CHAPTER 1

MANUFACTURING IN AMERICA

What has been will be again, what has been done will be done again; there is nothing new under the sun.

Ecclesiastes

1.1 Introduction

A fundamental premise of this book is that to manage something effectively, one must first understand it. But manufacturing systems are complex entities that can be viewed in many ways, many of which are integral to sound managerial insight. A particularly important perspective, which provides an organizing framework for all others, is that of history.

A sense of history is fundamental to manufacturing managers for two main reasons. First, in manufacturing, as in all walks of life, the ultimate test of an idea is the test of time. Since short-term success may be the result of luck or exogenous circumstances, we can only identify concepts of lasting value by taking the long-term view. Second, because the requirements for success in business change over time, it is critical for managers to make decisions with the future in mind. One of the very best tools for consistently anticipating the future is a sound appreciation of the past.

The history of American manufacturing, which follows its rise from meager colonial beginnings to undisputed worldwide leadership by mid-20th century, through a period of serious decline in the 1970s and 1980s, and into a revitalization in the complex global environment of the 1990s, is a fascinating story. Sadly, we have neither the space nor the expertise to offer comprehensive coverage here. Instead, we highlight major events and trends with emphasis on themes that will be crucial later in the book. We hope the reader will be sufficiently interested in these historical issues to pursue more basic sources. The following are attractive starting points. Wren (1987) provides an excellent general overview from a management perspective. Boorstin in The Americans trilogy

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1 For example, to a mechanical engineer a manufacturing system is a set of physical processes for altering material, to an operations manager it is a logistical network of product flows, to an organization behavior specialist it is a community of people with shared concerns, to an accountant it is a collection of interrelated cash flows, and so on.
(1958, 1965, 1973) offers a number of highly readable insights into American business in a cultural context. Chandler (1977, 1990) gives a towering treatment of the evolution of large-scale management in America, as well as Germany and Great Britain. We have drawn heavily on these works, and their references, in what follows.

1.2 The American Experience

In many ways, America began with a clean slate. A vast, wide-open continent offered unparalleled resources and unlimited opportunities for development. Unshackled by the traditions of the Old World, Americans were free to write their own rules. Government, law, cultural practices, and social mores were all choices to be made as part of the grand American experiment.

Naturally, these choices reflected the times in which they were made. In 1776, antimonarchist sentiment, which would soon fuel the French Revolution, was on the rise in both the Old World and the New. America chose democracy. In 1776, Scotsman Adam Smith (1723–1790) proclaimed the end of the old mercantilist system and the beginnings of modern capitalism in his Wealth of Nations, in which he articulated the benefits of the division of labor and explained the workings of the “invisible hand” of capitalism.2 America chose the free market system. In 1776, James Watt (1736–1819) sold his first steam engine in England and began the first industrial revolution in earnest. America embraced the new factory system, evolved a unique style of manufacturing, and eventually led the transportation and communications breakthroughs that sparked the second industrial revolution. In 1776, English common law was the standard for the civilized world. America adapted this tradition, borrowed from Roman law and the Code Napoléon, and rapidly became the most litigious country in the world.3

In almost all cases, Americans did not invent revolutionary concepts from scratch. Rather, they borrowed freely (and even stole) ideas from the Old World and adapted them to the New. Because the needs of the New World were different, because they were not bound by Old World customs and traditions, and, quite frankly, because they were naive, the social and economic institutions that resulted were uniquely American.

The very fact that America had the opportunity to create itself has done much to shape its national identity. Unlike the countries of the Old World, which coalesced as nations long after they had acquired a national spirit, the United States of America achieved nationhood as a composite of colonies with little sense of common identity. Hence, Americans actively sought an identity in the form of cultural symbols. The strongest and most uniquely American cultural icon was that of the rugged individualist seeking freedom on the frontier. This spawned the wild comic legends about Davy Crockett and Mike Fink and later played a large part in transforming Abraham Lincoln into a revered national icon as the “rail splitter” president. Even after the frontier was gone, the myth of the frontier lived on in popular literature and cinema about the cowboys, ranchers, gunfighters, and prospectors of the Old West.

In more recent times, the myth of the frontier evolved into the myth of the self-made person, which has roots stretching back to the aphorisms of Benjamin Franklin (1706–1790) and the essays of Ralph Waldo Emerson (1803–1882), and which found fertile ground in the Protestant work ethic. This myth made heroes out of successful

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2It is not coincidence that Henry Ford, one of the men most visibly associated with capitalism, would write a book 150 years after Smith’s and with the penultimate chapter entitled “The Wealth of Nations.”

3Two-thirds of the world’s lawyers practice in the United States where there are 1,000 lawyers to every 100 engineers. Japan, on the other hand, has 1,000 engineers to every 100 lawyers (Lamm 1988, 17).
industrialists of the 19th century (e.g., Carnegie, Rockefeller, Morgan) and provided
cultural support for the unvarnished pursuit of wealth by the corporate raiders of the
1980s. The terms that referred to the players in the takeover games of that “decade of
greed”—gunslinger, white knight, masters of the universe—were not accidental. Nor is
the fact that marketing and finance have consistently been more popular in American
business schools than operations management. The perception has been that in finance
and marketing, one can do something “big” or “bold” by starting daring new ventures or
launching exciting new products, while in operations management one can only struggle
to save a few pennies on the cost side—necessary, perhaps, but not very exciting.
Attention to detail may be a virtue in Europe or Japan, where resource limits have long
been a fact of life; it is decidedly dull in the land of the cowboy.

A third cultural force permeating the American identity is an underlying faith in the
scientific method. From the period of the Enlightenment, which in America took the form
of the popular science of Franklin and then the pragmatic inventions of Whitney, Bell,
Eastman, Edison, and others, Americans have always embraced the rational, reductionist,
analytical approach of science. The first uniquely American management system became
known as scientific management.4 The notion of “managing by the numbers” has deep
roots in our cultural propensity for things scientific.

The reductionist method favored by scientists analyzes systems by breaking them
down into their component parts and studying each one. This was a fundamental tenet
of scientific management, which worked to improve overall efficiency by decomposing
work into specific tasks and then improving the efficiency of each task. Today’s industrial
engineers and operations researchers still use this approach almost exclusively and are
very much a product of the scientific management movement.

While reductionism can be an extremely profitable paradigm for analyzing complex
systems—and certainly Western science has attained many triumphs via this approach—it
is not the only valid perspective. Indeed, as has become obvious from the huge gap
between academic research and actual practice in industry, too much emphasis on individual
components can lead to a loss of perspective for the overall system.

In contrast to the reductionism of the West, Far Eastern societies seem to maintain
a more holistic or systems perspective. In this approach, individual components are
viewed much more in terms of their interactions with other subsystems and in the light
of the overall goals of the system. This systems perspective undoubtedly influenced the
development of just-in-time (JIT) systems in Japan, as we will discuss more thoroughly
in Chapter 4.

The difference between the reductionist and holistic perspectives is starkly illus-
trated by the differing responses taken by the Americans and the Japanese to the prob-
lem of setups in manufacturing operations. Setup time is required for changeover of
a machine from making one product to making another. In the American industrial
engineering/operations research literature, for decades, setup times were regarded as
constraints, leading to the development of all sorts of complex mathematical models
determining “optimal” lot sizes that would balance setup costs against inventory carrying
costs. This view made perfect sense from a reductionist perspective, in which the setups
were a given for the subsystem under consideration. In contrast, the Japanese, looking at
manufacturing systems in the more holistic sense, recognized that setup times were not
a given—they could be reduced. Moreover, from a systems perspective, there was clear

4This is in spite of the fact that its developer, Frederick W. Taylor, himself preferred the terms task
management or the Taylor system.
value in reducing setup times. Clever use of jigs, fixtures, off-cycle preparations, and the like, which became known as single minute exchange of die, or SMED (Shingo 1985), enabled some Japanese factories to realize significantly shorter setup times than those in comparable American plants. In particular, the Japanese automobile industry became among the most productive in the world. These plants became simpler to manage and more flexible than their American counterparts.

Of course, the Japanese system had its weak points as well. Its convoluted pricing and distribution systems made Japanese electronic devices cheaper in New York than in Tokyo. Competition was tightly regulated by a traditional corporate network that kept out newcomers and led to bad investments. Strong profits of the 1980s were plowed into overvalued stocks and real estate. When the bubble burst in the 1990s, Japan found itself mired in an extended recession that precipitated the “Asian crisis” throughout the Pacific Rim.

1.3 The First Industrial Revolution

Prior to the first industrial revolution, production was small-scale, for limited markets, and labor- rather than capital-intensive. Work was carried out under two systems, the domestic system and craft guilds. In the domestic system, material was “put out” by merchants to homes where people performed the necessary operations. For instance, in the textile industry, different families spun, bleached, and dyed material, with merchants paying them on a piecework basis. In the craft guilds, work was passed from one shop to another. For example, leather was tanned by a tanner, passed to curriers, then passed to shoemakers and saddlers. The result was separate markets for the material at each step of the process.

The first industrial revolution began in England during the mid-18th century in the textile industry. This revolution, which dramatically changed manufacturing practices and the very course of human existence, was stimulated by several innovations that helped mechanize many of the traditional manual operations. Among the more prominent technological advances were the flying shuttle developed by John Kay in 1733, the spinning jenny invented by James Hargreaves in 1765 (Jenny was Mrs. Hargreaves), and the waterframe developed by Richard Arkwright in 1769. By facilitating the substitution of capital for labor, these innovations generated economies of scale that made mass production in centralized locations attractive for the first time.

The single most important innovation of the first industrial revolution, however, was the steam engine, developed by James Watt in 1765 and first installed by John Wilkinson in his iron works in 1776. In 1781 Watt developed the technology for transforming the up-and-down motion of the drive beam to rotary motion. This made steam practical as a power source for a host of applications, including factories, ships, trains, and mines. Steam opened up far greater freedom of location and industrial organization by freeing manufacturers from their reliance on water power. It also provided cheaper power, which led to lower production costs, lower prices, and greatly expanded markets.

It has been said that Adam Smith and James Watt did more to change the world around them than anyone else in their period of history. Smith told us why the modern factory system, with its division of labor and “invisible hand” of capitalism, was desirable. Watt, with his engines (and the well-organized factory in which he, his partner Matthew Boulton, and their sons built them), showed us how to do it. Many features of modern life, including widespread employment in large-scale factories, mass production
1.3.1 The Industrial Revolution in America

England had a decided technological edge over America throughout the 18th century and protected her competitive advantage by prohibiting export of models, plans, or people that could reveal the technologies upon which her industrial strength was based. It was not until the 1790s that a technologically advanced textile mill appeared in America—and that was the result of an early case of industrial espionage!

Boorstin (1965, 27) reports that Americans made numerous attempts to invent machinery like that in use in England during the later years of the 18th century, going so far as to organize state lotteries to raise prize money for enticing inventors. When these efforts failed repeatedly, Americans tried to import or copy English machines. Trench Coxe, a Philadelphian, managed to get a set of brass models made of Arkwright's machinery; but British customs officers discovered them on the dock and foiled his attempt. America finally succeeded in its efforts when Samuel Slater (1768–1825)—who had been apprenticed at the age of 14 to Jedediah Strutt, the partner of Richard Arkwright (1732–1792)—disguised himself as a farmer and left England secretly, without even telling his mother, to avoid the English law prohibiting departure of anyone with technical knowledge. Using the promise of a partnership, Moses Brown (for whom Brown University was named), who owned a small textile operation in Rhode Island, with his son-in-law William Almy, enticed Slater to share his illegally transported technical knowledge. With Brown and Almy's capital and Slater's phenomenal memory, they built a cotton-spinning frame and in 1793 established the first modern textile mill in America at Pawtucket, Rhode Island.

The Rhode Island system, as the management system used by the Almy, Brown, and Slater partnership became known, closely resembled the British system on which it was founded. Focusing only on spinning fine yarn, Slater and his associates relied little on vertical integration and much on direct personal supervision of their operations. However, by the 1820s, the American textile industry would acquire a distinctly different character from that of the English by consolidating many previously disparate operations under a single roof. This was catalyzed by two factors.

First, America, unlike England, had no strong tradition of craft guilds. In England, distinct stages of production (e.g., spinning, weaving, dying, printing in cotton textile manufacture) were carried out by different artisans who regarded themselves as engaged in distinct occupations. Specialized traders dealt in yarn, woven goods, and dyestuffs. These groups all had vested interests in not centralizing or simplifying production. In contrast, America relied primarily on the domestic system for textile production throughout its colonial period. Americans of this time either spun and wove for themselves or purchased imported woolens and cottons. Even in the latter half of the 18th century, a large proportion of American manufacturing was carried out by village artisans without guild affiliation. As a result, there were no organized constituencies to block the move toward integration of the manufacturing process.

Second, America, unlike England, still had large untapped sources of water power in the late 18th and early 19th centuries. Thus, the steam engine did not replace water power in America on a widespread basis until the Civil War. With large sources of water power, it was desirable to centralize manufacturing operations. This is precisely what Francis Cabot Lowell (1775–1817) did. After smuggling plans for a power loom out of Britain (Chandler 1977, 58), he and his associates built the famous cotton textile
factories at Waltham and Lowell, Massachusetts, in 1814 and 1821. By using a single source of water power to drive all the steps necessary to manufacture cotton cloth, they established an early example of a modern integrated factory system. Ironically, because steam facilitated power generation in smaller units, its earlier introduction in England served to keep the production process smaller and more fragmented in England than in water-reliant America.

The result was that Americans, faced with a fundamentally different environment than that of the technologically and economically superior British firms, responded by innovating. These steps toward vertical integration in the early-19th-century textile industry were harbingers of a powerful trend that would ultimately make America the land of big business. The seeds of the enormous integrated mass production facilities that would become the norm in the 20th century were planted early in our history.

1.3.2 The American System of Manufacturing

Vertical integration was the first step in a distinctively American style of manufacturing. The second and more fundamental step was the production of interchangeable parts in the manufacture of complex multipart products. By the mid-19th century it was clear that the Americans were evolving an entirely new approach to manufacturing. The 1851 Crystal Palace Exhibition in London saw the first use of the term American system of manufacturing to describe the display of American products, such as the locks of Alfred Hobbs, the repeating pistol of Samuel Colt, and the mechanical reaper of Cyrus McCormick, all produced by using the method of interchangeable parts.

The concept of interchangeable parts did not originate in America. The Arsenal of Venice was using some standard parts in the manufacture of warships as early as 1436. French gunsmith Honore LeBlanc had shown Thomas Jefferson musket components manufactured by using interchangeable parts in 1785; but the French had abandoned his approach in favor of traditional craft methods (Mumford 1934, Singer et al. 1958). It fell to two New Englanders, Eli Whitney (1765–1825) and Simeon North, to prove the feasibility of interchangeable parts as a sound industrial practice. At Jefferson’s urging, Whitney was contracted to produce 10,000 muskets for the American government in 1801. Although it took him until 1809 to deliver the last musket, and he made only $2,500 on the job, he established beyond dispute the workability of what he called his “Uniformity System.” North, a scythe manufacturer, confirmed the practicality of the concept and devised new methods for implementing it, through a series of contracts between 1799 and 1813 to produce pistols with interchangeable parts for the War Department. The inspiration of Jefferson and the ideas of Whitney and North were utilized on a large scale for the first time at the Springfield Armory between 1815 and 1825, under the direction of Colonel Roswell Lee.

Prior to the innovation of interchangeable parts, the making of a complex machine was carried out in its entirety by an artisan, who fabricated and fitted each required piece. Under Whitney’s uniformity system, the individual parts were mass-produced to tolerances tight enough to enable their use in any finished product. The division of labor called for by Adam Smith could now be carried out to an extent never before achievable, with individual workers producing single parts rather than completed products. The highly skilled artisan was no longer necessary.

It is difficult to overstate the importance of the idea of interchangeable parts, which Boorstin (1965) calls “the greatest skill-saving innovation in human history.” Imagine producing personal computers under the skilled artisan system! The artisan would first have to fabricate a silicon wafer and then turn it into the needed chips. Then the
printed-circuit boards would have to be produced, not to mention all the components that go into them. The disk drives, monitor, power supply, and so forth—all would have to be fabricated. Finally, all the components would be assembled in a handmade plastic case. Even if such a feat could be achieved, personal computers would cost millions of dollars and would hardly be "personal." Without exaggeration, our modern way of life depends on and evolved from the innovation of interchangeable parts. Undoubtedly, the Whitney and North contracts were among the most productive uses of federal funds to stimulate technological development in all of American history.

The American system of manufacturing, emphasizing mass production through use of vertical integration and interchangeable parts, started two important trends that impacted the nature of manufacturing management in this country to the present.

First, the concept of interchangeable parts greatly reduced the need for specialized skills on the part of workers. Whitney stated his aim as to "substitute correct and effective operations of machinery for that skill of the artist which is acquired only by long practice and experience, a species of skill which is not possessed in this country to any considerable extent" (Boorstin 1965, 33). Under the American system, workers without specialized skills could make complex products. An immediate result was a difference in worker wages between England and America. In the 1820s, unskilled laborers' wages in America were one-third or one-half higher than those in England, while highly skilled workers in America were only slightly better paid than in England. Clearly, America placed a lower premium on specialized skills than other countries from a very early point in her history. Workers, like parts, were interchangeable. This early rise of the undifferentiated worker contributed to the rocky history of labor relations in America. It also paved the way for the sharp distinction between planning (by management) and execution (by workers) under the principles of scientific management in the early 20th century.

Second, by embedding specialization in machinery instead of people, the American system placed a greater premium on general intelligence than on specialized training. In England, unskilled meant unspecialized; but the American system broke down the distinction between skilled and unskilled. Moreover, machinery, techniques, and products were constantly changing, so that open-mindedness and versatility became more important than manual dexterity or task-specific knowledge. A liberal education was useful in the New World in a way that it had never been in the Old World, where an education was primarily a mark of refinement. This trend would greatly influence the American system of education. It also very likely prepared the way for the rise of the professional manager, who is assumed able to manage any operation without detailed knowledge of its specifics.

1.4 The Second Industrial Revolution

In spite of the notable advances in the textile industry by Slater in the 1790s and the practical demonstration of the uniformity system by Whitney, North, and Lee in the early 1800s, most industry in pre-1840 America was small, family-owned, and technologically primitive. Before the 1830s, coal was not widely available, so most industry relied on water power. Seasonal variations in the power supply, due to drought or ice, plus the lack of a reliable all-weather transportation network, made full-time, year-round production impractical for many manufacturers. Workers were recruited seasonally from the local farm population, and goods were sold locally or through the traditional merchant network established to sell British goods in America. The class of permanent industrial workers was small, and the class of industrial managers almost nonexistent. Prior to 1840, there
were almost no manufacturing enterprises sophisticated enough to require anything more than traditional methods of direct factory management by the owners.

Before the Civil War, large factories were the exception rather than the rule. In 1832, Secretary of the Treasury Louis McLane conducted a survey of manufacturing in 10 states and found only 36 enterprises with 250 or more workers, of which 31 were textile factories. The vast majority of enterprises had assets of only a few thousand dollars, had fewer than a dozen employees, and relied on water power (Chandler 1977, 60–61). The Springfield Armory, often cited as the most modern plant of its time—it used interchangeable parts, division of labor, cost accounting techniques, uniform standards, inspection/control procedures, and advanced metalworking methods—rarely had more than 250 employees.

The spread of the factory system was limited by the dependence on water power until the opening of the anthracite coal fields in eastern Pennsylvania in the 1830s. From 1840, anthracite-fueled blast furnaces began providing an inexpensive supply of pig iron for the first time. The availability of energy and raw material prompted a variety of industries (e.g., makers of watches, clocks, safes, locks, pistols) to build large factories using the method of interchangeable parts. In the late 1840s, newly invented technologies (e.g., sewing machines and reapers) also began production using the interchangeable-parts method.

However, even with the availability of coal, large-scale production facilities did not immediately arise. The modern integrated industrial enterprise was not the consequence of the technological and energy innovations of the first industrial revolution. The mass production characteristic of large-scale manufacturing required coordination of a mass distribution system to facilitate the flow of materials and goods through the economy. Thus, the second industrial revolution was catalyzed by innovations in transportation and communication—railroad, steamship, and telegraph—that occurred between 1850 and 1880. Breakthroughs in distribution technology in turn prompted a revolution in mass production technology in the 1880s and 1890s, including the Bonsack machine for cigarettes, the "automatic-line" canning process for foods, practical implementation of the Bessemer steel process and electrolytic aluminum refining, and many others. During this time, America visibly led the way in mass production and distribution innovations and, as a result, by World War II had more large-scale business enterprises than the rest of the world combined.

1.4.1 The Role of the Railroads

Railroads were the spark that ignited the second industrial revolution for three reasons:

1. They were America’s first big business, and hence the first place where large-scale management hierarchies and modern accounting practices were needed.

2. Their construction (and that of the telegraph system at the same time) created a large market for mass-produced products, such as iron rails, wheels, and spikes, as well as basic commodities such as wood, glass, upholstery, and copper wire.

3. They connected the country, providing reliable all-weather transportation for factory goods and creating mass markets for products.

Colonel John Stevens received the first railroad charter in America from the New Jersey legislature in 1815 but, because of funding problems, did not build the 23-mile-long Camden and Amboy Railroad until 1830. In 1850 there were 9,000 miles of track
extending as far as Ohio (Stover 1961, 29). By 1865 there were 35,085 miles of railroad in the United States, only 3,272 of which were west of the Mississippi. By 1890, the total had reached 199,876 miles, 72,473 of which were west of the Mississippi. Unlike in the Old World and in the eastern United States, where railroads connected established population centers, western railroads were generally built in sparsely populated areas, with lines running from “Nowhere-in-Particular to Nowhere-at-All” in the anticipation of development.

The capital required to build a railroad was far greater than that required to build a textile mill or small metalworking enterprise. A single individual or small group of associates was rarely able to own a railroad. Moreover, because of the complexity and distributed nature of its operations, the many stockholders or their representatives could not directly manage a railroad. For the first time, a new class of salaried employees—middle managers—emerged in American business. Out of necessity the railroads became the birthplace of the first administrative hierarchies, in which managers managed other managers.

A pioneer of methods for managing the newly emerging structures was Daniel Craig McCallum (1815–1878). Working for the New York and Erie Railroad Company in the 1850s, he developed principles of management and a formal organization chart to convey lines of authority, communication, and division of labor (Chandler 1977, 101). Henry Varnum Poor, editor of the American Railroad Journal, widely publicized McCallum’s work in his writings and sold lithographs of his organization chart for $1 each. Although the Erie line was taken over by financiers with little concern for efficiency (i.e., the infamous Jay Gould and his associates), Poor’s publicity efforts ensured that McCallum’s ideas had a major effect on railroad management in America.

Because of their complexity and reliance on a hierarchy of managers, railroads required large amounts of data and new types of analysis. In response to this need, innovators like J. Edgar Thomson of the Pennsylvania Railroad and Albert Fink of the Louisville & Nashville invented many of the basic techniques of modern accounting during the 1850s and 1860s. Specific contributions included introduction of standardized ratios (e.g., the ratio between a railroad’s operating revenues and its expenditures, called the operating ratio), capital accounting procedures (e.g., renewal accounting), and unit cost measures (e.g., cost per ton-mile). Again, Henry Varnum Poor publicized the new accounting techniques and they rapidly became standard industry practice.

In addition to being the first big businesses, the railroads, along with the telegraph, paved the way for future big businesses by creating a mass distribution network and thereby making mass markets possible. As the transportation and communication systems improved, commodity dealers, purchasing agricultural products from farmers and selling to processors and wholesalers, began to appear in the 1850s and 1860s. By the 1870s and 1880s, mass retailers, such as department stores and mail-order houses, followed suit.

### 1.4.2 Mass Retailers

The phenomenal growth of these mass retailers provided a need for further advances in the management of operations. For example, Sears and Roebuck’s sales grew from $138,000 in 1891 to $37,789,000 in 1905 (Chandler 1977, 231). Otto Doering developed a system for handling the huge volume of orders at Sears in the early years of the 20th century, a system that used machinery to convey paperwork and transport items in the warehouse. But the key to his process was a complex and rigid scheduling system that gave departments a 15-minute window in which to deliver items for a particular order.
Departments that failed to meet the schedule were fined 50 cents per item. Legend has it that Henry Ford visited and studied this state-of-the-art mail-order facility before building his first plant (Drucker 1954, 30).

The mass distribution systems of the retailers and mail-order houses also produced important contributions to the development of accounting practices. Because of their high volumes and low margins, these enterprises had to be extremely cost-conscious. Analogously to the use of operating ratios by the railroads, retailers used gross margins (sales receipts less cost of goods sold and operating expenses). But since retailers, like the railroads, were single-activity firms, they developed specific measures of process efficiency unique to their type of business. Whereas the railroads concentrated on cost per ton-mile, the retailers focused on inventory turns or “stockturn” (the ratio of annual sales to average on-hand inventory). Marshall Field was tracking inventory turns as early as 1870 (Johnson and Kaplan 1987, 41), and maintained an average of between five and six turns during the 1870s and 1880s (Chandler 1977, 223), numbers that equal or better the performance of some retail operations today.

It is important to understand the difference between the environment in which American retailers flourished and the environment prevalent in the Old World. In Europe and Japan, goods were sold to populations in established centers with strong word-of-mouth contacts. Under such conditions, advertising was largely a luxury. Americans, on the other hand, marketed their goods to a sparse and fluctuating population scattered across a vast continent. Advertising was the lifeblood of firms like Sears and Roebuck. Very early on, marketing was more important in the New World than in the Old. Later on, the role of marketing in manufacturing would be further reinforced when makers of new technologies (sewing machines, typewriters, agricultural equipment) found they could not count on wholesalers or other intermediaries to provide the specialized services necessary to sell their products, and formed their own sales organizations.

### 1.4.3 Andrew Carnegie and Scale

Following the lead of the railroads, other industries began the trend toward big business through horizontal and vertical integration. In horizontal integration, a firm bought up competitors in the same line of business (steel, oil, etc.). In vertical integration firms subsumed their sources of raw material and users of the product. For instance, in the steel industry, vertical integration took place when the steel mill owners purchased mining and ore production facilities on the upstream end and rolling mills and fabrication facilities on the downstream end.

In many respects, modern factory management first appeared in the metal making and working industries. Prior to the 1850s, the American iron and steel industry was fragmented into separate companies that performed the smelting, rolling, forging, and fabrication operations. In the 1850s and 1860s, in response to the tremendous growth of railroads, several large integrated rail mills appeared in which blast furnaces and shaping mills were contained in a single works. Nevertheless, in 1868, America was still a minor player in steel, producing only 8,500 tons compared with Britain’s production of 10,000 tons.

In 1872, Andrew Carnegie (1835–1919) turned his hand to the steel industry. Carnegie had worked for J. Edgar Thompson on the Pennsylvania Railroad, rising from telegraph operator to division superintendent, and had a sound appreciation for the accounting and management methods of the railroad industry. He combined the new Bessemer process for making steel with the management methods of McCallum and
Thompson, and he brought the industry to previously unimagined levels of integration and efficiency. Carnegie expressed his respect for his railroad mentors by naming his first integrated steel operation the Edgar Thompson Works. The goal of the E. T. Worxs was "a large and regular output," accomplished through the use of the largest and most technologically advanced blast furnaces in the world. More importantly, the E. T. Worxs took full advantage of integration by maintaining a continuous work flow—it was the first steel mill whose layout was dictated by material flow. By relentlessly exploiting his scale advantages and increasing velocity of throughput, Carnegie quickly became the most efficient steel producer in the world.

Carnegie further increased the scale of his operations by integrating vertically into iron and coal mines and other steel-related operations to improve flow even more. The effect was dramatic. By 1879, American steel production nearly equaled that of Britain. And by 1902, America produced 9,138,000 tons, compared with 1,826,000 for Britain.

Carnegie also put the cost accounting skills acquired from his railroad experience to good use. A stickler for accurate costing—one of his favorite dictums was, "Watch the costs and the profits will take care of themselves"—he instituted a strict accounting system. By doggedly focusing on unit cost, he became the low-cost producer of steel and was able to undercut competitors who had a less precise grasp of their costs. He used this information to his advantage, raising prices along with his competition during periods of prosperity and relentlessly cutting prices during recessions.

In addition to graphically illustrating the benefits from scale economies and high throughput, Carnegie's was a classic story of an entrepreneur who made use of minute data and prudent attention to operating details to gain a significant strategic advantage in the marketplace. He focused solely on steel and knew his business thoroughly, saying

I believe the true road to preeminent success in any line is to make yourself master in that line. I have no faith in the policy of scattering one's resources, and in my experience I have rarely if ever met a man who achieved preeminence in money-making—certainly never one in manufacturing—who was interested in many concerns. The men who have succeeded are men who have chosen one line and stuck to it. (Carnegie 1920, 177)

Aside from representing one of the largest fortunes the world had known, Carnegie's success had substantial social benefit. When Carnegie started in the steel business in the 1870s, iron rails cost $100 per ton; by the late 1890s they sold for $12 per ton (Chandler 1984, 485).

1.4.4 Henry Ford and Speed

By the beginning of the 20th century, integration, vertical and horizontal, had already made America the land of big business. High-volume production was commonplace in process industries such as steel, aluminum, oil, chemicals, food, and tobacco. Mass production of mechanical products such as sewing machines, typewriters, reapers, and industrial machinery, based on new methods for fabricating and assembling interchangeable metal parts, was in full swing. However, it remained for Henry Ford (1863–1947) to make high-speed mass production of complex mechanical products possible with his famous innovation, the moving assembly line.

Like Carnegie, Ford recognized the importance of throughput velocity. In an effort to speed production, Ford abandoned the practice of skilled workers assembling substantial subassemblies and workers gathering around a static chassis to complete assembly. Instead, he sought to bring the product to the worker in a nonstop, continuous stream. Much has been made of the use of the moving assembly line, first used at Ford's Highland
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Park plant in 1913. However, as Ford noted, the principle was more important than the technology:

The thing is to keep everything in motion and take the work to the man and not the man to the work. That is the real principle of our production, and conveyors are only one of many means to an end. (Ford 1926, 103)

After Ford, mass production became almost synonymous with assembly-line production. Ford had signaled his strategy to provide cheap, reliable transportation early on with the Model N, introduced in 1906 for $600. This price made it competitive with much less sophisticated motorized buggies and far less expensive than other four-cylinder automobiles, all of which cost more than $1,000. In 1908, Ford followed with the legendary Model T touring car, originally priced at $850. By focusing on continual improvement of a single model and pushing his mass production techniques to new limits at his Highland Park plant, Ford reduced labor time to produce the Model T from 12.5 to 1.5 hours, and he brought prices down to $360 by 1916 and $290 by the 1920s. Ford sold 730,041 Model T’s in fiscal year 1916/17, roughly one-third of the American automobile market. By the early 1920s, Ford Motor Company commanded two-thirds of the American automobile market.

Henry Ford also made his share of mistakes. He stubbornly held to the belief in a perfectible product and never appreciated the need for constant attention to the process of bringing new products to market. His famous statement that “the customer can have any color car as long as it’s black” equated mass production with product uniformity. He failed to see the potential for producing a variety of end products from a common set of standardized parts. Moreover, his management style was that of a dictatorial owner. He never learned to trust his managerial hierarchy to make decisions of importance. Peter Drucker (1954) points to Henry’s desire to “manage without managers” as the fundamental cause of Ford’s precipitous decline in market share (from more than 60 percent down to 20 percent) between the early 1920s and World War II.

But Henry Ford’s spectacular successes were not merely a result of luck or timing. The one insight he had that drove him to new and innovative manufacturing methods was his appreciation of the strategic importance of speed. Ford knew that high throughput and low inventories would enable him to keep his costs low enough to maintain an edge on his competition and to price his product so as to be available to a large segment of the public. It was his focus on speed that motivated his moving assembly line. But his concern for speed extended far beyond the production line. In 1926, he claimed, “Our finished inventory is all in transit. So is most of our raw material inventory.” He boasted that his company could take ore from a mine and produce an automobile in 81 hours. Even allowing for storage of iron ore in winter and other inventory stock, he claimed an average cycle time of not more than 5 days. Given this, it is little wonder that Taiichi Ohno, the originator of just-in-time systems, of whom we will have more to say in Chapter 4, was an unabashed admirer of Ford.

The insight that speed is critical, to both cost and throughput, was not in itself responsible for Ford’s success. Rather, it was his attention to the details of implementing this insight that set him apart from the competition. The moving assembly line was just one technological innovation that helped him achieve his goal of unimpeded flow of materials through the entire system. He used many of the methods of the newly emerging discipline of scientific management (although Ford had evidently never heard of its founder, Frederick Taylor) to break down and refine the individual tasks in the assembly process. His 1926 book is filled with detailed stories of technical innovations—in glass making, linen manufacture, synthetic steering wheels, artificial leather, heat treating of steel, spindle screwdrivers, casting bronze bushings, automatic lathes, broaching
machines, making of springs—that evidence his attention to details and appreciation of their importance. For all his shortcomings and idiosyncrasies, Henry Ford knew his business and used his intimacy with small issues to make a big imprint on the history of manufacturing in America.

1.5 Scientific Management

Although management has been practiced since ancient times (Peter Drucker credits the Egyptians who built the pyramids with being the greatest managers of all time), management as a discipline dates back to the late 19th century. Important as they were, the practical experiences and rules of thumb offered by such visionaries as Machiavelli did not make management a field because they did not result from a systematized method of critical scrutiny. Only when managers began to observe their practices in the light of the rational, deductive approach of scientific inquiry could management be termed a discipline and gain some of the respectability accorded to other disciplines using the scientific method, such as medicine and engineering. Not surprisingly, the first proponents of a scientific approach to management were engineers. By seeking to introduce a management focus into the professional fabric of engineering, they sought to give its some of engineering's effectiveness and respectability.

Scientific observation of work goes back at least as far as Leonardo da Vinci, who measured the amount of earth a man could shovel more than 450 years ago (Consiglio 1969). However, as long as manufacturing was carried out in small facilities amenable to direct supervision, there was little incentive to develop systematic work management procedures. It was the rise of the large integrated business enterprise in the late 19th and early 20th centuries that caused manufacturing to become so complex as to demand more sophisticated control techniques. Since the United States led the drive toward increased manufacturing scale, it was inevitable that it would also lead the accompanying managerial revolution.

Still, before American management writers developed their ideas in response to the second industrial revolution, a few British writers had anticipated the systematizing of management in response to the first industrial revolution. One such visionary was Charles Babbage (1792–1871). A British eccentric of incredibly wide-ranging interests, he demonstrated the first mechanical calculator, which he called a “difference machine," complete with a punch card input system and external memory storage, in 1822. He turned his attention to factory management in his 1832 book On the Economy of Machinery and Manufactures, in which he elaborated on Adam Smith's principle of division of labor and described how various tasks in a factory could be divided among different types of workers. Using a pin factory as an example, he described the detailed tasks required in pin manufacture and measured the times and resources required for each. He suggested a profit-sharing scheme in which workers derive a share of their wages in proportion to factory profits. Novel as his ideas were, though, Babbage was a writer, not a practitioner. He measured work rates for descriptive purposes only; he never sought to improve efficiency. He never developed his computer to commercial reality, and his management ideas were never implemented.

The earliest American writings on the problem of factory management appear to be a series of letters to the editor of the American Machinist by James Waring Sec, writing under the name of “Chordal," beginning in 1877 and published in book form in 1880 (Muhs, Wrege, Murtaza 1981). See advocated high wages to attract quality workers, standardization of tools, good "housekeeping" practices in the shop, well-defined job
descriptions, and clear lines of authority. But perhaps because his book (Extracts from Chordal’s Letters) did not sound like a book on business or because he did not interact with other pioneers in the area, See was not widely recognized or cited in future work on management as a formal discipline.

The notion that management could be made into a profession began to surface during the period when engineering became recognized as a profession. The American Society of Civil Engineers was formed in 1852, the American Institute of Mining Engineers in 1871, and, most importantly for the future of management, the American Society of Mechanical Engineers (ASME) in 1880. ASME quickly became the forum for debate of issues related to factory operation and management. In 1886, Henry Towne (1844–1924), engineer, cofounder of Yale Lock Company, and president of Yale and Towne Manufacturing Company, presented a paper entitled “The Engineer as an Economist” (Towne 1886). In it, he held that “the matter of shop management is of equal importance with that of engineering... and the management of works has become a matter of such great and far-reaching importance as perhaps to justify its classification also as one of the modern arts.” Towne also called for ASME to create an “Economic Section” to provide a “medium for the interchange” of experiences related to shop management. Although ASME did not form a Management Division until 1920, Towne and others kept shop management issues in prominence at society meetings.

1.5.1 Frederick W. Taylor

It is easy in hindsight to give credit to many individuals for seeking to rationalize the practice of management. But until Frederick W. Taylor (1856–1915), no one generated the sustained interest, active following, and systematic framework necessary to plausibly proclaim management as a discipline. It was Taylor who persistently and vocally called for the use of science in management. It was Taylor who presented his ideas as a coherent system in both his publications and his many oral presentations. It was Taylor who, with the help of his associates, implemented his system in many plants. And it is Taylor who lies buried under the epithet “father of scientific management.”

Although he came from a well-to-do family, had attended the prestigious Exeter Academy, and had been admitted to Harvard, Taylor chose instead to apprentice as a machinist; and he rose rapidly from laborer to chief engineer at Midvale Steel Company between 1878 and 1884. An engineer to the core, he earned a degree in mechanical engineering from Stevens Institute on a correspondence basis while working full-time. He developed several inventions for which he received patents. The most important of these, high-speed steel (which enables a cutting tool to remain hard at red heat), would have been sufficient to guarantee him a place in history even without his involvement in scientific management.

But Taylor’s engineering accomplishments pale in comparison to his contributions to management. Drucker (1954) wrote that Taylor’s system “may well be the most powerful as well as the most lasting contribution America has made to Western thought since the Federalist Papers.” Lenin, hardly a fan of American business, was an ardent admirer of Taylor. In addition to being known as the father of scientific management, he is claimed as the “father of industrial engineering” (Emerson and Naehring 1988).

But what were Taylor’s ideas that accord him such a lofty position in the history of management? On the surface, Taylor was an almost fanatic champion of efficiency. Boorstin (1973, 363) called him the “Apostle of the American Gospel of Efficiency.” The core of his management system consisted of breaking down the production process into its component parts and improving the efficiency of each. In essence, Taylor was
trying to do for work units what Whitney had done for material units: standardize them and make them interchangeable. Work standards, which he applied to activities ranging from shoveling coal to precision machining, represented the work rate that should be attainable by a “first-class man.”

But Taylor did more than merely measure and compare the rates at which men worked. What made Taylor’s work scientific was his relentless search for the best way to do tasks. Rules of thumb, tradition, standard practices were anathema to him. Manual tasks were honed to maximum efficiency by examining each component separately and eliminating all false, slow, and useless movements. Mechanical work was accelerated through the use of jigs, fixtures, and other devices, many invented by Taylor himself. The “standard” was the rate at which a “first-class” man could work using the “best” procedure.

With a faith in the scientific method that was singularly American, Taylor sought the same level of predictability and precision for manual tasks that he achieved with the “feed and speed” formulas he developed for metal cutting. The following formula for the time required to haul material with a wheelbarrow, $B$, is typical (Taylor 1903, 1431):

$$B = \left\{ p + (a + 0.51 + (0.0048)\text{distance hauled}) \frac{27}{L} \right\} 1.27$$

Here $p$ represents the time loosening 1 cubic yard with the pick, $a$ represents the time filling a barrow with any material, $L$ represents the load of a barrow in cubic feet, and all times are in minutes and distances in feet.

Although Taylor was never able to extend his “science of shoveling” (as his opponents derisively termed his work) into a broader theory of work, it was not for lack of trying. He hired an associate, Sanford Thompson, to conduct extensive work measurement experiments. While he was never able to reduce broad categories of work to formulas, Taylor remained confident that this was possible:

After a few years, say three, four or five years more, someone will be ready to publish the first book giving the laws of the movements of men in the machine shop—all the laws, not only a few of them. Let me predict, just as sure as the sun shines, that is going to come in every trade.\(^5\)

Once the standard for a particular task had been scientifically established, it remained to motivate the workers to achieve it. Taylor advocated all three basic categories of worker motivation:

1. The “carrot.” Taylor proposed a “differential piece rate” system, in which workers would be paid a low rate for the first increment of work and a substantially higher rate for the next increment. The idea was to give a significant reward to workers who met the standard relative to those who did not.
2. The “stick.” Although he tried fining workers for failure to achieve the standard, Taylor ultimately rejected this approach. A worker who is unable to meet the standard should be reassigned to a task to which he is more suited and a worker who refuses to meet the standard (“a bird that can sing and won’t sing”) should be discharged.
3. Factory ethos. Taylor felt that a mental revolution, in which management and labor recognize their common purpose, was necessary in order for scientific management to work. For the workers this meant leaving the design of their

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\(^5\)Abstract of an address given by Taylor before the Cleveland Advertising Club, March 3, 1915, and repeated the next day. It was his last public appearance. Reprinted in Shafrirz and Ott 1992, 69–80.
work to management and realizing that they would share in the rewards of efficiency gains via the piece rate system. The result, he felt, would be that both productivity and wages would rise, workers would be happy, and there would be no need for labor unions. Unfortunately, when piecework systems resulted in wages that were considered too high, it was a common practice for employers to reduce the rate or increase the standard.

Beyond time studies and incentive systems, Taylor’s engineering outlook led him to the conclusion that management authority should emanate from expertise rather than power. In sharp contrast to the militaristic unity-of-command character of traditional management, Taylor proposed a system of “functional foremanship” in which the traditional single foreman is replaced by eight different supervisors, each with responsibility for specific functions. These included the inspector, responsible for quality of work; the gang boss, responsible for machine setup and motion efficiency; the speed boss, responsible for machine speeds and tool choices; the repair boss, responsible for machine maintenance and repair; the order of work or route clerk, responsible for routing and scheduling work; the instruction card foreman, responsible for overseeing the process of instructing bosses and workers in the details of their work; the time and cost clerk, responsible for sending instruction cards to the men and seeing that they record time and cost of their work; and the shop disciplinarian, who takes care of discipline in the case of “insubordination or impudence, repeated failure to do their duty, lateness or unexcused absence.”

Finally, to complete his management system, Taylor recognized that he required an accounting system. Lacking personal expertise in financial matters, he borrowed and adapted a bookkeeping system from Manufacturing Investment Company, while working there as general manager from 1890 to 1893. This system was developed by William D. Basley, who had worked as the accountant for the New York and Northern Railroad, but was transferred to the Manufacturing Investment Company, also owned by the owners of the railroad, in 1892. Taylor, like Carnegie before him, successfully applied railroad accounting methods to manufacturing.

To Taylor, scientific management was not simply time and motion study, a wage incentive system, an organizational strategy, and an accounting system. It was a philosophy, which he distilled to four principles. Although worded in various ways in his writings, these are concisely stated as (Taylor 1911, 130)

1. The development of a true science.
2. The scientific selection of the worker.
3. His scientific education and development.
4. Intimate friendly cooperation between management and the men.

The first principle, by which Taylor meant that it was the managers’ job to pursue a scientific basis for running their business, was the foundation of scientific management. The second and third principles paved the way for the activities of personnel and industrial engineering departments for years to come. However, in Taylor’s time there was considerably more science in the writing about selection and education of workers than there was in practice. The fourth principle was Taylor’s justification for his belief that trade unions were not necessary. Because increased efficiency would lead to greater surplus, which would be shared by management and labor (an assumption that organized labor did not accept), workers should welcome the new system and work in concert with management to achieve its potential. Taylor felt that workers would cooperate if offered higher pay for greater efficiency, and he actively opposed the rate-cutting practices by which companies would redefine work standards if the resulting pay rates were too high.
But he had little sympathy for the reluctance of workers to be subjected to stopwatch studies or to give up their familiar practices in favor of new ones. As a result, Taylor never enjoyed good relations with labor.

1.5.2 Planning versus Doing

What Taylor meant in his fourth principle by "intimate friendly cooperation" was a clear separation of the jobs of management from those of the workers. Managers should do the planning—design the job, set the pace, rhythm, and motions—and workers should work. In Taylor's mind, this was simply a matter of matching each group to the work for which it was best qualified.

In concept, Taylor's views on this issue represented a fundamental observation: that planning and doing are distinct activities. Drucker described this as one of Taylor's most valuable insights, "a greater contribution to America's industrial rise than stopwatch or time and motion study. On it rests the entire structure of modern management" (Drucker 1954, 284). Clearly, Drucker's management by objectives would be meaningless without the realization that management will be easier and more productive if managers plan their activities before undertaking them.

But Taylor went further than distinguishing the activities of planning and doing. He placed them in entirely separate jobs. All planning activities rested with management. Even management was separated according to planning and doing. For instance, the gang boss had charge of all work up to the time that the piece was placed in the machine (planning), and the speed boss had charge of choosing the tools and overseeing the piece in the machine (doing). The workers were expected to carry out their tasks in the manner determined by management (scientifically, of course) as best. In essence, this is the military system; officers plan and take responsibility, enlisted men do the work but are not held responsible. Taylor was adamant about assigning workers to tasks for which they were suited; evidently he did not feel they were suited to planning.

But, as Drucker (1954, 284) pointed out, planning and doing are actually two parts of the same job. Someone who plans without even a shred of doing "dreams rather than performs," and someone who works without any planning at all cannot accomplish even the most mechanical and repetitive task. Although it is clear that workers do plan in practice, the tradition of scientific management has clearly discouraged American workers from thinking creatively about their work and American managers from expecting them to. Juran (1992, 365) contended that the removal of responsibility for planning by workers had a negative effect on quality and resulted in reliance by American firms on inspection for quality assurance.

In contrast, the Japanese, with their quality circles, suggestion programs, and empowerment of workers to shut down lines when problems occur, legitimized planning on the part of the workers. On the management side, the Japanese requirement that future managers and engineers begin their careers on the shop floor also helped remove the barrier between planning and doing. "Quality at the source" programs are much more natural in this environment, so it is not surprising that the Japanese appreciated the ideas of quality prophets, such as Deming and Juran, long before the Americans did.

Taylor's error with regard to the separation of planning and doing lay in extending a valuable conceptual insight to an inappropriate practice. He made the same error by...
extending his reduction of work tasks to their simplest components from the planning stage to the execution stage. The fact that it is effective to analyze work broken down into its elemental motions does not necessarily imply that it is effective to carry it out in this way. Simplified tasks could improve productivity in the short term, but the benefits are less clear in the long term. The reason is that simple repetitive tasks do not make for satisfying work, and therefore, long-term motivation is difficult. Furthermore, by encouraging workers to concentrate on motions instead of on jobs, scientific management had the unintended result of making workers inflexible. As the pace of change in technology and the marketplace accelerated, this lack of flexibility became a clear competitive burden. The Japanese, with their holistic perspective and worker empowerment practices, consciously encouraged their workforce to be more adaptable.

By making planning the explicit duty of management and by emphasizing the need for quantification, scientific management played a large role in spawning and shaping the fields of industrial engineering, operations research, and management science. The reductionist framework established by scientific management is behind the traditional emphasis by the industrial engineers on line balancing and machine utilization. It is also at the root of the decades-long fascination by operations researchers with simplistic scheduling problems, an obsession that produced 30 years of literature and virtually no applications (Dudek, Panwalker, and Smith 1992). The flaw in these approaches is not the analytic techniques themselves, but the lack of an objective that is consistent with the overall system objective. Taylorism spawned powerful tools but not a framework in which those tools could achieve their full potential.

1.5.3 Other Pioneers of Scientific Management

Taylor's position in history is in no small part due to the legions of followers he inspired. One of his earliest collaborators was Henry Gantt (1861–1919), who worked with Taylor at Midvale Steel, Simon's Rolling Machine, and Bethlehem Steel. Gantt is best remembered for the Gantt chart used in project management. But he was also an ardent efficiency advocate and a successful scientific management consultant. Although Gantt was considered by Taylor as one of his true disciples, Gantt disagreed with Taylor on several points. Most importantly, Gantt preferred a “task work with a bonus” system, in which workers were guaranteed their day’s rate but received a bonus for completing a job within the set time, to Taylor’s differential piece rate system. Gantt was also less sanguine than Taylor about the prospects for setting truly fair standards, and therefore he developed explicit procedures for enabling workers to protest or revise the standards.

Others in Taylor’s immediate circle of followers were Carl Barth (1860–1939), Taylor’s mathematician and developer of special-purpose slide rules for setting “feet and speeds” for metal cutting; Morris Cooke (1872–1960), who applied Taylor’s ideas both in industry and as Director of Public Works in Philadelphia; and Horace Hathaway (1878–1944), who personally directed the installation of scientific management at Tabor Manufacturing Company and wrote extensively on scientific management in the technical literature.

Also adding energy to the movement and luster to Taylor’s reputation were less orthodox proponents of scientific management, with some of whom Taylor quarreled bitterly. Most prominent among these were Harrington Emerson (1853–1931) and Frank Gilbreth (1868–1924). Emerson, who had become a champion of efficiency independently of Taylor and had reorganized the workshops of the Santa Fe Railroad, testified during the hearings of the Interstate Commerce Commission concerning a proposed railroad rate hike in 1910–1911 that scientific management could save “a million dollars
a day." Because he was the only "efficiency engineer" with firsthand experience in the railroad industry, his statement carried enormous weight and served to emblazon scientific management on the national consciousness. Later in his career, Emerson became particularly interested in the selection and training of employees. He is also credited with originating the term dispatching in reference to shop floor control (Emerson 1913), a phrase which undoubtedly derives from his railroad experience.

Frank Gilbreth had a somewhat similar background to that of Taylor. Although he had passed the qualifying exams for MIT, Gilbreth became an apprentice bricklayer instead. Outraged at the inefficiency of bricklaying, in which a bricklayer had to lift his own body weight each time he bent over and picked up a brick, he invented a movable scaffold to maintain bricks at the proper level. Gilbreth was consumed by the quest for efficiency. He extended Taylor's time study to what he called motion study, in which he made detailed analyses of the motions involved in bricklaying in the search for a more efficient procedure. He was the first to apply the motion picture camera to the task of analyzing motions, and he categorized the elements of human motions into 18 basic components, or therbligs (Gilbreth spelled backward, sort of). That he was successful was evidenced by the fact that he rose to become one of the most prominent builders in the country. Although Taylor feuded with him concerning some of his work for nonbuilders, he gave Gilbreth's work on bricklaying extensive coverage in his 1911 book, The Principles of Scientific Management.

1.5.4 The Science in Scientific Management

Scientific management has been both venerated and vilified. It has generated both proponents and opponents who have made important contributions to our understanding and practice of management. One can argue that it is the root of a host of management-related fields, ranging from organization theory to operations research. But in the final analysis, it is the basic realization that management can be approached scientifically that is the primary contribution of scientific management. This is an insight we will never lose, an insight so basic that, like the concept of interchangeable parts, once it has been achieved it is difficult to picture life without it. Others intimated it; Taylor, by sheer perseverance, drove it into the consciousness of our culture. As a result, scientific management deserves to be classed as the first management system. It represents the starting point for all other systems. When Taylor began the search for a management system, he made it possible to envision management as a profession.

It is, however, ironic that scientific management's legacy is the application of the scientific method to management, because in retrospect we see that scientific management itself was far from scientific. Taylor's Principles of Scientific Management is a book of advocacy, not science. While Taylor argued for his own differential piece rate in theory, he actually used Gantt's more practical system at Bethlehem Steel. His famous story of Schmidt, a first-class man who excelled under the differential piece rate, has been accused of having so many inconsistencies that it must have been contrived (Wrege and Perroni 1974). Taylor's work measurement studies were often carelessly done, and there is no evidence that he used any scientific criteria to select workers. Despite using the word scientific with numbing frequency, Taylor subjected very few of his conjectures to anything like the scrutiny demanded by the scientific method.

Thus, while scientific management fostered quantification of management, it did little to place it in a real scientific framework. Still, to give Taylor his due, by sheer force of conviction, he tapped into the underlying American faith in science and changed our view of management forever. It remains for us to realize the full potential of this view.
1.6 The Rise of the Modern Manufacturing Organization

By the end of World War I, scientific management had firmly taken hold, and the main pieces of the American system of manufacturing were in place. Large-scale, vertically integrated organizations making use of mass production techniques were the norm. Although family control of large manufacturing enterprises was still common, salaried managers ran the day-to-day operations within centralized departmental hierarchies. These organizations had essentially fully exploited the potential economies of scale for producing a single product. Further organizational growth would require taking advantage of economies of scope (i.e., sharing production and distribution resources across multiple products). As a result, development of institutional structures and management procedures for controlling the resulting organizations was the main theme of American manufacturing history during the interwar period.

1.6.1 Du Pont, Sloan, and Structure

The classic story of growth through diversification is that of General Motors (GM). Formed in 1908 when William C. Durant (1861–1947) consolidated his own Buick Motor Company with the Cadillac, Oldsmobile, and Oakland companies, GM rapidly became an industrial giant. The flamboyant but erratic Durant was far more interested in acquisition than in organization, and he continued to buy up units (including Chevrolet Motor Company) to the point where, by 1920, GM was the fifth largest industrial enterprise in America. But it was an empire without structure. Lacking corporate offices, demand forecasting, and coordination of production, the corporation encountered financial difficulties whenever sales slowed. Du Pont Company came to Durant’s aid more than once by investing heavily in GM and finally forced him out in 1920 (Bryant and Dethloff 1990).

Pierre Du Pont (1870–1954) came out of semiretirement to succeed Durant as president with the hope of making the Du Pont Company’s GM investments profitable. A more capable successor could not possibly have been found. In 1902, he and his cousins Alfred and Coleman had purchased control of E. I. du Pont de Nemours & Company, a collection of single-function explosives manufacturers, and had consolidated it into a centrally governed, multid部mental, integrated organization (Chandler and Salsbury 1971). Well aware of scientific management principles, Du Pont and his associates installed Taylor’s manufacturing control techniques and accounting system, and introduced psychological testing for personnel selection. Perhaps Du Pont’s most influential innovation, however, was the refined use of return on investment (ROI) to evaluate the relative performance of departments. By 1917, Du Pont Powder Company stood as the first modern American manufacturing corporation.

When he moved to General Motors, Du Pont quickly identified Alfred P. Sloan (1875–1966) as his main collaborator and set out to reorganize the company. Du Pont

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7 A. J. Moxham and Coleman du Pont had hired Frederick Taylor as a consultant at Steel Motor Company, and were instrumental in implementing Taylor’s system when they later joined Du Pont as executives.
8 The other candidate for the first modern manufacturing corporation would be General Electric, formed in 1892 by the merger of Edison General Electric and ThomsonHouston Electric, both of which were themselves products of mergers. To manage this first major consolidation of machinery-making companies, GE set up a modern structure of top and middle management patterned after that used by the railroads. However, its financial measures were not as sophisticated as those used by Du Pont and, unlike in the modern American corporation, a board of directors dominated by outside financiers held considerable veto power (Chandler 1977).
and Sloan agreed that GM’s activities were too numerous, scattered, and varied to be amenable to the centralized organization in use at Du Pont Powder Company. With Du Pont’s support, Sloan crafted a plan to structure the company as a collection of autonomous operating divisions coordinated (but not run) by a strong general office. The various divisions were carefully targeted at specific markets (e.g., Cadillac at the high-priced market, Chevrolet at the low end to compete directly with Ford, and Buick and Oldsmobile in the middle; Pontiac was introduced between Chevrolet and Oldsmobile in the mid-1920s) in accordance with Sloan’s goal of “a car for every purse and purpose” (Cray 1979). Under Sloan’s reorganization, GM’s general office borrowed ROI methods from Du Pont Powder Company for evaluating units, and also developed sophisticated new procedures for demand forecasting, inventory tracking, and market share estimation. These techniques gradually became standard throughout American industry and are still used in modified form today.

Sloan’s strategy was stunningly effective. In 1921, GM was a distant second with 12.3 percent of the automotive market to Ford’s 55.7 percent. With its targeted product lines and regular introduction of new models, GM increased its share to 32.3 percent by 1929, while Ford, which waited until 1927 to replace the Model T with the Model A, fell to 31.3 percent. By 1940, Ford, which was still run by Henry, his son Edsel, and a tiny group of executives, was in serious trouble, having fallen to 18.9 percent and third place behind Chrysler’s 23.7 percent share and far behind GM’s 47.5 percent (Chandler 1990). Only a massive reorganization by Henry Ford II, beginning in 1945 and following the GM model, saved Ford from extinction.

In addition to forging hugely successful firms, Pierre Du Pont and Alfred Sloan shaped the American manufacturing corporation of the 20th century. While exhibiting many variations, all large industrial enterprises in the 20th century have used one of two basic structures. The centralized, functional department organization developed at Du Pont is used predominantly by firms with a single line of products in a single market. The multidivisional, decentralized structure developed at GM is the rule for firms with several product lines or markets. The environment in which we practice manufacturing today owes its existence to the efforts of these two innovators and their many associates.

1.6.2 Hawthorne and the Human Element

As industrial organizations grew larger and more technologically complex, the role of the worker took on increased importance. Indeed, the primary goals of scientific management—motivating workers and matching workers to tasks—were essentially behavioral. However, Taylor, being a true engineer, seemed to believe that human beings could be optimized in the same sense as a metal-cutting machine. For example, he observed that because a worker "strains every nerve to secure victory for his side" in a baseball game (Taylor 1911, 13), he or she should be capable of similar exertion at work. Despite the fact that he was an accomplished athlete, Taylor did not show the slightest appreciation for the psychological difference between work and play. Similarly, while he could spend countless hours studying and educating workers in the science of shoveling, he had no patience for a worker's sentimental attachment to the shovel he had handled for years. Although his writings certainly indicate a concern for the workers, Taylor never managed to understand their points of view.

In spite of Taylor's personal blind spots, scientific management served to catalyze the behavioral approach to management by systematically raising questions on authority, motivation, and training. The earliest writers in the field of industrial psychology
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acknowledged their debt to scientific management and framed their discussions in terms consistent with Taylor's system.

The acknowledged father of industrial psychology was Hugo Munsterberg (1863–1916). Born and educated in Germany, Munsterberg came to America and established a famous psychology laboratory at Harvard, where he studied a wide range of psychological questions in education, crime, and philosophy as well as industry. In his 1913 book *Psychology and Industrial Efficiency*, he paid tribute to scientific management and directly addressed it in three parts entitled "The Best Possible Man" (i.e., worker selection), "The Best Possible Work" (i.e., training and working conditions), and "The Best Possible Effect" (i.e., achieving management goals). Munsterberg's groundbreaking work paved the way for a steady stream of industrial psychology textbooks and a psychological testing fad shortly after World War I.

Among the Americans who led the way in the application of psychology to industry was Walter Dill Scott (1869–1955), who studied worker selection and rating for promotion (Scott 1913). A series of articles he wrote in 1910 to 1911 for *System* magazine (now *BusinessWeek*) under the title "The Psychology of Business" were highly influential in raising awareness of the field of psychology among managers. He later turned to psychological research in advertising, defined the proper role of the newly arising personnel management function, and served as president of Northwestern University.

Lillian Gilbreth (1878–1972) was an early and visible proponent of industrial psychology from inside the ranks of scientific management. Wife of scientific management pioneer Frank Gilbreth and matriarch of the brood made famous by the book *Cheaper by the Dozen* (Gilbreth and Carey 1949), Gilbreth was one of the pioneers of the scientific management movement. In addition to collaborating with her husband on his motion studies work and carrying on this work after his death, she became one of the first advocates of psychology in management with her book *The Psychology of Management* (1914), based on her doctoral thesis in psychology at Brown University. In this book she contrasted scientific management with traditional management along various dimensions, including individuality. Her premise was that because of its emphasis on scientific selection, training, and functional foremanship, scientific management offered ample opportunity for individual development, while traditional management stifled such development by concentrating power in a central figure. Although the details of her work in psychology read today like an apology for scientific management and have largely been forgotten, Lillian Gilbreth deserves a place in management history for her early call for the humanization of the management process.

Mary Parker Follett (1868–1933) belonged chronologically to the scientific management era, but her thinking on the sociology and psychology of work was far ahead of its time. Like Lillian Gilbreth, she found in Taylor's functional foremanship a sound basis for allocating authority:

One person should not give orders to another person, but both should agree to take their orders from the situation... We have here, I think, one of the largest contributions of scientific management; it tends to depersonalize orders. (Follett 1942, 59)

However, Follett was repelled by the relegation of the worker to simply carrying out tasks given and designated by management. She held that "not consent but participation is the right basis for all social relations" (Follett 1942, 211). By "participation," Follett meant to include the workers' ideas as well as their labor. Her rationale was that the ideas are valuable in themselves, but more important, the very process of participation is essential to establishing a functional work environment. Although at times her ideas
sound idealistic, the depth and range of her work are astonishing and many of her insights still apply today.

A major episode in the quest to understand the human side of manufacturing was the series of studies conducted at the Western Electric Hawthorne plant in Chicago between 1924 and 1932. The studies originally began with a simple question: How does workplace illumination affect worker productivity? Under sponsorship of the National Academy of Science, a team of researchers from Massachusetts Institute of Technology observed groups of coil-winding operators under different lighting levels. They observed that productivity relative to a control group went up as illumination was increased, as had been expected. Then, in another experiment, they observed that productivity also went up when illumination was decreased, even to the level of moonlight (Roethlisberger and Dickson 1939).

Unable to explain the results, the original team abandoned the illumination studies and began other tests—of the effects on productivity of rest periods, length of work week, incentive plans, free lunches, and supervisory styles. In most cases, the trend was for higher-than-normal output by the groups under study.

Various experts were brought in to study the puzzling Hawthorne data, most notably George Elton Mayo (1880–1949) from Harvard. Approaching the problem from the perspective of the “psychology of the total situation,” he came to the conclusion that the results were primarily due to “a remarkable change of mental attitude in the group.” In the legend that subsequently grew up around the Hawthorne studies, Mayo’s interpretation was reduced to the simple explanation that productivity increased as a result of the attention received by the workers under study, and this was dubbed the Hawthorne effect. However, in his writings, Mayo (1933, 1945) was not satisfied with this simple explanation and modified his view beyond this initial insight, arguing that work is essentially a group activity and that workers strive for a sense of belonging, not simply financial gain, in their jobs. By emphasizing the need for listening and counseling by managers in order to improve worker collaboration, the industrial psychology movement shifted the emphasis of management from technical efficiency, the focus of Taylorism, to a richer, more complex, human relations orientation.

1.6.3 Management Education

In addition to fostering the human relations perspective, the rise of the modern integrated business enterprise solidified the position of the professional managerial class. Prior to 1920, the majority of large-scale businesses were run by owner-entrepreneurs such as Carnegie, Ford, and Du Pont. Growth and integration after World War I resulted in systems too large to be run by owners (although Henry Ford tried, with disastrous results). Consequently, more and more decision-making responsibility was given to managers, middle and upper, who were without significant holdings in the firm.

In the 19th and early 20th centuries, it was not uncommon for these professional managers to be drawn from the ranks of the skilled workers (e.g., machinists). But as the modern business enterprises matured, formal university training became increasingly necessary. Many managers of this era were educated in traditional engineering disciplines (e.g., mechanical, electrical, civil, chemical). Some, however, began to seek education directly related to management, in either business schools or industrial engineering programs, both of which were emerging in the wake of the scientific management movement at the turn of the century.

The first American undergraduate business program was established in 1881 at the University of Pennsylvania’s Wharton School. This was followed by schools at Chicago
and Berkeley in 1898, and at Dartmouth (with the first master’s level program), New York University, and Wisconsin in 1900. By 1910 there were more than a dozen separately organized schools of business at American universities, although the programs were generally small and had curricula restricted to background (e.g., economics, law, foreign languages) with anecdotes about the best industrial practices. The leading program of the time, Harvard, was organized in large part by Arch Shaw who had previously lectured at Northwestern and, as head of a Chicago publishing house, had published *Library of Factory Management*. Shaw relied heavily on outside lecturers from the scientific management movement (e.g., Frederick Taylor, Harrington Emerson, Carl Barth, Morris Cooke) and was instrumental in introducing the case method, which became Harvard’s trademark and would heavily influence business education across America (Chandler 1977).

Between 1914 and 1940, American business schools grew and diversified their curricula. During this period most of the state universities introduced business programs; among them were Ohio State (1916); Alabama, Minnesota, North Carolina (1919); Virginia (1920); Indiana (1921); Kansas and Michigan (1924) (Pierson 1959). As the number of programs grew, so did the number of degrees granted: from 1,576 BAs and 110 MBAs in 1920, to 18,549 BAs and 1,139 MBAs in 1940 (Gordon and Howell 1959). At the same time, the functional areas of a business education were being standardized; by the mid-1920s, more than half of the 34 schools belonging to the American Association of Collegiate Schools of Business required students to take courses in accounting, business law, finance, statistics, and marketing. Textbooks supporting this functional orientation also began to appear (e.g., Hodge and McKinsey 1921 in accounting, Lough 1920 and Bonneville 1925 in finance, and Cherington 1920 in marketing).

American engineering schools also responded to the need for management education by introducing industrial engineering (IE) programs. Like the early business schools, the first IE departments were heavily influenced by the scientific management movement. Hugo Diemer taught the first shop management course in the mechanical engineering department of the University of Kansas in 1901 to 1902 and later went on to found the first IE curriculum at Penn State in 1908. Other engineering schools followed, and by the end of World War II there were more than 25 IE curricula in American universities. After the war, growth of the IE field tracked that of the economy; by the 1980s the number of IE programs had reached about 100 (Emerson and Naehering 1988).

The tools of industrial engineering evolved as the field grew during the interwar period. In addition to the methods of time and motion study (Gilbreth 1911; Barnes 1937), techniques of cost engineering (Fish 1915; Grant 1930), quality control (Shewhart 1931; Grant and Leavenworth 1946), and production/inventory management (Spiegl and Lansburgh 1923; Mitchell 1931; Raymond 1931; Whitin 1953) were presented in textbook form and widely introduced into industrial engineering curricula. By the end of World War II, all the major components of the IE discipline were in place, with the exception of the quantitative tools of operations research, which did not appear in a major way until after the war.

### 1.7 Peak, Decline, and Resurgence of American Manufacturing

Although the modern American manufacturing enterprise had largely been formed by the 1920s, the depression of the 1930s and the war of the 1940s prevented the country from reaping the full benefits of its powerful manufacturing sector. Thus, it was not until the post–World War II period, in the 1950s and 1960s, that America enjoyed a golden
era of manufacturing. This era shaped the attitudes of a generation of managers, heavily influenced business and engineering schools, and set the stage for the not-so-golden era of manufacturing in the 1980s and 1990s.

1.7.1 The Golden Era

American manufacturing went into World War II in an extremely strong position, having mastered the techniques of mass production and distribution and management of large-scale enterprises. It emerged from the war in a position of undisputed global dominance. In 1945 the American industrial plant was easily the strongest in the world. The American market was 8 times the size of the next-largest market in the world, giving American firms a huge scale advantage. American per capita income was 8 times that of Japan in the 1950s, providing a vast source of capital, despite the fact that savings rates were lower than those in other countries. The American primary and secondary education system was the finest in the world. And with the GI Bill added to the land grant college system, America outpaced the rest of the world in higher education as well. Labor productivity (measured as gross domestic product per worker-hour) was nearly double that of any European country, and fully 3 times that of Germany and 7 times that of Japan (Maddison 1984). With its huge domestic market, ready capital, and well-trained, productive workforce, America could produce and distribute goods at a pace and scale unthinkable to anyone else.

In contrast, the rest of the world lay virtually in ruins. The industrial plant in Europe and Japan had been physically devastation by the war. The scientific establishments of many countries were in disarray as America inherited some of their best brains. Furthermore, at the war’s end, because transportation was expensive and trade policies protectionist, economies were far less global than they are today. Because the primary market for almost everything was in America, other countries would have been at a disadvantage even without their inferior physical plants and disrupted R&D base.

The resulting postwar boom in American manufacturing was undoubtedly exhilarating and was certainly profitable. Americans saw per capita disposable income (in constant 1996 dollars) rise from $5,912 in 1940 to $12,823 in 1970 (U.S. Department of Commerce 1972). In 1947, the 200 largest industrial firms in America were responsible for 30 percent of the world’s value added in manufacturing and 47.2 percent of total corporate manufacturing assets. By 1963, they accounted for 41 percent of value added and 56.3 percent of assets. By 1969 the top 200 American industrials accounted for 60.9 percent of the world’s manufacturing assets (Chandler 1977, 482). For a while the living was easy. But as many of the baby boom generation enjoyed “Leave It to Beaver” lives in suburbia, the competitive world that would be their inheritance was being shaped as America’s former enemies and allies recovered from the war.

1.7.2 Accountants Count and Salesmen Sell

During the golden era following World War II, the principal opportunities for American manufacturing firms were plainly in the areas of marketing, to develop the huge potential markets for new products, and finance, to fuel growth. As we mentioned earlier, America already had a stronger history in advertising than the Old World. Moreover, as indicated by the reliance of Du Pont and GM on financial measures to coordinate their large-scale enterprises, American manufacturers were well acquainted with the tools of finance. The manufacturing function itself became of secondary importance. American dominance
in manufacturing was so formidable that eminent economist John Kenneth Galbraith proclaimed the problem of production "solved" (Galbraith 1958).

But as the manufacturing boom of the 1950s and 1960s turned into the manufacturing bust of the 1970s and 1980s, it became plain that something was wrong. The simplest explanation is that since the details of manufacturing didn't matter during the golden era, American firms became lax. Because American goods were the envy of the world, firms could largely dictate the quality specifications of their products, and managers learned to take quality for granted. Because of the American technological advantage and the lack of competition, continual improvement was unnecessary to maintain market share, and managers learned to take the status quo for granted. When foreign firms, which could not afford to take anything for granted, recovered sufficiently to present a legitimate challenge, many American firms lacked the vigor to meet it.

While this simple explanation may be accurate for some firms or industries, it does not give the whole story. The influences of the golden era on the current condition of American manufacturing are subtle and complex. Besides promoting a deemphasis on manufacturing details, the emphasis on marketing and finance in the 1950s and 1960s profoundly influenced today's American manufacturing firms. Recognizing these areas as having the greatest career potential, more and more of the "best and brightest" chose careers in marketing and finance. These became the glamour functions, while manufacturing and operations were increasingly viewed as dead-end "career breakers." This led to the simultaneous rise of the marketing and finance outlooks as dominant perspectives in American manufacturing firms. We trace some of the consequences below.

The Marketing Outlook. With top executives and rising stars increasingly preoccupied with selling, the organizations themselves took on more of the marketing outlook. While there is nothing intrinsically wrong with the marketing outlook for the marketing department, it can be an overly conservative perspective for the firm as a whole. The principal task of marketing is to analyze the introduction of new products. But the products that are most amenable to analysis tend to be imitative, rather than innovative.

A good case history that illustrates the pitfalls of the marketing outlook is that of IBM and the xerography process. In the late 1950s, Haloid Company (which had introduced the first commercial xerographic copier in 1949 and later changed its name to Xerox) offered IBM the opportunity to jointly develop the first practical office copier. IBM enlisted Arthur D. Little, a Boston management consulting firm, to conduct a market study on the potential for such a product. A. D. Little, basing its conclusions on consumption of carbon paper and assessments of which offices needed to make paper copies, estimated maximum demand to be no more than 5,000 machines, far less than necessary to justify the development costs (Kearns and Nadler 1992). IBM declined the offer, and Xerox went on to make so much money that royalties to Battelle Memorial Institute, the research laboratory where the process was developed, threatened its not-for-profit status.

The conclusion is that the marketing outlook will often not justify the high-risk, high-payoff ventures associated with truly innovative new products. The Xerox machine created a demand for paper copies that did not previously exist. While hard to analyze, revolutionary products such as this can be enormously profitable. An overreliance on marketing may have caused large American manufacturing firms to take on fewer of these ventures than they should have. As evidence of this, consider that the last major automotive innovation to appear first on an American car was the automatic transmission in the 1940s. Four-wheel drive, four-wheel steering, turbocharging, antilock brakes, and
hybrid gas/electric vehicles were all introduced first by foreign automakers (Dertouzos, Lester, Solow 1989, 19).

The Finance Outlook. As noted earlier, Du Pont pioneered the use of ROI as a measure of the effectiveness of capital in a large-scale enterprise shortly after the turn of the century. However, in the 1910s, Du Pont Powder Company was primarily owned and managed by the Du Pont family; so there was no question that it was to be managed for the long-term benefit of its owners. Pierre Du Pont would never have used short-term ROI to evaluate the performance of individual managers. By the 1950s and 1960s, high-level managers were no longer owners, and the pervasiveness of the finance outlook had extended short-term ROI in the form of quarterly reports to a measure of individual performance.

An overreliance on short-term ROI discouraged managers from pursuing high-risk or long-term ventures and thus further aggravated the tendency toward the conservatism promoted by the marketing outlook. Short-term ROI can be artificially inflated for a while, possibly many years, through reduction in the investment base by forgoing process upgrades, equipment and maintenance, and replacement, and by purchasing less than state-of-the-art facilities. However, in the long run, such practices can put a firm at a distinct competitive disadvantage. For instance, Dertouzos, Lester, and Solow (1989, 57) cite statistics showing that the rate of business-sector capital investment as a percentage of net output in Japan and West Germany has significantly outpaced that of America since 1965, precisely the period over which these countries significantly narrowed the productivity gap between themselves and America.

Moreover, the finance outlook, which views manufacturing management as essentially analogous to portfolio management, implies that the way to minimize risk is to diversify. The portfolio manager diversifies investments by purchasing various types of securities. The manufacturing executive diversifies by acquiring businesses outside the firm’s core activities. As the rest of the world recovered from the war and began to give American firms serious competition in the 1960s, manufacturing firms increasingly turned to the financial response of diversification, almost to the point of mania in the late 1960s. In 1965 there were 2,000 mergers and acquisitions in America; by 1969 the number had risen to more than 6,000. Moreover, of the assets acquired during the 1963–1972 merger wave, nearly three-fourths were for product diversification, and one-half of these were in unrelated products (Chandler 1977). The effect was a dramatic change in the character of America’s large manufacturing firms. In 1949, 70 percent of the 500 largest American firms earned 95 percent of revenues from a single business. By 1969, 70 percent of the largest firms no longer had a dominant business (Davidson 1990).

Like the marketing outlook, the finance outlook is too restrictive a perspective for the entire firm. While managers of purely financial portfolios are certainly rational in their use of diversification to achieve stable returns, manufacturing firms that use the same strategy are neglecting an important difference between portfolio and manufacturing management: Manufacturing firms influence their destinies in a far more direct way than do investors. The profitability of a manufacturing business is a function of many things, including product design, product quality, process efficiency, customer service, and so forth. When a firm moves away from its core business, there is a danger that it will fail to perform on these key measures. This can mean more than offset any potential advantage from diversification and can even threaten the existence of the company.

Indeed, the preponderance of statistical evidence paints a negative picture of the effectiveness of the merger-and-acquisition strategy. A detailed survey by Ravenscraft and Scherer (1987) of mergers during the 1960s and early 1970s showed that, on
average, profitability and efficiency of firms decline after they are acquired. Hayes and Wheelwright (1984, 13) cite further statistics from Pruhan (1979) and *Forbes* magazine showing that highly diversified conglomerates tend to underperform relative to firms with highly focused product markets. In the realm of popular culture, books like *Barbarians at the Gate* (Burrough 1990) and *Merchants of Debt* (Anders 1992) graphically illustrate how far pure unbridled greed can take the merger-and-acquisition process from any consideration of manufacturing effectiveness. Scherer and Ross (1990, 173), in a comprehensive survey of firm structure and economic performance, sum up the effectiveness of the merger-and-acquisition approach with this statement: “The picture that emerges is a pessimistic one: widespread failure, considerable mediocrity, and occasional successes.”

1.7.3 The Professional Manager

The rapid growth following World War II profoundly shaped the manufacturing manager in two additional ways. First, strong demand for managers prompted an acceleration of the promotion process, under the “fast-track manager” system. Second, unable to nurture enough managers internally, industry increasingly looked to the universities to provide professional management training. Before the war, MBA-trained managers were still a rarity; only 1,139 master’s degrees in business were granted in 1940 (Gordon and Howell 1959, 21). After the war, this tripled to 3,357 in 1948 and continued growing steadily, so that by the end of the 20th century American business schools were turning out roughly 100,000 MBAs per year. The net result has been that the MBA has become the standard credential for business executives, which has led to changes in the character of both corporations and business schools.

**The Fast-Track Manager.** As Hayes and Wheelwright (1984) point out, before the war, it was traditional for managers to spend considerable time—a decade or more—in a job before being moved up the managerial ladder. After the war, however, there were simply not enough qualified people to fill the expanding need for managers. To fill the gap, business organizations identified rising stars and put them on fast tracks to executive levels. These individuals did shorter rotations through lower-level assignments—2 or 3 years—on their way to upper-level positions. As a result, top manufacturing managers who came of age in the 1960s and 1970s were likely to have substantially less depth of experience at the operating levels than their predecessors.

Worse yet, the concept of a fast-track manager, first introduced to fill a genuine postwar need, gradually became institutionalized. Once some “stars” had moved up the promotion ladder quickly, it became impossible to convince those who followed to return to the slower, traditional pace. A bright young manager who was not promoted quickly enough would look for opportunities elsewhere. Lifelong loyalty to a firm became a thing of the past in America, and it became commonplace for top managers in one industry to have come up from the ranks of an entirely different one. American business schools preached the concept of the professional manager who could manage any firm regardless of the technological or customer details, and American industry practiced it.

The days of Carnegie and Ford, owner-entrepreneur-managers who knew the details of their businesses from the bottom up, were gone.

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9For example, John Scully came from Pepsi to head Apple Computer, and Archie McCabe came from Xerox to head International Harvester.

10For that matter, American government practiced it. When Secretary of the Treasury Donald Regan and White House Chief of Staff James Baker exchanged jobs during the Reagan administration, there was little mention of it in the press—except to note the different management styles of the two men.
Academization of Business Schools. As business schools expanded after the war to meet the demand for professional managers, their pedagogical approaches came under increasing scrutiny. In 1959, two influential studies of American business schools, commissioned by Ford Foundation (Gordon and Howell 1959) and Carnegie Corporation (Pierson 1959), were released. These studies criticized American universities for taking an overly vocational approach to business education and called for an increase in academic standards and a broadening of emphasis to promote general knowledge, based on the “fundamental disciplines” of the behavioral sciences, economics, and mathematics and statistics. The studies advocated an interesting mix of specialization (i.e., emphasis on more sophisticated analytical techniques\textsuperscript{11}) and generalization (i.e., development of professional managers who are prepared to deal with virtually any management problem).

Having been on the fringe of academic respectability from their inception, the business schools took the studies’ recommendations seriously. They hired faculty specialists in psychology, sociology, economics, mathematics, and statistics—many without any business background whatever. They revised curricula to include more courses in these basic “theoretical” subjects and reduced courses aimed at training students for specific jobs. Operations research, which had burst onto the scene with some well-publicized military successes during World War II and was developing rapidly in the 1960s with the evolution of the digital computer, was quickly absorbed into operations management. The concept of the professional manager became the ruling paradigm in American business education.

This “modernizing” of the business schools did more than produce a generation of managers long on general theories and short on specific practical skills. It eroded the business schools’ traditional, albeit small, role as repositories of the best of industry practice. With specialists in psychology and mathematics pursuing narrowly focused research in arcane academic journals, it is hardly surprising that when productivity growth declined in the late 1970s and early 1980s, industry did not look to the universities for help. Instead, it turned to Japanese examples (e.g., Schonberger 1982) and anecdotal surveys of industry practice by consultants (e.g., Peters and Waterman 1982). Thus, after being educated in the “scientific” tools of management, the MBA-trained professional managers of the 1980s and 1990s were wooed by an endless stream of quick fixes for their management woes. Fads based on buzzwords, such as theory Z, management by objectives, zero-based budgeting, decentralization, quality circles, restructuring, “excellence,” management by walking around, matrix management, entrepreneurship, value chain analysis, one-minute managing, just-in-time, total quality management, time-based competition, business process reengineering, and many others, came and went with numbing regularity. While many of these “theories” contain valuable insights, the sheer number of them is evidence that the fix is not quick.

The ultimate irony occurred in the 1980s when, in a desperate attempt to win back the trust of students alienated by the almost total disconnect between classroom and boardroom, many operations management courses began to teach the buzzword fads themselves. In doing so, business schools gave up their role as arbiter of what works and what does not. Instead of being trendsetters, they became trend followers.

By the 1990s it was apparent that business schools and corporations had swung far apart, with industry naively relying on glib buzzword approaches and academia leaning too far toward specialized research and imitative teaching. It remains to be seen whether this gap can be closed. To do so, business schools must recover their foundation in

\textsuperscript{11}Presumably this had something to do with the fact that the studies were done in the era of Sputnik—a time of widespread faith in science.
practice, in order to focus their tools on problems of real industry interest instead of an abstract intellectual challenge. Industry must recover its appreciation of the importance of the technical details of manufacturing and develop the capacity to systematically evaluate which management practices work, instead of lurching from one bandwagon to the next. By adjusting the attitudes of both academics and practitioners, we have the potential to apply the tools and technology developed in the decades since World War II to sustain manufacturing as a solid base of the American economy well into the 21st century.

1.7.4 Recovery and Globalization of Manufacturing

The 1990s are likely to be remembered as an era of irrational exuberance in the stock market and overblown hype of the dot-com sector. But they also represented a dramatic resurgence of American manufacturing after the decline of the 1970s and 1980s. Annual productivity increases in manufacturing had returned to a healthy rate above 3 percent during much of the '90s and averaged above 4 percent from 2000 to 2003. In 1997, manufacturing profits were at a 40-year high and unemployment was at its lowest level in more than 2 decades. Seven years of economic growth had spurred investment in physical plant, so that nonresidential equipment owned by business nearly doubled between 1987 and 1996 (BusinessWeek, June 9, 1970, 70).

Good times for American manufacturers also extended beyond the domestic market. The Institute for Management Development in Lausanne, Switzerland, ranked America as the most globally competitive nation in the world every year during the period 1993 to 1997. A 1993 survey by the Center for the Study of American Business (CSAB) at Washington University in St. Louis of 48 manufacturing executives found that 90 percent considered their firms more competitive than they had been 5 years earlier (Chilton 1995). Large majorities of these executives also reported that quality and product development time had improved substantially over this same period.

While encouraging, the situation in the mid-1990s was far from a return to that of the mid-1960s. Total employment in manufacturing increased only modestly (by 700,000 jobs) during the boom years from 1992–1998, and fell substantially (by over 2.5 million jobs) between 1998–2003. The recession in 2001 was partially responsible. But so were the above–cited productivity increases, which were needed to keep pace with elevated global competition. For example, despite improved performance of America’s “big three,” Toyota remained widely regarded as the world’s premier automaker and steadily gained market share (Taylor 1997). The CSAB survey reported that 75 percent of manufacturing executives strongly agreed (and an additional 10 percent somewhat agreed) that the competition they faced in 1993 was much stiffer than that 10 years earlier, and large majorities agreed that even more improvements in quality and product development times would be needed in the next 5 years in order to keep pace.

As managers searched frantically for ways to improve their competitiveness, the 1990s became a decade of manufacturing fads. Books, videos, software, and gurus promised (nearly) instant improvements. While these were often described with dazzling buzzwords (and acronyms), their substance fell into three basic trends focusing on efficiency, quality, and integration. While certainly not new concepts, the intensity with which they were pursued reached new heights as accepted performance standards rose ever higher.

The efficiency trend is as old as manufacturing itself and was at the core of the Scientific Management movement of the early 20th century. But it received a substantial boost in the 1970s and '90s with the emergence of the Japanese just-in-time (JIT) system, particularly at Toyota. We will discuss this in more depth in Chapter 4. For now we will
simply note that a key focus of JIT was elimination of unnecessary inventory (i.e., waste) in production systems. After some half-hearted copycatting in the 1980s, American firms flirted with a more radical waste elimination approach labeled business process reengineering (BPR) (Hammer and Champy 1993). After BPR became discredited as synonymous with "downsourcing," the efficiency emphasis of JIT was reborn as lean manufacturing. Whether the name "lean" persists or not, the efficiency trend will. So, we will examine the underlying science of lean in Chapter 9.

The quality trend dates back at least to the pioneering work of Shewhart (1931), but also received an important stimulus in the 1970s and '80s from Japan under the banner of total quality management (TQM). After an intense love affair with "quality speak" in the 1980s, many firms became convinced that TQM was being oversold with grandiose claims such as "quality is free" (Crosby 1979) and the term fell into disfavor. But the quality trend was soon revived when General Electric borrowed the statistically based Six Sigma system from Motorola and used it to great success in the 1990s. Again, whether the "Six Sigma" label lasts or not, quality is here to stay, so we will examine the Japanese influence of this trend in Chapter 4 and probe it more deeply in Chapter 12.

The integration trend traces its roots back to the increasingly sophisticated methods needed to manage the vertically integrated large-scale enterprises of Carnegie, Ford, and Sloan. Attempts to computerize these methods led to the emergence of material requirements planning (MRP) in the 1970s. These steadily grew in scope and acquired loftier names, such as manufacturing resource planning (MRP II), business requirements planning (BRP), and enterprise resource planning (ERP). But by the 1990s, the pressure of global competition was inducing many firms to deintegrate by outsourcing noncore processes. This led to an enormous growth in the contract manufacturing industry. The need to coordinate manufacturing and distribution operations that were increasingly spread around the globe led to the rise of supply chain management (SCM). The supply chain allure was so strong that many ERP systems were transformed (almost overnight) into SCM systems. Regardless of the name, the manufacturing integration problem, and software systems for dealing with it, will be with us for a very long time. Hence, we study the MRP roots of the (computerized) integration trend in Chapter 3 and return to it from a supply chain perspective in Chapter 17.

The net effect of globalization is that manufacturing management is a much more complex and larger-scale activity than it once was. Successful firms must not only master skills necessary to run effective production facilities, they must also coordinate these across multiple levels, firms, and cultures. It is safe to say that the "production problem" Galbraith pronounced solved in 1958 will be with us for some time to come.

1.8 The Future

America's manufacturing future cannot help but be influenced by its past. The practices and institutions used today have evolved over the past 200 years. The influences range from the ramifications of the myth of the frontier to our love affair with finance and marketing, and they will not evaporate overnight. An appreciation of what has gone before can at least make us conscious of what we are dealing with (a brief summary of manufacturing milestones is given in Table 1.1). But history shapes only the possibilities

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12 For example, electronics manufacturing services (EMS) had become a $140 billion industry by 2003. The largest EMS firms, such as Solectron and Flextronics, had grown into multi-billion-dollar enterprises and had expanded well beyond contract manufacturing by providing services throughout the supply chain, from new product introduction to post-sale service, and even management of overall supply chain integration.
<table>
<thead>
<tr>
<th>Date</th>
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<tbody>
<tr>
<td>4000 B.C.</td>
<td>Egyptians coordinate large-scale projects to build pyramids.</td>
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<td>1500</td>
<td>Leonardo da Vinci systematically studies shoeing.</td>
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<td>1733</td>
<td>John Kay invents the flying shuttle.</td>
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<td>1765</td>
<td>James Hargreaves invents the spinning jenny.</td>
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<td>1765</td>
<td>James Watt invents the steam engine.</td>
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<td>1776</td>
<td>Adam Smith publishes <em>Wealth of Nations</em>, introducing the notions of division of labor and the invisible hand of capitalism.</td>
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<tr>
<td>1776</td>
<td>James Watt sells his first steam engine.</td>
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<tr>
<td>1781</td>
<td>James Watt invents a system for producing rotary motion from up-and-down stroke of steam engine.</td>
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<tr>
<td>1785</td>
<td>Honoré LeBlanc shows Thomas Jefferson interchangeable musket parts.</td>
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<tr>
<td>1793</td>
<td>First modern textile mill in America established in Pawtucket, RI.</td>
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<tr>
<td>1801</td>
<td>Eli Whitney contracted by U.S. government to produce muskets, using system of interchangeable parts.</td>
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<td>1814</td>
<td>Integrated textile facility established in Waltham, MA.</td>
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<td>1852</td>
<td>Charles Babbage publishes <em>On the Economy of Machinery and Manufactures</em>, dealing with organization and costing procedures for factories.</td>
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<td>1840</td>
<td>Opening of anthracite coal fields in eastern Pennsylvania provides first American source of inexpensive nonwater power.</td>
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<td>1851</td>
<td>Crystal Palace Exhibition in London displays “American system of manufacturing.”</td>
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<td>1854</td>
<td>Daniel C. McCallum develops and implements earliest large-scale organization management system at New York and Erie Railroad.</td>
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<td>1855</td>
<td>Henry Bessemer patents a process for refining iron into steel that was far better suited to mass production than earlier “puddling” processes.</td>
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<td>1869</td>
<td>The first transcontinental railroad, the Union Pacific–Central Pacific, is completed.</td>
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<td>1870</td>
<td>Marshall Field makes use of inventory turns as a measure of retail operation performance.</td>
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<td>1875</td>
<td>Andrew Carnegie opens the Edgar Thompson Steel Works in Pittsburgh, the first integrated Bessemer iron mill built from scratch and for decades the largest steel works in the world.</td>
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<tr>
<td>1877</td>
<td>Arthur Wellington publishes <em>The Economic Theory of the Location of Railways</em>, the first book to present methods of capital budgeting.</td>
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<td>1880</td>
<td>American Society of Mechanical Engineers (ASME) founded.</td>
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<td>1886</td>
<td>Charles Hall of the United States and Paul Heroult in Europe simultaneously invent electrolytic method for reducing bauxite into aluminum.</td>
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<td>1886</td>
<td>Henry Towne presents paper at ASME calling for an “Economic Section” devoted to shop management.</td>
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<td>1910</td>
<td>Hugo Diemer publishes <em>Factory Organization and Administration</em>, the first industrial engineering textbook.</td>
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<tr>
<td>1911</td>
<td>F. W. Taylor publishes <em>The Principles of Scientific Management</em>.</td>
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<td>1913</td>
<td>Henry Ford introduces first moving automotive assembly line in Highland Park, MI.</td>
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<tr>
<td>1913</td>
<td>Ford W. Harris publishes <em>How Many Parts to Make at Once</em>.</td>
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<tr>
<td>1914</td>
<td>Lillian Gilbreth publishes <em>The Psychology of Management</em>.</td>
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<tr>
<td>1915</td>
<td>John C. L. Fish publishes <em>Engineering Economics: First Principles</em>, the first text to present discounted cash flow methods.</td>
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<tr>
<td>1916</td>
<td>Henri Fayol publishes first overall theory of management as <em>Administration industrielle et générale</em> (not translated into English until 1929).</td>
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<td>1920</td>
<td>Alfred P. Sloan reorganizes General Motors to consist of a general office and several autonomous divisions.</td>
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<td>1924</td>
<td>Hawthorne studies begin at Western Electric plant in Chicago; they continue to 1932.</td>
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<td>1931</td>
<td>Walter Shewhart publishes <em>Economic Control of Quality of Manufactured Product</em>, introducing the concept of the control chart.</td>
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<td>1945</td>
<td>ENIAC (Electronic Numerical Integrator and Calculator), the first fully electronic digital computer, is built at the University of Pennsylvania. John Bardeen, Walter Brattain, and William Shockley coinvent the transistor at Bell Labs.</td>
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<td>1947</td>
<td>Herbert Simon publishes <em>Administrative Behavior</em>, marking a change in focus of organization theory from the structure of organizations to the process of decision making.</td>
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<td>1953</td>
<td>Thomson Whittom publishes <em>The Theory of Inventory Management</em>, the first book to develop a theory to underlie the practice of inventory control.</td>
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<td>1954</td>
<td>Peter Drucker publishes <em>The Practice of Management</em>, introducing the concept of management by objectives (MBO) on a wide scale.</td>
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<td>1964</td>
<td>The IBM 360 becomes the first computer based on silicon chips.</td>
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<td>1975</td>
<td>Joseph Orlicky publishes <em>Material Requirements Planning</em>.</td>
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<td>1977</td>
<td>Introduction of the Apple II starts the personal computer revolution.</td>
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<tr>
<td>1978</td>
<td>Taiichi Ohno publishes <em>Toyota seisun hoshiki</em> on the Toyota production system.</td>
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for the future, not the future itself. It is up to the next generation of manufacturing managers to evolve the American system of manufacturing to its next level.

What will this level be? Although no one can say for sure, it is our belief that the concept of the professional manager is intellectually bankrupt. In a world of intense global competition, simply setting appropriate general guidelines is not enough. Managers need detailed knowledge about their business, knowledge that must include technical details. Unfortunately, the rise of such monolithic software packages as enterprise requirements planning (the subject of Chapter 3), which purport to encapsulate “best practices,” may prove to be a giant step backward in terms of managers better understanding their practices.

In the future, survival itself is likely to depend on understanding these details. The manufacturing function is no longer a necessary evil that can be taken for granted; it is a vital strategic function. In an era when products move from cutting-edge technology to commodities in the blink of an eye, inefficient manufacturing is likely to be fatal. The economic recovery of the 1990s and the fact that several universities have initiated programs in manufacturing management that stress the technical aspects and operating details of manufacturing are encouraging signs that we are adjusting to the new era.

But change will not come uniformly to all of American manufacturing. Some firms will adapt—indeed, have already adapted—to the new globally competitive world of manufacturing; others will resist change or will continue to seek some kind of technological quick fix. American firms will not rise or fall as a group. Firms that master the intricacies of manufacturing under the new world order will thrive. Those that cling to the methods evolved under the unique, and long-gone, conditions following World War II will not. Those that continue to increase profits by squeezing their employees to increase productivity without allowing real wages to rise will also fail (it appears that the General Motors strike in the summer of 1998 was a crack in the veneer of new American juggernaut).

To make the transition to the new era of manufacturing, it is crucial to remember the lessons of history. Consistently, the key to effective manufacturing has been not technology alone, but also the organization in which the technology was used. The only way for a manufacturing firm of the future to gain a significant strategic advantage over the long term will be to focus and coordinate its manufacturing operation, in conjunction with product and market development, with customer needs. The goal of this book is to provide the manufacturing manager with the intuition and tools needed to do just this.

**Discussion Points**

1. Before 1900, despite its weaknesses in effective management of workers, manufacturing leadership was well provided by top management. They were technological entrepreneurs, architects of productive systems, veritable lions of industry. But when they delegated their production responsibilities to a second-level department, the factory institution never recovered its vitality. The lion was tamed. Its management systems became protective and generally were neither entrepreneurial nor strategic. Production managers since then have typically had little to do with initiating substantially new process technology—in contrast to their predecessors before 1900 (Skinner 1985).
   
   (a) Do you agree with Skinner?
   
   (b) What structural differences between manufacturing enterprises before 1890 and after 1920 contributed to this difference in managerial orientation?