

Industrialization: The First Phase

While Europe's "great men" plotted grand schemes to pursue their political and intellectual ambitions during the crisis of the Old Regime, French Revolution, and Napoleonic wars, obscure British inventors designed machines whose impact would dwarf their efforts. They industrialized textile making by using machines and new power sources to accomplish a task formerly done by human and animal power. They began what has been called by some the Industrial Revolution.

The huge increase in productivity made possible by using machines can be shown in the amount of raw cotton Britain imported in 1760 and 1850. In 1760 the British imported a bit over 1000 tons; in 1850 the number had risen to over 222,000 tons. The story behind the growth of the textile industry is one of a continual "catch-up" game between the spinners and weavers to respond to a growing market. After the 1707 Act of Union with Scotland, Britain possessed an expanding population with a larger per capita income than that of any other European state. The population growth stemmed from a gradual decline in death rates and an increase in the birth rate. ^14 It provided more customers and workers.

[Footnote 14: J. D. Chambers, "Enclosures and the Labour Supply in the Industrial Revolution," *Economic History Review*, 2nd series, V, 1953, pp. 318-343, as cited in David Landes, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present* (Cambridge: Cambridge University Press, 1969), p. 115.]

The Revolution In Making Cloth

Practical people seeing the need for greater output solved the practical problems of production. In the many steps from the raw cotton to the finished cloth, there were bottlenecks primarily in making yarn and weaving the strands together. In 1733, John Kay (1704-1764), a spinner and mechanic, patented the first of the great machines - the flying shuttle. This device made it possible for one person to weave wide bolts of cloth by using a spring mechanism that sent the shuttle across the loom. This invention upset the balance between the weavers of cloth and the spinners of yarn: ten spinners were required to produce enough yarn needed by one weaver. James Hargreaves (d. 1778), a weaver and carpenter, eliminated that problem in 1764 with his spinning jenny, a mechanical spinning wheel that allowed the spinners to keep up with the weavers.

Five years later, a barber named Richard Arkwright (1732-1792) built the water frame that made it possible to spin many threads into yarn at the same time. Ten years after that Samuel Crompton (1753-1827), a spinner, combined the spinning jenny and water frame into the water mule, which, with some variations, is used today. By this time the makers of yarn were outpacing the weavers, but in 1785 Edmund Cartwright (1743-1823) invented the power loom that mechanized the weaving process. In two generations what had once been a home-based craft became an industry.

The appetite of the new machines outran the supply of cotton. Since most of the material came from the United States, the demand exceeded the capability of the slave-based southern economy to fill the supply. The best worker could not prepare more than five or six pounds of cotton a day because of the problems of the seeds. American inventor Eli Whitney (1765-1825), among others, devised the cotton gin, a machine that enabled a worker to clean more than fifty times as much cotton a day. This device coincidentally played a major role in the perpetuation of slavery in the United States.

Finally, the textile industry became so large that it outgrew the possibilities of its power source: water power. Steam came to drive the machines of industrializing Britain. In the first part of the eighteenth century a mechanic, Thomas Newcomen (1663-1729), made an "atmospheric engine" in which a piston was raised by injected steam. As the steam condensed, the piston returned to its original position. Newcomen's unwieldy and inefficient device was put to use pumping water out of mines. James Watt (1736-1819), a builder of scientific instruments at the University of Glasgow, perfected Newcomen's invention. Watt's steam engine also was first used to pump water out of mines. It saved the large amounts of energy lost by the Newcomen engine and led to an increase in coal productivity. After 1785 it was also used to make cloth and drive ships and locomotives. The application of steam to weaving made it possible to expand the use of cloth-making machines to new areas, and after 1815 hand looms began to disappear from commercial textile making, replaced by the undoubted superiority of the cloth-making machines.

These inventors made their contributions in response to the need to solve a particular problem. Their machines and the new power sources expanded productivity and transformed society in ways never before dreamed of. The transition from a rural agrarian to an urban lifestyle merits applying the term revolutionary to the process of industrialization. The steps in increasing textile production were repeated and continue to be repeated in other goods as well. The liberation from the productive limitation of human and animal power to satisfy essentially unlimited demand is the great gift of industrialization.

Britain's Dominance

Industrialization began in Britain in the eighteenth century for a number of reasons. Neither the richest nor the most populous country in western Europe, it did, nevertheless, possess at virtually all levels of society a hard-working, inventive, risk-taking private sector that received strong support from the government. Industrialization could not begin and grow without individual business owners who took a chance on something new. The British kept this close tie between private initiative and creative governmental support throughout the eighteenth and nineteenth centuries.

Thanks to early governmental support of road improvements and canal construction, Britain had a better transportation network than any other country in Europe. The British also had mastery of the seas, excellent ports, and a large merchant fleet. They enjoyed the advantage of living safely on their island, away from the carnage of war, even during the Napoleonic wars. The chance to industrialize in stable conditions gave them the opportunity to profit from war contracts between 1792 and 1815. They developed their industrial capacity without fear of battle damage or loss of life.

Probably the most important factor was the relative flexibility of the British social and political systems. Members of the elite, unlike their colleagues on the continent, pursued their wealth in the new industrial framework with great energy. They worked closely with the middle classes and workers, even to the point during the nineteenth century of sponsoring gradual reform efforts to stifle any chance of revolution from below.

The combination of inventiveness, growing markets, governmental support, and social flexibility made Britain the world's dominant economic power until the end of the nineteenth century. Napoleon's interference had hurt economic growth, but had also spurred the British to look for new manufacturing methods and markets. Once the wars were over, Britain flooded the continent and the Americas with high-quality, inexpensive goods. No nation could compete against British efficiency. When Britain began industrializing before 1789, there were isolated areas on the continent such as the French Le Creusot works that could have served as the base for a similar growth. Twenty-six years of revolution and mercantile policies made that competition impossible. ^15

[Footnote 15: E. J. Hobsbawm, *The Age of Revolution, 1789-1848* (New York: New American Library, 1964), pp. 44-73.]

Cotton production continued to increase and was supplemented by the arrival of the modern Iron Age. In 1800 Russia and Sweden had exported iron to Britain. By 1815 Britain exported more than five times as much iron as it imported. By 1848 the British produced more iron than the rest of the world combined. As in textile production, in ironmaking a number of inventions appeared to respond to problems. Refining of the brittle cast iron was improved to make it more malleable and tougher. At the same time more efficient mining processes for both coal and iron ore were used to ensure a constant supply of raw materials.

To further dominate the metals market, in the 1850s Henry Bessemer (1813-1898) developed a process to make steel, a harder and more malleable metal, quickly and cheaply. So effective was the process that between 1856 and 1870 the price of British steel fell to one half the amount formerly charged for the best grade of iron. The drastic reduction in price, a mark of industrialization, had a positive impact on all areas of the economy.

In the period after midcentury Britain produced more than two-thirds of the world's coal and more than half of the world's iron and cloth. Industrial development encouraged urbanization and by 1850 more than half of the population lived in cities and worked in industries. The British continued to enjoy the highest per capita income in the world, and the island nation stood head and shoulders above the world in terms of economic and material strength.

Industrialization: The Second Phase

The second phase of industrialization brought new products and power sources to the continent. Increased food production and improved health standards and diet led to a population explosion that promised both economic gains and bureaucratic burdens. The rapid and massive growth of cities brought with it the social problems of urbanization. Workers united to fight for their interests, while the middle classes extended their wealth and influence. Both groups changed the nature of social and political life.

Food And Population Increases

Liberated from many of the restraints of the past by the French, Napoleonic, and Industrial revolutions, most Europeans made the transition from a society based on agriculture to a modern urban society. The spectacular growth of the industrial sector makes it easy to overlook the great strides in food production during the nineteenth century. Because of the improved global transportation network and better farming methods, the expanding number of city dwellers had more and better food to eat in 1914 than they had had in 1815.

It is estimated that in 1815 around 60 percent of the money and 85 percent of the Europeans were tied to farming. These large quantities of capital and labor were not effectively used, because the advances made in Holland and Britain in the seventeenth and eighteenth centuries had not spread to the continent. However, progressive landowners gradually introduced these

improved methods when they saw the money to be made feeding the growing population of the cities.

By the end of the nineteenth century farmers on the continent were plowing new lands and using higher yielding crop varieties to survive in the worldwide agricultural competition. Industrial nations such as Britain, in which only 10 percent of the population was engaged in farming, imported more than a fourth of their food. Farmers in the Americas, Australia, and New Zealand competed with each other in the cutthroat export market. The peasants of Ireland and southern and eastern Europe were unable to produce efficiently enough to prosper in this new setting. Russia, where the peasantry comprised 70 percent of the population, had to export to bring in foreign capital to finance industrialization. When the country had to compete with efficient foreign farmers, the tsarist minister of finance stated, "we may go hungry, but we will export." ^16

[Footnote 16: I. Vyshnegradsky, quoted in William L. Blackwell, *The Industrialization of Russia: An Historical Perspective* (New York: Thomas Y. Crowell, 1970), p. 24.]

The expanded food supply supported the growth in European population from 175 million to 435 million. ^17 This 130 percent increase between 1800 and 1910 partially disproved the views the British clergyman Thomas Robert Malthus (1766-1834) set forth in his *Essay on Population*. Malthus asserted that human reproduction could easily outrun the earth's ability to produce food. ^18 In his own day he could point to the limited food supply and rapidly increasing population. From this evidence he concluded that the inevitable fate of humanity was misery and ruin, since the number of people would rise geometrically while food supply would grow only arithmetically. The experience of the next two centuries has at least temporarily disproved Malthus' thesis.

[Footnote 17: Fernand Braudel, *Capitalism and Material Life: 1400-1800* (New York: Harper & Row, 1975), p. 11; William Langer, "Checks on Population Growth: 1750-1850," *Scientific American* 226 (1972), pp. 92-99.]

[Footnote 18: Thomas Malthus, "An Essay on Population," in *Introduction to Contemporary Civilization in the West*, vol. II (New York: Columbia University Press, 1955), p. 196.]

A gradual decline in mortality rates, slightly better medical care, more food, earlier marriages, and better sanitary conditions contributed to the population increase. The number of people grew so rapidly in Europe that although 40 million Europeans emigrated throughout the world, the continent still showed a population increase in one century that was greater than that of the previous two thousand years. Where the economies were advanced, such as in northern and western Europe, the population growth could be absorbed. But in the poorer countries of southern and eastern Europe, the masses faced the choices of overcrowding and starvation or emigration.

The Ties That Bind: New Networks

To bring the increased food supply to the growing population, to distribute new resources to larger markets, and to connect augmented capital with essential information, Europeans built the most complete and far-reaching transportation and communication networks ever known. Without rapid and dependable transport and contact the Industrial Revolution could not have occurred, cities would not have grown, factories could not have functioned, and the new millions of Europeans would not have been fed. The new networks became the arteries and nervous system of Europe.

The Duke of Bridgewater made a major step forward in water transportation in 1759 when he built a seven and one-half mile long canal from his mines to Manchester. Water transport cut the price of his coal in half and gave Britain a vivid lesson in the benefits of canals. Nearly four thousand miles of improved rivers and canals were built, with strong governmental support by the 1830s, making it possible to ship most of the country's products by water. Following the British example, canal building spread through Europe and North America and then to Egypt with the Suez Canal in 1869 and Latin America with the Panama Canal in 1914. The first project cut the sailing time between London and Bombay India by nearly half, while the second did away with the need to sail around South America to reach the Pacific Ocean.

Until 1815 most roads were muddy, rutted paths that were impassable during spring thaws and autumn rains. In that year a Scotsman, John McAdam, created the all-weather road by placing small stones in compact layers directly on the road bed. The pressure of the traffic moving over the highway packed the stones together to give a fairly smooth surface. This practical solution cut the stagecoach time for the 160 miles from London to Sheffield from four days in the 1750s to 28 hours.

Steam-powered vessels replaced the graceful though less dependable sailing ships in ocean commerce. Clipper ships are among the most beautiful objects ever built, but they could not move without wind. Sturdy, awkward-looking steamships carried larger cargo with greater regularity and revolutionized world trade. The price of American wheat on the European market dropped by three-fourths in the last part of the century, thanks to a considerable degree to the savings made possible by the large, reliable steam ships. Transatlantic passenger and mail services were also improved by the use of steam to power seagoing vessels.

The most important element in the European arterial network was the

railroad. Between 1830 and 1860 rails linked every major market in Europe, and the United States. By 1903 the Russians had pushed the Trans-Siberian railroad to the Pacific Ocean. Railroads cheaply and efficiently carried large amounts of material and people long distances and knit countries and continents closer together. Within cities, urban rail lines and trolleys were widespread by the end of the century; these had an impressive effect on housing and business patterns by permitting a wider diffusion of workers. London established subways first in the 1860s, followed by Budapest in 1896 and Paris in 1900.

[See English Royal Train: This English Royal train was built in the early 1840s for the special use of Queen Victoria in her travels over the nation's rapidly expanding railway system. courtesy L'illustration, December 9, 1843]

Connected with the growth of the transportation networks and technological innovation, major improvements came in the area of communications. Postal agreements among the various countries made cheap and dependable mail service possible. The modern postage stamp and improved transportation brought astronomical increases in the amount of letters and packages mailed after 1850. ^19 Starting in the 1840s the electric telegraph, undersea cable, telephone, wireless telegraph, and typewriter expanded humanity's ability to exchange ideas and information. No longer would distance be a critical obstacle after the transportation and communications revolutions. The world became a smaller, if not more unified, place.

[Footnote 19: Eugen Weber, *A Modern History of Europe* (New York: W. W. Norton, 1971), p. 988.]

The Continent Industrializes

The continent faced many hurdles to economic growth after 1815. Obstacles to mobility, communication, and cooperation among the classes prevented the social structures there from adapting as easily to change as had the British. The farther south and east the social system, the more repressive was the structure. In many parts of the continent, the restored nobilities reclaimed their power, and they were neither intellectually nor financially prepared to support industrial development. Fragmented political boundaries, geographical obstacles, and toll-takers along primary river and road systems hampered growth, especially in central Europe. In eastern Europe, the middle classes were weaker and more isolated than in the west.

At the end of the Napoleonic wars, the initial stages of industrialization could be found in Belgium, France, and Germany. In Sweden, Russia, and Switzerland there were pockets of potential mechanized production, but the total of all of these activities was tiny compared to Britain's economy. In 1850 only Belgium could compete with British products in its own markets. There a combination of favorable governmental policies, good transportation, and stability brought some success.

Governments and businesses sent officials and representatives to Britain to try to discover the secrets of industrialization. The British tried to protect their advantage by banning the export of machines and processes and limiting foreign access to their factories. Industrial espionage existed then as now, and continental competitors did uncover some secrets. Britain's success could be studied, components of it stolen, and its experts hired, but no country on the continent could combine all the factors that permitted Britain to dominate.

After midcentury, a long period of peace, improved transportation, and strategic government assistance encouraged rapid economic growth in France and the German states. Population increased 25 percent in France and nearly 40 percent in the Germanies, providing a larger market and labor supply. Two generations of borrowed British technology began to be applied and improved upon; but the two most important developments came in banking and customs and toll reforms.

After 1815, aggressive new banking houses appeared across Europe, strengthened by the profits they had made extending loans to governments during the Napoleonic wars. They saw the money to be made investing in new industries such as railroads and worked with both governments and major capitalists. Firms such as Hope and Baring in London, the Rothschilds in Frankfurt, Paris, Vienna, and London, and numerous Swiss bankers were representative of the private financiers who had well-placed sources and contacts throughout the state and business communities. ^20

[Footnote 20: Sidney Pollard, *European Economic Integration: 1815-1970* (New York: Harcourt Brace Jovanovich, 1974), pp. 56-62.]

Banking changed radically during this period to satisfy the growing demands for money. Long-range capital needs were met by the formation of investment banks, while new institutions were created to fill the need for short-term credit. The ultimate source of financial liquidity was the middle classes - the thousand of little people who put their money in banks to make their own profits on interest earned. More money could be gained from the many small investors than from the few rich families who used to dominate banking.

The Germans led the way in the other major development, the Zollverein (customs union), that began under Prussian leadership in 1819. This arrangement helped break down the trade barriers erected by state boundaries and in the next twenty-three years came to include most of central and northern Germany. Instead of the more than 300 divisions fragmenting the Germans in 1800, there was a virtual free trade market, something Britain had

enjoyed since the union of Scotland and England in 1707 - and which the European Economic Community will create after 1992. The significance of the Zollverein was that it allowed goods to circulate free of tolls and tariffs, thus reducing prices and stimulating trade.

In the second half of the century, industrialization grew rapidly, aided by the increased flow of credit and elimination of many internal barriers. Tariff walls throughout the area fell to a degree not matched until after World War II. Major firms such as the German Krupp works and the French silk industries controlled portions of the European market and competed effectively with Britain throughout the world.

Technological Growth And Advances

Another reason for the continent's economic emergence was a wide range of new technologies using new materials, processes, and transportation. New competitors began with state-of-the-art factories that allowed them to outproduce Britain, whose older factories were less productive.

The basic change in the second phase of industrialization was the use of electricity in all aspects of life. Scientists had discovered electricity's basic principles a century earlier, but it was difficult to generate and transmit power across long distances. When the first dependable dynamo, a device that changed energy from mechanical into electrical form, was perfected in 1876, it became possible to generate electricity almost anywhere. Inventors such as the American Thomas A. Edison began to use the new resource in industry, transportation, entertainment, and the home. Humanity had finally found a source of power that could be easily transported and used. The British took the lead in bringing electricity to home use. The Germans made the most advanced application of electric technology to industry.

[Hear P. T. Barnum]
Edison's early recording of PT Barnum

Another fundamental change came in the use of gas and oil in the newly devised internal combustion engine. Steam power's use was limited by its appetite for huge amounts of fuel and its sheer bulk. Gottlieb Daimler perfected the internal combustion engine used in most automobiles today. In 1892 Rudolf Diesel invented the engine that bears his name. It burned fuel instead of harnessing the explosions that drove the Daimler engine.

These new developments led directly to the search for and use of petroleum and the beginning of the passenger car industry. By 1914 the making of cars was a key part of the Italian, Russian, German, French, and American economies. Automobile manufacturing called for a number of "spinoff" industries such as tires, ball bearings, windshields - the list extends to hundreds of items. Leaving aside the passenger car's economic contribution, the world's cities and people felt the complex impact of this new form of transportation, with consequences extending from the range of an individual's world to the increased noise level and pollution that changed the character of urban areas.

Other new machines changed life. Bicycles became commonplace in the 1890s, as did sewing machines, cameras, and typewriters, to name a few. Never had people had the ability to transform ideas almost instantly into products accessible to the average person. This was another dividend of industrialization and a symbol of a rapidly changing Europe.

The Human Costs Of Industrialization

Industrialization drove society from an agricultural to an urban way of life. The old system in which peasants worked the fields during the summer and did their cottage industry work in the winter to their own standards and at their own pace, slowly disappeared. In its place came urban life tied to the factory system. The factory was a place where people did repetitive tasks using machines over long hours to process large amounts of raw materials. This was an efficient way to make a lot of high-quality goods at cheap cost. But the factories were often dangerous places and the lifestyle connected to them had a terrible effect on the human condition.

In the factory system the workers worked and the owners made profits. The owners wanted to make the most they could from their investment and to get the most work they could from their employees. The workers, in turn, felt that they deserved more of the profits because their labor made production possible. This was a situation guaranteed to produce conflict, especially given the wretched conditions the workers faced in the first stages of industrialization.

The early factories were miserable places, featuring bad lighting, lack of ventilation, dangerous machines, and frequent breakdowns. Safety standards were practically nonexistent and workers in various industries could expect to contract serious diseases - workers with lead paint suffered lung problems, pewter workers fell ill to palsy, miners suffered black lung disease, and primitive machines claimed many fingers, hands, and even lives. Not until late in the century did health and disability insurance come into effect. In some factories workers who suffered accidents were deemed to be at fault, and since there was little job security, a worker could be fired for virtually any reason.

The demand for plentiful and cheap labor led to the widespread employment of women and children. Girls as young as six years old were used to haul carts

of coal in Lancashire mines, and boys and girls of four and five years of age worked in textile mills - their nimble little fingers could easily untangle jammed machines. When they were not laboring, the working families lived in horrid conditions in such wretched industrial cities as Lille, France, and Manchester, England. There were no sanitary, water, or medical services for the workers and working families were crammed twelve and fifteen to a room in damp, dark cellars. Bad diet, alcoholism, cholera, and typhus led to a reduction of life span in the industrial cities. Simultaneous with, and perhaps part of, the industrialization process was the vast increase in illegitimate births. Up to midcentury, corresponding to the time of maximum upheaval, continent-wide figures indicate that at least one-third of all births were out of wedlock. ^21

[Footnote 21: Edward Shorter, "Illegitimacy, Sexual Revolution, and Social Change in Modern Europe," in Theodore K. Rabb and Robert I. Rotber, eds., *The Family in History* (New York: Harper & Row, 1973), pp. 48-84.]

Later generations profited from the sacrifices made by the first workers in the industrialization, and factory owners came to understand that they could make more profit from an efficient factory staffed by contented workers.

Urban Crises

Huge population increases and industrialization prompted a massive growth of European cities in the nineteenth century, as can be seen in the following table. ^22

CITY	1800	1910
London	831,000	4,521,000
Paris	547,000	2,888,000
Berlin	73,000	2,071,000
Vienna	247,000	2,030,000
St. Petersburg	220,000	1,907,000

[Footnote 22: Heinz Gollwitzer, *Europe in the Age of Imperialism: 1880-1914* (New York: Harcourt Brace Jovanovich, 1969), p. 20.]

In addition, new towns sprang up throughout the continent and soon reached the level of over 100,000 inhabitants. Even in agrarian Russia, where 70 percent of the population worked on the land, there were seventeen cities of more than 100,000 by the end of the century.

Political leaders faced serious problems dealing with mushrooming city growth. The factory system initially forced families to live and work in squalor, danger, and disease, a condition to be found today in countries undergoing the first stages of industrialization. City leaders had to maintain a clean environment, provide social and sanitation services, enforce the law, furnish transportation, and - most serious of all - build housing. They uniformly failed to meet the radical challenges of growth.

Until midcentury human waste disposal in some parts of Paris was taken care of by dumping excrement in the gutters or the Seine or through street-corner manure collections. Not until Haussman's urban renewal in the 1850s and 1860s did the city get an adequate garbage, water, and sewage system. Police protection remained inadequate or corrupt. Other cities shared Paris' problems to a greater or lesser degree. The new industrial towns were in even worse condition than the older centers.

[See *London Slum: This illustration, Over London - By Rail*, vividly depicts the problems that accompanied urbanization - cramped living spaces, crime, and air and water pollution. courtesy From Gustav Dore and Blanchard Jerrold, "London: A Pilgrimage" Grant and Co. London, 1872.]

The terrible life in the industrial towns touched observers like novelist Charles Dickens, who in his book *Hard Times* described a typical British factory town:

It was a town of red brick, or of brick that would have been red if the smoke and ashes had allowed it; but as matters stood, it was a town of unnatural red and black, like the painted face of a savage. It was a town of machinery and tall chimneys, out of which interminable serpents of smoke trailed themselves for ever and ever, and never got uncoiled. It had a black canal in it, and a river that ran purple with ill-smelling dye, and vast piles of building full of windows where there was a rattling and trembling all day long, and where the piston of the steam engine worked monotonously up and down, like the head of an elephant in a state of melancholy madness. It contained several large streets all very like one another, and many small streets still more like one another, inhabited by people equally like one another, who all went in and out at the same hours, with the same sound upon the same pavement, to do the same work, and to whom every day was the same as yesterday and tomorrow, and every year the counterpart of the last and the next. ^23

[Footnote 23: Charles Dickens, *Hard Times* (London: Thomas Nelson and Sons, n.d.), p. 26.]

By the end of the century, however, governments began to deal effectively with urban problems. By 1914, most major European cities began to make clean running water, central heat, adequate street lighting, mass public education, dependable sewage systems, and minimal medical care available for their people.

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