2 Emergence of Manufacturing 19th century

Early view of Lowell. Painting by Benjamin Mather, 1825.
(Courtesy of Lowell Historical Society)

By the beginning of the 19th century, New England had developed a relatively diverse economy with many small mills and shops producing wood and metal products and items of apparel. This varied assortment of small production facilities was a firm foundation for what would follow. Over the next few decades, these small facilities would increasingly share the landscape with, and give way to, large-scale manufacturing enterprises. Eventually, manufacturing would make New England one of the most prosperous regions of the country—and the world. One manufacturing industry—textiles—would lead the way and would come to dominate most of the region.

Textile Industry

Samuel Slater built the first mechanized textile mill in the United States in 1790 in Rhode Island. It spun yarn, which was woven into cloth by local households. Francis Cabot Lowell and his associates built the first mill in the country in which weaving was also mechanized. Lowell's facilities were on a much larger scale than previously seen in this country, creating a true industrial complex.

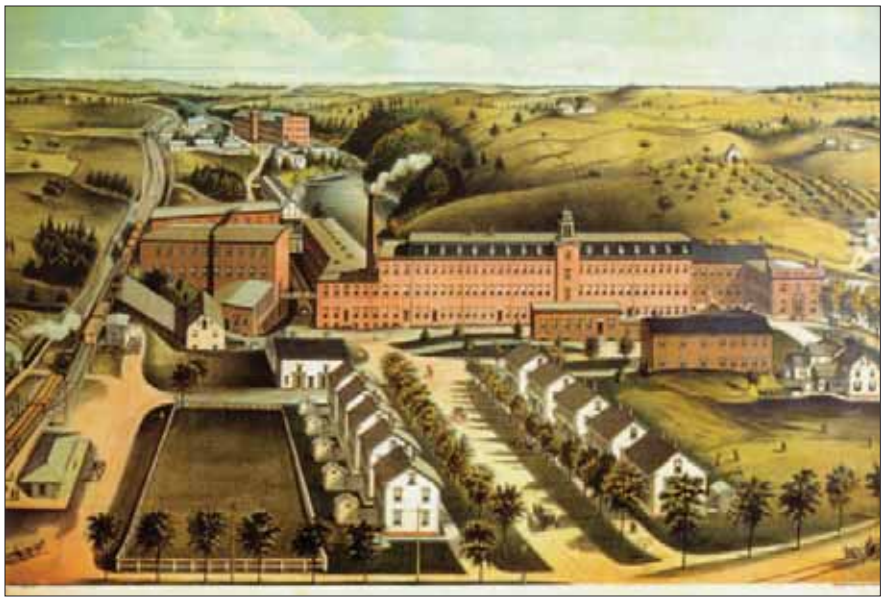
Manufacturing would eventually make New England one of the most prosperous regions of the country—and the world.

Young Woman Tending a Loom. Winslow Homer woodcut.
(Photo Courtesy of Lowell National Historical Park)

The Lowell story is worth special attention.[1] It shows the interplay of technology, investment, financial resources, personal initiative, and culture in the development of a successful entrepreneurial endeavor.

Francis Cabot Lowell began his career as a merchant and trader. Initially, he did quite well, but disruptions to trade arising from the Napoleonic Wars severely reduced the income available from trading and related activities. Lowell and his colleagues sought other opportunities. The

manufacture of cotton textiles held promise, as the trade disruptions had boosted the price for domestic textile products, while driving down the price of raw cotton from the South. (The invention of the cotton gin by New Englander Eli Whitney had greatly increased the productivity of cotton production in the South.)



Sawyer Wool Mills. *(Illustration courtesy of American Textile History Museum, Lowell, MA)*

Francis Cabot Lowell visited England and Scotland and memorized the carefully guarded technology for power looms. Lowell, Nathan Appleton, and Lowell's brother-in-law, Patrick Tracy Jackson, then approached a small group of friends and colleagues to finance the building of a new manufacturing enterprise. The financial vehicle was the joint stock company, which had funded early colonizing efforts but had fallen out of use. The joint stock company provided continuity; it allowed fund-raising over time and on a large scale; and it allowed investors to withdraw by selling their shares without jeopardizing the enterprise's operations. The desired payoff was a relatively secure return on invested funds.

The Boston Associates, as Lowell's group has come to be called, built their first mill in Waltham in 1814. It was successful, and a second mill was quickly built. When the water power at the Waltham site was exhausted, the Boston Associates looked for another location. What is now Lowell was chosen because of its large supply of water power. A very large integrated operation was developed, with all aspects of textile production taking place on-site. The site even had its own machine shop to build and repair the equipment. The Associates also made profits from water rights and from the sale of land as the city of Lowell grew. Textile production spread throughout New England. The U.S. market for cotton textiles was growing rapidly, and many manufacturers became quite successful. The Boston Associates dominated the industry.

In its early years, however, with the cessation of hostilities and the gradual resumption of trade after the War of 1812, the textile industry was threatened by imported cotton from England and Asia. Lowell successfully persuaded Congress to impose a tariff. By seeming to target lower-quality, lower-priced imports from India and China, rather than high-quality cloth from Britain, he was able to deflect the opposition of southern cotton producers who exported to Britain.

Tariff reform newspaper advertisement. *(Illustration courtesy of New Hampshire Historical Society)*

In sum, many factors came together to make Francis Cabot Lowell's endeavor successful. A new technology, in the form of a new machine—the power loom—allowed for a much larger scale and more efficient form of operation. An innovative financial arrangement—the joint stock company—made it possible to raise capital on a large scale. Support from the government provided needed tariff protection. And none of this would have been possible had Lowell not been able to recreate the power loom from memory.

Protective Tariffs

Whether tariffs should be used to protect industries that have growth potential, sometimes called infant industries, is one of the more contentious issues in economics. Comparative advantage argues against tariffs. Trade allows residents of the trading countries to have access to lower-cost goods than would otherwise be the case; and the gains from this exchange should be sufficient that all can be better off. The tariff on imported cloth forced Americans to pay more for textiles and reduced the export opportunities for southern producers of cotton.

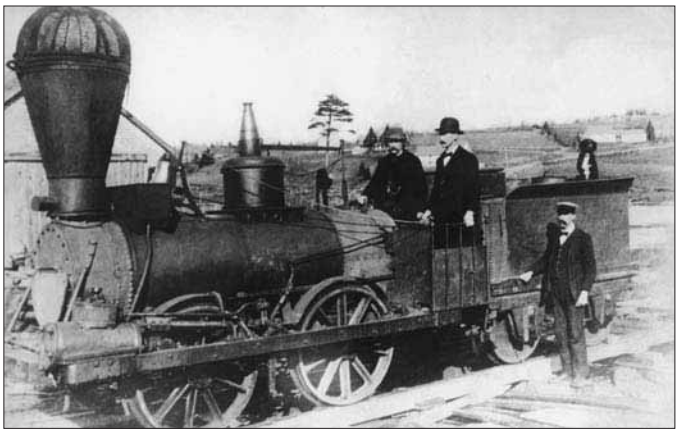
Whether tariffs should be used to protect industries that have growth potential, sometimes called infant industries, is one of the more contentious issues in economics.

The counter-argument takes a long run view. It argues that the protected industry has particularly desirable attributes and that its growth will confer benefits on the rest of the economy through workers acquiring new skills or through the development of new technologies and supporting industries. Thus, in the case of textiles, the industry's growth stimulated the growth of ancillary activities including machine shops and financial enterprises. The protected industry may also become sufficiently efficient eventually that protection is no longer necessary.

Enough successful examples exist of countries using protective tariffs to foster "learning by doing" to make the infant industry argument plausible. But the same argument has been used to justify protection that has conferred no benefits; and regardless of the eventual outcome, those who are deprived of lower-cost imported goods or kept from pursuing export opportunities are disadvantaged.

Machine Tools and Interchangeable Parts

Through much of the 19th century, the textile industry was an engine of growth for a second emerging industry, the machinery industry.[2] Indeed, an early step in building Lowell's Waltham mill was engaging Paul Moody, a highly regarded "mechanic," to build the facility. At Lowell, canals and water wheels all needed to be put in place. Machinery business was brisk, as new textile machines had to be built from scratch and then kept in good repair.

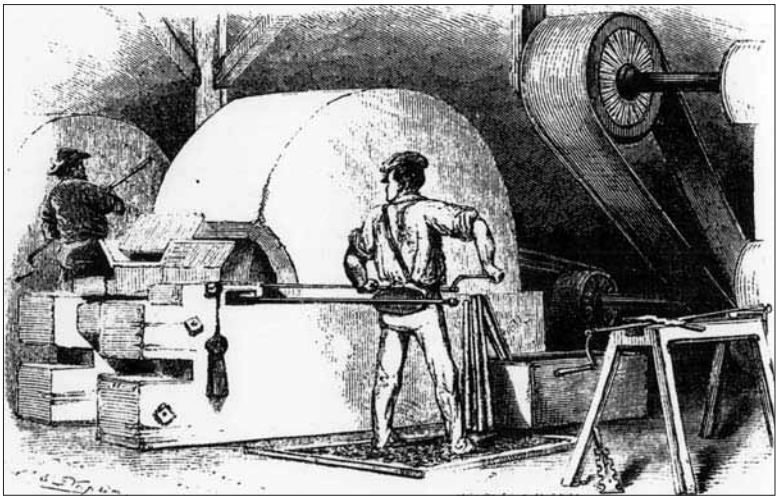


Locomotive engine. *(Photo courtesy of Worcester Historical Society)*

Over time, machine shops once set up strictly to serve a specific mill became independent and began to produce machinery for other purposes, such as paper-making and clock-making. The Lowell Machine Shop became a manufacturer of locomotive engines.

Also driving the development of the machinery industry in New England—and the nation—were a series of technological advances that came to be characterized as the American System of Manufacturers. The essence of the American System was the combination of interchangeable parts and machine tools. ("Interchangeable parts"are product parts that are exactly uniform so that a new part can be substituted for a broken part of the same kind. "Machine tools" are power-driven tools used to cut, shape, or finish a manufactured product.)

By breaking a complex product, such as a firearm, into small components, it is possible to make the product using machines rather than by hand. Production using machines can take place on a much larger scale and at a much lower cost than production by hand. Before the use of machines, intricate products were made by skilled craftsmen, who spent much time "fitting" the various pieces to make them work together. Machine-made parts were more uniform than parts produced by hand by craftsmen. Accordingly, it was possible to assemble the final product from batches of standard parts and to repair a broken gun, for example, by replacing the defective part with a standard replacement.



Grinding machines, Springfield Armory, Springfield, Massachusetts. *(From* Harper's New Monthly Magazine*, vol. 5, no. 26, July 1852. Courtesy of U.S. Department of the Interior, National Park Service, Springfield Armory National Historic Site)*

Eli Whitney, the inventor of the cotton gin, is commonly credited as being the first in the United States to apply the technology of machine-made standard parts. In 1798, by promoting the concept of standard parts, Whitney secured a large contract to make muskets for the U.S. government. It took many years and the contributions of many individuals, however, to achieve true interchangeability and realize the efficiencies of machine production.

A key role was played by the U.S. government armory at Springfield, Massachusetts.[3] Firms making arms under government contract were required to make their innovations in manufacturing technologies available to the armories at Springfield and Harper's Ferry, Virginia. The armories,

Springfield bicycle club members displaying trophies, 1884.
(Photo courtesy of Pocumtuck Valley Memorial Association, Memorial Hall Museum, Deerfield, Massachusetts)

in turn, shared this information with anyone interested in learning about the latest technological advances.

A community of arms manufacturers—Colt, Winchester, and Smith & Wesson—and machine tool manufacturers developed in the Springfield-Hartford area and elsewhere along the Connecticut River. Ideas and innovations were freely shared. Techniques suitable to producing guns could be used for a host of complex metal products, from watches to sewing machines to agricultural equipment to bicycles. Moreover, the same machine tools could be re-calibrated to produce different products.

Colonel Albert Pope was the most prominent of the bicycle manufacturers.[4] The Boston-based Pope contracted with the Weed Sewing Machine Company of Hartford to manufacture his bicycles. Weed operated in a former arms factory and was well known for its use of interchangeable parts. With the introduction of the safety bicycle in the late 1880s, demand for bicycles boomed. This expansion was accompanied by a proliferation of innovations both in the bicycle itself and in manufacturing technology. Many of these carried over to the automobile industry. Besides innovations in product design and production technology, Pope also helped pave the way for the automobile by vigorously lobbying for better roads and by promoting the concept of personal transportation.

Interchangeable parts and machine tools significantly changed people's lives. They vastly expanded the array of products accessible to ordinary people and made it possible for one worker to produce much more output per hour or day of work.

Over time, building machines that could produce other machines became an important industry—the machine tool industry—in its own right. The machine tools performed very narrowly defined tasks, such as drilling, cutting, or grinding, that could be applied to the production of a host of products. Improvements to machine tools to ensure that they did not wear or become distorted with use allowed parts to be assembled much more precisely.

Once again, as in the Lowell textile story, both technology and government played a role in the development of the machine tool industry and complex machine-made products in New England. The new technology—machine tools and interchangeable parts—permitted production on a much larger scale than previously. The products (guns, clocks, bicycles, and eventually motor vehicles) were considerably more complex than cotton textiles, but the government again played an important role, both as an early source of demand and as a disseminator of technology.

Four shoemakers, 1840 -1860.
(Photo courtesy of Library of Congress, Prints & Photographs Division [reproduction number: LC-USZ62-110212])

Interchangeable parts and machine tools significantly changed people's lives. They vastly expanded the array of products accessible to ordinary people and made it possible for one worker to produce much more output per hour or day of work. When more guns or clocks or bicycles can be produced per hour of work, in the language of economists, labor productivity is greater. It became possible to pay workers more because they were producing more. On the downside, the craftsmen who once produced these products by hand found their skills much less valued and much less in demand.

Shoe and Boot Industry [5]

While the metalworking and machinery industries were important sources of productivity growth, the second largest employer in New England in the late 19th century, after textiles, was the boot and shoe industry. Previously, much of the work of shoemaking was done in homes. In the 1850s and 1860s, the development of powerful sewing machines that could work with leather and were powered by steam shifted the making of boots and shoes to a factory setting.

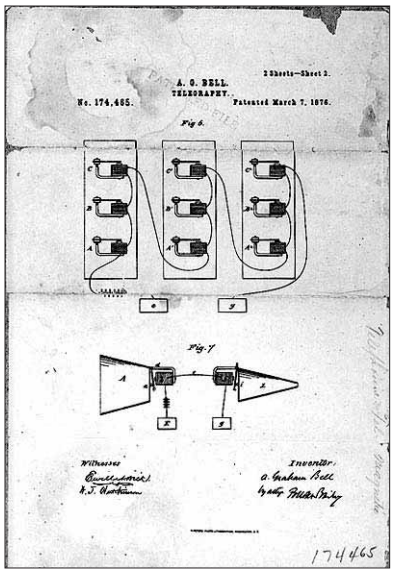
Interestingly, in the making of clothes, the sewing machine did not lead to large factories. These machines could be powered with foot peddles, rather than a centralized power source.

Communications and Transportation

The 19th century saw tremendous advances in transportation and communications. The cost and time required to transport both goods and people fell dramatically. This opened up the central and western regions of the country and tied the country together. New England producers enjoyed a growing domestic market for their goods, but also found themselves exposed to competition from other parts of the country. New Englanders could travel more freely, and through improved communications, they could quickly learn what was happening elsewhere.

The Erie Canal opened in 1825, contributing greatly to the growth of the central states and mid-western cities like Chicago. New York also grew in importance, relative to Boston, as the port serving this hinterland. New England agriculture was challenged by the availability of produce from the mid-western states; and some New Englanders moved west to better opportunity.

Railroads appeared in the 1830s and spread rapidly through New England in the 1840s. With the railroads came the telegraph. In 1877, Alexander Graham Bell used a telephone to communicate between Lowell and Boston.



Alexander Graham Bell's patent for telegraphy. *(Photo courtesy of United States Patent and Trademark Office, Arlington, VA)*

Standards of Living in the 19th Century

More and more people lived in towns rather than farms. In the early 19th century, one saw more and more craftspeople and shopkeepers, but over time, more and more New Englanders began working in the factories that were springing up everywhere. Women were the dominant workers in the textile mills. Men worked in the machine shops. Both worked in shoe-making. The opportunities for women in industry provided a financial independence that was unusual for this time period.

A development that had a major effect on the quality of life, although probably only a modest impact on economic activity at that time, was the discovery of anesthesia. While several individuals have some claim to this discovery, the successful demonstration of anesthesia's use at the Massachusetts General Hospital in the 1840s ushered in a new era in medicine. Not only could people undergo surgical procedures without experiencing pain, but also surgery was launched on an upward trajectory that continues to this day. With patients immobilized, surgeons could undertake increasingly delicate and ambitious operations.

One adverse consequence of growth in the 18th century was the increasing prevalence of infectious diseases that accompanied the crowding that came with urbanization. Life expectancy was lower in the mid-19th century than 100 years earlier.[6]

Ether Day 1846 by Warren and Lucia Prosperi. Illustrates the first demonstration of anesthesia use. *(Courtesy of Massachusetts General Hospital)*

Oil stove in use in a home. Advertisement for Florence Oil Stoves.
(Photo courtesy of New Hampshire Historical Society)

Endnotes

[1] Rothenberg in *Engines of Enterprise*, pp. 95-102; Peter Temin, "The Industrialization of New England 1830-1880," in *Engines of Enterprise*, pp. 121-125; Robert F. Dalzell, Jr., "The Waltham-Lowell System: Motiviation, Location and Structure," background paper for New England Economic History Museum Schematic Design Report.

[2] Temin in *Engines of Enterprise*, p. 123, and Merritt Roe Smith, "New England Industry and the Federal Government," in *Engines of Enterprise*.

[3] Smith in *Engines of Enterprise*. David A. Hounshell, *From the American System to Mass Production, 1800-1932*, (Johns Hopkins University Press, 1984), chapter 1.

[4] See the Pope biography in the Adventure website for sources on Pope.

[5] Temin, p. 142, and Joshua L. Rosenbloom, "The Challenges of Economic Maturity," in *Engines of Enterprise*, p. 156.

[6] Rosenbloom in *Engines of Enterprise*, p. 175.

Written by Lynn Browne, Executive Vice President and Economic Advisor,
Federal Reserve Bank of Boston, July 2003