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Article

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Asia and the Global Economy (AGE)

Provided in Cooperation with:

Asia Economic Community Foundation, Incheon

Suggested Citation: Brada, Josef C.; Park, Jehoon (2024) : The fourth industrial revolution: Implications for the global economy and for the strategic competition between the United States and China, Asia and the Global Economy (AGE), ISSN 2667-1115, Elsevier, Amsterdam, Vol. 4, Iss. 2, pp. 1-10,
<https://doi.org/10.1016/j.aglobe.2024.100097>

This Version is available at:

<https://hdl.handle.net/10419/340971>

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The fourth industrial revolution: Implications for the global economy and for the strategic competition between the United States and China[☆]

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ARTICLE INFO

Keywords:

industrial revolution
China-US competition
Technological change
Historical materialism
Political system

ABSTRACT

During the First Industrial Revolution, industrialization led to incompatibilities between the economic sphere and a political sphere based on rule by monarchs and land-owning nobles. These incompatibilities led to poor economic outcomes for workers and, ultimately, to deep changes in the political system. In the Second and Third Industrial Revolutions, compatibility emerged between new technologies and political systems based on representative democracy, leading to favorable outcomes. The changes in technology brought by the Fourth Industrial Revolution may lead to a growing incompatibility between the productive and political spheres, marked by polarization and conflict both within and among countries. A key aspect of this conflict is the rivalry between the United States and China. We evaluate the strengths of the respective countries and analyze which of them is likely to win the competition for dominance during the Fourth Industrial Revolution.

1. Introduction

The industrial revolution, which began in Great Britain around the middle of the 18th century, ended a long period of economic stagnation and political stasis. Prior to the start of the industrial revolution, technology, living standards, and populations had changed little for centuries (Prescott, 1998; Lucas, 2002). Similarly, political institutions had changed little. A ruler and a ruling elite exercised control over the government and owned much of the land and, in many cases, labor as well. Since the start of the industrial revolution, economic output, the use of new technology, and living standards have increased at a rapid pace. Moreover, political systems have changed as well, with variants of royal or autocratic regimes eclipsed in favor of democratic or populist systems of governance. In this paper, we examine the dynamics of the industrial revolution and its effects on societies, and we draw implications of the most recent technological developments, popularly called the Fourth Industrial Revolution, for the strategic competition between the United States and China as well as for the global economy.

2. Methodological prologue

This essay uses two concepts as the backbone of its analysis. One of these is the concept of revolution, which in our framework involves two separate meanings. The second is the theory of historical materialism, which proposes a relationship between the way in which the production of goods and services takes place and the social and political structures that may or may not be consistent with the way in which economic activity takes place.

2.1. What is a revolution?

The concept of a revolution has two meanings. One is that of a profound and long-lasting change in intellectual, social, political or economic arrangements or in some combination of these (Cohen, 1985). For instance, in addition to the industrial revolution that is the subject of this essay, we have experienced other sorts of revolutions, such as the scientific revolution, the French and the Bolshevik Revolutions, the computer revolution, and, for economists, the Keynesian revolution, to name just a few. Thus, to call the developments in technology, in the organization of production and in living standards of the past 300 years

[☆] This article was evaluated under the auspices of a member of the editorial board and that Josef Brada and Jehoon Park were not directly involved in the decision to publish this article.

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<https://doi.org/10.1016/j.aglobe.2024.100097>

Received 11 November 2024; Received in revised form 17 November 2024; Accepted 19 November 2024

Available online 29 November 2024

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a revolution is quite natural and appropriate. Nevertheless, as Cohen (1985) notes, there is another meaning to revolution, and that is the regular motion of one body around another. For example, the earth makes a revolution around the sun, but after a year, it returns to where it started; the hands of a clock make a similar revolution. Thus, we should also see revolutions as an ongoing process, with one revolution following another. This is why many scholars divide the industrial revolution into a sequence of revolutions, of which the fourth is the one in which we are now engaged. In this essay, we emphasize both meanings of revolution in our analytical framework.

All revolutions have common characteristics. These characteristics are well expressed by the painting “Liberty Leading the People” by Eugène Delacroix shown in Fig. 1. The first point the painting makes is that, during a revolution, the participants do not have a clear idea of what will be the ultimate consequences of the revolution. Lady Liberty, holding a gun and a flag, is treading surefootedly over the jumbled cobblestones of a barricade, but note that she is looking backward, not forward, suggesting that she does not have much interest in where she is going and is more interested in ensuring that her followers are in support of her.¹ The second point that the painting makes is that a successful revolution needs strong support. Delacroix includes among Liberty’s many followers individuals from different social groups: a member of the bourgeoisie in a top hat holding a fearsome gun, workers of various sorts, and a young lad with two pistols who symbolizes coming generations and is emblematic of the promise of revolutions to make the future better for all. This promise is underscored by the man in the red cap kneeling at Liberty’s feet. The red cap, called the Phrygian cap, and also worn by Liberty, was a popular revolutionary symbol during the First French Revolution, but, more tellingly, it was commonly worn in Roman times by slaves who had been freed by their masters, so a revolution promises that it will free the people from toil and social and political burdens. Finally, note the corpses piled up at Liberty’s feet. A revolution promises gains, but it will surely impose loss and suffering for some. We will examine these themes as we analyze various stages of the industrial revolution.

2.2. Historical materialism and the industrial revolution

The core message of historical materialism is that productive forces, meaning the available resources and technology and the way in which they are used, and which we call the economic or productive base, in the long run determine the social superstructure, meaning social relations and the political system and its institutions, including the form of government, as well as religious and other social institutions etc..² In other words, “economics dominates politics.” Materialism posits that, in the short run, the economic base and the social superstructure may be incompatible to some degree, which creates social and political conflict, both within a country and among countries. These conflicts are resolved by revolutionary, but possibly non-violent, changes in the social superstructure to bring it into line with the needs of the economic base. Moreover, the primacy of the economic base comes not only from the fact that the social sphere will eventually adapt to the requirements of

the economic base if the entire system is to continue functioning effectively, but also from the fact that changes in the economic base are the source of changes both in production and in social relations. This is because changes in technology and resource availability occur exogenously, creating a periodic dissonance between the needs of the economic sphere and the organization of the social superstructure. Of course, the social superstructure is the creation of those currently in power, and these actors will resist social and political change because it threatens their position in society even if they cannot suppress changes in the productive sphere. In times of rapid changes in technology and resources, the structure of the social sphere thus becomes incompatible with the needs of the economy, leading to pressure for changes in the social superstructure that take the form of political revolutions.³ Although there may be a range of social superstructures that are consistent with a given productive system, there is uncertainty about how narrow this range of social superstructures is, a problem to which we turn at the end of this essay.

We use this framework to analyze how technological change brought about by the Fourth Industrial Revolution may be creating a need for changes in existing social and political structures or in the capacity of the social sphere to deal with these new pressures, both domestically and globally.

3. The first industrial revolution

Prior to the First Industrial Revolution, which began in the middle of the 18th century and ended in the middle of the 19th century, the main factors of production were human power and land. Human labor power was supplemented to a small extent by wind- and waterpower and by the use of animals. But these supplements to human labor power were limited in the extent to which they could replace the work performed by people because they were complements not substitutes for human labor. For example, draft animals could supplement power supplied by humans, but draft animals required close human supervision, and people were limited in how many animals they could control and by practical limits, for example, on how many oxen could be harnessed to a plough in order to increase production. Thus, the key socio-political objective of pre-industrial revolution societies was to obtain control over land and people.

The First Industrial Revolution began with the application of steam power as a substitute for the power provided by workers, in the first instance in the textile industry.⁴ Steam-powered machinery vastly expanded how much supplemental power a worker could control, and this rapidly expanded production. Although the revolution began in Great Britain, it quickly moved to France and Germany and, with less success, to Italy, Russia and the Austro-Hungarian Empire (Gerschenkron, 1962) and, after the Meiji Restoration, to Japan (Rosovsky, 1981). New technologies and, thus, rapid growth of productivity also shifted quickly from the textile industry to ferrous metallurgy, machine tools and, by the end of the First Industrial Revolution, commonly dated to around 1850, to chemicals. The size of industrial

¹ This uncertainty about the ultimate effects of revolutions is evident in the wide range of outcomes predicted in current debates about the likely effects of artificial intelligence (AI). Some observers view AI as a benign source of vast productivity gains, but, at the other extreme, other experts worry that, unless strictly controlled, AI will cause social and economic harm and possibly take over the world and do away with humans or at least render them useless or irrelevant.

² We may ask “Why we are talking about historical materialism, which is popularly associated with the thought of Karl Marx, in the 21st Century?” This is because historical materialism is a broader concept than the “dialectical materialism” of Marx, has been used extensively by non-Marxists, and is quite applicable to modern society. This is true especially when we focus on the relationship between technology and social governance.

³ Thus, feudalism in its various forms was a social system compatible with an agrarian economy undergoing little technological progress, but it was not compatible with a capitalist economy based on new and rapidly evolving industrial technologies. Below, we ask whether the social and political systems that were compatible with the early stages of the industrial revolution are still compatible with the current productive sphere as embodied in the so-called Fourth Industrial Revolution.

⁴ The increased span of control that workers had over cooperating capital was accompanied by a loss of autonomy in how they carried out their work, since they were to a greater extent subject to the rhythm of the machines with which they cooperated. This is, of course, the essence of the Marxist concept of alienation. The trend towards less autonomy and a greater need for workers to conform to the pace and requirements of machinery and equipment seems an integral part of technological progress.



Fig. 1. Liberty leading the people by Eugène Delacroix.

firms also grew during this period as did their need for financing, which increasingly relied on large banks, bourses, and government support (Gerschenkron, 1962).

The effects on economic performance were, indeed, revolutionary. Per capita incomes in Western Europe had grown at 25 % per century between 1500 and 1800, meaning they would double over a period of 300 years. With the onset of the industrial revolution, they grew by about 500 % per century (Maddison, 1991). Such rapid growth in output created both winners and losers. We take as our example the United Kingdom, although the broad outline of events applies to other countries that experienced industrialization. The major winners were the new industrialists, who reaped a large share of the gains in productivity and output. The major losers were landless people who had to migrate to urban areas and workers. Due to the Enclosure Laws, agricultural employment in England had become more precarious (Hobsbawm and Rudé, 2014), and many agricultural families supplemented their incomes by undertaking spinning and weaving in their homes. There were also highly skilled workers in the cities who were often members of guilds and made a good living producing products such as silk stockings that were widely worn by the upper classes. The mechanization of textile production and later of other industries put these people out of work. Rural workers were forced to seek employment in cities that had neither the infrastructure nor the housing to sustain them. As a result, they were crowded into slums, living in appalling conditions that are well

described in the works of Charles Dickens, who himself was sent to work in a London factory when he was 12 years old, and in Victor Hugo's monumental *Les Misérables*. Dickens' experience as a child laborer was not unique because child labor was common, children being cheaper than adult workers. A typical workweek consisted of 6 days of work, often for 14 hours or more per day. Mokyr's (1988) analysis of working-class living standards in England from 1790 to 1850 concludes that his calculations "strongly suggest that the hypothesis of no or little improvement cannot be rejected". Feinstein (1998) is only slightly more optimistic, reporting that "the standard of living of the average (English) working-class family improved by less than 15 % between the 1780s and 1850s".

Changes in the relative fortunes of landowners, who dominated the social and political superstructure of society, and the new class of wealthy industrialists created political tensions between the two groups. Social and political change came only slowly. As late as 1831 only about 5 % of Britons could vote, and there was heavy overrepresentation of rural and relatively underpopulated districts. In Continental Europe, too, landowners dominated the governments. Workers were restive. In England, riots that involved the destruction of the newly-introduced machinery in both agriculture (Hobsbawm and Rudé, 2014) and in industry were common enough that Parliament made such acts punishable by death. Some riots had to be suppressed by the army, and many rioters were either hanged or shipped to penal servitude in Australia.

Conflict within countries between the landowner-centric social and political system and the needs of the new productive system spilled over into international relations as well. The new forms of production owed their competitive advantage in part to economies of scale. Thus, countries competed for ever-larger markets for their products as well as for supplies of needed raw materials, giving a new impetus to colonization and resulting in tensions and wars. Moreover, prior to the industrial revolution, all countries had more or less similar standards of living, and so military power and the size of armies depended mainly on country size, which tended to change only slowly, providing a stable balance of power. With the dawn of the industrial revolution, military power shifted to those countries that were more industrialized than their rivals (Colley, 2021).⁵ Social and political relations between and within European countries were governed by the system established at the Congress of Vienna, which was designed to maintain the primacy of the old system of royal prerogative and land ownership by the nobility as the basis of political power and social organization, a situation that was increasingly inconsistent with the emerging industrial economy.

Given these domestic and foreign stresses on the political system, people began to question the ability of existing governments to manage the changes that were occurring. This loss of faith in the existing political systems and the growing dissonance between the political and social systems in place and the needs of the productive sphere resulted in a series of popular revolts in Europe collectively known as the Revolutions of 1848.⁶ Although these were harshly crushed, they eventually led to limited social change, such as the abolition of serfdom in some countries, and they set some limits on the absolute power of the existing rulers.

4. The second industrial revolution

If the First Industrial Revolution left the working classes as victims of technological and economic progress and the productive sphere and the social and political sphere misaligned with each other, the Second Industrial Revolution, covering the period 1870 to 1914, brought the fruits of economic progress to workers and better aligned the productive and social spheres with each other. The Second Industrial Revolution was based on the concept of mass production, the use of electricity to power machinery, which permitted the dispersion of production to new places, the use of the internal combustion engine to revolutionize the distribution of goods and people and a host of other technological breakthroughs that not only increased productivity but also provided significant gains for workers. It was also noteworthy for the increasing application of science to develop new and to perfect old technologies (Mokyr, 1990).

The invention of the telegraph and the telephone allowed managers to control a wider span of economic activities, not only within their own countries but also overseas, thus facilitating international exchanges of goods. The introduction of iron ships and refrigeration was a major boost to the welfare of European workers because iron ships lowered shipping costs so that more and bulkier goods could be transported, as could new types of goods.⁷ Refrigeration allowed ships that had carried wool from Australia to England to now carry both wool for English textile factories and mutton for the workers who toiled in them. Similarly, ships that had carried hides to Europe from Argentina to make shoes could now carry

both hides and frozen beef. Moreover, lower shipping costs facilitated shipments of agricultural staples such as grain, and refrigeration brought perishable foods to European consumers. Workers benefited from these developments because their diets improved, and food prices fell relative to wages. Moreover, international conflicts over trade and tariffs were reduced among some countries as Great Britain and other countries moved toward freer trade, for example with the signing of the Cobden-Chevalier Treaty (Krasner, 1976). Elsewhere, governments supported industrialization by raising tariffs to promote their own industrialization. In both cases, government action was taken by the public as a sign that the governments were meeting their newly found obligation to promote prosperity. Despite tensions over colonies, fueled in part by newcomer imperialists such as Germany, Italy, Japan and the United States, the incidence of wars diminished during the period of the Second Industrial Revolution, ushering in a period of relative international peace, with deaths caused by wars declining through much of this period to levels rarely seen before or since (Colley, 2021).

Another aspect of globalization that improved the welfare of workers was an upsurge in factor movements, as large amounts of capital and millions of workers emigrated from Europe and, to a lesser degree, from Asia. This both raised the returns to capital and reduced overpopulation in areas of outmigration, defusing political tensions and improving incomes. Much of the increase in factor movements was due to the emergence of so-called settler economies (Lloyd and Metzger, 2013). Settler economies were large land areas, either colonies or countries, settled mostly by Europeans that were sparsely populated at the time of settlement or whose original inhabitants were exterminated by the newly-arrived settlers through war, the introduction of foreign diseases, etc. The most prominent of these economies were Argentina, Australia, Canada, and the United States.⁸ Improvements in transportation and communications integrated these countries into the global economy, and all of them were destinations for European capital and Asian and European emigrants. For example, some 24 million Italians emigrated during the Second Industrial Revolution, many going to Argentina or the United States; the latter country also saw large inflows of people from Central and Eastern Europe and the United Kingdom. Capital flows to settler economies were also large. For example, by the end of this period, about half of the Argentine capital stock was foreign owned, and British investment had financed much of the expansion of railroads in the United States and elsewhere, thus helping integrate settler economies into the global trading system.

Domestically, the social sphere increasingly aligned itself with the needs of an industrial economy. While many countries remained monarchies, they increasingly became constitutional monarchies, with elected parliaments assuming greater authority. Governments also became more responsive to workers' needs. For example, the United Kingdom legalized labor unions in 1871, and social welfare programs to improve workers' welfare were implemented in many advanced economies. Given the need of industry for literate workers, universal education became an important government objective. A greater equality in incomes led to more saving by the working classes and more investment in human capital, setting the stage for the emergence of an urban middle class. Governments also assumed greater responsibility for public health measures, such as inoculations, improved food safety, etc., much of it based on the pioneering work of Jenner, Pasteur, and others.

While the changes described above proceeded slowly, leaving tensions between workers and industrialists as a source of social instability, people increasingly felt that the new social and political superstructure was more in line with the needs of the economy and that governments were increasingly better equipped to cope with the challenges posed by the Second Industrial Revolution. Greater popular trust in government

⁵ In Japan, for example, this was succinctly summed up by the slogan "Rich Country, Strong Army", which became popular in the years following the Meiji Restoration (Samuels, 1994).

⁶ The loss of confidence in the existing political structures occurred later but more rapidly in Japan, culminating in the Meiji Restoration.

⁷ Wooden ships generally could not be much longer than 30 m, but iron ships could be as much as 90 m in length. Since a longer ship was also wider and had a deeper draft, if these dimensions increased in proportion to the length, then an iron ship potentially had 27 times the carrying capacity of a wooden one, often without a corresponding increase in crew size.

⁸ Thus India, for example, would not be considered a settler economy although it was large because it had and retained a large native population during its colonization.

capacity resulted in part from the introduction of policies to spur industrialization, to promote the spread of railroads, and to support improved working conditions. One challenge that governments faced at this time was the emergence of cartels, trusts, and monopolies, which raised prices and profits by restricting output. Governments only slowly adopted measures to reduce the market power of such arrangements, eventually further increasing public trust in their capacity to regulate the economy.

5. The third industrial revolution

The Third Industrial Revolution, which began shortly after the end of World War II, was marked by the confluence of rapid technological change and a host of exogenous social and geopolitical factors that led to prosperity in the second half of the 20th century. Perhaps the biggest exogenous factor was the recovery of the global economy from the ruinous effects of the global depression of the 1930s and of more than six years of global war. Peace brought with it a deferred demand for housing and consumer durables, for infrastructure and for new investments in productive equipment. This robust demand led to rapid growth in many countries. In the United States, the GI Bill and other post-war policies led to higher levels of education, to the movement of people from rural areas and from agricultural employment to an urban (and suburban) lifestyle, to a shift of employment toward manufacturing and, eventually, into the service sector. The process was repeated in other advanced economies, as witnessed by the emergence of Japan as a manufacturing and technological powerhouse and by the so-called “German Economic Miracle”. The rapid growth of Asian economies through gains in total factor productivity was also a major driver of economic growth (Prescott, 1998).

Internationally, this period was characterized by the Cold War, by decolonization, and by an upsurge of regional economic integration. One effect of the Cold War was the near total absence of the Soviet Bloc and of China from the global trading system. Because these Communist countries were relatively labor abundant, the global economy became more capital abundant than it would have been had these countries remained as part of the world trading system, and, as a result, labor incomes in capitalist countries were higher in the early part of the Third Industrial Revolution than they would have been if the Communist countries had stayed in the international trading system. Decolonization also opened opportunities for trade and investment with regions that, before the war, had been the exclusive economic sphere of activity of their colonial masters.

The creation of a new rules-based international economic order based on the US dollar and on commonly accepted rules of behavior led to an upsurge in trade and foreign investment. New institutions included the Bretton Woods System of the IMF, the World Bank, and the General Agreement on Tariffs and Trade (GATT), which sharply reduced the high tariffs that had preceded World War II. Regional economic integration in Europe and subsequently in Asia and Latin America also promoted economic progress and the globalization of economic activity. As a result, international trade increased more rapidly than did output, leading to the belief that globalization was a vital component of ever-increasing prosperity. Foreign direct investment (FDI) replaced international portfolio flows as the main vehicle for the international movement of capital. FDI was seen as a more effective force for economic growth because it combined capital flows with flows of technology and managerial expertise.

Alongside these political developments came a variety of technological changes. The most noteworthy of these was the development of semiconductors and the subsequent digital or computer revolution and the creation of the internet. These developments expanded the capacity to process and transmit vast amounts of data and information. They also led to changes in manufacturing, including computer assisted design (CAD) and computer numerical control (CNC), in the greater use of digital rather than analogue methods of controlling production

processes and in sharing data within and between firms. There were also major changes in transportation technologies. Jet aircraft effectively shortened distances between different parts of the globe. The development of container ships and of very large bulk carrier ships reduced shipping costs (Levinson, 2006), which accelerated offshoring, the development of global value chains where manufacturing of components was distributed to locations where it was cheapest and then these components were combined into final products using just-in-time logistics to minimize the need for inventories, cutting manufacturing costs even more. Globalization of economic activity intensified, prosperity spread to more regions of the world, and a consensus emerged that continued technological advances, further globalization, and free market policies would sustain growth indefinitely.⁹ This optimism was justified by the evidence: low inflation and rising employment and productivity. Global trade and investment flows increased rapidly as did profits and stock prices. Thus, the so-called Washington Consensus (Williamson, 1990; 2002), which began as a commonsensical and limited set of policy prescriptions for Latin American and, later, for the transition economies of the former Soviet Bloc, became a doctrinaire template for all countries. It stressed privatization, the primacy of markets in allocating resources, sound fiscal and monetary policies, and a limited role for government.

Part of the reason for faith in the economic and political structure that emerged during the Third Industrial Revolution was the end of the Cold War. The Soviet Bloc effectively dissolved following the fall of the Berlin Wall in 1989, and, more important, China abandoned its policy of autarky and quickly expanded its international trade. These events were seen as proof that a capitalist economic system based on the technology of the Third Industrial Revolution, coupled with a political system based on liberal democracy, was the best combination for all countries, and, in the terminology of historical materialism, the productive sphere and the social sphere were congruent with each other, continuing and solidifying the relationship established during the Second Industrial Revolution (Fukuyama, 1992).

6. The fourth industrial revolution

The term Fourth Industrial Revolution was coined by Schwab (2017). Schwab argued that rapid changes in technology, including artificial intelligence (AI), more sophisticated automation, the internet of things, the smart factory, digital fabrication, ubiquitous sensors to gather information, etc. would produce an economy where computers would begin to take on activities that required some measure of sentience or at least to increasingly deal with more complex situations. Thus, computers would increasingly be able to control production activities without human intervention (e.g., autonomous cars), the “internet of things” would link machines and production processes, resulting in the smart factory, which could to some extent “think for itself” to make business decisions. The term Fourth Industrial Revolution might have remained the province of business executives, management gurus and professors in business schools had not, in 2023, the computer program Chat-GPT been released, bringing the concept of artificial intelligence (AI) to the attention of the general public as the hallmark of the Fourth Industrial Revolution.

Although the Fourth Industrial Revolution is still in its infancy, and thus conclusions about its consequences must be tentative, there are several early developments that give us an inkling of what the future may hold for the sociopolitical sphere as it reacts to the changes in the productive sphere wrought by the Fourth Industrial Revolution. These developments suggest that, not unlike during the First Industrial

⁹ There were contrary views, such as those of Cowen (2011), Gordon (2000, 2016), who argued that the technological innovations of the Third Industrial Revolution were less fundamental and less stimulative of growth than those of the previous industrial revolutions. Moreover, some observers, such as Rodrik (1997), Stiglitz (2002), began to raise doubts about the benefits of more intense globalization.

Revolution, changes in the productive sphere may be becoming increasingly incompatible with the existing sociopolitical system. One troubling feature of the Fourth Industrial Revolution, one that also mirrors what occurred during the First Industrial Revolution, is that a large part of the population in many countries has ceased to see gains in living standards despite rapidly evolving technologies and continuous gains in productivity. This has led to social and political unrest that could result in the unraveling of Fukuyama's (1992) belief in the compatibility of capitalism with liberal democracy (Brada and Bah, 2013). Another important feature of the Fourth Industrial Revolution is that large parts of the economy are no longer governed by the law of diminishing returns, and this has changed the way in which both firms and countries compete with each other, leading to a marked increase in the concentration of capital and to a decline in faith in the ability of governments to manage economic activity.

6.1. The fourth industrial revolution and the distribution of income

Troubling developments in the distribution of income were noted even before the start of the Fourth Industrial Revolution. Studies of individual countries or specific groups of countries by Guscina (2006), Lübker (2007), Krämer (2011) among others identified a decline in labor's share of national income beginning in the 1980s. Rodriguez and Jayadev (2010), Karabarbounis and Neiman (2014), Guerriero (2019) extended these studies to more countries and updated them, confirming that the decline in labor's share has continued and applies to most of the economies of the world. This decline in labor's share was variously attributed to changes in technology and difficulties in substituting capital for labor, to changes in the global capital-to-labor ratio resulting from China and the former Soviet Bloc countries returning to the global economy, to the effects of globalization through offshoring of jobs from developed countries, to the effects of FDI on labor's bargaining power, and to labor market rigidities or the decline in union membership.¹⁰ Most of these explanations for the decline in labor's share are largely a Third Industrial Revolution story because they point to economic developments that we have identified as being an important part of the Third Industrial Revolution.

The consensus is that labor's share of national income had fallen by as much as 10 percentage points between the mid-1980s and the start of the Fourth Industrial Revolution, and it has continued its decline since then due to reasons that are the result of forces that are unique to the Fourth Industrial Revolution. Because wealth is much less equally distributed than wages, an increase in capital's share of national income means, as matter of simple arithmetic, that income distributed on the basis of wealth must become less equally distributed. Moreover, the increase in returns to capital and the lower interest rates that marked the beginning of the Fourth Industrial Revolution increased the value of both financial and real assets, increasing inequality even more. The decline in labor's share of income has been joined by a shift in wages toward the richest segments of the population. The wage incomes of top earners have grown rapidly, those of the lowest income groups have stagnated and the middle class has borne the brunt of these developments (Darvas and Savona, 2022; Pew Research Center, 2020).¹¹

¹⁰ Brada (2013) surveys and critiques the earlier studies. A key point of his critique is that much of the evidence covers only the period when labor's share was in decline. Thus, tests of various explanations of the decline are likely to be self-confirming because periods when labor's share increased are often not included in the samples.

¹¹ It is noteworthy that the innovations such as AI have not affected the incomes of the least skilled (Ferguson and Storm, 2024). This is because AI applications are expensive to implement, so it makes little sense to invest in replacing low-wage unskilled workers with expensive AI. Unskilled workers can more easily be replaced by automation, as many wrongly feared would happen during the Third Industrial Revolution (Guarascio et al., 2024). Instead, AI is replacing skilled workers such as medical doctors, lawyers, computer programmers, and creative individuals (;).

As DeSilver (2018) sums it up, in the United States "... today's real average wage (that is, the wage after accounting for inflation) has about the same purchasing power it did 40 years ago. And what wage gains there have been have mostly flowed to the highest-paid tier of workers." Growing inequality and stagnating living standards despite gains in labor productivity may be most pronounced in the United States, but in many developed and developing countries, the same trends are evident. This, of course, mirrors the stagnation of living standards that occurred during the First Industrial Revolution, as we described above in Section 3. Moreover, there has been a shift in the income of the wealthy as entrepreneurs in technology-intensive sectors have amassed huge amounts of wealth as well as greater political influence. This development also mirrors the gains of industrialists relative to landowners during the First Industrial Revolution.

6.2. Competition in the fourth industrial revolution

The second major change in the productive sphere ushered in by the Fourth Industrial Revolution was in the nature of the firm and its organization. Kahle and Stulz (2017) report that the number of publicly owned firms in the United States has decreased, resulting in greater concentration in most sectors of the economy. Moreover, research and development ($R + D$) expenditures and $R + D$ assets have increased relative to expenditures on physical capital, suggesting that the dominance of these firms depends more on their technological skills and assets than on their factories and machinery. These trends, along with the decline in labor's share of income discussed above, gave rise to the theory of the superstar firm. Autor et al. (2020) present evidence that, in many sectors of the economy, so-called superstar firms have emerged. These firms take advantage of firm-specific technological advantages or of opportunities for globalization to become more productive than their competitors, and, as a result, they come to dominate their industries, achieving larger market shares as well as higher productivity, markups and profits.¹² Moreover, these firms utilize fewer workers, thus driving the decline in labor's share of GNP. Autor et al. (2020) find that the evidence supports their hypothesis for both US firms and for firms in other countries.

An often-neglected element of this story is that these changes in firm behavior and competition are driven by the rise of the platform company (Rochet and Tirole, 2003). However well the superstar firm theory explains developments in the industrial structure of the modern economy, it gives inadequate attention to a critical aspect of the new economy, the emergence of the platform company. A platform company does not necessarily produce a tangible product. Rather, it provides a service by creating an infrastructure that enables sellers and buyers to connect with each other or it creates a technological ecosystem that is of value to third-party users. Examples of such firms include Uber, eBay, Alibaba and Amazon, all of which facilitate contacts between buyers and sellers who are not necessarily part of the platform company. For example, Uber provides transportation to those needing it and facilitates the ability of potential suppliers to provide such transportation to those seeking it. Uber, however, does not own the vehicles that provide the rides, nor does it employ the drivers of those cars. Other platform companies, such as Apple, Microsoft, Google/Alphabet, and Zoom provide a technological ecosystem that is of value to potential users.¹³

The platform company is much more than just a new business model because its rise has important implications for competition both within

¹² One such benefit of globalization has been the ability of firms to establish affiliates in tax-haven countries and to direct their profits to those tax havens by means of transfer pricing. The practice is well known, but countries have reacted only hesitantly toward limiting this practice.

¹³ Evans and Gawer (2016) provide a concise explanation of the concepts behind the platform company and a survey of the platform economy, and Fu et al. (2021) discuss some of the economic effects of platform companies.

and among countries. The typical platform company has high fixed costs. Often this involves the creation of an internet infrastructure for connecting buyers and sellers and a distribution network, as in the case of Uber or Alibaba. Alternatively, as in the case of firms such as Microsoft or Apple that provide a technological ecosystem, there are high costs to creating this ecosystem. This means that entry costs are high and switching costs for users are often high as well, so the competitive positions of first movers are quite strong, also in part due to network effects where the greater the number of users or customers, the more attractive the offerings of the platform company become to other potential users. More important, the marginal cost to a platform company of providing its services to users is very low or zero. For example, the cost to Zoom of allowing more participants to participate in a Zoom-based conference is nearly zero as is the cost to Google of allowing an additional user to undertake a web search. Similarly, the cost to Microsoft of allowing a user to download a Windows 11 operating system is close to zero as is YouTube's cost of allowing a visitor to access its site to view content.

Firms with high fixed costs and low or zero marginal costs (in the absence of congestion costs) are the classic example of what is called a natural monopoly, and this makes their behavior fundamentally different from that of "normal" firms that face diminishing returns to the variable factor of production and thus increasing marginal costs as they increase production.¹⁴ A traditional firm, if it has a monopoly on the market for its product, will restrict output so that its (increasing) marginal cost is equal to marginal revenue. A natural monopoly has a marginal cost that is always below its marginal revenue, so profit maximization implies that the firm wants to produce as much as it can. Moreover, welfare economics teaches us that, if the production technology involves low or no marginal costs, then a natural monopoly is not only the most profitable but also the most socially efficient way of supplying the product.

As a result, government efforts to regulate the activity of platform firms have not been effective. In part, this is because traditional antitrust activity focused on firms that were restricting output, so neither the mindset of regulatory authorities nor existing antitrust legislation have adapted well to dealing with firms whose objective is to maximize their output and market share (Hsu, 2018), thus exacerbating income inequalities in favor of tech-savvy entrepreneurs and distorting competition.¹⁵ Platform companies have also become a major part of the economy. For example, at the turn of the 20th century, the ten largest US firms by market capitalization included US Steel (ferrous metallurgy), Standard Oil (petroleum), Armour & Co. (food processing), International Harvester (farm machinery), EI Dupont (chemicals) and US Rubber (tires and chemicals). All these firms produced tangible products, operated with increasing marginal costs, likely used their market power to restrict output, and none were platform companies. At the turn of 21st century, the ten largest firms by market capitalization included Apple, Alphabet, Amazon, Facebook and Microsoft, all of which are platform companies; only Exxon-Mobile (petroleum) and Johnson and Johnson (pharmaceuticals) were top ten companies that made a physical product under conditions of increasing marginal costs. Thus, it is reasonable to infer that a large part of the growing market concentration and reliance on technological assets rather than on physical assets reported by Kahle and Stulz (2017) as well as the growing importance of

superstar firms that are taking over their industries is intimately connected to the phenomenon of platform companies. Consequently, it can be argued that the technological innovations of the Fourth Industrial Revolution that gave rise to the platform company are responsible for potentially fundamental changes in the productive sphere.

The rise of the platform company also has implications for globalization and the attitude of countries towards international trade and investment. In a world dominated by firms with increasing marginal costs of production, all countries could benefit from participating in global trade and investment. Even if a country's steel industry, for example, was less efficient than the world standard, if its exchange rate were low enough, it could export steel profitably and thus benefit from international trade. Foreign investments could augment domestic resources and technology and improve export performance and increase the gains from trade. In the case of platform companies, international trade and investment changes from a win-win proposition for participants in the global economy to a zero-sum winner-take-all scenario. The economic logic of the platform company is that it wants to, and economic logic impels it to, become as large as possible, in part by expanding to other countries. Thus, a country that could devalue its currency to make its steel exports viable has no such opportunity to lower its exchange rate so as to make a locally developed search engine competitive with Google. A local search engine faces high fixed costs, benefits from few if any network effects and faces a limited market from which to cover its high fixed costs. In a world dominated by platform companies, there is little hope that every country can develop some form of platform that will be competitive on the world stage. Moreover, foreign investments by platform companies have little direct effect on the export capacity of the countries in which they invest. At this stage, most of the world-dominant platforms are based in the United States and only some countries such as China or regions such as the EU can hope to develop their own platform companies. In such a world, protectionism and efforts to subsidize domestic champions are likely to arise, impelled by the logic of a winner-take-all global economy. Such developments are often called technonationalism, an effort by countries to gain technological independence from, and dominance over, the global economy (Luo, 2022; Park, 2023).

Parts of the foregoing analysis apply to all economies, since the technological changes wrought by the Fourth Industrial Revolution affect all countries to a greater or lesser extent, but we also need to consider whether these technological changes apply to all economic systems or only to some. We have already mentioned the case of the centrally planned economies of the Soviet Bloc, which faced economic stagnation and a collapse in popular support in the face of their inability to effectively apply the technology of the Third Industrial Revolution. This suggests that, whatever sociopolitical system a country has, major changes in technology will present a need for changes in the sociopolitical system. In the Soviet Bloc, this involved a series of reforms in the organization of production that included decentralization and the introduction some market incentives, but these failed to improve the functioning of society because the sociopolitical system remained the same. In China, by way of contrast, in the wake of the Great Leap Forward, the Great Famine that accompanied it, and the Cultural Revolution, there were changes in the productive sphere with the introduction of the responsibility system, gradual acceptance of private enterprise and a quasi-market economy, and an opening up to the global economy. At the same time, there were changes in the sociopolitical sphere. While the Communist Party retained its leading role, Mao, who had dominated policy, was sidelined, and the Party became less reliant on rule through the "cult of personality", eventually going so far as to institute the regular rotation of the top leaders of the country. In recent years, Chinese economic performance has deteriorated, suggesting that China, too, is facing tension between a productive sphere that is changing in response to the emerging technology of the Fourth Industrial Revolution and the sociopolitical sphere. As a result, there have been changes in the sociopolitical sphere, with the emergence of Xi Jinping, who has assumed a more authoritarian approach to governance by engineering the end of

¹⁴ The classical example of a natural monopoly is a toll bridge across a river. Once the bridge is built, the marginal cost of letting an additional car drive across it is zero and the bridge owners thus gains the amount of the toll for each car that uses the bridge. A single bridge is the most socially efficient and the most profitable way to provide a river crossing until the bridge is used by so many cars as to cause congestion and delays.

¹⁵ Some platform companies have been subject to sanctions for anti-competitive behavior, but these sanctions have been imposed largely on behavior that has little to do with the firms' character as a natural monopoly.

the two-term limit on his presidency, by strengthening and centralizing Party discipline, and by increasing support for state-owned firms, thus shifting control over the economy from the market to the state. As we argue below, this trend toward a Chinese sociopolitical system that involves greater authoritarianism is similar to trends evident in other countries, suggesting that, at least in the case of the Fourth Industrial Revolution, both capitalist and communist economies face similar pressures and are responding to them in similar ways.

7. The way ahead for the global economy and implications for the strategic competition between the US and China

The Fourth Industrial Revolution, because of the breakthroughs in technology that have accompanied it, has created major stresses for the world's economy. On the domestic side, a large proportion of the population has seen little or no improvement in living standards. There has also been a greater concentration of wealth and less upward mobility. Moreover, governments have not been seen as effective in addressing these problems and in creating greater prosperity. As a result, there is dissatisfaction in many countries, both with the way in which the economy works and with the elites who are running national economies and the global trading system. This has given rise to populism and authoritarianism in many countries, as voters seek more radical solutions to these problems because they have concluded that "more of the same" policies offered by existing elites and experts are ineffective. The international economy and the institutions upon which it depends are also under attack. Globalization is now seen as a major contributor to the stagnation of living standards, and protectionism and nationalistic and corporatist economic policies are increasingly coming to the fore (Drabek, 2024). Above, we drew parallels with the First Industrial Revolution, where stagnation of living standards, the perceived inability of governments to manage the economy, and international tensions led to the demise of a political system based on the primacy of nobles and landowners. While most would applaud the change from feudalism to democracy as the dominant political system during the First Industrial Revolution, it is also possible that any changes in the sociopolitical superstructure brought about by the Fourth Industrial Revolution could lead to a more authoritarian political system that could give very wealthy individuals undue power to shape economic and social policy through their influence over elections, give governments more power to regulate both political and economic activity and to redistribute resources by means of non-market mechanisms, and to limit the participation of citizens in governance. There are signs in many countries around the world that such a change in the sociopolitical superstructure, caused by the Fourth Industrial Revolution, is gaining support. For example, major global players, such as China, India, Russia and the United States have all moved toward more autocratic, or populist, or nationalist forms of government, admittedly from different starting positions. The proportion of the world's population living in closed autocracies or electoral autocracies has increased sharply since 2016, while the proportion of those living in electoral or liberal democracies has fallen correspondingly (V-Dem Institute, 2024).

7.1. Can the current combination of a market economy and liberal democracy be saved?

In Section 2 of this paper, we stressed that a characteristic of revolutions is that the kind of future social and economic system they will bring about is very uncertain as the revolution is taking place. Thus, the Fourth Industrial Revolution could bring about many possible outcomes. An optimistic view has been put forward by Fukuyama (1992). At the end of the Cold War and using the same historical materialist framework that is used in this essay, he concluded that history had shown that the market economy and liberal democracy were the productive sphere and the sociopolitical sphere that were most congruent with each other and would remain so, if not forever then at least for a long time. While Fukuyama's thesis has led to considerable controversy, it does bring to

the fore the question of whether, even with the technological changes brought about by the Fourth Industrial Revolution and the social and political stresses they have caused, the close connection between the market economy and liberal democracy will be preserved. If so, then some form of a system based on democracy and the market economy can continue to sustain social and economic progress. If not, then some alternative form of sociopolitical system will have to evolve to bring the social superstructure into line with the new technological underpinnings brought by the Fourth Industrial Revolution to the productive sphere.

Preservation of the existing social and economic system, however, requires that the current stressors of this system be addressed and, if not eliminated, at least reduced. There are strategies that have the potential to reduce inequality and polarization by addressing the tensions between the productive sphere and the sociopolitical superstructure. We face several global crises such as climate change, pandemics and deteriorating economic outcomes. To solve these crises, we should increase the possibility of greater cooperation at both the national and international levels. Such efforts could lead to a new global governance system.¹⁶ If we focus on political issues from this perspective, we see that political polarization is based on both a deteriorating political culture as well as on growing economic inequality, so, in addition to reducing inequality, we also need to establish a new political culture. One of the interesting characteristics of 21st century political culture is that it is increasingly like the current fandom culture toward entertainers such as movie stars, media idols and influencers. For this kind of culture, whose origin may be traced to Korea and fans of certain Korean entertainers and is thus called K-pop fandom, the emphasis is not on substance or creativity but on media presence, particularly presence on the internet. Such fandom has also emerged in politics. For example, many supporters of Donald Trump who emotionally and unconditionally support him like fans of movie stars or of popular bands do so without evaluating his policies in any depth. Leaders in other countries have also taken notice of this phenomenon, and they have developed similar national and international web and popular media followings for themselves, often by taking control of media outlets in their countries.

Internet content providers have strong financial interests in aiding politicians and other "influencers" to amass as many followers as possible. In an effort to maximize users' interaction with material posted on the internet, website algorithms steer people toward posts and individuals who espouse more extreme positions, reducing the possibility of dialogue and amplifying the public's interaction with material that promotes extremism on many substantial topics (Chayka, 2024). Sunstein (2002) argues that the more people interact with others who hold similar views, they increasingly adopt more extreme versions of these views. Thus, the sorting of people into like-minded groups tends to promote rather than mitigate political radicalization. We can learn from the positive examples of K-Pop fandom evolution. For example, an increase in the number of, and the diversification of, idol groups has led to a decrease of violence among K-Pop fandoms in Korea. The strengthening of fandoms for moderate politicians could reduce the current extremism of fandom politics. As part of such an effort, moderate politicians should try to create fandoms against populism and anti-intellectualism.¹⁷

A second strategy would use developments in productive forces and technology to reduce inequality and conflict. This would involve developing new technologies to eliminate or minimize inequality or polarization, for instance, by means of pro-environment energy technology.¹⁸ The recent "RT (Reinvent Toilet)" project co-developed by

¹⁶ For more comprehensive discussion of these solutions, see Piketty (2021) and Acemoglu and Johnson (2023).

¹⁷ Growing distrust of, if not outright hostility toward, expert knowledge of any kind is an important component of the new political landscape (Nichols, 2024).

¹⁸ Here we are dealing with just one example of energy technology, even though there could be many other cases of new technologies such as AI.

Samsung and the Bill and Melinda Gates Foundation and intended for use in developing countries is one such example. More important, hydrogen energy could become an important component of pro-environment energy technology (Rifkin, 2002, 2019). It may be noted that “European interest in green hydrogen has grown after the invasion of Ukraine, with many governments eyeing green hydrogen as a medium-term alternative to Russian gas while remaining true to their climate goals” (Friedman, 2022). A more important point is that “those concerned with global equality see a chance to shrink the gap between the global North and the global South” (Friedman, 2022). Green hydrogen is also expected to shrink the gap between the rich and the poor in a country because green hydrogen could be produced and consumed at a price that favors substituting away from fossil energy in the near future.

7.2. Implications for US- China strategic competition

7.2.1. The war in Ukraine - prospects

After the war in Ukraine ends, we will face a new alignment of regional blocs instead of US-led globalization. There will be three blocks. One is the US-EU block, the other is the China-Russia block, and the last is the neutral block. Also, there will be a trend toward reconstructing two different regional value chains, one based on the “value systems” of democracy and the other on authoritarianism.

The war will accelerate the end of the era of fossil fuel. “Europe has called the Russian war in Ukraine its 9/11. The terrorist attacks of that day brought about a new security order that dominated the international landscape for 20 years and is still a dominant feature of world affairs. One legacy of the Ukraine war will be a new energy order, originating in Europe but radiating to the farthest reaches of the global economy. It will be defined by the dual imperatives of energy security and climate action” (Bordoff and O’Sullivan, 2022). The war will also accelerate the end of the energy system of hierarchical centralization. Likewise, we will have a more decentralized, horizontal political/social system as well as a more decentralized and horizontal energy system. Only if we have these, will we enter the era of the Fourth Industrial Revolution in full.

7.2.2. Three scenarios

There are three scenarios for the world of the Fourth Industrial Revolution. The first is an optimistic scenario, where we would see a tipping point for the collapse of the fossil fuel civilization by 2028 (Rifkin, 2019). The second, a more pessimistic one, where there would be a transitional 20–30 year hybrid period of coexistence of fossil fuel and renewable energy. The last scenario is an intermediate version with 10–15 years of a transitional hybrid period and the long-term coexistence of fossil fuel and renewable energy. Here it should be emphasized that we would have a “Long Transition Period” from the Third Industrial Revolution to the “genuine” Fourth Industrial Revolution. In this period, there would be the coexistence of (1) fossil fuels and renewable energy, (2) the centralized old system and a decentralized new system in the economy and society, and (3) old and new ideas and thoughts.

7.2.3. The US- China strategic competition

It is unclear when and who will be the winner of this competition. It could be said that whichever country best manages the challenges of the Fourth Industrial Revolution will be more likely to win this competition. Consider the US first. How quickly the United States can solve the following problems will be key.¹⁹ There is deeply ingrained racism in American society, a distrust by the middle and lower classes of the

mainstream elite of the United States, and the deterioration of the competitiveness of the American economy especially in manufacturing. On the other hand, China has the questions of (1) whether the current Xi Jinping system can smoothly replace the old collective leadership system and establish itself as a stable system, (2) who will create a ruling system after Xi Jinping, and (3) whether the current economic system can remain viable as the Chinese economic system that combines socialism and the market economy increasingly has to deal with the end of the period of rapid growth and with China’s population’s ageing and decline.

If China continues to cooperate with Russia and relies on cheap Russian oil and gas, this may result in winning in the short run but losing in the long run, particularly in the energy revolution that is crucial in competition with the US. Likewise, if we see the issue in terms of production relations, it could be said that China has short term strength in controlling strategies and policies and making centralized decisions for competing with the US, while the US has long term strength in formulating strategies and policies from the bottom up.

8. Conclusion

We noted that, during a revolution, the participants do not have a clear idea of what will be the ultimate consequences of the revolution. Therefore, we cannot predict what will be the ultimate consequences of the Fourth Industrial Revolution. So far, developments suggest that, not unlike during the First Industrial Revolution, changes in the productive sphere may be becoming increasingly incompatible with the existing sociopolitical system. We also found that it seems probable that any changes in the sociopolitical superstructure brought about by the Fourth Industrial Revolution would bring about a more authoritarian political system that would give the government more power to regulate large firms, to redistribute resources by means of non-market mechanisms, and to limit the participation of citizens in governance. However, we cannot conclude that, as in the First Industrial Revolution, we will have a fundamentally different political system even though the roles of the state and government may be considerably expanded. Regarding the strategic competition between the US and China, the country that succeeds in reducing inequality and maintaining growth will win the competition. At least in terms of an energy revolution from the bottom up, such as green hydrogen, democracy has more advantages than does authoritarianism in reducing economic inequality and maintaining growth. A telling historical example is the former Soviet Union, which failed to match its political system to the Third Industrial Revolution in the 20th century.

In terms of historical materialism, we argue that the winner in the competition of the Fourth Industrial Revolution or technological competition will be the winner in the competition between the two countries. However, the country that succeeds in constructing institutional compatibility between the productive forces or economic base, whether this be the market or the state, or large corporations, and politics, whether democracy or authoritarianism, will be the winner.

CRedit authorship contribution statement

Josef C. Brada: Writing – review & editing, Writing – original draft, Formal analysis. **Jehoon Park:** Writing – review & editing, Writing – original draft, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

¹⁹ Technological revolutions need not always lead to zero-sum competition between great powers. Instead, they can create opportunities for collaboration or for third-party states to emerge as significant players. Nevertheless, in the case of the Fourth Industrial Revolution, and even before, the relationship between the United States and China has trended toward competition.

Acknowledgment

We are grateful for useful comments received from the referees of this journal and during presentations at the INFER-PUEB Conference on “New Economics: Innovation, Digitalization and Revolution” and at the Asia Economic Community Forum.

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