The Second Industrial Revolution has Brought Modern Social and Economic Developments

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Abstract

The American Industrial Revolution (IR) is considered as the Second IR (IR2) which creates rural to an urban society. Great inventions during the IR2 are electricity, internal combustion engine, the chemical industries, petroleum and other chemicals, alloys, electrical communication technologies, and running water with indoor plumbing. The development of steel and oil refining has affected US industry. Transportation and communications technology has changed business practices and daily life style of many people. Inventions of medicine and medical instruments have reduced the rates of infections and death from many diseases and public health has improved greatly. Global political, economic, and social systems have widely changed very rapidly. Between 1820 and 1920 about 33 million people, mainly labors, have migrated to the USA for seeking greater economic opportunity and cities become overcrowded. Low wage, dangerous working conditions, long working hours, child labor, discrimination in wages, etc. have created labor dissatisfaction. Moreover jobless and wage cut of labors railroad strike has broke out in many cities of the USA. An attempt has taken in this study to discuss aspects of the IR2.

Keywords: Second Industrial Revolution, innovation and invention, electricity, steel, oil and petroleum, economic development, railroad strike

1. Introduction

The period 1860–1914 is called the Second Industrial Revolution (IR2) or the US IR due to the invention of a large number of new technologies, such as electricity, internal combustion engine, the chemical industries, alloys, petroleum and other chemicals,

electrical communication technologies (telegraph, telephone and radio), and running water with indoor plumbing (Gordon, 2000). During the IR2, the inventions and innovations were science-based that were centered on iron and steel, railroads, electricity, and chemicals (Atkeson & Kehoe, 2001).

Vaclav Smil (1943–), a Czech-Canadian scientist and policy analyst, called the period 1867–1914, "*The Age of Synergy*", during which most of the great inventions and innovations were developed (Smil, 2005). The IR2 is the creation of a modern industrial economy, advancements of steam power, and transportation, and new era of communication. The start of the IR2 is often attributed to Samuel Slater (1768–1835), an early English-American industrialist, who opened the first industrial mill in Beverly, Massachusetts of the USA in 1790. He introduced a vital new technology in the USA and was known as the "*Father of the American Industrial Revolution*" (Hughes, 1989).

In 1783, the USA won its Independence against Britain. After the independent it had been imported most of the manufactured goods from Britain. The domestic production of the country was poor and it also suffered shortage of labor. The story of the US IR is an epic tale, full of heroes and heroines, villains and vagabonds, accomplishments and failures, sweated toil and elegant mechanisms, grand visions and unintended consequences (Gangopadhyay et al., 2009).

In 1807, Robert Fulton (1765–1815), an American engineer and inventor, used steam power to create the first steamboat on the Hudson River that changed the way and the speed (Buckman, 1907). The use of steam-powered railways, boats and ships had increased dramatically. More industries used interchangeable parts and machinery in steam powered (Landes, 2003).

Thomas Alva Edison (1847–1931), an US inventor, created revolutionary new technologies, such as light bulb, mass communication, phonograph, kinetograph (motion-picture camera), and electric dynamo in the 1880s (Sproule, 2000). By 1874, Alexander Graham Bell (1847–1922), a Scottish-born scientist and American inventor, invented telephone. He founded the American Telephone and Telegraph Company (AT&T) in the USA in 1885 (Richard, 2010).

1813, Francis Cabot Lowell (1775–1817), a businessman and industrial spy of Boston, visited the textile factories of England and memorized the details of how the machines operated. He and four other investors revolutionized the US textile industry. New England was the first area in the USA to industrialize (Rosenberg, 2011).

Charles Babbage (1791–1871), an English mechanical engineer considered the "*father of the computer*". He invented the first mechanical computer in the early 19th century. The invention of the computer brings blessings in the IR2 (Halacy, 1970).

American railroad travel was more comfortable for adjustable upholstered seats. Railroads helped for low-priced transportation of materials and products. Cheap coal helped to develop steam locomotives. By 1850, more than 14,000 km of railroad lines had been built in the USA (van Oss, 1893).

In 1856, the USA banned slavery; in 1868, recognized Blacks as citizens, and in 1920, gave women the right to vote (Noltemeyer et al., 2012). At the end of the IR2, higher wages and improved conditions in cities raised the standard of living for urban workers. The scale of the standard of living in the USA was huge biggest than that was during the IR1 in England (Gordon, 2012). The companies of Germany and the USA started to sell their goods all over the world. Scientific discoveries and inventions in the IR2 rapidly changed social structures, such as scientific thought, art and culture, architecture, and life style (Mokyr, 1999).

2. Literature Review

Joel Mokyr discloses in his book '*The Lever of Riches*' that IR2 accelerated the mutual feedbacks between science and technology. Living standards and the purchasing power of money increased rapidly, as the new technologies reaches like never before into the daily lives of the middle and working classes. The growth in some industries of huge economies of scale and some vast concerns emerged, far larger than anything seen before (Mokyr, 1990). David. S. Landes stresses on the importance of new technologies, such as the internal combustion engine and petroleum, new materials and substances, including alloys and chemicals, electricity and invention of telegraph, telephone and radio for the IR2 (Landes, 2003).

According to Andrew Atkeson and Patrick J. Kehoe, many new technologies, including electricity, were invented during the IR2 that launched a transition to a new economy. They have used several models to show the benefits of use of electricity. They build a quantitative model of technology diffusion which they use to study the transition to a new economy (Atkeson & Kehoe, 2001). M. J. Peterson stated that invention of the telegraph in the 1840s, telephone services, which first emerged in the late 19th century, development of radio in the 1920s and television in the 1950s changes in communication technology more quickly (Peterson, 2008).

Aimee Chin, Chinhui Juhn, and Peter Thompson have examined the impact of a major technological innovation and the wage structure in the merchant shipping industry. They have found that the technical change created a new demand for skilled workers in the USA during the IR2 (Chin et al., 2004). Adam Cook and Isaac Ehrlich have stated that in the 20th century, just after the IR2, the USA had overtook the European countries in economic superpower, per capita GDP, education, information, entrepreneurship, productive and

innovation skills, etc. They have emphasized that the US human capital was one of the main factors in this regard (Cook & Ehrlich, 2018).

Amity L. Noltemeyer, Julie Mujic, and Caven S. McLoughlin have discussed the discrimination and inequality in gender (male and female), language, race and ethnicity, national origin, color (Black and White), disabilities, etc. in the US education system during the 18th to 20th centuries (Noltemeyer et al., 2012). Claudia Goldin and Lawrence F. Katzhave affirmed that during the mid-19th century, the USA surpassed the impressive enrollment in primary school education. They have also examined the expansion of US secondary schooling by exploiting the wide variation in education, income, wealth, and economic and demographic structure across states and cities from 1910 to 1940 (Goldin & Katz, 1997).

Sukkoo Kimhas indicated that skilled workers were very limited to run the factories; unskilled workers (about 33 million) immigrated to the USA during the IR2. As a result, the growth and spread of factory manufacturing increased; also cities growth equivalently in the USA (Kim, 2007). Robert J Gordon has discussed the US economic growth during the 1st to the 3rd IR. He has shown the various inventions and developments that happened during that period (Gordon, 2012).

Alex Bowen, Chris Duffy, and Sam Fankhauser have observed that a new Industrial Revolution is required to implement green growth in the society that is related to climate change. Hence, the green growth will be large, system-wide and structural. They stress on climate-resilient development, carbon pricing and revenues, green jobs, and competitiveness and innovation to advance on the way of green growth (Bowen et al., 2016). Naomi R. Lamoreaux noticed that real gross domestic product (GDP) of the USA became more than seven times between 1865 and 1920, and real per capita product grew more than doubled. Hence, the US economy expanded more by adding new inputs than it did by increasing productivity (Lamoreaux, 2010).

3. Methodology of the Study

Research methodology provides us the principles for organizing, planning, designing and conducting a good research. Hence, it is the science and philosophy behind all researches (Legesse, 2014). It indicates that the logic of development of the process used to generate theory that is procedural framework within which the research is conducted (Remenyi et al., 1998). The methodology of this article is a historical background. The IR1 had begun in England which is considered as the turning point in human history. The IR1 has created the new era. Many kinds of industries, such as Cort's puddling and rolling process, Crompton's mule for spinning cotton, and the Watt steam engine had developed during the IR1 (Mohajan, 2019). In the IR2 is also called the US IR. In the IR2 the inventions and innovations, such as electricity, internal combustion engine, the chemical industries, petroleum and other chemicals, paper, electrical communication technologies (telegraph,

telephone and radio), running water with indoor plumbing, etc. were science-based. The IR2 rapidly changed social structures, such as scientific thought, art and culture, architecture, life style, etc. than that was during the IR1. Development of economic, business, transportation, and communication were dramatically during the IR2.

In this study we have tried to discuss various improvements of the IR2. Secondary data are used to prepare this paper. The data are collected from books of various authors, previous published articles, theses, conference papers, newspapers, public records and statistics, historical documents, case studies, various research reports, and websites.

4. Objective of the Study

This study analyzes incredible developments of various areas during the IR2. This study also discusses the following specific objectives:

- to show the social situation, education system, and inventions of the IR2,
- to show the positive and negative effects of the IR2, and
- to show the aspects of developments during the IR2.

5. Social Situation, Education, and Inventions

5.1. Social Situation

During the IR2 the USA has a diverse nation. In 1877, total population of the USA was just 47 million. Birth rate was very high; 15% of married women had 10 or more children, and another 22% had between 7 and 9. Half of the total population was aged 20 or less. In 1900, the US population became 76.2 million (US Census Bureau, 2019). The birth rate was also very high in Britain. The population in London was 0.96 million by 1800, 1.4 million by 1815, 3 million by 1860, and 6.5 million by 1900 (Hardy, 1988).

In 1870, globally there was no electricity in the houses. In night, rooms were lighted with candles and oil lamps. Cooking was done by biomasses and stoves. Rooms were dark and unhealthy with smoke and polluted air. Water for cooking and other household works, and remove of wastewater was carried out by the housewife (Gordon, 2012).

In the late 19th century the USA was a society without social security. Medicare, antibiotics, health insurance, radio, television, computers, airplanes, and automobiles had invented during the IR2. After the invention of telephone there were only 9 in the entire USA. The US government had only 22,000 federal employees excluding military and post office. There was no civil service system and no income tax in the country (Williams, 2005).

The late 19th century, from the 1870s to about 1900, is called the "Gilded Age" by Mark Twain and Charles Dudley Warner which they meant that the period was glittering on the surface but corrupt underneath. During this period there were greedy, corrupt industrialists, bankers and politicians who enjoyed extraordinary wealth and opulence at the expense of the working class. Most of the working class lived below the poverty level (Nichols & Unger, 2017). During the IR2 there were greed and guile in the society, such as unscrupulous entrepreneurs and corporate buccaneers, rapacious Robber Barons, scandal-plagued politics, shady business practices, vulgar display, corruptions, conspicuous consumption, unfettered capitalism, etc. On the other hand, during the IR2 agrarian society were transformed into an urban society dominated by industrial corporations, the creation of a modern industrial economy, development of national transportation and communication network, a managerial revolution transformed business operations, etc. Also during the IR2 there were some turbulence, such as labor violence, rising racial tension, militancy among farmers, and discontent among the unemployed in the society. By 1900, one in 200 US populations was addicted to opiates or cocaine (Spooner, 2014).

As the production advances, the need for laborers grew rapidly in the industrialized countries. Adults (men and women) and children worked in factories, coal mines, and mills. More than 33 million people entered the ports of the USA, massive from Europe. Immigrants and their children totaled 30–40% of the white population in the USA. Urban populations grew very quickly because of the vast migration to cities from rural areas. America is considered as a nation of immigrants or a "melting pot" (Kim, 2007). Gas and water supply, and sewage systems in large cities were advanced. Wages for workers in Europe and America increased after 1870. As transportation costs reduced, prices for manufactured goods became lower (Gordon, 2012).

Karl Marx (1818–1883), German journalist, and his co-author Friedrich Engels (1820–1895), a German political thinker, son of a textile mill owner, wrote '*The Communist Manifesto*' in 1848. This book made bold steps to create the new industrial economy and the breakthroughs in industrial technology (Marx & Engels, 1848). They blamed the system of industrial capitalism for horrible conditions in factories. They demanded that the IR1 had enriched the rich but made insolvent the poor. They showed logically that government control factories, mines, railroads, and other key industries that would end poverty and promote equality which they called socialism (Wright, 1986). Later they demanded that all land, mines, factories, railroads, and businesses, would be owned by the people which they called communism (Engels, 1969).

In 1875, based on Marx's ideas working-class leaders formed German Social Democratic Party (SPD). In the 1912 elections, SPD received four million votes and became the largest single party in Germany. In the 1900s, communism became popular in some countries of Europe and Asia. In the 1980s, about 20 countries of the world were Communist-controlled but at the beginning of the 21st century only three countries; Chine,

Cuba and North Korea have communism. Unpopular to the communism is due to the worldwide popularity of democracy, and growth of autocracy in the communism nations (Lindemann, 1983).

5.2. Education System

During the IR2 the education system of the USA was not developed as that is seen at present. In the early 19th century education was primarily for the elite and the wealthier middle class. In 1870, enrollment in US elementary schools was 7 million and 80,000 in secondary schools. About 20% of the entire adult population and 80% of the black population was illiterate. But by 1900, about 44% of blacks remained illiterate. By 1910, about 80% of children were attending school and in 1920 the figure grew to 100% (Snyder, 1993; Bandieraet al. 2018).

Most governments in America and Europe began to set up state-financed primary schools where both boys and girls between the ages of 6 and 12 were required to attend in these schools. In western and central Europe, most adults could read by 1900. About 79% of adults in Serbia and Russia still could not read by 1900. In California in the 1800s, for example, school administrators routinely denied Chinese American children entrance into schools based on their ancestry (Noltemeyer et al., 2012).

In the 19th century formal education of the USA was very poor, only about three in five children attended school; and most left school in their early ages. The schools had dirt floors, and rough plank desks or benches. The buildings were quite small, and the ceiling, walls, and roof were all made with sod, straw, and mud. Disobedient students were punished in various peculiar and complicated ways (Boyer, 1983). From 1910 to 1940, the USA achieved an impressive educational transformation. Secondary-school enrollment and graduation rates increased very rapidly (Goldin & Katz, 1997). The diverse curriculum, vocational courses, tracking, electives, 45-minute periods; were invented in the USA during the first decades of the 20th century, which are considered standard scale in many countries at present (Krug, 1972).

In the 19th century women and girls of the USA had limited opportunity to study in schools at different times of the day when boys did not attend, such as summertime or holidays. Schools provide a moral, literary, and domestic education for young women. They had job facilities only for nursing or teaching in church schools (Madigan, 2009). The first institution to offer baccalaureate degrees to women in 1836 was the Georgia Female College (Reef, 2009). About 2.5% the school aged students graduated from high school. In 1877, only one Master's degree was awarded in the whole country by the help of the scholars of German and Britain. There was no female lawyer in the US bar (Parkerson & Parkerson, 2001).

There were more than two hundred languages that had been spoken in the USA. So the education in native languages was difficult in the country. Prior to the 20th century, the US government had actively imposed the use of English among Native Americans and the inhabitants of the incorporated territories of the Southwest. In 1906, the Nationality Act in Texas approved that English is officially designated as the only language to be taught in schools for naturalization (McCarty, 2002). Congress passed the Bilingual Education Act of 1968, for the Elementary and Secondary level which was considered the most important law in recognizing linguistic minority rights in the history of the USA. In classrooms, students were able to develop their skills in content subjects taught in their native languages, and at the same time, develop their knowledge of a second language, English (Crawford, 1989).

The first public high school–the English Classical School, opened in Boston in 1821. By 1870, there were only 500 public high schools with 50,000 students in the USA (Boyer, 1983). The first three women's colleges-Georgia Female College, Mount Holyoke Seminary, and Elmira Female College, established in the USA. Even girls with strong academic records were compelled to take home economics or domestic science (Tyack & Hansot, 1990; Astin & Hirsch, 1978).

Higher education was restricted to men in the early 1800s. During the IR2 there were very few Master's or PhD degree holders in the USA. Because academic institutions of the country were in their infancy and religious denominated, and there were very few supervisors for higher degree. The US higher education was borrowed from both the British undergraduate college and German Research University (Eckel& King, 2004).

In 1910, only about 10% of US children attended high school. In 1918, half of the teachers were 16 to 20 years old, 38% were 21 to 25 years old, and the rest were older than 25 years. One teacher found 10 to $15 in each month by doing several tasks including teaching (Boyer, 1983). During the colonial period, individuals with disabilities were either kept at home or mistreated in a myriad of ways. By the 1850s, several philanthropic institutions gave them facilities of education (Osgood, 2008).

5.3. Inventions

American inventors produced many new machines that could be applied to industry as well as to agriculture. Oliver Evans (1755–1819), an American inventor, engineer and businessman designed a steam engine more powerful than that of James Watt (Hunter, 1985).

Humphrey Davy (1778–1829), a Cornish chemist and inventor, had demonstrated its lighting capabilities as early as 1808. In 1831, Cyrus McCormick (1809–1884), an American inventor and businessman, invented harvesting machine that boosted American

wheat production. In 1837, Samuel F. B. Morse (1791–1872), a New England painter and inventor, first sent electrical signals, the biggest increase in the speed of communication in human history, over a telegraph. It is the communication process using wires with electricity. The telegraph instantly sent messages within seconds to the entire USA and even in the UK. Very soon continents were linked with undersea cables and whole world came with telegraph communication. By 1966, Western Union, the leading telegraph company had more than 2,000 telegraph offices (Morse & Morse, 1912).

In 1846, Elias Howe (1819–1867), an American inventor, invented the sewing machine. In 1851, I. M. Singer (1811–1875), an American mathematician, improved the sewing machine by inventing a foot treadle (Brandon, 1977). In 1876, Scottish-born inventor Alexander Graham Bell (1847–1922) patented the telephone. By the end of the 1800s, Bell Telephone Company had installed more than one million telephones. In 1901, Italian inventor Guglielmo Marconi demonstrated the first transatlantic signal using Morse Code and Wireless Telegraphy. In 1906, the first human voice signal was transmitted across the Atlantic through radio transmissions using the airwaves (Richard, 2010).

Typewriters with various keyboards had been invented as early as 1714 by English inventor Henry Mill (1683–1771) (Weller, 1918). In 1867, Christopher Sholes (1819–1890), an American inventor, invented typewriter with QWERTY keyboard (Hendrickson, 1956). In 1877, Thomas Alva Edison invented Phonograph in the USA. He also created light bulb in 1879 and Joseph Swan (1828–1914), English physicist, chemist, and inventor, invented carbon paper light in 1860 in Great Britain, and opened homes and cities to electric lights (Williams, 2005). In 1885, a German engineer, Gottlieb Daimler, invented a light, portable internal combustion engine (Wise, 1974). In 1903, Orville and Wilbur Wright of the USA made the first airplane (Anderson, 2004).

Richard Jordan Gatling (1818–1903), an American inventor, invented the Gatling Gun in 1862. This was the first automated machine gun (Keller, 2008). In 1866, Robert Whitehead (1823–1905), an English engineer, produced the first self-propelled underwater missile naval torpedo. It had speed to 13 km/h and could hit a target 640 m away (Gray, 1991). Mathematics played a significant role in the development and application of scientific inventions. During the IR1 and IR2 many mathematicians had developed science (Wigner, 1960).

6. Development of Industries

During the IR1 textiles, railroads, coal, and iron had developed. Iron and steel, coal, and railroads developed at the beginning of the IR2 and later developed chemicals, electricity, paper, and petroleum (Chandler, 1993, Mohajan, 2019). Edward Alfred Cowper (1790–1852), an English printing engineer, inventor, and academic, developed the Cowper stove in 1857 that was used firebrick as a storage medium, solving the expansion and cracking

problem. It was capable of producing high heat, which resulted in very high throughput of blast furnaces (Landes, 2003).

By 1900, Great Britain, Belgium, France, the Netherlands**,** Germany, the western part of the Austro-Hungarian Empire, and northern Italy became advanced industrialized core. The citizens of these countries had a high standard of living. By the early 20th century, the USA became the world's leading industrial nation (Smil, 2005).

As new industries expanded, more and more people lived in cities by the end of the 19th century. In the early 1850s, 40% English, 15% French, 10% German, and 5% Russian lived in cities. By 1890, these figures grew 60%, 25%, 30%, and 10% respectively. Between 1800 and 1900, the population in London grew from 0.96 to 6.5 million (Hardy, 1988).

6.1. Steel

Sir Henry Bessemer (1813–1898) in Britain created process of mass steel production from molten pig iron in 1850 that revolutionized steel manufacture by decreasing its cost, increasing the scale and speed of production of steel, and decreasing the labor requirements for steel making. By the application of this process, 15,000 tons of steel produced in 1865 and 28 million tons in 1919 (Lord, 1945). Sidney Gilchrist Thomas (1850–1885), a British metallurgist and inventor, developed a more complicated process to eliminate the phosphorus from iron. Andrew Carnegie (1835–1919), a Scottish-American industrialist, business magnate, and philanthropist, established the first steel mills in the USA for mass producing steel. He is often identified as one of the richest people in the history. Abundance of steel helped to spur the IR2 in the USA (Bostaph, 2015).

In 1857, Sir Charles William Siemens (1823–1883), a German-British engineer and entrepreneur, developed 70–80% heat saving furnace. In 1865, French engineer Pierre-Émile Martin (1824–1915) for the first time used Siemens's furnace to produce steel. By 1880, the cheap steel used to build buildings, large bridges, railroads, skyscrapers, and large ships. Steel cable, steel rod, and sheet steel were produced for household use. Steel was used to make guns, tanks, armored fighting vehicles and naval ships. The US steel industry production increased 68,000 tons in 1870 to 4.2 million tons in 1890 (Clerk, 1897).

In 1860, Great Britain, France, Germany, and Belgium produced 125,000 tons of steel and by 1913 the production reached to 32 million tons (Mokyr, 1999).

6.2. Oil

Refine of crude oil produces kerosene which used in lamp to produce light or used as fuel. In 1859, Edwin Drake (1819–1880), an American businessman, used steam engine to drill

for oil near Titusville, Pennsylvania. By the 1880s oil wells produced 25 million barrels of oil in Pennsylvania and West Virginia (Tarbell, 1963).

In 1863, John D. Rockefeller (1839–1937), an American oil industry business magnate, industrialist, and philanthropist, entered the growing oil industry and eventually founded Standard Oil Company in 1870. He made horizontal integration of oil industry. In 1880, Standard Oil Company controlled 90% of the rail industry. He is widely considered as the wealthiest American of all time and the richest person in the modern history (Bringhurst, 1979).

6.3. Petroleum Production

The petroleum industry, both production and refining, began in 1848 with the first oil-works in Scotland (Clerk, 1897). In 1850, James Young (1811–1883), a Scottish chemist, built the first truly commercial oil-works and oil refinery in the world at Bathgate. He is often referred to as Paraffin Young. Using oil he extracted from locally mined turbinate, shale, and bituminous coal to manufacture naphtha and lubricating oils (Russell, 2003).

In 1859, Edwin Drake (1819–1880), dug the first modern oil well near Titusville, Pennsylvania. It brought a major boom in oil production in the USA. The first primary product was kerosene for lamps and heaters which was much more efficient and less expensive than vegetable oils, tallow, and whale oil (Tarbell, 1963; Vassiliou, 2009).

6.4. Paper

Sealy Fourdrinier (1773–1847) and Henry Fourdrinier (1766–1854), British paper-making entrepreneurs, first built the Fourdrinier paper machine. By the 1840s, Charles Fenerty (1821–1892), a Canadian inventor and Friedrich Gottlob Keller (1816–1895), a German machinist and inventor, extracted the fibers from wood and madenews paper that created a new era for paper making (Burger, 2007). Fountain pen and mass-produced pencil were invented in the same period. Advent of the steam driven rotary printing press helped the boost paper use in the 19th century (Fischler & Schneider, 1992).

6.5. Chemicals

Although Britain developed chemistry in the IR1, Germans took the lead in the beginning of the IR2. German chemists, such as Friedrich Wöhler, Robert Bunsen, Leopold Gmelin, August von Hofmann, and Friedrich Kekulé von Stradonitz, jointly created modern organic chemistry. In 1856, William Henry Perkin (1838–1907), a British chemist and entrepreneur, student of von Hofmann, discovered Synthetic dye, mauveine, made from aniline (Holme, 2006). Three years later a French chemist, Emanuel Verguin, discovered aniline red (magenta) (Haber, 1958).

In 1869, a group of German chemists synthesized alizarin. In 1875, German chemists succeeded in developing indigo tin and sulfuric acid. By 1900, the German chemical industry dominated the world market for synthetic dyes. In 1913, eight firms of Germany produced almost 90% of the world supply of dyestuffs (Burhop, 2009). In the 1860s, Soda-making had been revolutionized by the Belgian chemist, industrialist and philanthropist Ernest Solvay (1838–1922).

Alfred Nobel (1833–1896), a Swedish businessman, chemist, engineer, inventor, and philanthropist, discovered dynamite that is used in the construction of tunnels, roads, oil wells, and quarries (Mokyr 1999). John Wesley Hyatt (1837–1920), an American inventor, first invented synthetic plastic (celluloid) in 1869, which was used to make combs, knife handles, piano keys, and baby rattles (Seymour & Kauffman, 1992). Leo Baekeland (1863–1944), a Belgian chemist, invented Velox photographic paper in 1893, and Bakelite in 1909 (Bijker et al., 1987). The number of chemists developed in the US economy that increased by more than six-fold between 1900 and 1940 (Kaplan & Casey, 1958).

6.6. Electricity

The famous English scientist and experimentalist Michael Faraday (1791–1867) established the basis for the concept of the electromagnetic field in physics. Sir Humphrey Davy (1778–1829), a Cornish chemist and inventor, using electricity isolated a series of elements for the first time: potassium and sodium in 1807 and calcium, strontium, barium, magnesium and boron the following year, as well as discovered the elemental nature of chlorine and iodine (Knight, 1992).

In 1870, there was no supply of electricity in the houses and offices. The insides of dwelling units were not only dark but also smoky from the burning of candles and oil lamps, and cooking by iron stove and hearth (Gordon, 2012). In the 1870s, the use of electricity expanded quickly. In 1886, Frank J. Sprague (1857–1934), an American naval officer and inventor, developed the electric motor, electric railways, and electric elevator. He was known as the "*Father of Electric Traction*" (Dalzell, 2009).

By the 1880s, streetcars and subways of major European cities are lighted by electricity. Electricity could be easily converted into other forms of energy, such as heat, light, and motion, and moved easily through space by means of wires. By the use of electric lights, factories could remain open 24 hours every day. Telephone, radio, conveyor belts, cranes, and machines could all be powered by electricity. By 1910, hydroelectric power stations and coal-fired steam generating plants established (Smil, 2005).

6.7. Business

In 1904, about 2,000 largest firms in the USA made up less than 1% of the country's businesses that dealt 40% of the national goods. Firms distributed their products to regional or national markets due to the improvement of transportation. Prices for manufactured goods were lower because of reduced transportation costs.

Development of new financial institutions, such as the stock market, commercial banks, and investment in houses increased the opportunities for collecting capital. Corporation organizers raised money by selling shares of stock in the company. The US entrepreneurs took advantage of changes in business organization. In cities new type of departmental stores, such as Macys, Wanamakers, Marshall Fields and chain store Woolworths had formed to start modern type of business. The sale of clocks, bicycles, electric lights, and typewriters had increased (Jones & Wadhwani, 2006).

During the IR2, business leaders of the USA turned to corporations which raised money by selling shares of stocks in the company and Stockholders received dividends. Stock broker Jay Gould (1836–1892), an American railroad developer and speculator, earned 77 million trading railroad stock. Later some companies formed trusts. Trusts indicate when companies turn control of their stock to a common board of trustees. If a trust gains an exceptional control of an industry, a company holds complete control over the price and quality of the product (Alef, 2009).

Andrew Carnegie (1835–1919) created corporations and used vertical integration to dominate the steel industry. In 1899, he organized all his companies into the Carnegie Steel Company. In 1901, he sold his company to banker J. P. Morgan for $500 million and retired as the world's richest man (Bostaph, 2015). John Davison Rockefeller (1839–1937), an American oil industry business magnate, industrialist, and philanthropist, also created corporations and used horizontal integration to dominate the oil industry (Bringhurst, 1979).

George Westinghouse (1846–1914), an American entrepreneur and engineer, introduced and controlled a crucial railroad innovation, the compressed-air brake (Fogel, 1964). George Pullman (1831–1897), an American engineer and industrialist, controlled the passenger-railroad-car industry. He designed and manufactured the Pullman sleeping car and founded a company town. He made long-distance rail equipped with sleeping cars, dining cars, and luxurious cars for wealthy passengers. Cornelius Vanderbilt (1794–1877), an American business magnate, built his wealth in railroads and shipping. He controlled the New York Central Railroad and extended his railroad system by purchasing many other smaller lines (4,500 miles) of worth $100 million (Schlichting, 2001).

6.8. Economy

In 1877, the average income of an US urban family was $738. Two-thirds of that earning was spent on food and heating. A family can save only $44 after managing other family expenditures. But there was a rapid economic growth at the late 19th century. Old economy with a relatively slow speed of technical changed to a new one with a relatively fast speed. Real gross domestic product (GDP) became more than seven times (about 1.7% per year) between 1865 and 1920 (Carter et al., 2006). The US economy also experienced sustained and gradually accelerating real per capita growth rates of 1–2% per year for the next two centuries Industrial production, appears to have increased at a sustained rate of about 5% per year from 1790–2014. Between 1869 and 1910, the value of the US manufacturing rose from $3 billion to $13 billion. Germany and the USA captured the markets and occupied superior ranks in the world economy (Johnston & Williamson, 2019).

After the Civil War a new economy emerged in the USA on the basis of steam-powered manufacturing, the railroad, the electric motor, the internal combustion engine, and the practical application of chemistry (Imai & Weinstein, 2000). At the beginning of the Civil War, there were only 400 millionaires in the USA and by 1892; the number had risen to 4,047 due to the rise of big business. By 1929, nine out of ten Americans had electricity and indoor plumbing, four-fifths had automobiles, two-thirds had radios, and nearly half had refrigerators and phonographs (Long, 1971).

In 1790, there were only three local, corporate banks inthe USA, with a combined capital of $3 million. In 1791, Congress authorized Hamilton's Bank of the USA, was a much larger corporation than any of the local banks, with $10 million of capital. From 1816 to 1836 it has capital $35 million. Alexander Hamilton (1755–1804) was an American statesman and one of the Founding Fathers of the USA. In the country, there were 20 state banks by 1795 and 1,600 by 1860. National banks could use the bonds as collateral for national bank note issues (Allen et al., 2010). In 1914, there were 27,213 independent banks, of which 7,518 were national and 19,718 were state-chartered institutions (Federal Reserve System, 1959).

State banking systems expanded rapidly and the rapid growth of the economy increased demands for credit. Many banks were established by entrepreneurs who used them as funding agencies (Lamoreaux, 1994). In the early 1790s, Philadelphia and New York opened stock exchanges. By 1860, the states had chartered about 30,000 corporations that became ten-fold by the early 20th century. There were record 75,000 miles of track in the USA in the 1880s. The corporate securities financed for the railroad expansion from the 1830s into the early 20th century. Public stock markets grew rapidly from the 1880s to the 1930s to make liquid the securities of increasing numbers of large, capital-intensive enterprises (O'Sullivan, 2007).

European countries developed railways, mines, electrical power plants, and banks. Europe dominated the world economy by the beginning of the 20th century (van Oss, 1893).

7. Transportation and Communication

Development of steel and oil refining industry has changed the construction of sophisticated machinery, bridges, tall buildings, etc. (Chandler, 1993). In 1897, Rudolf Diesel (1858–1913), a German inventor and mechanical engineer, invented the Diesel engine which was used both in road cars and locomotives. Maximum efficiency was obtained from it by isothermal expansion so that very few energy was wasted, and a cheap, crude fuel could be used to boot (Cummins, 1993; Herring, 2000).

7.1. Road Automobile

By 1876, Nikolaus August Otto (1832–1891), a German engineer, after 14 years of effort, invented compressed charge internal combustion engine four-stroke powered by gasoline. It was the first successful horseless carriage. Within the 20 years of his invention, Charles Duryea (1861–1938) and J. Frank Duryea (1869–1967) built the first practical motorcar in the USA. Only wealthy class passengers could use those cars (Clerk, 1897).

In 1885, Gottlieb Daimler (1834–1900), a German engineer, industrial designer and industrialist, invented a light, portable internal combustion engine. In 1889, Daimler and Wilhelm Maybach designed a vertical cylinder version engine of two-wheeler that called the first internal combustion motorcycle. It could move 10 miles per hour. In 1926, Daimler and Karl Benz manufactured the Mercedes-Benz (Wise, 1974).

Cars made at the late of the 19th century were handmade, expensive, slow speed (14 miles per hour), and unable to climb steep hills. In 1908, Henry Ford (1863–1947), an American industrialist, business magnate, and the founder of the Ford Motor Company, made mass-produced Model T on October 1, 1908 that reduced production costs. As a result, Ford lowered the price of the automobile that was affordable to middle class people and became popular among Americans. A Model T cost $850 in 1908 but only $360 by 1916 and produced 735,000 cars in a year (Bak, 2003).

John K. Starley (1854–1901), an English inventor and industrialist, built the modern Rover safety cycle in 1885 that could balance position and easy to move (Hadland & Lessing, 2014).

7.2. Railroads

The USA followed and copied British rail technology. From the 1720s the USA had wooden railroads (wagon ways). In 1827, the first passenger and freight line started

between the Baltimore and Ohio railroad using horses to pull train cars. The South Carolina Canal and Rail Road Company used steam locomotives in 1830 (Dilts, 1996).

During the IR2, railroads became faster, safer, and more comfortable that played a significance role in the development of the USA. The availability of cheap steel had an impact on the railroad industry. Steel had greater strength, durable, and can make longer lengths to use in railroads. George Westinghouse (1846–1914) had developed an air compressed brake, which made the locomotives safer. Steel was used to make rails that lasted over ten times longer than iron rails (Fogel, 1964). In 1857, Robert Forester Mushet (1811–1891), a British metallurgist and businessman, used steel to make rails. In 1863, some 700 trains had passed daily over the steel rails. In 1869, the transcontinental railroad was built in the USA by the Union Pacific and the Central Pacific, and made a single railroad from Nebraska to the Pacific Ocean (van Oss, 1893).

Beginning in the early 1870s, railroad construction in the USA increased dramatically. By 1850, about 14,000 km, in 1870, about 17,700 km, and by 1880 about 120,675 km of rail lines had been built in the USA. By 1880, the USA had 17,800 freight locomotives carrying 23,600 tons of freight, and 22,200 passenger locomotives. The Southern network expanded from 17,700 km in 1870 to 46,700 km in 1890 (Chandler, 1981).

The total kilometers of railroad track in the USA increased from just 23 in 1830 to 14,000 km by 1850 to 35,000 by the end of the Civil War (1861–1865) to a peak of 254,251 in 1916 (Schivelbusch, 2014).

7.3. Ships

In the late 19th century, American shipyards built modern metal ships that are better than the British. By 1870, steel ships built by the USA were much larger, more powerful, and faster than wooden ships. Gustav de Laval (184–1913), a Swedish engineer and inventor, and Charles Parson (1854–1931), an Anglo-Irish engineer, invented steam turbine in 1884 that moves at 63 km/h (Scaife, 1999).

7.4. Airplanes

In 1903, Orville (1871–948) and Wilbur (1867–1912) Wright (Wright brothers) of Ohio were two American aviation pioneers generally credited with inventing, building, and flying the world's first successful airplane for the first time at Kitty Hawk, North Carolina. Internal combustion engine used to run the flights.Orville took off first and flies 37 m in 12 seconds, and later Wilbur flies 260 m in 59 seconds (Anderson, 2004). *Deutsche Luftschiffahrts-Aktiengesellschaft I* (DELAG) was the world's first airline that was founded on November 16, 1909. From 1916 European luxurious interiors and comfort airlines started to fly throughout the Europe. In 1919, the first regular passenger air service was established (Pirie, 2009).

Tony Jannus (1889–1916), an early American pilot, conducted the US first scheduled commercial airline flight on 1 January 1914 for the St. Petersburg-Tampa Airboat Line that travelled 15 m for 23 minute with a maximum speed of 121 km/h. Abram C. Pheil, former mayor of St. Petersburg, won an auction for the first ticket with a winning bid of $400 and was a passenger on the inaugural flight. By the mid-1920s, the Postal Service had developed its own air mail network, based on a transcontinental backbone between New York City and San Francisco (Davis, 1964).

7.5. Communication

The invention of telegraph and telephone has allowed businesses to place long-distance orders very quickly; sent information for businesses to the government, newspapers, and private citizens (Richard, 2010). The invention of typewriter has created the opportunities of quick production of legible documents and several copies at once with carbon paper that helped the economic development (Hendrickson, 1956).

In 1901, Italian inventor and electrical engineer Guglielmo Marconi (1874–1937) successfully commercialized radio at the turn of the century (Hong, 2001). He built high-powered stations on both sides of the Atlantic and began a commercial service to transmit nightly news summaries to subscribing ships in 1904 (Roy, 2008).

8. Labors and their Organizations

Working conditions during the IR2 was low wage, dangerous working conditions, long working hours, etc. The average US worker was jobless for three or four months a year due to illness, rough weather, or seasonal unemployment. The average income of an urban worker was only about $400 to $500 in a year that was unable to support a family. The rest was made up by the income of their wives and children. About 20% of the family income came from the children of aged less than 16 (Fink, 1988).

8.1. Labor Immigration

The period between 1820 and 1920 is defined America as a nation of immigrants or "*a melting pot*". Many immigrants came for seeking greater economic opportunity. During this time more than 33 million people entered the ports of the USA. Between 1860 and 1900, about 14 million immigrants came to the USA to provide workers in industries (Kim 2007).

From the 17th to 19th centuries, about 4 million of African black slaves came to the USA against their will. Between 1820 and 1920 about 4 million Italians, 3.7 million Austria-Hungarian, 3.2 Russians, 1 million Swedish and about 4 million people from other

countries of Europe had migrated to the USA. During that period about 25,000 Chinese and more than 2 million Jews fled from Eastern Europe for religious persecution and entered the USA (Alexander, 2009).

Mass immigration during 1847–1854 was due to potato famine in Ireland and in other European countries. Between 1820 and 1930, some 4.5 million Irish migrated to the USA. Majority of these Irish migrants were unskilled workers, British (about 2.5 million) were unskilled laborers and skilled artisans, and Germans (about 5.5 million) were farmers and skilled artisans. Few skilled workers operated machines and supervised most of the unskilled workers (Hatton & Williamson, 2005).

8.2. Labor Unions

During the 1870s and 1880s, American workers began to form national labor unions to improve their living conditions. Craft-oriented labor unions, such as carpenters, printers, shoe makers and cigar makers, grew steadily in the industrial cities of the USA after 1870 (Dubofsky & Dulles, 2010).

The Knights of Labor, founded in 1869, was one of the most important early labor organizations in the USA. In 1885, its members became 700,000. It demanded an eight-hour work day, the abolition of child labor, improved safety in factories, equal pay for men and women, and compensation for on-the-job injury. By the 1880s, American Federation of Labor, a union of skilled workers was formed and Samuel Gompers (1850–1924) was its first president. It gradually replaced the Knights as the nation's largest labor organization. It spread to most cities, reaching a peak membership in 1919. It rejected socialism (Livesay, 1993; Zinn, 2005).

8.3. Labor Strike

Dangerous working conditions, long hours, and concern over wages and child labor contributed to the growth of labor unions. In the 1870s, in Great Britain, unions won the right to strike. Workers organized strikes and work stoppages that helped to publicize their problems (Cronin, 1987).

Many rail lines became bankrupt and were unable to pay the interest on their bonds major due to global economic depression. As a result, many workers became jobless and those were in job cut larger part of wages. For example, in 1877, the Pennsylvania Railroad, the nation's largest railroad company cut wages of labors by 10% in May, and another 10% in June. Other railroads followed it (Salvatore, 1980). The railroads had their own separate unions. The great railroad strike happened in 1877 that was the first general strike in the US history. Labors agitated for higher wages, equal pay for equal work, shorter hours, end to child labor, and better working conditions, or for more fundamental transformations in the nation's economy (Bacon, 2007).

On May 1, 1886, about 40,000 of workers in Chicago against McCormick Harvesting Machine Company began demonstrations in behalf of an 8 hour workday. The strike began in West Virginia and Martinsburg. The strike and related violence spread to Maryland, Cumberland, Pittsburgh, Baltimore, Philadelphia, Chicago, Buffalo and the Midwest states over a period of 45 days in response to the cutting of wages for the second time in a year. Their slogan was, "*Eight hours for work, eight hours for rest, and eight hours for what we will*" (Stover, 1997).

In the USA, during the early 1880s, there were about 500 strikes in a year involving about 150,000 workers, by the 1890s the figures become 1,000 and 700,000 respectively, by the early 1900s, the figures become 4,000 and 4,000,000 respectively. About 500 times government sent federal troops to put down labor strikes. The strikes and the violence paralyzed the country's commerce for few days (Wiebe, 1961). By 1900, there were two million and by 1914, there were almost four million workers in British trade unions (Cronin, 1987).

By 1890, about 10% of the population of the USA controlled close to 75% of the nation's wealth due to monopolies. As the government policies only favored the industrialists but not the workers. As a result uproar from the public became extreme. In 1890, government passed the Sherman Anti-trusts that reduced monopolies and trusts. Angry crowd in Pittsburgh destroyed 39 buildings, 104 engines, 46 passenger cars, and over 1,200 freight cars of valued more than $4 million (Filippelli, 1990).

8.4. Action against Labor Strike

In the Chicago railroad strike of 1877, workers gathered throughout the city on July 26. There were some violent clashes between rioters and police. In the clashes 14 to 30 rioters were dead, and 35 to 100 civilians and 9 to 13 policemen were wounded (McCabe & Martin, 1971).

On May 3, 1886, a conflict in Chicago between police and strikers happened where 2 strikers dead. In protest, the workers met at Haymarket Square of Chicago. Then, 200 police officers arrived to disperse the crowd and the chaos started between police and strikers. A bomb exploded by an unidentified individual upon the police officers and about 60 officers injured and 7 officers and one civilian were dead. Police immediately arrested and charged 8 men; in the judge 4 were hanged, and a 5th committed suicide in his cell (Filippelli, 1990).

In 1892, workers of Carnegie Steel Company in Homestead of Pennsylvania called strike against wage cut and 16 were dead in the violence. More than a hundred died in the

country in the violence of strike, including 40 people in Pittsburgh, 11 in Baltimore and a dozen in Reading, Pa. (Foner, 1978).

9. Effects of the IR2

There were both advantages and disadvantages during the IR2.The IR2 began in the USA in the mid 19th century and later spread throughout many other parts of the world. It developed global political, ecological, and cultural spheres.It helped to create global import and export markets.In the IR2 the existing manufacturing and production methods of IR1 were improved. For example, instead of iron, steel had used for the construction of ships, skyscrapers, and larger bridges.

9.1. Benefits

There were enormous benefits during the IR2. Inventions of elevators, electric machinery and consumer appliances brought comfort in daily lives; motorcar, truck, and airplane made easier and comfortable transportation; building of highways, suburbs, and supermarkets made the daily lives smooth; construction of sewers to carry the wastewater away made the cities clean (Gordon, 2012).

In the IR2 many nations became more productive than the IR1. After the invention of electricity factories could produce necessary products for 24 hours and could pile more products. Industries produced items faster and sold in cheaper rates. Mass production lowered the costs of necessary household things for the common people. Industrialization reduced the emphasis on landownership as the chief source of personal wealth (Dalzell, 2009).

Invention and development of telephone, phonograph, and motion pictures brought easier and comfortable communication and entertainment around the globe, and also became rapid economic development. Government tariff reductions, graduated income tax, helped farmers to repay loans. The IR2 elevated many people's standard of living, and that it expanded the economies of many nations. Railroads and steam boats had increased that made life easier. More workers found their ways of living (Richard, 2010).

As various advances were in medicine, public health also improved greatly that reduced the rates of infections and death from many diseases. Inventions of medical instruments, such as scalpels, microscope, lenses, test tubes, and other equipments made efficient roll to the physicians for cures and treatments (Kaplan and Casey, 1958).

9.2. Negative Effects

Organizations were burdened by heavy debts; as a result farm prices fall. Exploitation of labors had increased. They worked in unsafe and in unhealthy environments for 14–16

hours per day and six days per week. People living in such close proximity by poor working conditions and drinking unsafe water; cholera, smallpox, tuberculosis, and other infectious diseases broke out. On the other hand, efficient machines did more laborious works; so dominated leisure time, and obesity increased that resulted heart diseases, diabetes, cancer, etc. Therefore, the overall health of the workforce declined (Kaplan & Casey, 1958).

Expert artisans and craftsmen also lost their livelihoods. Children and women got fewer wages than men. The gap between rich and poor had widened. As more workers joined in factories, there were fewer people in the fields and agriculture dropped drastically (Gordon, 2012).

The IR2 created global challenges, such as air pollution, biodiversity reduction, water pollution, habitat destruction, etc. The use of fossil fuels increased exponentially during the IR2 that increased environment pollution, greenhouse gas emissions, global warming and climate change. Harmful pesticides were used for boost production in agriculture (Mohajan 2013).

As many people migrated to the USA, cities were overcrowded. The cities became very dirty and dangerous. Families were separated as the place of work shifted from the home to factories. Machines decreased the demand for labor, and many women lost their manufacturing jobs and ultimately took prostitution as profession (Kim, 2007).

10. Conclusions and Recommendations

In the study we have tried to discuss the aspects of the Second Industrial Revolution. During the IR2 the USA had developed in every sector. All nations of the world had benefited from the IR2.

During the IR2 global humanity has been developed on the basis of science. Electricity, internal combustion engine, the chemical industries, indoor plumbing, etc. technologies advanced the human civilization. Invention of sewing machine, harvesting machine, steamboat, typewriter with QWERTY keyboard, telegraph, telephone, radio, phonograph, light bulb, motion-picture camera, electric dynamo, electric railways, electric elevator, airplane, etc. had created modern era. The invention of Gatling Gun, underwater missile, tanks, armored fighting vehicles and naval ships clearly ahead the defense power. Buildings, large bridges, railroads, skyscrapers, and large ships had built due to mass steel production.

During the IR2 businesses had developed due to the improvement of the stock market, commercial banks and transportation. As a result economic development became very rapidly. Labor strikes and work stoppages had broken out due to dangerous working

conditions, long hours, and wage cut. It is recommended that the IR2 has both benefit and negative effects but, benefits are so enormous that it has created modern sustainable era.

References

Alef, D. (2009). *Jay Gould*: *Ruthless Railroad Tycoon (Titans of Fortune)*. Titans of Fortune Publishing.

Alexander, J. G. (2009). *Daily Life in Immigrant America, 1870–1920: How the Second Great Wave of Immigrants Made Their Way in America*. 2nd Ed., Ivan R. Dee, Chicago.

Allen, F., Capie, F., Fohlin, C., Miyajima, H., Sylla, R., Wood, G., & Yafeh, Y. (2010). *How Important Historically were Financial Systems for Growth in the UK, US, Germany, and Japan*? World Bank Project on Financial Structure.

Anderson, J. D. (2004). *Inventing Flight: The Wright Brothers and their Predecessors*. Baltimore, Maryland: Johns Hopkins University Press.

Astin H., & Hirsch, W. (1978). *The Higher Education of Women: Essays in Honor of Rosemary Park*. New York: Praeger.

Atkeson, A., & Kehoe, P. J. (2001). The Transition to a New Economy after the Second Industrial Revolution. *Working Paper No. 606*. Federal Reserve Bank of Minneapolis, Research Department.

Bacon, K. (2007). *The Dark Side of the Gilded Age*. The Atlantic, USA.

Bak, R. (2003). *Henry and Edsel: The Creation of the Ford Empire.* pp. 54–63, Hoboken, NJ: John Wiley & Sons.

Bandiera, O., Mohnen, M., Rasul, I., & Viarengo, M. (2018). Nation-Building through Compulsory Schooling during the Age of Mass Migration. *The Economic Journal*, 129(617), 62–109.

Bijker, W. E., Hughes, T. P., & Pinch, T. F. (1989). *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. MIT Press, Cambridge.

Bostaph, S. (2015). *Andrew Carnegie: An Economic Biography*. Lexington Books, Lanham, MD.

Bowen, A., Duffy, C., & Fankhauser, S. (2016). Green Growth and the New Industrial Revolution. *Policy Brief Paper*, Grantham Research Institute on Climate Change and the Environment. Grantham Foundation, London School of Economics and Political Science.

Boyer, E. L. (1983). *High School: A Report on Secondary Education in America*. New York: Harper and Row.

Brandon, R. (1977). *Singer and the Sewing Machine: A Capitalist Romance*. Kodansha International, New York.

Bringhurst, B. (1979). *Antitrust and the Oil Monopoly: The Standard Oil Cases, 1890–1911*. Westport, Connecticut: Greenwood Press.

Buckman, D. L. (1907). *Old Steamboat Days on the Hudson River*. The New York: The Grafton Press.

Burger, P. (2007). *Charles Fenerty and his Paper Invention*. Toronto: Peter Burger.

Burhop, C. (2009). Pharmaceutical Research in Wilhelmine Germany: The Case of E. Merck. *Business History Review*, 83(3), 475–503.

Carter, S. B., Gartner, S. S., Haines, M. R., Olmstead, A. L., Sutch, R., & Wright, G. (Eds.) (2006). *Historical Statistics of the United States: Earliest Times to the Present*. Millennial Edition, Volume 5, Cambridge University Press, Cambridge.

Chandler, A. D. (1981). *The Railroads, the Nation's First Big Business: Source and Readings*. Ayer Company Publishers, Inc., New York.

Chandler, A. D. (1993). *The Visible Hand: The Management Revolution in American Business.* Belknap Press of Harvard University Press.

Chin, A., Juhn, C., & Thompson, P. (2004). Technical Change and the Wage Structure during the Second Industrial Revolution: Evidence from the Merchant Marine, 1865–1912. *Discussion Paper No. 1285*. The Institute for the Study of Labor (IZA), Germany.

Clerk, D. (1897). *Gas and Oil Engines*. London: Longman Green & Co.

Cook, A., & Ehrlich, I. (2018). Was Higher Education a Major Channel through which the US Became an Economic Superpower in the 20th Century? *IZA DP No. 11648*. IZA–Institute of Labor Economics.

Crawford, J. (1989). *Bilingual Education: History, Politics, Theory, and Practice*. Los Angeles: Bilingual Educational Services, Inc.

Cronin, J. E. (1987). Strikes and Power in Britain, 1870–1920. *International Review of Social History*, 32(2), 144–167.

Cummins, C. L. Jr. (1993), *Diesel's Engine: Volume 1: From Conception to 1918*. Wilsonville, OR: Carnot Press.

Dalzell, F. (2009). *Engineering Invention: Frank J. Sprague and the US Electrical Industry, 1880–1900*. MIT Press.

Davis, R. E. G. (1964). *A History of the World's Airlines*. Oxford University Press.

Dilts, J. D. (1996). *The Great Road: The Building of the Baltimore and Ohio Railroad, 1828–1853*. Palo Alto, CA: Stanford University Press.

Dubofsky, M., & Dulles, F. R. (2010). *Labor in America: A History.* New York: Wiley-Blackwell.

Eckel, P. D., & King, J. E. (2004). *An Overview of Higher Education in the United States: Diversity, Access, and the Role of the Marketplace*. Washington, DC: American Council on Education.

Engels, F. (1969). *Anti-Dühring*. London: Lawrence and Wishart.

Federal Reserve System (1959). *All-Bank Statistics: United States, 1896–1955*. Washington, DC: Board of Governors of the Federal Reserve System.

Filippelli, R. L. (1990). *Labor Conflict in the United States: An Encyclopedia*. New York: Garland Publishing Co.

Fink, L. (1988). The New Labor History and the Powers of Historical Pessimism: Consensus, Hegemony, and the Case of the Knights of Labor. *Journal of American History*, 75(1), 115–136.

Fischler, G., & Schneider, S. (1992). *Fountain Pens and Pencils*. New York: Shiffer Publishing.

Fogel, R. W. (1964). *Railroads and American Economic Growth: Essays in Econometric History.* Baltimore and London: The Johns Hopkins Press.

Foner, P. S. (1978). *History of the Labor Movement in the United States*. Volume 1: From Colonial Times to the Founding of the American Federation of Labor. New York: International Publishers.

Gangopadhyay, P., Ebersole, D., Spencer, R., Greuther, M., & Casey, B. (2009). NEH Landmarks of American History. Workshop for School Teachers on '*America's Industrial Revolution*' at The Henry Ford.

Goldin, C., & Katz, L. F. (1997). Why the United States Led in Education: Lessons from Secondary School Expansion, 1910 to 1940. *NBER Working Paper No. 6144*. National Bureau of Economic Review.

Gordon, R. J. (2000). Does the "New Economy" Measure up to the Great Inventions of the Past? *Journal of Economic Perspectives*, 14(2), 49–74.

Gordon, R. J. (2012). Is US Economic Growth Over? Faltering Innovation Confronts the Six Headwinds. *The Centre for Economic Policy Research, Policy Insight No. 63*. North-western University, London.

Gray, E. (1991). *The Devil's Device: Robert Whitehead and the History of the Torpedo*. Annapolis: Naval Institute Press.

Haber, L. F. (1958). *The Chemical Industry during the Nineteenth Century*. Clarendon Press, Oxford.

Hadland, T., & Lessing, H.-E. (2014). *Bicycle Design, an Illustrated History*. MIT Press.

Halacy, D. S. (1970). *Charles Babbage, Father of the Computer*. Crowell-Collier Press, New York.

Hardy, A. (1988). Diagnosis, Death, Diet: The Case of London, 1750–1909. *Journal of Interdisciplinary History*, 18(3), 387–401.

Hatton, T. J., & Williamson, J. G. (2005). *Global Migration and the World Economy: Two Centuries of Policy and Performance*. Cambridge: MIT Press.

Hendrickson, W. B. (1956). The Three Lives of Frank H. Hall. *Journal of the Illinois State Historical Society*, 49(3), 271–294.

Herring, P. (2000). *Ultimate Train*. London: Dorling Kindersley.

Holme, I. (2006). Sir William Henry Perkin: A Review of His Life, Work and Legacy. *Coloration Technology*, 122 (5), 235–251.

Hong, S. (2001). *Wireless: from Marconi's Black-Box to the Audion*. Cambridge, Massachusetts: MIT Press.

Hughes, T. P. (1989). *American Genesis: A Century of Invention and Technological Enthusiasm, 1870–1970*. New York: Viking.

Hunter, L. C. (1985). *A History of Industrial Power in the United States, 1730–1930, Vol. 2: Steam Power*. Charlottesville, VA: University of Virginia Press.

Imai, K., & Weinstein, J. (2000). Measuring the Economic Impact of Civil War. *CID Working Paper No. 51*, Centre for International Development at Harvard University.

Johnston, L., & Williamson, S. (2019). *What Was the U.S. GDP Then? Measuring Worth*. http://www.measuringworth.org/usgdp/

Jones, G., & Wadhwani, R. D. (2006). Entrepreneurship and Business History: Renewing the Research Agenda. *Working Paper No. 07-007*, Harvard Business School, Boston MA.

Kaplan, D. L., & Casey, M. C. (1958). Occupational Trends in the United States, 1900 to 1950. *Bureau of the Census Working Paper No. 5*. Washington, DC: G.P.O.

Keller, J. (2008). *Mr. Gatling's Terrible Marvel: The Gun that Changed Everything and the Misunderstood Genius Who Invented it*. Viking Adult, New York.

Kim, S. (2007). Immigration, Industrial Revolution and Urban Growth in the United States, 1820–1920: Factor Endowments, Technology and Geography. *NBER Working Paper Series, Working Paper 12900*, Washington, DC.

Knight, D. (1992). *Humphry Davy: Science and Power.* Cambridge, UK: Cambridge University Press.

Krug, E. A. (1972). *The Shaping of the American High School: Volume 2, 1920–1941*. Madison, WI: University of Wisconsin Press.

Lamoreaux, N. R. (1994). *Insider Lending: Banks, Personal Connections, and Economic Development in Industrial New England*. Cambridge, UK: Cambridge University Press.

Lamoreaux, N. R. (2010). Entrepreneurship in the United States, 1865–1920. In David S. Landes, Joel Mokyr, and William J. Baumol (Eds.). *The Invention of Enterprise:*

Entrepreneurship from Ancient Mesopotamia to Modern Times, pp. 367–394, Princeton University Press.

Landes, D. S. (2003). *The Unbound Prometheus: Technical Change and Industrial Development in Western Europe from 1750 to the Present* (2nd Ed.). New York: Cambridge University Press.

Legesse, B. (2014). *Research Methods in Agribusiness and Value Chains*. School of Agricultural Economics and Agribusiness, Haramaya University.

Livesay, H. C. (1993). *Samuel Gompers and Organized Labor in America.* Scott Foresman & Co.

Lindemann, A. S. (1983). *A History of European Socialism*. New Haven/London: Yale University Press.

Long, E. B. (1971). *The Civil War Day by Day: An Almanac, 1861–1865.* Garden City, NY: Doubleday.

Lord, W. M. (1945). *The Development of the Bessemer Process in Lancashire, 1856–1900. Transactions of the Newcomen Society*, 25, 163–180.

Madigan, J. C. (2009). The Education of Girls and Women in the United States: A Historical Perspective. *Advances in Gender and Education*, 1, 11–13.

Marx, K., & Engels, F. (1948). *Manifesto of the Communist Party*. Progress Publishers, Moscow.

McCabe, J. D., & Martin, E. W. (1971). *The History of the Great Riots: The Strikes and Riots on the Various Railroads of the Universited States and in the Mining Regions Together with a Full History of the Molly Maguires*. A. M. Kelley publishers, the University of Wisconsin–Madison.

McCarty, T. L. (2002). Between Possibility and Constraint: Indigenous Language Education, Planning, and Policy in the US. In J. W. Tollefson (Ed.), *Language Policies in Education: Critical Issues. Mahwah*, NJ: Lawrence Erlbaum Associates, Inc.

Mohajan, H. K. (2013). *Global Greenhouse Gas Emissions and Climate Change*. Lambert Academic Publishing, Germany.

Mohajan, H. K. (2019). The First Industrial Revolution: Creation of a New Global Human Era. *Journal of Social Sciences and Humanities*, 5(4), 377–387.

Mokyr, J. (1990). *The Lever of Riches*. Oxford: Oxford University Press.

Mokyr, J. (1999). The Second Industrial Revolution, 1870–1914. In Valerio Castronovo (Ed.), pp. 219–245. *Storiadell' Economia Mondiale*. Rome: Laterza Publishing.

Morse, E., & Morse, S. (1912). Letters of Samuel Morse 1812. I. *The North American Review*, 195 (679), 773–787.

Nichols, C. M., & Unger, N. C. (Eds.) (2017). *A Companion to the Gilded Age and Progressive Era*. John Wiley & Sons: Wiley-Blackwell Publisher.

Noltemeyer, A. L., Mujic, J., & McLoughlin, C. S. (2012). The History of Inequality in Education. In A. L. Noltemeyer & C. S. McLoughlin (Eds.), *Disproportionality in Education and Special Education*. Springfield, IL: Charles C. Thomas Publisher Ltd.

Osgood, R. L. (2008). *The History of Special Education: A Struggle for Equality in American Public Schools*. Westport, CT: Praeger.

O'Sullivan, M. (2007). The Expansion of the US Stock Market, 1885–1930: Historical Facts and Theoretical Fashions. *Enterprise & Society*, 8 (9), 489–542.

Parkerson, D. H., & Parkerson, J. A. (2001). *Transitions in American Education: A Social History of Teaching*. New York, Routledge.

Peterson, M. J. (2008). *Roots of Interconnection: Communications, Transportation and Phases of the Industrial Revolution*. International Dimensions of Ethics Education in Science and Engineering. IDEESE Project.

Pirie, G. H. (2009). Incidental Tourism: British Imperial Air Travel in the 1930s. *Journal of Tourism History*, 1(1), 49–66.

Reef, C. (2009). *Education and Learning in America*. New York: Facts on File, Incorporated.

Remenyi, D. S. J., Swartz, E., Money, A., & Williams, B. (1998). *Doing Research in Business and Management: An Introduction to Process and Method*. SAGE Publications, London.

Richard, J. (2010). *Network Nation: Inventing American Telecommunications.*Cambridge: Belknap Press of Harvard University Press.

Rosenberg, C. (2011). *The Life and Times of Francis Cabot Lowell.* Blue Ridge Summit, PA: Lexington Books.

Roy, A. (2008). Cambridge Pioneer Honour for Bose. *The Telegraph*, Kolkata.

Russell, L. S. (2003). *A Heritage of Light: Lamps and Lighting in the Early Canadian Home.* University of Toronto Press, Scholarly Publishing Division, Toronto, Canada.

Salvatore, N. (1980). Railroad Workers and the Great Strike of 1877. *Labor History*, 21(4), 522–245.

Scaife, W. G. S. (1999). *From Galaxies to Turbines: Science, Technology and the Parsons Family*. CRC Press.

Schivelbusch, W. (2014). *The American Railroad*. University of California Press.

Schlichting, K. C. (2001). *Grand Central Terminal: Railroads, Engineering, and Architecture in New York City.* Johns Hopkins University Press.

Seymour, R. B., & Kauffman, G. B. (1992). The Rise and Fall of Celluloid. *Journal of Chemical Education*, 69(4), 311–314.

Smil, V. (2005). *Creating the Twentieth Century: Technical Innovations of 1867–1914 and their Lasting Impact*. Oxford; New York: Oxford University Press.

Snyder, T. D. (1993). *120 Years of American Education: A Statistical Portrait*. Center for Education Statistics, U.S. Department of Education.

Spooner, F. (2014). Serving Students with Healthcare Needs.In M. Agran (Ed.), *Equity and Full Participation for Individuals with Severe Disabilities: A Vision for the Future*. Baltimore, MD: Paul H. Brookes Pub.

Sproule, A. (2000). *Thomas Alva Edison: The World's Greatest Inventor. Woodbridge.* CT: Blackbirch Press.

Stover, J. F. (1997). *American Railroads* (2nd Ed.). Chicago: University of Chicago Press.

Tarbell, I. M. (1963). *The History of the Standard Oil Company*. Gloucester, MA: Peter Smith.

Tyack, D., & Hansot, E. (1990). *Learning Together: A History of Coeducation in American Schools*. New Haven and London: Yale University Press.

US Census Bureau (2019). *Historical Statistics of the United States*. US Census Bureau, USA.

van Oss, S. F. (1893). *American Railroads and British Inventors.* London: Effingham Wilson & Co.

Vassiliou, M. S. (2009). *Historical Dictionary of the Petroleum Industry*. Lanham, MD: Scarecrow Press, Rowman & Littlefield.

Weller, C. E. (1918). *The Early History of the Typewriter.* Chase & Shepard, Printers.

Wiebe, R. H. (1961). The Anthracite Strike of 1902: A Record of Confusion. *Mississippi Valley Historical Review*, 48(2), 229–251.

Wigner, E. (1960). The Unreasonable Effectiveness of Mathematics in the Natural Sciences. *Communications on Pure and Applied Mathematics*, 13(1), 1–14.

Williams, H. (2005). *Cassell's Chronology of World History*. London: Weidenfeld & Nicolson.

Wise, D. B. (1974). Daimler: Founder of the Four-Wheeler. In Tom Northey (Ed.), *World of Automobiles*, 5. pp. 481–483, London, Orbis.

Wright, A. (1986). *Socialisms: Theories and Practices*. Oxford and New York: Oxford University Press.

Zinn, H. (2005). *A People's History of the United States: 1492-Present*. New York: Harper Perennial Modern Classics.