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Fourth Industrial Revolution: Technological Drivers, Impacts and Coping Methods

LI Guoping[1], HOU Yun[2], WU Aizhi[3]

(1. *School of Government*, *Peking University*, *Beijing* 100871, *China*; 2. *NUS Business School*, *National University of Singapore*, *Singapore* 117592, *Singapore*; 3. *Library*, *Peking University*, *Beijing* 100871, *China*)

Abstract: The world is marching into a new development period when the digital technology, physical technology, and biological technology have achieved an unprecedented development respectively in their own fields, and at the same time their applications are converging greatly. These are the three major technological drivers for the Fourth Industrial Revolution. This paper discusses the specific technology niches of each kind technological driver behind the Fourth Industrial Revolution, and then evaluates impacts of the Fourth Industrial Revolution on global industrial, economic, and social development. At last this paper proposes possible measures and policies for both firms and governments to cope with the changes brought by the Fourth Industrial Revolution.

Keywords: Fourth Industrial Revolution; technological drivers; global impacts; firm-level adjustments; government policies

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1 Introduction

There have been three major technological advances by now. The First Industrial Revolution started in the Great Britain. It introduced hydraulic and steam machine to factories. The Second Industrial Revolution achieved the separation of components and the assembly of products based on labor division. It took people to an age of affordable consumer products of mass production. The Third Industrial Revolution featured a wide application of the electronic and information technology and the continuous automation of manufacturing process.

Today we are standing on the cusp of the Fourth Industrial Revolution. It is distinct from the first three industrial revolutions and it is characterized by the widespread application of cyber-physical systems in the manufacturing environment (Liu and Xu, 2017). The fundamental background of the Fourth Industrial Revolution is the deep integration of intelligence and networking system (Zhang, 2014). At the 2011 Hanover Fair, the German Government put forward the concept of Industrial 4.0, and later in 2013 released the Recommendations for Implementing the Strategic Initiative Industry 4.0. This action posed great impacts to the whole world and pulled over the curtain of the Fourth Industrial Revolution.

The term Fourth Industrial Revolution is often understood as the Cyber Physical Systems (CPSs) (Drath and Horch, 2014; Mosterman and Zander, 2017). In the North America, the Industrial Internet (Leber, 2012; Xu *et al.*, 2016), which was put forward by the General Electric, holds similar technological idea with CPSs. They are both enabling technologies which create the integration of the virtuality and the reality (Jopp, 2013), a network where intelligent objects communicate with each other. This popular understanding causes some confusion about the essence of the Fourth Industrial Revolution. In fact, CPSs are not equal to the Fourth

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Corresponding author: LI Guoping. E-mail: lgp@pku.edu.cn
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Industrial Revolution, rather, one part of the Fourth Industrial Revolution.

The Fourth Industrial Revolution is not limited to industrial production. It is manifested in all aspects of the society, including technology (Xu *et al.*, 2013; Lalanda *et al.*, 2017; Theorin *et al.*, 2017), production (Kube and Rinn, 2014; Webster, 2015), consumption and business (Sommer, 2015; Gentner, 2016; Ivanov *et al.*, 2016), and it is influencing every field of human life (Home *et al.*, 2015; Singer, 2015; Qin and Cheng, 2016; Sackey and Bester, 2016; Weiss *et al.*, 2016). So far, we have not reached a concrete understanding about this technological trend. This paper aims at taking a first step at gaining a comprehensive understanding about the Fourth Industrial Revolution and how to cope with it. This work can thus be useful in clarifying the basic concepts about the Fourth Industrial Revolution as well as thought-provoking for further research on related topics.

The Industrial 4.0 strategy has brought great opportunities for the development of China's strategic emerging industries as well as the high technology industries. It corresponds with China's important policy about the 'Made in China 2025' plan. Learning from Industry 4.0 can help to achieve China's development goals (Ding and Li, 2014; Pei and Yu, 2014; He and Pan, 2015) in ten key sectors and nine tasks identified as priorities for future economic development. Meantime, Internet, new energy, new materials, and biotechnology are creating increasing industrial capacity and markets in a fast pace. The manufacturing sector is being upgraded into a higher level. The literature review on technological drivers, impacts and coping methods of the Fourth Industrial Revolution can not only help us understand the worldwide economic and social development trends but also provide suggestions to foster the building of global competence for China's manufacturing industry.

2 Technological Drivers

The developments of digital, physical, and biological technologies are three fundamental technological drivers of the Fourth Industrial Revolution. At its heart, the Fourth Industrial Revolution is driven by enduring new breakthroughs in these three areas within their respective areas as well as a great fusion with each other. These three technological drivers can be summarized in Table 1. While the major technological drivers for the Third Industrial Revolutions came from the hardware field, technological drivers for the Fourth Industrial Revolution mainly originate from the software field.

Table 1 Technological drivers for the Fourth Industrial Revolution

Technology drivers	Fields
Digital	The Internet of Things (IoT)
	Artificial intelligence and machine learning
	Big data and cloud computing
	Digital platform
Physical	Autonomous Cars
	3D printing
Biological	Genetic Engineering
	Neurotechnology

2.1 Digital

Digital technology is the fundamental driving force for the Fourth Industrial Revolution. Nearly all the innovations and advances coming with the Fourth Industrial Revolution tide are made possible and enhanced through digital power (Schwab, 2016). This technology cluster is making the whole world a digitally connected one. Digital technology is mainly manifested on four aspects, namely the Internet of Things, artificial intelligence and machine learning, big data and cloud computing, and digital platforms.

The basic idea of the Internet of Things (IoT) is to make pervasive presence of things around us communicate with each other to achieve common goals. The major features of IoT are the integration of various identification and tracking technologies, such as wired and wireless sensors and actuator networks, enhanced communication protocols, and distributed intelligence for smart objects (Atzori *et al.*, 2010). The IoT technology can identify, locate, track as well as monitor subjects; it can even trigger the corresponding event autonomously and in real-time (Sarma and Girão, 2009). Now the products of IoT play an increasingly important role in smart homes, traffic logistics, environmental protection, public security, intelligent fire control, industrial monitoring, personal health and other fields.

Accompanying the advances of calculation speed, the expansion of storage capacity and the progress of network technology, artificial intelligence (AI) has developed tremendously. AI is a technology that has been used to simulate the thinking and behaving process (such as studying, reasoning, thinking and planning) of human beings (Pfeifer and Scheier, 2001). To enable the computer to achieve high-level application, it manufactures intelligent machines or systems that are similar with the human brain. This technology starts in the 1990s, but not until recently does it gain rapid progress. Machine learning is one of the most active niche within the AI field. Machine learning provides the computer with the ability to find hidden insights without exactly being programmed beforehand. Using algorithms that can iteratively learn from existing data, machine learning enables computers to adapt and make reliable, repeatable decisions when exposed to new data. Nowadays, machine learning has been widely applied to text-based sentiment analysis, biometric identification, security market analysis and image recognition, *etc*.

Big data and cloud computing is the third aspect of digital technology. With the development of sensors, the improvement of storage capacity, and the progress of machine learning, the volume of data is roaring. The most widespread definition of big data is the '4V' theory: big data comes from a variety of resources and contains a great volume of data; that big data streams in at a high rate and must be handled timely implies its velocity; big data comes in a variety of formats; big data has to be cleaned to ensure the veracity (Fernández *et al*., 2014). While big data analysis may entail a huge commitment of hardware using the old hardware storage method, the emergence of cloud computing offers a promise to make it small (Purcell, 2014). Except for big data analysis, cloud computing can also allow leasing of IT capabilities, whether they are infrastructure, platform, or software applications, to provide subscription-oriented services in a pay-as-you-go model (Buyya and Sukumar, 2011).

Except for the aspects discussed above, a significant innovation enabled by the network effects of digitization is the platform. On a global scale, technology-enabled platforms make what is now called the on-demand economy (referred by some as the sharing economy) possible. Digital platforms have dramatically reduced the transaction and friction costs incurred when individuals or organizations share the use of an asset or provide a service. These platforms, which are easy to use on a smartphone, convene people, assets, and data, creating entirely new ways of consuming goods and services. As is known to all, Uber, the world's largest taxi company, owns no vehicles; Facebook, the world's most popular media owner, creates no content; Alibaba, the most valuable retailer, has no inventory. These platforms are rapidly multiplying to offer new services ranging from laundry to shopping, from chores to parking, from home-stays to long-distance rides. These platforms work as information brokers to match supply and demand in a very accessible (low cost) way, provide consumers with diverse goods, and allow both parties to interact and give feedback.

2.2 Physical

Physical technology, which has visible achievements, rapid applications, and broad prospects, is probably the best-known technology drivers of the Fourth Industrial Revolution, since it has the most direct impacts on daily lives. There are two primary physical manifestations: autonomous vehicles and 3D printing.

The invention of autonomous (also called self-driving, driverless, or robotic) vehicles make it possible for cars to operate without manual manipulations. It uses traditional vehicle production techniques along with advanced sensors, adaptive cruise control, active steering, brake by wire, GPS navigation, lasers and radar. AVs have the potential to fundamentally alter transportation systems by averting deadly crashes, providing critical mobility to the elderly and disabled, increasing road capacity, saving fuel, and lowering emissions (Fagnant and Kockelman, 2015). Also, autonomous vehicles, as one of the most innovating fields in industry production, will set up a new fire in economic growth. According to estimation, Economic benefits brought by autonomous vehicles will accelerate over time to over £ 51×10^9 in 2030 in UK (KPMG, 2015).

3D printing, or additive manufacturing, is a technology that creates a physical object into a three-dimensional shape by printing layer upon layer from a digital 3D drawing or model, while the existing subtractive manufacturing technology produces a desired shape by removing layer by layer from a piece of material. The realization of 3D printing starts with a 3D model, which is a virtual design of the object that you want to make. 3D technology encourages innovations with an unprecedented design freedom. There is no need for any specific machines for manufacturing, which avoids extra costs and leads times (3D Printing Industry, 2014). For the moment, applications are confined mainly in the automotive, aerospace and medical industries. However, it is stretching to more fields like arts, sculptures, design and architecture. One interesting example is 3D printing food, like chocolate and sugar. Now people are even experimenting on 3D printing of meat at the cellular protein level (3D Printing Industry, 2014).

2.3 Biological

Major breakthroughs of biotechnological development that drives the Fourth Industrial Revolution are centered around genetic technology and neurotechnologies.

Genetic study is always one of the vital branches of biological research. With the advancements in computing power, considerable progress has been achieved in reducing the cost, increasing the ease and efficiency in genetic sequencing, activating and editing. It took more than ten years, at a cost of 2.7×10^9 USD to complete the Human Genome Project. Today, a genome can be sequenced in a few hours with less than 1000 USD (Ho, 2000). On the treatment side, IBM's Watson supercomputer system can make personalized treatment plans for cancer patients by comparing the past data of patients, treatments and genetic information with update medical knowledge in just a few minutes. Also, progress in genetic engineering helps people obtain higher agricultural yields by enhancing the robustness, effectiveness and productiveness of crop breeding.

Neurotechnology can help us monitor brain activity and look at how the brain changes and interacts with the outside world. The goal of neurotechnology is to confer the performance edge of animal systems on robotic machines (Ayers *et al*., 2002). It is estimated that by 2008, the neurotechnology industry has reached a value over 144×10^9 USD (MaRS Advisory Services, 2009). With the efforts of research institutions and the combination of information and artificial intelligence technology, applications in brain sciences have been increased gradually. There are more and more neuroimaging and neurostimulation devices coming into the market; though in its relative infancy, neurotechnology is enhancing education, communication, intelligence, cognitive ability, disease treatments, and the military (Potomac Institute, 2014). For individual users, neurotechnology application can now help paralyzed people control prosthetic limbs or wheelchairs 'with their minds' (Hochberg *et al*., 2012). Neurofeedback, the technology to monitor brain activity in real time, offers countless opportunities to help fight addictions, regulate food behavior, and improve performances ranging from sports to the classroom. As for medical treatment, being able to collect, process, store and compare large amounts of brain activity-related data allow us to improve diagnosis and treatment efficiency of brain disorders and mental health-related issues. In addition, the next generation of computers, whose design has been triggered by brain science, are able to reason, predict and react just like the human cortex.

3 Impacts of Fourth Industrial Revolution

3.1 Industrial manufacturing

3.1.1 Informatization of manufacturing process

The Fourth Industrial Revolution brings the informatization of the manufacturing process and greatly change the way manufacturing industry works. New manufacturing concept emphasizes equipment dispersion and control independence as well as intelligent equipment connection via networks. Take the Cyber Physical Systems (CPSs) as an example, this system utilizes technical means to realize effective control on manufacturing in real time and with a broad scope, thereby making an organic combination of human resource, machinery, and raw materials (Wang *et al.,* 2015). With an open, active, dynamic and flexible communication system equipped with information technology, this new production model has a capability to maximize the optimization potential, increase production efficiency as well as encourage innovation ideas. A fortune 500 consumer goods company once drastically increased its production speed of the diaper production line by adopting a new technology. Coordination problems then came when a mistake in production procedure would affect the entire production line. Afterward, this company worked with IMS to upgrade the monitoring and control systems of the diaper production line. Unmanned operation upgrading through machine learning was then achieved, which made the entire production line more intelligent. This improvement in production efficiency increased the company's revenue by 4.50×10^8 USD.

3.1.2 Customization of products

Instead of massive production, manufacturers are putting more and more emphasis on product customization. The trend reveals that more and more consumers are getting tired of uniformed products, and they are increasingly chasing after customized ones. Factories are forced to take measures to cater to the diverse and preferences of individual customers. Thus, many industries are introducing new technologies with the support of big data and artificial intelligence to adjust their design, promotion, delivery as well as customer service system (Monostori, 2014). This new mode of production could totally subvert the current value chain from the production side to the design and service side. In this way, customers will be allowed to adjust order specifications not only before the order submission, but also during design, manufacturing, assembly, and testing.

Products, therefore, transformed from being massed produced to customize. Qingdao Red Collar Clothing Co., Ltd. can be regarded as a good illustration of this transformation (Wang *et al*., 2016). This garment factory is now using big data technology to progress seamlessly from a customized order submission to the production process. Customers will now receive their orders within one week of order submission as opposed to three to six months in the traditional model. In 2014, through such large-scale customized manufacturing, this garment firm got the capability to cover 2000 different types of customized order and achieve 150% in growth with none-inventory.

3.1.3 Networking of production lines

The networking of production lines is also a critical change brought by the tide of the Fourth Industrial Revolution. Once intelligent manufacturing becomes a mainstream concept, the manufacturing industry can thus foster the integration of production, marketing and customer service. This would push a product-orientated industry into a service-centered direction. This new way of doing business brings more opportunities for manufacturing firms to succeed in the great technology transformation tide.

Shenyang Machine Tool Co., Ltd (SMTCL) began the preparation of overhaul from the traditional mode to the innovative mode as early as 2010. To do this, SMTCL started a new company called UNIS. This customer oriented company provides overall services including but not limited to product sales, financial services, productivity lease, machine repurchasing and remanufacturing. SMTCL finished building up a comprehensive network amongst its production lines and transformed to an innovative product sales model.

3.1.4 Business mode adjustment

Technology leaders, bringing advanced new products, have greatly changed customers' expectation about how products ought to be. This expectation adjustment will compel following companies to alter the present business mode and launch strategical adjustment to rise to this challenge. These adjustments may include extending the production chains and enhancing service capability. If a company could not respond to the market change timely and positively, it is likely to suffer in the future competition, and even to be in the face of collapse.

The business mode adjustment is by no means an easy one. It is costly as well as painful. There are a lot of fixed costs and investments involved. Meanwhile, if the current industries bent on the pursuit of efficient transformation, they not only have to solve the problem that existing fixed are gradually losing profit, but also need more fund to support new developments and investments in the future, which is a great challenge and may result in a huge shock.

3.1.5 Shortage of innovative human resource

With increasing pressure to cater the new customer demands and to employ the advanced technologies brought by the Fourth Industrial Revolution, timely innovation as well as supporting facilities are in want. This is calling for more and more qualified human resources that can catch up with and participate in this trend. Currently, efficient and high-quality skills training as well as innovative talent cultivation are getting more and more urgent since innovative human capitals are still in short supply.

3.2 Economic development

3.2.1 Great development opportunity

The advances of three main technology drivers in the Forth Industrial Revolution provide a broader prospect for future economic development. Since 1995, the IT industry has accounted 20 percent of US GDP growth; the value added by IT service in OECD countries grew by 115 percent from 1996 to 2008 (OECD, 2011); globally the IT industry accounted for 7.1 percent of GDP in 2010 (Shapiro and Mathur, 2011).

It can be deduced that the breakthroughs in the Fourth Industrial Revolution can cause profound effects on global economy. Also, the Fourth Industrial Revolution can strengthen the connections between producers and consumers, regulate economic fluctuations, minimize periodic fluctuation, thus accelerating the development of global economy in a more steadier approach.

3.2.2 Acceleration of economic restructuring

The Fourth Industrial Revolution could affect nearly every industry. The benefits are obvious when the conventional manufacturing industries use updated technologies to nurture new business with innovative ideas. At the same time, we may also witness the fall-down of firms or industries lack of innovation capability. Consequently, a restructure of the whole economy is expected.

In China, the developments of new businesses supported by network, big data, and e-commerce technologies are considerably rapid. According to the National Bureau of Statistics of the People's Republic of China, in 2012, the online retailing trading volume reached 1.25×10^{12} yuan (RMB), occupying 6.1% of the gross trading volume. In 2015, this two variables reached 3.88×10^{12} and 11%. Online retailing has become an irreplaceable driving force for current economic growth in China.

Overall, the development of the Fourth Industrial Revolution can have benefits on the transformation of economic growth further into a new era, in other words, the tendency of knowledge operation growth, innovation-driven growth, resource regenerative growth and connotation development growth.

3.2.3 Increase in production efficiency

Technology, different from conventional factors of production such as land or labor force, has non-exclusive and instant diffusive features. The IoT system overcomes the limitation of physical carriers, saving the cost of searching and reducing information asymmetry. Besides, sufficient evidences indicate that the input of information and intelligence can greatly save natural resources: the more advanced digital technology is involved, the fewer resources are consumed. Finally, the intelligent production can incredibly save the human resource and socially necessary labor time, reducing the consumption on repeating the essential work. The Fourth Industrial Revolution can thus save the resources, improve the production efficiency and eventually benefit the profits in economic growth.

3.2.4 Shifting of Global Value Chains

The Fourth Industrial Revolution will further accelerate the return of manufacturing jobs from developing countries back to developed countries as a policy response to the 2008 financial crisis (Daper, 2013).

The trends of outsourcing and offshoring have dominated the world trade system for quite a while. The development of transnational corporations has been associated with the growth of integrated international production network through foreign direct investments to other countries (Sako, 2005). FDI flows promote global economic convergence and integration, as well as bring great growth opportunity for many underdeveloped countries. The importance of global production chains is obvious: the trade in intermediate inputs now represent more than half of the goods imported by OECD economies and close to three-fourths of the imports of large developing economies, such as China and Brazil (Ali and Dadush, 2011).

Now this global value chains, initially created by foreign direct investments, offshoring, and outsourcing, are undergoing a 'turning back to the past' geography shifting. Developed countries, especially the US, are calling the return of manufacturing sector as a new stimulus to economic growth. The US president, Donald Trump, keeps emphasizing that he will take measures to bring overseas manufacturing jobs back to the US. This policy would be supported not only by the shrinking labor cost gap between the developed and the developing but also by the Fourth Industrial Revolution. The Fourth Industrial Revolution, by highly increasing the productivity, replacing labor with capital, and leading to an innovation-driven manufacturing, gives more economic priorities to countries equipped with high technology in manufacturing. This will lead to a shift of global value chains. After all, the direction of this shift is determined by the forces both from all countries that participate in the chains, which may differ from industries to industries.

3.3 Employments and social equality

3.3.1 Creation of new positions

The Fourth Industrial Revolution is accompanied by a capitalization effect in which the demand for new goods and services increases, thus leading to the creation of new occupations, businesses, and even industries. Take the mobile application industry as an example. This industry only began in 2008 when Steve Jobs, the founder of Apple, let outside developers create applications for iPhone. With its rapid development, according to the market researcher App Annie, the mobile app market reached 1.89×10^{12} USD in 2015, with an average growth rate of 114 percent from 2014 to 2016.

3.3.2 Broadening of social inequity

With the rapid progress of robots and algorithms, the whole economy shows a tendency to substitute capital for labor. The great beneficiaries of the Fourth Industrial Revolution are the providers of intellectual or physical capital: the innovators, the investors, and the shareholders. This could explain the rising wealth gap between those who depend on their labor and those who own capital. As author and Silicon Valley software entrepreneur Martin Ford predicts, a hollowing out of the entire base of the job skills pyramid would lead to growing inequality social tensions unless we prepare for these changes today. Among the 29 global risks and 13 global trends identified in the Forum's Global Risks Report 2016, the strongest interconnections occur between rising income disparity, unemployment or underemployment, and profound social instability (Schwab, 2016).

The concentration of benefits in just a small percentage of people is also exacerbated by the so-called platform effect, in which digitally-driven organizations create networks that match buyers and sellers of a wide variety of products and services and thereby enjoy increasing returns to scale. The consequence of the platform effect the dominance of markets by a few powerful platforms, such as Alibaba. It does enable consumers to obtain more convenience and higher value with lower costs. When it comes to social inequality, a loss of social welfare occurs large platforms are driving out most of the small-size players. To prevent the over-concentration of value and power, we have to find ways to balance the benefits and risks of digital platforms (including industry platforms) by ensuring openness and opportunities for collaborative innovation.

3.3.3 Generation of structural unemployment

Many work categories, particularly those that involve repetitive manual labor, are increasingly being automated. More will follow as computing power continues to grow exponentially. Technology rumors even indicate that professions that involve creation and analysis, such as lawyers, financial analysts, doctors, journalists, accountants, insurance underwriters or librarians, may be partly or wholly replaced. One of the most creative professions, writing, is already under threat with the advent of automated narrative generation. Sophisticated algorithms can create stories in any style that appeal to different audiences. These contents created by algorithms could be quite human-sounding. A quiz conducted by New York Times showed that it was impossible for a reader to tell whether one piece of story was written by a real writer or by a robot.

So far, all the evidences show: The Fourth Industrial Revolution seems to be creating much fewer new positions than previous revolutions. An estimate from the Oxford Martin Program on Technology and Employment proposed that only 0.5% of the US workforce is employed in industries that did not exist at the turn of the century, a much more lower percentage than 8% of new jobs created in new industries during the 1980s and the 4.5% of new jobs created during the 1990s. This is further corroborated by a recent US Economic Census, which sheds some interesting light on the relationship between technology and unemployment. It shows that innovations in information and other disruptive technologies tend to raise productivity by replacing existing workers.

4 Coping Methods Toward Fourth Industrial Revolution

Great technology advance can sometimes be disruptive to the incumbent firms as well as to existing society structure. To ensure a sustainable growth, not only the firms but also the governments should take measures to cope with the challenges and seize the opportunities that the Fourth Industrial Revolution brings.

4.1 Coping method for firms

4.1.1 Manufacturing mode change

The traditional manufacturing tools and methods will be eliminated under the fierce pressure for high efficiency and customized products during the Fourth Industrial Revolution. Firms have to change their present mass and cost-saving production mode to adopt intellectual, informative, digital and automatic production mode. Intelligent, connected and flexible factories will become dominant in future industrial production. This new production mode can use data interaction technology as a joint between equipment and plants, in the meantime, to achieve the automation of production process and monitoring adjustment by watching scattered production bases.

With the assistance of intelligent manufacturing system, enterprises will acquire the capability to produce personalized products in large-scale with great efficiency and flexibility. This ensures low cost and fast speed to put products onto the market. At the same time, enterprises are supposed to reduce the uncertainty in the producing process gradually, as to make adjustment to the market and turn the Reactive Manufacturing into the Predictive Manufacturing.

4.1.2 Strategic adjustment

The advanced technologies that the Fourth Industrial Revolution brings have induced the pursuit of personalized production and consumption of consumers as well as the integration of online and offline network. Faced with rapid changes, firms must escalate intellectual manufacturing system to improve innovation ability, production performance as well as guarantee the safety and reliability of network data to maintain peculiarity and innovation.

Under a fiercely competitive environment, enterprises should also change their attitudes towards competition. Talented manufacturing companies are inclined to go directly to the net of the global market platform; they organize reasonably the layout of the production, logistics, and consumers to strive for the leading position in the competition. The ideal model should be that consumers all over the world pass the demands on the Internet to the intellectual robot center. The intellectual center will guide the enterprises to make arrangement of production. Consumers then supervise the whole producing process including design, production and transportation on the Internet. Under the condition of Industry 4.0, global market is becoming more and more unified. The sufficiency of information and choices not only opened a vast market but also put firms to a new challenge stage; Excellent enterprises must own a global perspective layout to survive in the fierce competition.

4.1.3 Organization reform

Comparing to those manufacturing tycoons that possess core technology, those traditional firms are at short of efficiency, flexibility and humanity. A thorough reform on organization structures would help for late-comers to catch up.

The future organization structure of enterprises is similar with that of special forces featuring great flexibility. Different types of groups, such as research group, production group, selling group as well as service group, would become fundamental units of the firm. These groups are responsible for their respective segments independently. The senior management team makes strategic decisions in the firm level while distribute some of the decision power to different divisions, making a balance of centralization and decentralization. *Mandatory Management* will transform into *Cooperate Management*. Only by this reform can enterprises function with efficiency, flexibility, and full of humanized atmosphere.

4.1.4 Flexible human resource management

Under the stimulus of the Fourth Industrial Revolution wave, most firms will increase the proportion of R&D staff. Human resource recruitment plan and working content design, to satisfy this demand, will encounter a significant change. Some firms with high intellectual level could possibly eliminate specialized human resource departments.

Labor markets are changing globally. As noted before, positions are being replaced rapidly with artificial intelligence technology and intelligent manufacturing technology. However, man and artificial intelligence are not completely standing against each other. Managers should enhance staff training and help them improve their capabilities so they can cooperate their job and work with those intellectual technologies.

4.2 Coping methods for governments

4.2.1 Implementation of new development plan

The experiences of Britain and the United States proved that every industrial revolution would change the world hierarchy in any way. Considering the profound influences of the Fourth Industrial Revolution on manufacturing, economic growth, social developments as well as international trade, governments from different countries and districts should take actions to positively cope with this trend. For developing countries, it could be an opportunity to achieve leapfrog development during this time. It's also a chance for the developed countries to leave their rivals far behind. Many counties have already made national strategies to overwhelmingly respond to the Fourth Industrial Revolution.

In 2008, Germany put forward the concept of Industry 4.0 featuring intellectual production. The German government considers the Internet of Things and the servitization of manufacturing as a symbol of the Fourth Industrial Revolution's arrival. Germany has already listed Industry 4.0 into the High-Tech Strategy 2012.

The European Union said they would be devoted to improving high-tech innovation ability, reforming the innovation system and giving priority to the development of six key industries in the future. In 2014, the Japanese government revised the Revitalization Strategy of Japan. In this revision, Japan confirmed the important role of industrial revitalization and IT Industry for their development.

In 2015, China officially released the strategy report made in China 2025. This report embraces the mainline of a combination between advanced information technology and industrial manufacturing. It also emphasizes the so called ‘four reforms, five projects, and ten crucial areas’. Its purpose is to change the current situation which called a ‘big but not strong’ manufacturing industry in China. By implementing this strategy, the Chinese government seeks to build a strong manufacturing nation with productivity and creativity in the coming 10 years.

4.2.2 Acceleration of infrastructure building

The convenient, efficient, customized production and consumption modes in the Fourth Industrial Revolution are based on digitalization, informatization, intelligence and network. The improvement of the intelligent level of public facilities and network server infrastructure is very critical.

Germany considers intelligent manufacturing and intelligent factory as the major development goals. They make great efforts to the developments of the Internet of goods, service networks and smart city to compensate for the shortage of usage of the information technology in manufacturing industry. The US has been trying to activate the traditional manufacturing via software services. With the silicon-valley model, the US obtained an edge in software technology over the world. The software industry has also become the basis of connecting the virtual world with the real world. To complete the Internet of Things of intelligent industry, European Union is committed to upgrading the network infrastructure. The EU will invest 60 billion euros to each member country for the construction of the Smart Grid by 2020 (European Commission, 2016).

4.2.3 Development of high-end human capital

Now the Fourth Industrial Revolution has already spread out high-tech competition to the whole world. This is not only the competition between enterprises but also between nations. Competition between countries will be completely shifted from hardware industry technology or production costs to the competition in frontier scientific research, software industry and innovative ideas. Top talents are now the most competitive development resources.

In many cases, technical innovations have disruptive effects on the industry chain, or even the whole field of production and consumption; it can guide capital flows, and bring huge economic as well as social benefits. Some of them can also affect national military and security strategies. It is high time for the governments to take measures to accelerate the elimination of extensive manufacturing mode which depends on capital and labor input, while make the knowledge-intensive, technology innovation intelligent manufacturing the dominance of economic growth. Governments should also launch public policy schemes for the protection of technological innovation and intellectual property. Also, governments should pay attention to cultivate and attract top talent for the implementations of the Science and Technology Strategy and Talent Strategy.

4.2.4 Overall industry update

People are paying more and more attention to efficiency, greenness and differentiation in daily life in the Fourth Industrial Revolution era. The majority of the population pursue the integration of competition, environmental protection, and energy saving, as well as humanization and differentiation.

Although the government do not take direct charge of technology development and product manufacturing, a responsible and far-sighted government should guide technology research and enterprise production through a series of measures including laws, policies, tax, governance, rewards, punishments, and cooperation properly. The government is suggested to play a catalytic and supervisory role in these processes and at the same time, accelerate and guarantee proper industry transformation

4.2.5 Control of social inequity

Every industrial revolution creates new positions. It is majority of the population accompanied by structural unemployment problem with a portion of the existing industrial jobs being replaced. The income from replaced jobs will flow to new technical jobs which contribute more to production. Meanwhile, the increased social wealth may continue to widen the society income gap, leading to social problems which require the government preparation.

The government should require and encourage enterprises to organize skill training courses and assist them to adapt to new technologies. If the new technology learning obstacle is too difficult for the worker to overcome, the government can take measures to guide and encourage labor mobility between industries in case of severe social problems. For instance, workers in old manufacturing industries can be transferred to pension industry or housekeeping service industries.

To solve the increasingly serious income distribution problem, the government should also take possible measures to maintain a proper ratio of the middle class in society and avoid income polarization. Specifically, governments ought to pay more attention to ensure the equal education rights. Besides, enhancing the wages of middle class such as public servants and professional technical personnel, utilizing the leverage effect of tax and social security are also possible solutions.

5 Conclusions

This paper aims to offer an comprehensive understanding of the Fourth Industrial Revolution. The uniqueness about the Fourth Industrial Revolution lies in three aspects. Firstly, it involves three aspects of technology advances and the integration of them. Secondly, via the Internet, technological fruits are spreading to every corner of the world in a rapid pace and relatively low costs. Thirdly, the influences are broad enough to reach every aspect of human life. By clarifying the fundamental features, impacts and possible coping methods of the Fourth Industrial Revolution, this paper has progressed one step ahead for people to understand this trend better.

Limitations of this study and possible future studies are discussed as follows. Firstly, this study tries to picture a holistic of the overall development trend thus neglecting detailed evidences or points overall development the specific areas of the Revolution. Future studies could explore the respective industries, such as the Internet and the manufacturing, to examine the real effects of this revolution. Secondly, by stressing the introduction of software industries, digitalization and the decline of communication costs, this study does not reach out an integration of the role of geographical factors such as resources, locations, agglomerations. Future studies regarding the new technology progress and new international trade pattern, new location choice pattern and new industrial clusters are in want. Thirdly, we only propose an analytical framework of the Fourth Industrial Revolution. Empirical evidence is absent here. More empirical analysis should be conducted in the future for us to understand this revolution more thoroughly.

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