The Fourth Industrial Revolution: Opportunities and Challenges

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Abstract

The fourth industrial revolution, a term coined by Klaus Schwab, founder and executive chairman of the World Economic Forum, describes a world where individuals move between digital domains and offline reality with the use of connected technology to enable and manage their lives. (Miller 2015, 3) The first industrial revolution changed our lives and economy from an agrarian and handicraft economy to one dominated by industry and machine manufacturing. Oil and electricity facilitated mass production in the second industrial revolution. In the third industrial revolution, information technology was used to automate production. Although each industrial revolution is often considered a separate event, together they can be better understood as a series of events building upon innovations of the previous revolution and leading to more advanced forms of production. This article discusses the major features of the four industrial revolutions, the opportunities of the fourth industrial revolution, and the challenges of the fourth industrial revolution.

Keywords: fourth industrial revolution, five ages of civilization, 3D printing technology, artificial intelligence, IoT, fusion of technology, robotics

1. Introduction

The speed and measure of the changes coming about by the fourth industrial revolution are not to be ignored. These changes will bring about shifts in power, shifts in wealth, and knowledge. Only in being knowledgeable about these changes and the speed in which this is occurring can we ensure that advances in knowledge and technology reach all and benefit all.

The first industrial revolution started in 1760 with the invention of the steam engine. The steam engine allowed the transition from farming and feudal society to the new manufacturing process. This transition included the use of coal as the main energy while trains were the main means of transportation. Textile and steel were the dominant industries in terms of employment, value of output, and capital invested. The second industrial revolution began in 1900 with the invention of the internal combustion engine. This led to an era of rapid industrialization using oil and electricity to power mass production. The third industrial revolution started in 1960 and was characterized with the implementation of electronics and information technology to automate production. Under the old ways, making things involved screwing or welding lots of parts together. The fourth industrial revolution now involves computer generated product design and three dimensional (3D) printing, which can create solids object by building up successive layers of materials. (Prisecaru, 57-62) Table 1 shows a short presentation of the industrial revolutions from 1760 to the present.

Table 1. Main characteristics of industrial revolutions

Period	Transition Period	Energy Resource	Main Technical Achievement	Main Developed Industries	Transport Means
I: 1760-1900	1860-1900	Coal	Steam Engine	Textile, Steel	Train
II: 1900-1960	1940-1960	Oil Electricity	Internal Combustion Engine	Metallurgy, Auto, Machine Building	Train, Car
III: 1960-2000	1980-2000	Nuclear Energy Natural Gas	Computers, Robots	Auto, Chemistry	Car, Plane
IV: 2000-	2000-2010	Green Energies	Internet, 3D Printer, Genetic Engineering	High Tech Industries	Electric Car, Ultra-Fast Train

Source: Prisecaru, P. (2016). "Challenges of the Fourth Industrial Revolution." *Knowledge Horizons. Economics*, 8(1), 57-62. Web https://search-proquest-com.ezproxy.libraries.udmercy.edu:2443/docview/1793552558?accountid=28018.

Now a Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last century. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres.

There are three reasons why today's transformations represent not merely a prolongation of the Third Industrial Revolution but rather the arrival of a Fourth and distinct one: velocity, scope, and systems impact. The speed of current breakthroughs has no historical precedent. When compared with previous industrial revolutions, the Fourth is evolving at an exponential rather than a linear pace. Moreover, it is disrupting almost every industry in every country. And the breadth and depth of these changes herald the transformation of entire systems of production, management, and governance." (Schwab 2015)

2. Opportunities of the Fourth Industrial Revolution

There are similarities between four industrial revolutions and the five ages of civilization: the hunter and gather age, the agricultural age, the industrial age, the information worker age, and the emerging age of wisdom. Therefore, we may infer the opportunities of the fourth industrial revolution through the characteristics of these five ages of civilization presented by Steven Covey in his book 8th Habit. (2011, 12-17) First, the productivity of each subsequent age goes up fifty times over the preceding age. Consider for example, the increase in productivity of the industrial age over the agricultural age. Second, each subsequent age destroys many of the jobs of the preceding age. The information age is replacing the jobs created by the industrial age. Much of losses in our industrial age jobs have less to do with government policy and free trade agreements than they do with dramatic shift in our economy to the knowledge worker.

Third, in the first three ages of civilization manual workers produced most goods and services with their body, but in the last two ages, knowledge workers produce most goods and services with their mind. Knowledge workers are the link to a company's other investments. They provide focus, creativity, and leverage in using those investments to achieve the organization's objectives more efficiently. In other words, knowledge is an integral part of total management and cuts across functional boundaries. The main assets and primary drivers of the industrial age were machines and capital. People were necessary but replaceable. The management style of the industrial age simply does not work in the new economy. Management focused on motivating employees to perform the physical labor needed to produce the products and services. In the fourth industrial age, the challenge now is how companies can motivate their knowledge workers to release their human potential.

Leading researchers argue that the fourth industrial revolution will shape the future through its impacts on government and business. People have no control over either technology or the disruption that comes with the fourth industrial revolution. However, we can predict the opportunities that comes with the fourth industrial revolution: 1) lower barriers between inventors and markets, 2) more active role for the artificial intelligence (AI), 3) integration of different technics and domains (fusion), 4) improved quality of our lives (robotics) and 5) the connected life (Internet).

First, Chris Anderson predicts that the fourth industrial revolution is likely to reduce barriers between inventors and markets due to new technologies such as 3D printing for prototyping. (2012) For example, tissue engineers use rapid prototyping techniques to produce 3D porous scaffolds. The 3D printing technique fabricates scaffolds with a novel micro- and macro-architecture and these in turn help shape the new tissue as it regenerates. New technologies, like this 3D printing, allow entrepreneurs with new ideas to establish small companies with lower start-up costs. The entrepreneur can bring the product 'to reality' with 3D printing, without the traditional time constraints often encountered with traditional prototyping methods. The typical barriers to entry are removed from the marketing equation.

Second, increasing trends in artificial intelligence point to significant economic disruptions in the coming years. Artificial systems that rationally solve complex problems pose a threat to many kinds of employment, but also offers new avenues to economic growth. A report by McKinsey & Company found that half of all existing work activities would be automated by currently existing technologies, thereby enabling companies to save billions of dollars and to create new types of jobs. (Manyika et al. 2017) For example, driverless cars may modestly replace tax and Uber drivers, but autonomous trucks may radically transform shipping with far fewer jobs for truck drivers.

Third, innovative technologies will integrate different scientific and technical disciplines. Key forces will come together in "a fusion of technologies that is blurring the lines between physical, digital, and biological spheres." (Schwab 2015) This fusion of technologies goes beyond mere combination. Fusion is more than complementary technology, because it creates new markets and new growth opportunities for each participant in the innovation. It blends incremental improvements from several (often previously separated) fields to create a product.

Fourth, robotics can and will change our lives in the near future. Technically robots are automated motorized tools. They cook food, play our music, record our shows, and even run our cars. But we just do not see it because robots do not have a face we to whom we can talk or a butt we can kick. (Tilden) Consequently, robots have the potential to improve the quality of our lives at home, work, and many other places. Customized robots will create new jobs, improve the quality of existing jobs, and give people more time to focus on what they want to do.

Fifth, the Internet of things (IoT) is the Internetworking of physical devices. Typically, the IoT is expected to offer advanced connectivity of devices, systems, and services that goes beyond machine-to-machine (M2M) communications and covers a variety of protocols, domains, and applications. (Holler, et al. 2014) The interconnection of these embedded devices is expected to usher in automation in nearly all fields, while also enabling advanced applications like a smart grid, and expanding to areas such as smart cities. The revolution of the connected life came about thanks to the advance of the Internet. In 1969, the first data was transmitted over the Internet and linked two main frame computers. Now, the Internet is connecting personal computers and mobile devices. "By 2010, the number of computers on the Internet had surpassed the number of people on the earth." (Gershenfeld and Vasseur 2014, 28)

3. Challenges of the Fourth Industrial Revolution

“We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before. We do not yet know just how it will unfold, but one thing is clear: the response to it must be integrated and comprehensive, involving all stakeholders of the global polity, from the public and private sectors to academic and civil society.” (Schwab 2015) This paragraph gives us some idea of the challenges surrounding the fourth industrial revolution. The enormity of the challenges and the breadth required of the response are reinforced by Peters. (2017, 28)

The evolution of global industries in the fourth industrial revolution is both exciting and scary. Life will change with the 3D printing, the IoT, and the fusion of technologies. The fourth industrial revolution can raise income levels by allowing entrepreneurs to "run" with their new ideas. It will improve the quality of life for many people around the world. (Jee 2017, 255-256) Consumers are likely to gain the most from the fourth industrial revolution. “[T]echnological innovation will also lead to a supply-side miracle, with long-term gains in efficiency and productivity. Transportation and communication costs will drop, logistics and global supply chains will become more effective, and the cost of trade will diminish, all of which will open new markets and drive economic growth.” (Schwab 2015)

While there are many benefits of the fourth industrial revolution, there are several key challenges that lie ahead. At the same time, the revolution could yield greater inequality, particularly in its potential to disrupt labor markets. As automation substitutes for labor across the entire economy, the net displacement of workers by machines might

exacerbate the gap between returns to capital and returns to labor. The scarcest and most valuable resource in an era driven by digital technologies will be neither ordinary labor nor ordinary capital; rather it will be those people who can create new ideas and innovations. In the future, talent, more than capital, will represent the critical factor of production. People with ideas, not workers or investors, will be the scarcest resource. (Brynjolfsson, McAfee, and Spence 2014). In 2017 Bloomberg Global Business Forum, Apple CEO Tim Cook commented – "If I were a country leader, my goal would be to monopolize the world's talent." (Leswing 2017) The quest for talent will give rise to a job market that may become increasingly segregated. Low skilled and low wage jobs will be replaced by computers and digitization. The higher paid jobs requiring more skills are less likely to be replaced. This increased dichotomization can lead to an increase in social tensions. (Wolf 2015, 125)

In addition to the threat of massive job displacement under the ongoing fourth industrial revolution, there are a variety of challenges, such as cybersecurity, hacking, risk assessment, and others. (Lambert 2017) A higher level of alert is raised up when our lives become extensively connected to various devices, from our cell phones, cars, and light switches to our home security cameras, and smart speakers. One of the biggest trends in 2018 Consumer Electronics Show is that everything is connected and there is no going back. (Goode 2018)

Having everything attached to everything else in the IoT is going to monumentally increase the vulnerabilities present in any given network. With more knobs, connections and burden of connectivity, systems are going to have to be more secure. The fourth industrial revolution calls for greater cybersecurity. Companies will need to map their networks, assessing the risk and critical factors relating to security. Such an assessment should examine accessibility to systems, such as possible threats from internal sources, from disgruntled employees to internal human error, and external sources including hackers and cyber terrorists. Further, companies must assess risk and determine if these risks will be accepted, reduced, shared via insurance or other vehicles, or rejected. Risks can be from both intentional and unintentional sources. If your house lights turn on via your computer, but you have lost the wireless connection to your house, you may be living in the dark. Unintentional sources of risk can include error s promulgated by company employees or nature itself such as storms causing disruptions in connectivity. Individuals too should assess their risks, just as companies will. It may come that the Internet will have more information about individuals than the family, friends, and colleagues of the individuals. Certainly, the ability of data to be processed and the speed in which it can be done surpasses the ability and speed of individuals. It is necessary to examine the value of processes and assets, from machinery to intellectual property, ensuring that there is insurance, security measures and that any vulnerability is sufficiently identified.

When we consider the changing nature of security threats - from employees connecting personal devices to company networks to brute force attacks from hackers - the situation is further complicated. The sophistication in risk identification and neutralization has to change with it. While data can be lost or stolen by employees, either inadvertently or intentionally, the biggest attacks in recent years have been external malicious attacks, collectively or commonly referred to as hacking. These could be hacking to move money around, such as when Russian hackers stole $10 million from Citibank customer accounts, Internet terrorism, such as the $2 million damages caused to WeaKnees.com over a six week botnet attack, Internet pump-and-dump fraud where hackers take advantage of manipulating stock prices, or software piracy which is estimated to cost over $50 billion a year. (Romney and Steinbart 2017, 159-167)

The fourth industrial revolution is more than just technology-driven change. Rather, it is powered with disruptive innovation to positively impact our core industries and sectors, such as education, health and business. In education, with the previous industrial revolutions, the focus of education changed. With the first industrial revolution, education was focused on standard modes of learning, such as the McGuffey reader. With move toward mass production in the second industrial revolution and standardized testing. Education is service oriented and with the move into the third industrial revolution we come to see students under a customer learning model. Now in the fourth industrial revolution, technologies really blur the lines between physical, digital and biological spheres. Disruptive innovation makes its way into higher education in which it redefines the conventional ways universities deliver their content to students. New modes of curriculum and teaching arise, and the focus changes from modes of teach to modes of learning. Alternative curriculums are being constantly developed. Disruptive innovation also reshapes how businesses operate. Thinking has really moved outside of the box. New markets are created and new products are defined. Netflix is competing with traditional television. Taxis must compete against Uber and Lyft. These offered similar product offered to customers in new ways. You could watch your shows from your home or get a ride somewhere. With the Airbnb alternative overnight accommodations are competing against traditional hotels and motels. (Jules 2017)

Last, in an era featuring AI, automation, robots, and genetic engineering, we have new ethical concerns emerging. Lots of debates have arisen in genetic engineering about the use of tools and research technologies. On one hand, preventing genetic disease by genetic engineering is desirable. On the other hand, what guidelines, or regulation, or ethical boundaries we should establish in order to prevent the over manipulation genetics for desirable traits? Is there such a thing as over manipulation? Infused with artificial intelligence and machine learning ability, robots have become smarter and more autonomous, but they still lack an essential feature - the capacity of moral reasoning. This limits their ability to make good or ethical decisions in complex situations. Further, the most critical question is whose moral standards should robots inherit. Moral values differ greatly from individual to individual, across countries, religions, and ideological boundaries. Uncertainty over which moral framework to adopt underlies the difficulty and limitations to ascribing moral values to artificial systems. (Al-Rodhan 2015)

4. Conclusion

We have recently entered the dawn of the fourth industrial evolution, in which it differs in speed, scale, complexity, and transformative power compared to previous revolutions. This article has examined the opportunities and challenges that are likely to arise as a result of the fourth industrial revolution. As industrial revolutions have moved from the mechanization of production in the first industrial revolution, to the mass production in the second, and then to the automation of production in third, the standards of living for most people around the world have greatly improved. Undoubtedly, the capability of advancing technology coming forth from the latest industrial revolution has the potential to make even bigger and greater improvements on every aspect of our lives changes than the first three industrial revolutions summed together.

On the other hand, there are a variety of challenges stemming from the fourth industrial revolution to overcome. From income inequality to cybersecurity, the benefits of the fourth industrial revolution have obstacles that must be harnessed, directed and overcome, such as income inequality, cybersecurity, and ethical dilemmas. Technology and advancements in science drive transformation around the world. They create ripple effects on societies, institutions, and economies. They will transform the ways in which we live, work, and interact with one another. Understanding these new technologies and their disruption potential is critical for all nations and especially developing countries.

The fourth industrial revolution may affect society and economy in a variety of ways. (Prisecaru 2016) First, a large portion of people around the world are likely to use social-media platforms to connect, learn, and change information. Second, a variety of innovative producers and competitors will have easy access to digital platforms of marketing, sales, and distribution, thereby improving the quality and price of goods and services. Third, consumers will be more and more involved in the production and distribution chains. The main effects of this revolution on the business environment are the impact it will have on consumer expectations, product quality, the move toward collaborative innovation, and innovations in organizational forms.

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