is the current supply chain philosophy? Companies adopting the supply chain concept now view the entire set of activities from raw material production to final customer purchase, to final disposal as a linked chain of activities. To yield optimal performance for customer service and cost, it is felt that the supply chain of activities should be managed as an extension of the partnership. This implies many issues, but three critical ones are as follows:

1. Flow of materials.
2. Flow and sharing of information.
3. Flow of funds.

In addition, a new trend is emerging to manage the recovery, recycling, and reuse of material, known as **reverse logistics**.

The primary supply chain management approach is a conceptual one. All portions of the material production, from raw materials to final customer, are considered to be in a linked chain. The most efficient and effective way to manage the activities along the chain is to view each separate organization in the chain as an extension of one's own organization. There can be many organizations in a supply chain. Take as an example the chain of organizations that represents the flow from raw silicon used to make computer chips to the delivery and disposal of the computer itself in Figure 1.3.

What is illustrated here is but one chain of a set of different component chains that represent a network of suppliers and distributors for a product.

Most companies work with a network of supply chains, obtaining a variety of materials from multiple suppliers and sending products to multiple customers. Even a grocery

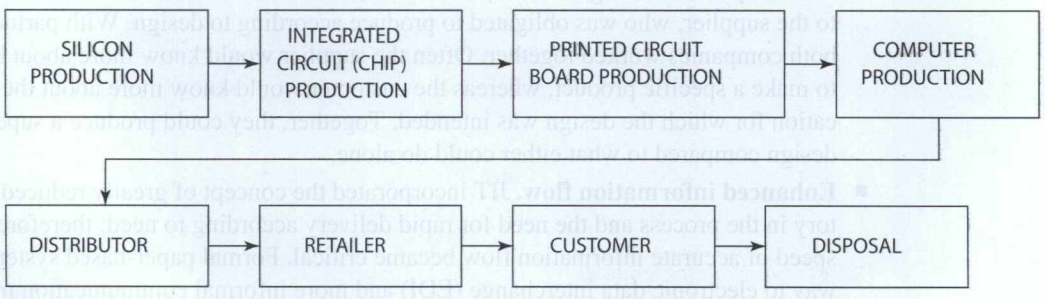

FIGURE 1.3 Supply chain organizations.

store has to deal with suppliers of dry goods, magazines, frozen and fresh products, and small suppliers of local produce or specialty goods.

The many independent businesses that make up a supply chain have individual profit motives and do not naturally cooperate to gain savings. This requires someone to take the initiative. Any member of the supply chain can work with other members to show the benefits of sharing information on forecasts, sales information, or schedules. **Orchestrator** or **channel master** are two emerging terms that describe the individual or company that takes the initiative to integrate both the upstream and downstream supply chain, getting members to work cooperatively to lower total costs and achieve greater efficiency. This is often the nucleus firm within the supply chain. The result is a network of companies that openly share information.

To manage a supply chain, one must not only understand the network of suppliers and customers along the chain but also try to efficiently plan material and information flows along each chain to maximize cost efficiency, effectiveness, delivery, and flexibility. This clearly implies not only taking a different conceptual approach to suppliers and customers but also a highly integrated information system and a different set of performance measures. Overall, the key to managing such a concept is with rapid flows of accurate information and increased organizational flexibility.

Supply Chain Metrics

A **metric** is a verifiable measure stated in either quantitative or qualitative terms defined with respect to a reference point. Without metrics, no firm can expect to function effectively or efficiently on a daily basis. Metrics give us

1. Control by superiors.
2. Reporting of data to superiors and external groups.
3. Communication.
4. Learning.
5. Improvement.

Building the right metrics is vital to a company, as metrics communicate expectations, identify problems, direct a course of action, and motivate people. Problems must be anticipated and corrective action taken before they become severe and costly. Companies cannot risk waiting to react until the order cycle is completed and feedback from customers is received.

Today, production control works in a demanding environment shaped by six major challenges:

1. Customers that are rarely satisfied.
2. A supply chain that is large and must be managed.
3. A product life cycle that is getting shorter and shorter.
4. A vast amount of data.
5. An emphasis on profit margins that are more squeezed.
6. An increasing number of alternatives.

A firm typically has a corporate strategy that states how it will treat its customers and what services it will supply. This identifies how a firm will compete in the marketplace. It is the customer who assesses the firm's offering by its decision to buy or not to buy. How metrics link strategy to operations is shown in Figure 1.4. Focus describes the particular

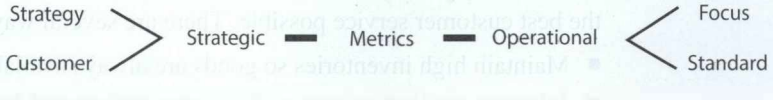

FIGURE 1.4 Metrics context.

activity that is to be measured. Standards are the yardstick that is the basis of comparison on which performance is judged.

There is a difference between performance measurements and performance standards. A **performance measure** must be both quantified and objective and contain at least two parameters. For example, the number of orders per day consists of both a quantity and a time measurement.

Transforming company policies into objectives and specific goals creates **performance standards**. Each goal should have target values. An example of this would be to improve order fill rate to 98% measured by number of lines. Performance standards set the goal, while performance measures reveal how close to the goal the organization reached.

Many companies do not realize the potential benefits of performance measurement, nor do they know how to measure performance, and often try to use them without performance standards. This might occur when the concept of performance measurement and standards is new. Only when standards are put into use can management begin to monitor the company. The old saying "What you do not measure, you cannot control" is as valid today as it was when first stated.

The necessary steps in implementing such a program are as follows:

1. Establish company goals and objectives.
2. Define performance.
3. State the measurement to be used.
4. Set performance standards.
5. Educate the participant.
6. Make sure the program is consistently applied.

Although financial performance has traditionally been the measure of success in most companies, today the focus is on continuous improvement and, with this, an increase in standards. Emphasis should not be placed on a "one-shot" improvement but on such things as the rate of improvement in quality, cost, reliability, innovation, effectiveness, and productivity.

Conflicts in Traditional Systems

In the past, supply, production, and distribution systems were organized into separate functions that reported to different departments of a company. Often, policies and practices of the different departments maximized departmental objectives without considering the effect they would have on other parts of the system. Because the three systems are interrelated, conflicts often occurred. Although each system made decisions that were best for itself, overall company objectives suffered. For example, the transportation department would ship in the largest quantities possible so it could minimize per-unit shipping costs. However, this increased inventory and resulted in higher inventory-carrying costs.

To get the most profit, a company must have at least four main objectives:

1. Provide best customer service.
2. Provide lowest production costs.
3. Provide lowest inventory investment.
4. Provide lowest distribution costs.

These objectives create conflict among the marketing, production, and finance departments because each has different responsibilities in these areas.

Marketing's objective is to maintain and increase revenue; therefore, it must provide the best customer service possible. There are several ways of doing this:

- Maintain high inventories so goods are always available for the customer.
- Interrupt production runs so that a non-inventoried item can be manufactured quickly.
- Create an extensive, and consequently costly, distribution system so goods can be shipped to the customer rapidly.

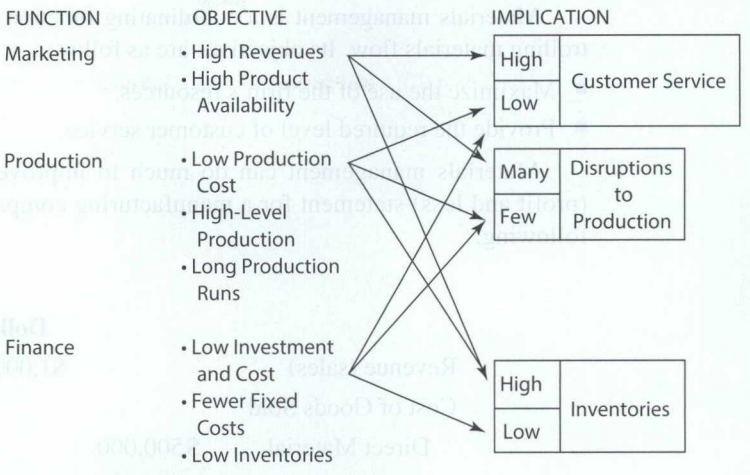

FIGURE 1.5 Conflicting objectives.

Finance must keep investment and costs low. This can be done in the following ways:

- Reduce inventory so inventory investment is at a minimum.
- Decrease the number of plants and warehouses.
- Produce large quantities using long production runs.
- Manufacture only to customer order.

Production must keep its operating costs as low as possible. This can be done in the following ways:

- Make long production runs of relatively few products. Fewer changeovers will be needed and specialized equipment can be used, thus reducing the cost of making the product.
- Maintain high inventories of raw materials and work-in-process so production is not disrupted by shortages.

These conflicts among marketing, finance, and production center on customer service, disruption of production flow, and inventory levels. Figure 1.5 shows this relationship.

Today, the concepts of lean production stress the need to supply customers with what they want, when they want it, and to keep inventories at a minimum. These objectives put further stress on the relationship among production, marketing, and finance. Chapter 15 will discuss the concepts of lean production and how it influences materials management.

One important way to resolve these conflicting objectives is to provide close coordination of the supply, production, and distribution functions. The problem is to balance conflicting objectives to minimize the total of all the costs involved and maximize customer service consistent with the goals of the organization. This requires some type of integrated materials management or logistics organization that is responsible for supply, production, and distribution. Rather than having the planning and control of these functions spread among marketing, production, and distribution, they should occur in a single area of responsibility.

WHAT IS MATERIALS MANAGEMENT?

The concept of having one department responsible for the flow of materials, from supplier through production to consumer, thereby minimizing total costs and providing a better level of customer service, is known as **materials management**. Other names include distribution planning and control, supply chain management, and logistics management, but the one used in this text is materials management. As will be discussed in Chapter 15, lean production not only requires efficient individual operations but also requires all operations to work together. A materials management department can improve this coordination by having overall responsibility for material.

Materials management is a coordinating function responsible for planning and controlling materials flow. Its objectives are as follows:

- Maximize the use of the firm's resources.
- Provide the required level of customer service.

Materials management can do much to improve a company's profit. An income (profit and loss) statement for a manufacturing company might look something like the following:

		Dollars	Percent of Sales
Revenue (sales)		$1,000,000	100
Cost of Goods Sold			
Direct Material	$500,000		50
Direct Labor	$200,000		20
Factory Overhead	$200,000		20
Total Cost of Goods Sold		$900,000	90
Gross Profit		$100,000	10

Direct labor and direct material are costs that increase or decrease with the quantity sold. Overhead (all other costs) does not vary directly with sales. For simplicity, this section assumes overhead is constant, even though it is initially expressed as a percentage of sales.

If, through a well-organized materials management department, direct materials can be reduced by 12%, the improvement in profit would be

		Dollars	Percent of Sales
Revenue (sales)		$1,000,000	100
Cost of Goods Sold			
Direct Material	$440,000		44
Direct Labor	$200,000		20
Overhead	$200,000		20
Total Cost of Goods Sold		$840,000	84
Gross Profit		$160,000	16

Profit has been increased by 60%. In other words, managing inventory effectively goes right to the bottom line of a company's profit. To get the same increase in profit ($60,000) by increasing revenue, sales would have to increase to $1.2 million.

		Dollars	Percent of Sales
Revenue (sales)		$1,200,000	100
Cost of Goods Sold			
Direct Material	$ 600,000		50
Direct Labor	$ 240,000		20
Overhead	$ 200,000		17
Total Cost of Goods Sold		$1,040,000	87
Gross Profit		$160,000	13

Example Problem

a. If the cost of direct material is 60%, direct labor is 10%, and overhead is 25% of sales, what will be the improvement in profit if cost of direct material is reduced to 55%?

b. How much will sales have to increase to give the same increase in profit? (Remember, overhead cost is constant.)

ANSWER

a.

	Before Improvement		After Improvement	
Revenue (sales)		100%		100%
Cost of Goods Sold				
Direct Material	60%		55%	
Direct Labor	10%		10%	
Overhead	25%		25%	
Total Cost of Goods Sold		95%		90%
Gross Profit		5%		10%

b. Profit = sales − (direct material + direct labor + 0.25)

= sales − (0.6 sales + 0.1 sales + 0.25)

= sales − 0.7 sales − 0.25

0.1 = 0.3 sales − 0.25

0.3 Sales = 0.35

$$\text{Sales} = \frac{0.35}{0.3} = 1.17$$

Sales must increase 17% to give the same increase in profit.

Work-in-Process

Inventory not only accounts for the raw materials and purchased components, but is also made up of the product as it is processed into finished goods. This type of inventory is called **work-in-process (WIP)**. WIP is a major investment for many companies, and reducing the amount of time that inventory spends in production is a good way to reduce the costs associated with this investment. Labor, materials, and overhead are applied to goods continuously through-out production, which increases the value of WIP. Further discussion on WIP and reducing it is covered in Chapters 9 and 15.

Example Problem

On average, a company has a 12-week production lead time and an annual cost of goods sold of $36 million. Assuming the company works 50 weeks per year:

a. What is the dollar value of the WIP?

b. If the lead time could be reduced to 5 weeks, and the annual cost of carrying inventory was 20% of the inventory value, what would be the annual savings?

ANSWER

Weekly cost of goods sold = $36,000,000 per year/50 weeks per year

= $720,000/week

WIP value at 12 weeks LT = 12 weeks × $720,000/week = $8,640,000

WIP value at 5 weeks LT = 5 weeks × $720,000/week = $3,600,000

Reduction in WIP = $8,640,000 − 3,600,000 = 5,040,000

Annual Savings = $5,040,000 × 20% = $1,008,000

Reducing cost contributes directly to profit. Increasing sales increases direct costs of labor and materials so profit does not increase in direct proportion. Materials management can reduce costs by being sure that the right materials are in the right place at the right time and the resources of the company are properly used.

There are several ways of classifying this flow of material. A very useful classification, and the one used in this text, is manufacturing planning and control and physical supply/distribution.

Manufacturing Planning and Control

Manufacturing planning and control are responsible for the planning and control of the flow of materials through the manufacturing process. The primary activities carried out are as follows:

1. **Production planning.** Production must be able to meet the demand of the marketplace. Finding the most productive way of doing so is the responsibility of production planning. It must establish correct priorities (what is needed and when) and make certain that capacity is available to meet those priorities. It involves:
   a. Forecasting.
   b. Master planning.
   c. Material requirements planning.
   d. Capacity planning.
2. **Implementation and control.** These functions are responsible for putting into action and executing the plans made by production planning. These responsibilities are accomplished through production activity control (often called *shop floor control*) and purchasing.
3. **Inventory management.** Inventories are materials and supplies carried on hand either for sale or to provide material or supplies to the production process. They are part of the planning process and provide a buffer against the differences in demand rates and production rates.

Production planning, implementation, control, and inventory management work hand-in-hand. Inventories in manufacturing are used to support production or are the result of production.

Inputs to the manufacturing planning and control system There are five basic inputs to the manufacturing planning and control system:

1. **Product description.** The product description shows how the product will appear at some stage of production. *Engineering drawings* and *specifications* are methods of describing the product. Another method, and the most important for manufacturing planning and control, is the **bill of material**. As used in materials management, this document does two things:
   - Describes the components used to make the product.
   - Describes the subassemblies at various stages of manufacture.
2. **Process specifications.** Process specifications describe the steps necessary to make the end product. They are a step-by-step set of instructions describing how the product is made. This information is usually recorded on a route sheet or in a **routing**. These are documents or computer files that give information such as the following on the manufacture of a product:
   - Operations required to make the product.
   - Sequence of operations.
   - Equipment and accessories required.
   - Standard time required to perform each operation.

3. **Time.** The time needed to perform operations is usually expressed in **standard time**, which is the time taken by an average operator, working at a normal pace, to perform a task. It is needed to schedule work through the plant, load the plant, make delivery promises, and cost the product. Standard times for operations are usually obtained from the routing information.
4. **Available facilities.** Manufacturing planning and control must know what plant, equipment, and labor will be available to process work. This information is usually found in the work center information.
5. **Quantities required.** This information will come from forecasts, customer orders, orders to replace finished goods inventory, and the material requirements plan.

Physical Supply/Distribution

Physical supply/distribution includes all the activities involved in moving goods, from the supplier to the beginning of the production process, and from the end of the production process to the consumer.

The activities involved are as follows:

- Transportation.
- Distribution inventory.
- Warehousing.
- Packaging.
- Material handling.
- Order entry.

Materials management is a balancing act. The objective is to be able to deliver what customers want, when and where they want it, and to do so at minimum cost. To achieve this objective, materials management must make tradeoffs between the level of customer service and the cost of providing that service. As a rule, costs rise as the service level increases, and materials management must find that combination of inputs to maximize service and minimize cost. For example, customer service can be improved by establishing warehouses in major markets. However, that causes extra cost in operating the warehouse and in the extra inventory carried. To some extent, these costs will be offset by potential savings in transportation costs if lower cost transportation can be used.

By grouping all those activities involved in the movement and storage of goods into one department, the firm has a better opportunity to provide maximum service at minimum cost and to increase profit. The overall concern of materials management is the balance between priority and capacity. The marketplace sets demand and materials management must plan the firm's priorities (what goods to make and when) to meet that demand. Capacity is the ability of the system to produce or deliver goods. Materials management is responsible for planning and controlling priority and capacity to meet customer demand at minimum cost.

SUMMARY

Manufacturing creates wealth by adding value to goods. To improve productivity and wealth, a company must first design efficient and effective systems for manufacturing. It must then manage these systems to make the best use of labor, capital, and material. One of the most effective ways of doing this is through the planning and control of the flow of materials into, through, and out of manufacturing. There are three elements to a material flow system: supply, manufacturing planning and control, and physical distribution. They are connected, and what happens in one system affects the others.

Traditionally, there are conflicts in the objectives of a company and in the objectives of marketing, finance, and production. The role of materials management is to balance these conflicting objectives by coordinating the flow of materials so customer service is maintained and the resources of the company are properly used.

This text will examine some of the theory and practice considered to be part of the body of knowledge of materials and supply chain management.

KEY TERMS

Assemble-to-order 16
Available facilities 25
Bill of material 24
Channel master 19
Configure-to-order 16
Engineer-to-order 15
Enterprise resource planning (ERP) 18
Implementation and control 24
Inventory management 24
Make-to-order 15
Make-to-stock 16
Materials management 21
Metric 19
Orchestrator 19
Order qualifiers 14
Order winners 14
Performance measure 20
Performance standards 20
Postponement 16
Process specifications 24
Product description 24
Production planning 24
Quantities required 25
Reverse logistics 18
Routing 24
Standard time 25
Supply chain management 17
Work-in-process (WIP) 23

QUESTIONS

1. What is wealth, and how is it created?
2. What is value added, and how is it achieved?
3. Name and describe four major factors affecting operations management.
4. What are an order qualifier and an order winner?
5. Describe the five primary manufacturing strategies. How does each affect delivery lead time?
6. What is a supply chain? Describe five important factors in supply chains.
7. What must manufacturing management do to manage a process or operation? What is the major way in which management plans and controls?
8. Name and describe the three main divisions of supply, production, and distribution systems.
9. What are the four objectives of a firm wishing to maximize profit?
10. What is the objective of marketing? What three ways will help it achieve this objective?
11. What are the objectives of finance? How can these objectives be met?
12. What are the objectives of production? How can these objectives be met?
13. Describe how the objectives of marketing, production, and finance are in conflict over customer service, disruption to production, and inventories.
14. What is the purpose of materials management?
15. Name and describe the three primary activities of manufacturing planning and control.
16. Name and describe the inputs to a manufacturing planning and control system.
17. What are the six activities involved in the physical supply/distribution system?
18. Why can materials management be considered a balancing act?
19. What are metrics? What are their uses?
20. A computer carrying case and a backpack are familiar items to a student of manufacturing planning and control. Discuss the manufacturing planning and control activities involved in producing a variety of these products. What information from other departments is necessary for manufacturing planning and control to perform its function?
21. Describe at least three supply chains that provide products to your school book store. Do they use cooperative supply chain methods to help reduce their costs?
22. From the bookstore example in question 21, describe how one of the supply chains would use a supply chain "channel master."

23. Which manufacturing strategies are used in a fast-food business? How does this affect the lead time from the customers' point of view?
24. Give an example of a postponement activity.

PROBLEMS

1.1 If the cost of manufacturing (direct material and direct labor) is 60% of sales and profit is 10% of sales, what would be the improvement in profit if, through better planning and control, the cost of manufacturing was reduced from 60% of sales to 50% of sales?

Answer. Profits would improve by 100%.

1.2 In problem 1.1, how much would sales have to increase to provide the same increase in profits?

Answer. Sales would have to increase 25%.

1.3 On the average, a company has a 12-week production lead time and an annual cost of goods sold of $38 million. Assuming the company works 50 weeks per year:

a. What is the dollar value of the WIP?

b. If the lead time could be reduced to 5 weeks, what would be the reduction in the WIP?

Answer. a. $9,120,000

b. $5,320,000

1.4 On the average, a company has a WIP lead time of 8 weeks and an annual cost of goods sold of $40 million. Assuming that the company works 50 weeks a year:

a. What is the dollar value of the work-in-process?

b. If the work-in-process could be reduced to 5 weeks and the annual cost of carrying inventory was 15% of the WIP inventory value, what would be the annual savings?

1.5 Flex Electronics has recorded sales of $20 million in the last year. The company's spend on the cost of direct material was 55%, direct labor was 15%, and overhead was 25% of sales. What will be the improvement in profit if the cost of direct material is reduced to 50%?

a. What will be the profit before improvement?

b. What will be the profit after improvement?

c. How much will sales have to increase to give the same increase in profit?

CASE STUDY 1.1

Priya's Cakes

Three years ago, Priya decided to pursue a profession that combined her passion for baking and her unique artistic ability. She opened a cake shop in the heart of her city. She focused on using the best and latest technology in the field of baking and confectionery. Soon, her talent and her dedication to providing quality products made her shop, Priya's Cakes, one of the most popular local cake shops. In the first two years of operations, she focused primarily on make-to-stock standard cake orders. She also supplied her friends and family with uniquely designed cakes on special occasions such as baby showers, wedding ceremonies, anniversaries, and birthdays. This triggered positive word-of-mouth advertising for her business, resulting in frequent requests for custom cakes. In the third year, she finally introduced make-to-order custom cakes as a formal product offering. Since then, her business has grown substantially, and revenue from custom cakes now makes half of her total revenue. But introducing custom cakes has also brought numerous unanticipated challenges for her business. She pondered over how to deal with these

challenges, intending to take the necessary actions immediately in order to be ready for an upcoming busy wedding season. The following are some of the major issues she wanted to discuss with her business consultant in the next meeting.

Business Strategy: From the beginning, she had aimed to provide quality products by ensuring that there would be superior ingredients, expert chefs, and the latest equipment. Twelve varieties of cakes were offered each day: eight standard flavors and four flavors that changed on a daily basis. All of these cakes were prepared by focusing on make-to-stock arrangements, with minor decorations and a message or name added at the time of purchase. Most of the orders were walk-in purchases. The orders for sugar-free, gluten-free, and eggless cakes were pre-booked and delivered in limited flavors. High-product quality, good variety, competitive pricing, short lead time, and nice hospitality soon made Priya's Cakes a preferred "cakery" among the locals.

As this business segment appealed to her creative and artistic abilities and had higher profit margins, she started offering make-to-order custom cakes too. She viewed this as an opportunity to create and deliver a delicious centerpiece that everyone would rave about. This required her thorough involvement with the customers to finalize various cake features, such as seasonal ingredients, tailored pictures, new flavor combinations, types of cream, the choice of available tier shapes (round, square, hexagonal, oval, and heart-shaped), decorations, and fruit toppings. All tailored cakes were baked freshly against order. The majority of these orders were for wedding cakes. She also started offering various types of cupcakes and chocolate brownies on order, especially for wedding ceremonies. In a short time, she had a good relationship with many happy customers, and this business segment grew substantially. However, the growth also caused several difficulties due to the following business characteristics:

a. One of the special attractions of her custom cakes was the option of having sculpted pictures, such as cartoons and toys for kids and romantic images for couples. These premium cakes were initially baked by her personally. As the orders for custom cakes increased, Priya hired Megha, another skilled artist and an old friend, to work with her. Over the time, they used their creativity and various Internet and print sources to develop a catalog of picture cakes. However, things didn't work out the way they anticipated. Several customers complained about the brightness of the colors and the 3D presentation of the handmade figures and pictures on the delivered cakes. When Megha and Priya looked into the problem, they realized how this situation arose: because of high demand, the regular chefs were made to work on the picture cakes while the two of them were busy dealing with the new customers. Further, the demand for these premium cakes was uncertain and having additional full-time artists could mean an increase in fixed labor cost. Later, she tried hiring some part-time skilled artists during rush orders. This proved satisfactory but reduced her profit margins significantly. She knew that she needed to address this issue urgently because not delivering what had been promised could mean the permanent loss of a good potential customer as well as negative word-of-mouth.

b. The pricing of custom cakes had become a headache for her as well. The price of these cakes varied depending on the design and flavor, seasonal and tailored cake flavors, choice of tier shapes, icing design work, decorations and toppings, and choice of sculpted pictures and figures. As these cakes required more time to be made and were labor-intensive, their prices were highly variable. She and Megha decided the prices based on their experience, but the absence of a standard pricing procedure meant that negotiating with customers took much of their time. Further, she and Megha were also required to assist various customers in designing custom cakes, which frequently pulled them away from working on their existing orders. Scheduling an appointment with customers had also become an issue due to their busy schedule.

c. Many customers suggested that Priya launch a website where they could order standard cakes and schedule their pickups, as they often found it quite inconvenient to visit her shop more than once. Another group of customers wanted to explore the available cake flavors, custom designs, and various product offerings from their