

# History of Industrial Revolutions – the International Order in Innovation



Author Guo Sizhi

By Guo Sizhi

## Introduction

The balance of power in the international political economy has been pointing toward significant change since the early 2020s. Britain controlled the global political economy from the second half of the 18th century through the end of the 19th century in the age referred to as Pax Britannica, and since then, control of the global political economy shifted to the United States during the 20th century under Pax Americana. At the same time, the absolute global economic power of the US waned and became unstable from the mid-20th century as West Germany and Japan recovered from WWII and underwent high growth. Then, since the 1990s, developing countries including China and the newly industrialized economies (NIEs) of Asia rose to prominence, and as globalization accelerated their export trade and share of global GDP grew. Nevertheless, the US continues to play a significant role in the global political economy.

Since the beginning of the 21st century, however, and especially since the global financial crisis, the structure and balance of power in the global political economy have been pointing toward significant change. The structure of the global political economy is shifting from a unipolar structure led by the US and other developed countries to a multipolar structure in which the US, European nations, and other developed countries coexist with China and other developing countries. This is causing major disruption and changing the appearance of the structure and order of the existing global political economy.

Attention is being given to the shape the global political structure and international political-economic order will take from now on, and how that will happen. In this article, I would like to examine the changes in the international order using examples from industrial revolutions and innovation.

## Innovation & Industrial Revolution

Innovation is generally seen as a “new combination”, “new form” or “new creation” of something. This refers not only to the invention or creation of new technologies, but also to the creation of new, meaningful value from new ideas that lead to major social changes in things like production methods and lifestyles that broadly transform people, organizations, and society.

According to the Austrian political economist Joseph Schumpeter, innovation is the creation of something new, for example things like new conversions or new combinations of resources and other

production factors, the introduction of new products and new production methods, the development of new markets, and the birth of new organizational structures. The drivers of innovation, particularly in terms of implementation and promotion, are entrepreneurs and managers. Innovation is an important opportunity to move or change social hierarchies and organizations. It is only in a capitalist, market economy that people can become entrepreneurs without already having necessary funds, and it is because these opportunities and mechanisms are present in the social structure of a capitalist, market economy that the foundation for innovation exists and its output is promoted. In other words, a succession of people and companies pursuing the challenge of innovation is what leads to industrial and economic development. Furthermore, creative destruction through constant innovation is important for continuous economic development.

Another thing to point out is Thomas Kuhn’s concept of paradigms and paradigm shift. Kuhn was an American scientific historian who introduced the concept of paradigm in his 1962 book *The Structure of Scientific Revolutions*, in which he asserted that paradigm shifts cause the world itself to be transformed. The word paradigm comes from the Greek *paradeigma*, meaning “example”, and today is the concept of a dominant or leading view, idea, or cognitive framework.

A paradigm transformation or change means a change in the way of thinking, the disappearance of an established concept, or the introduction of a new idea that leads to changes in the ways people produce goods and live their lives, having a significant impact on the economy and society. Kuhn’s paradigm transformation and change can in fact be seen as the indispensable key to innovation and industrial revolution.

The term “industrial revolution” was first used by the French economist Jérôme-Adolphe Blanqui (1798-1854). Later, it became a defined academic term with its use by Arnold Toynbee in his 1884 “Lectures on the Industrial Revolution in England”, and spread via the German thinker Friedrich Engels 1845 work *The Condition of the Working Class in England in 1844*. The term initially referred to the first industrial revolution, which took place in Britain from the 1760s to the 1830s with things like the steam engine and power revolution, but along with civil revolution in the so-called stages of social development theory, it was regarded as the dividing line between the modern and pre-modern eras, and the industrial revolution that began in Britain triggered industrial revolutions in other countries including Belgium, France, the US, and Germany. First, let us look at industrial and technological revolutions in innovation to date.

## Industrial Revolutions Throughout History

The first industrial revolution occurred in Britain and was driven mainly by a revolution in power and energy. James Watt's invention of his steam engine in 1769 put in motion the mass consumption of coal and launched the first "power revolution", focusing on textiles, shipping, and railways. This led to the building of railway lines on land and global maritime navigation with steam-powered ships crossing the seven oceans, inevitably causing major changes in production methods and people's daily lives. The first industrial revolution began in Britain in the second half of the 18th century, and brought about significant industrial, economic, and social transformations. With the shift in the primary method of production from manual operations in factories to machine operations in factories, the volume of industrial production increased significantly, promoting the establishment of a capitalist system. Until the first half of the 19th century, Britain saw production activity become increasingly mechanized and motorized, creating a factory system that in turn led to the birth of industrial cities, promoted urbanization, and saw the rapid rise of an industrial capitalist class and a factory worker class, resulting in a rapid, drastic transformation from an agricultural society to a capitalist industrial society.

As a result of the first industrial revolution, industrial cities dramatically emerged across much of Britain. Manchester became a center of the industrial revolution focusing on the cotton industry, Birmingham grew out of the metals and materials industry, Liverpool prospered as a port city, and cities like Bristol, Leeds, and Glasgow were known for industries including shipbuilding, tobacco, and sugar, with all of these becoming major cities on a par with London. These cities experienced a shift from commercial capitalism to industrial capitalism, with industrial capitalists establishing a dominant position in all segments of the capitalist system, and the work at factories shifting from manual labor to mechanized operations.

"The industrial revolution was an economic event as well as an engineering event. That is to say that it brought about a transformation in the quantity and distribution of resources."<sup>1</sup> In this way, in the history of economic development, the industrial revolution triggered transformation that was closely tied to engineering and economics, which in turn expanded economic growth and saw the beginning of growth in national income.

The second industrial revolution occurred from 1865 to 1900, in the sense that it was the second stage of the industrial revolution that occurred in the 1760s. During this time, German and US industrial strength increased significantly, moving them ahead of Britain as the world's leading industrialized countries. This is when railways, steamships, and other transportation infrastructure developed, and the major innovations of the Bessemer process and the Siemens open hearth process occurred in the steel industry. In the US, Thomas Edison, Nikola Tesla, and George Westinghouse produced pioneering inventions and applications of electricity, while

scientific management theories derived from Frederick Taylor led to great increases in manufacturing efficiency. This marked the establishment of mass production.

We should point out that unlike the first industrial revolution, the second industrial revolution was primarily a "revolution in the heavy and chemical industries". Beginning with the internal combustion engine developed by Gottlieb Daimler in 1885, this period saw the birth of major technological innovation focusing on steel, automobiles, petrochemicals, and electricity, bringing about a revolution in the heavy and chemical industries.

Advances in automobiles led not only to the building of an ordinary road network, but also expressways, making the movement of people and goods increasingly active. Later, large airplanes and high-speed ships meant that people and goods could be transported and move at even faster speeds and in greater volume, making social and industrial activity function more smoothly and promoting globalization.

In addition, as a result of the technological advances during this period in heavy and chemical industries including steel, petroleum, chemicals, and electrical power, the framework for mass production of mass-market consumer goods took shape, bringing about changes in the daily lives of the general public with the mechanization of the manufacturing and sewing of things like foods, drinks, and clothing, innovation in modes of transportation, and in terms of entertainment, the development of cinema, radio, and the phonograph. The effect of employment also expanded, increasing the consumption capacity of the masses.

Economic and business systems during the second industrial revolution were based on mass production and mass sales. This meant that large companies that required large-scale fixed capital and capital investment could reduce unit costs by manufacturing (or procuring) and selling large quantities of a single product, creating profit through economies of scale that became the source of their competitiveness.

The third industrial revolution was primarily an "information revolution" focusing on the telecommunications industry. This meant using calculations of original "information" for things like processing and extraction to obtain other forms of information through a process called information processing, which created added value in economic and business activity, and also increased convenience and efficiency for society as a whole.

In 1971, Intel introduced the microprocessor, the world's first "information engine", and with the dramatic development of the Internet from the early 1990s, digital technologies created an "information revolution". This led to e-commerce and a variety of other new networked services that transformed telecommunications into a huge industry<sup>2</sup> and changed lifestyles and methods of production.

The third industrial revolution used microelectronics (ME) and information technology (IT), primarily in telecommunications networks. This achieved automation in automated processes and

1 T. S. Ashton, *The Industrial Revolution 1760-1830*, Oxford University Press 1948 (Translated by Keiichiro Nakagawa, Iwanami Bunko, 1973; p. 108).

2 Naoki Sakai, "We are now seeing history's fourth 'industrial revolution'", *Gendai Business*, July 13, 2013; p. 2.

controls through combinations of programmable logic controllers (PLCs), electricity, and IT. With the emergence of computers in the second half of the 20th century, automated controls led to advances in the automation of factory production, for even further advances in mass production. The performance of the circuit elements that controlled computers' processing increased in stages through integration – from vacuum tubes to transistors and from integrated circuits (ICs) to large-scale integrated circuits (LSIs) – leading to rapid development in manufacturing industries.

This third industrial revolution brought about and saw the expansion of things including automation and electronic transactions between companies and users, with industrial robots transforming manufacturing processes, and the industrial structure shifting toward knowledge- and technology-intensive products that were lighter, thinner, shorter and smaller, or in other words a shift toward products and sectors based on information, knowledge, and services. Unlike the mass production and mass distribution that typified the period of the second industrial revolution, the primary trend in production and distribution was small-lot production of multiple varieties and volumes with high-frequency distribution, which in turn led to networked transactions. This was against a backdrop of the replacement of the previous production and distribution systems for mass production of fewer product varieties, with production systems for smaller volumes of more product varieties becoming increasingly necessary to respond flexibly to market and environmental changes in the manufacturing and distribution industries and to the diversification of consumer needs.

Among these three industrial revolutions, the global economy experienced a relatively higher rate of growth during the second industrial revolution. For example, growth rates of developed countries during the first industrial revolution were 2.0% for Britain (1790-1820), 2.7% for Germany (1850-1880), 3.0% for the US (1820-1850), and 4.0% for Japan (1876-1900), but during the second industrial revolution, and the latter part in particular, these countries were achieving growth rates of 5.0% during 1960-1968.<sup>3</sup> Labor productivity in developed countries grew significantly as well, from 1.61 in 1870 to 3.12 in 1913, to 5.54 in 1950, and to 16.21 in 1973.<sup>4</sup> At the same time, developing countries learned and used the technological achievements and expertise of secondary industries in developed countries to develop manufacturing industries, primarily in labor-intensive industries and processes, increasing their share of global industrial production and exports. Many developing countries successfully used technological achievements, including those from the second industrial revolution, through direct internal investment and technology transfers from multinational corporations headquartered in the developed countries of Japan, the US, and in Europe.

For example, China has been receiving internal investment from developed countries for 40 years, from 1979 to the present. As of the first half of 2020, direct investment in China from countries including

Japan, the US and European nations totaled more than 2 trillion yen. Multinational companies have roughly 1 million subsidiaries and business locations in China. Among these, there are more than 30,000 affiliates of US and Japanese companies each. Most multinationals with operations in China are in the manufacturing sector, making China the top country globally in terms of exports and trade in 2012, accounting for more than 25% of global industrial production. These multinationals from developed countries have played a large role in this. For example, until a few years ago multinationals accounted for more than 60% of China's exports, and multinationals' high-tech products in particular have come to account for more than 80% of China's exports of these products today, contributing to China's No. 1 position globally as an exporting and industrial country.

In addition, with multinationals based in the US and other developed countries shifting production and business locations to China and other developing countries, the technologies that matured during the second industrial revolution are being used overseas in developing countries, raising local levels of technology and increasing profits.

Currently, a fourth industrial revolution is underway and is causing major changes in socioeconomic production methods and people's lives in existing areas, including the Internet of things, artificial intelligence, robotics, and big data. Successes in the research and development of innovative new energy sources to replace depleting fossil fuel resources and in environmental technologies to rein in global warming are still scarce, however. The urgency of inventing new energy sources that can replace petroleum as a major source of energy, to replace depleting fossil fuels and avert the crises of climate change and global warming in the future, cannot be overstated, and the high cost and environmental impact from today's energy is having a negative impact on society's productivity and people's lives. This is the most urgent issue for the fourth industrial revolution. Technological innovation and discovery in the medical field to address the ongoing coronavirus pandemic is also an urgent and crucial issue.

## New Structure, Reordering & Future of the International Political Economy

Economic development and the industrialization of and innovation in various countries associated with the world's industrial revolutions to date are having a major impact on economic systems and changing the structure of the global political economy. In the 21st century, and particularly since the early 2010s, a multipolar structure has been emerging from the acceleration of the global political economy. In addition, within the current fourth industrial revolution, confrontation is intensifying between the two major countries – the US and China – for control of the global political economy in areas including technological hegemony, and this

3 Economic Planning Agency, "Economic Report for 1970 – Conditions for New Development", Dec. 18, 1969 (<https://www5.cao.go.jp/keizai3/sekaikeizaiwp/wp-we70/wp-we70-02401.html>)

4 Koichi Mashiyama, "Global Economic Development and Technological Innovation – From the First Industrial Revolution to the Early 20th Century", *Economic Research*, Meiji Gakuin University #126, 2003; p. 6.

escalating tension is leading to the reality of a new cold war. Other countries, which are stuck between a rock and a hard place *vis-à-vis* the US and China, are particularly concerned about the effect that the US and China, and their relationship with each other, will have on the future direction of the global political-economic order.

### *1. Changes in today's global political-economic structure*

As is well known, since the 1970s, the increase in Germany's and Japan's industrial strength via the third industrial revolution has brought high economic growth and expanding current account surpluses to those countries. In contrast to this increasing global economic presence, the US economy has been sluggish and weakened, shaking US hegemony under Pax Americana, and this has begun to redraw the map of power in the global economy.

In addition, since the beginning of the 21st century, China and other developing countries have been aiming to industrialize by catching up, and have used inward investment and technology transfers from developed countries to achieve export-driven growth. The global share of China and developing countries' GDP, trade, and investment is growing, and this is bringing about major changes in the structure of the global political economy. In other words, power shifts in the global economy are causing major changes in the global political economy and governance systems. The G7, IMF, WTO, and major international institutions and organizations, which have been controlled by the US and other developed countries that played the leading role in the global economy to date, have addressed problems in areas including global finance, investment, trade, and the environment.

Nevertheless, with the rise and growing power of China and other developing countries, developed countries have become unable to respond to global problems on their own. In response to the global financial crisis, in 2009 the G20, which includes developing countries, arose as the new venue for governance to respond to major global issues in areas including the economy and finance, and the environment and energy.

With the decline in the global dominance of the US and other developed countries, their share of global GDP declined from close to 90% in 1990 to roughly 70% in 2000, and to the 50% level in 2020. On the other hand, China and other developing countries global share has risen during that same time, from 14.6% to 26%, and to 44.5%.

Since the beginning of the 21st century, the growth in the global influence of China and other developing countries has created a multipolar global political-economic structure, and recently this trend has been accelerating and is becoming visible.

### *2. Rebuilding of supply chains and intensifying confrontation between the US, China, and Western countries shaking the international political-economic order, making it more complex and confrontational*

China's power, in particular in high-tech areas like 5G, is increasing. Technological hegemony is the key factor behind the battle for leadership in the international political structure. To maintain its existing leadership and predominance in the international political-economic structure and international order, the

US is strengthening its technological and other innovation while at the same time working to curtail the rise of advanced technologies of its rival China, eliminate its reliance on China for things like semiconductors and rare earth metals, and remove China from its high-tech supply chains.

The administration of President Joe Biden, which took office in January 2021, continued the sanctions on China of his predecessor Donald Trump, and has in fact been working to get allies and friendly nations to join it.

At the same time, whether China will be able to replace the US as the dominant country in the realignment of the global political-economic order is a focus of much attention around the world. To date, many international institutions have been predicting that China's total GDP will surpass that of the US and become the world's largest by around 2035. On Dec. 26, 2020, Britain's Centre for Economics and Business Research (CEBR) announced a forecast that against the backdrop of the global pandemic, China's economy was recovering and growing more quickly than those of other countries and would surpass the US as the world's largest economy by as early as 2028.

Incidentally, as of the end of 2020, China's nominal GDP had reached more than 70% of US GDP, at 70.4%. China's GDP has grown from 9% of global GDP in 2010 to more than 17%. The CEBR's forecast is that the contrast in coronavirus responses will accelerate this convergence, and China will overtake the US in 2028. Considering China's weakness in semiconductor and other high-tech sectors and limited soft power, however, it would seem that China will not take the world's No. 1 position in terms of comprehensive, actual strength.

The US is likely to maintain its dominance in the shifting global political-economic structure. A change in hegemony or dominance in a realigned global political-economic structure and order will take time. I believe this change in position before 2050 is impossible.

In other words, with China's rise and further growth in economic power, conflict and confrontation between the US and China for dominance will grow and become more intense. This will further shake the international political-economic order and relationships among international political economies, leading to instability and a new cold war.

**JS**

Dr. Guo Sizhi is a member of the Faculty of Economics and Graduate School of Economics at Teikyo University. He specializes in the international economy, the energy economy, and the Chinese economy. His current research focuses on the transformation of international political and economic order, new energy, and economic security toward carbon neutrality, and decarbonization technology innovation. He is the author of numerous books, including *A History of the Industrial Revolution: The Transition of the International Order as Seen through Innovation* and *The Decarbonizing Industrial Revolution*.