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Evaluation of the Theory of the 4th Industrial Revolution[1]

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Abstract As of the end of August 2017, there were 392 academic articles for 4th Industrial Revolution in Korea. Is the vigorous discussion on the 4th Industrial Revolution in Korea normal? We checked the main theories on this topic by existing theories and responses of major countries and industries. The findings are that there are technologies called a Technological Revolution, and the industrial application of some technologies is in the starting stage. If comes, the Industrial Revolution is expected with the structure as follows: excellence science, core technologies, base technologies, application and infrastructure, and institutions. Nonetheless, the brisk studies are from three branches such as the Industry 4.0, social connection and artificial intelligence. The Industry 4.0, the digital transformation of manufacturing is the on-going issue in the industry, and artificial intelligence brings the biggest discourse. The 392 literature are mostly from introduction and preparation for future; technology 15.8%, industry 26.3%, society 24.5%, education 19.1%, policy 10.7%. The labor and employment is only 3.6%.

Keywords 4th Industrial Revolution, Industry 4.0, techno-economic paradigm, AI, IoT

I. Introduction

Klaus Schwab delivered a keynote speech on the Revolution in January 2016 at the Davos Forum he established, following Germany's nation-wide activity in the Industry 4.0. In addition, he published a book (2016) entitled "The 4th Industrial Revolution". Before Schwab's book, another book also entitled the 4th Industrial Revolution (Ha and Choi, 2015) was published in Korea and became a best-seller for one and a half years in the largest Korean book store.

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The Industry 4.0, the origin of the discussion about the 4th Industrial Revolution, focuses on the digital transformation of manufacturing. However, in Korea, the current discourse is focused on the 4th Industrial Revolution rather than the meaning of the Industry 4.0. As of the end of August 2017, there were 392 academic articles in Korea, searched in the RISS DB with the keyword of '4th Industrial Revolution' and 'industrial revolution' only in the title. The number of articles per year is 2 in 2015, 67 in 2016, and 323 in 2017. We did not count the news and discussions in the media because this number of academic articles gives enough signals to the brisk discourse about the revolution.

Is the vigorous discussion on the 4th Industrial Revolution in Korea normal? The reason for this significant attention may come from the lack of proper understanding about digital economy and society. Then, what are the facts? Or how do we understand the revolution and how to response to this change? This article provides an answer to these questions.

We will review three representative theories on the 4th Industrial Revolution in section 2, and evaluate it from the perspective of existing theories and also from the actual response of government and industry in section 4. In section 5, we will suggest the structure and nature of the revolution and will add a fact.

II. Method

1. A Literature Review

There are many branches of discussions on technological or industrial revolutions. Among these, we simply call a theory if there are sequential studies, and opinions or hypotheses if those have no further elaborations.

The first theory of technological change is the techno-economic paradigm (Perez, 1983). The main elements of this theory are as follows: 1) there are long economic waves (Kondratiev, 1935) resulting from innovation waves (Schumpeter, 1939); 2) Innovation waves last 50-60 years, which trigger economic boom and depression; 3) Key technologies for a wave should have three characteristics such as continuous cost decrease, unlimited supply, and application ability (Freeman, 1982)

Perez (1983) elaborated this innovation wave with the concept of techno-economic paradigm. Technologies in certain wave induce changes in the economy, and the mix of technologies and economy brings a new techno-economic paradigm. This paradigm develops with three branches; motive branches, carrier branches and infrastructures. This theory is a mixture of three dimensions such as technology, economy and time.

The second theory, called theory on microelectronics revolution or simply ME revolution is not a well-elaborated theory, but a group of discussions. In this branch, historical changes were called as several titles such as computer era (Dertouzos and Moses, 1979), microelectronics revolution (Mably, 1980; Forester, 1981), computer revolution (Evans, 1979; Heitlinger, 1984), microcomputer revolution (Braun, 1981; Calhoun, 1981), or personal computer (PC) revolution (Edwards, 2016). Key technologies in this discourse are microelectronics, microprocessor, computer or PC. Seol (1986) pointed out the economic meanings of microelectronics as a real economic revolution.

The third theory is on industrial revolution following the lecture note of Toynbee (1894). In this theory, the industrial revolution is not mere industrial technique and change of production, but brings social revolution accompanying social reasons and social impact (Perkin, 1969).

Key technologies were many such as textile manufacturing, metallurgy, steam power, machine tools, chemicals, cement, gas lighting, glass making, and paper machine. Industries were textiles, mining, canals and railroads. In society domain, also many changes appeared: factory system and labor, impact on women and family life, standards of living such as food and nutrition, and housing and clothing. Of course, this theory is developed on time flows.

2. Basic Perspective

Let us extract the keywords from existing theories. The techno-economic paradigm uses the concept of technology, economy and time. The ME discourse is based on technology, economy and society. The groups on industrial revolution also stand on technology, economy, and society on time. These facts lead us to the 4-dimensional approach to technological wave: technology, industry/economy, society and time. Without time in the discussion about technological change, all the discourse may become a scientific or technological fiction. The time dimension is quite common in history studies, but not in future studies. Many futurists depict future without any time consideration.

The inclusion of time in the analysis of technology-originated change is not new. The interaction of technology and industry or the economy is the main theme of techno-economic paradigm aforementioned. Adding the time variable in the relationship between technology and industry is the main theme of evolutionary perspective of neo-Schumpeterian (Freeman 1982; Perez, 1983). In addition, the relationship between technology and society is the main theme of science, technology and society (STS) studies such as MacKenzie and

Wajcman (1985) and Bijker, Hughes and Pinch (1987). Nonetheless, many current studies on the 4th Industrial Revolution do not consider the time variable. The time dimension requires the difference between technology to product and product to industrial or economic impact. The concept of maturity or the process of diffusion means the time issue.

III. Theories of the 4th Industrial Revolution

1. Discourse of the Industry 4.0

Some German experts discussed the future factory since 2004. This effort is connected to the establishment of the Technology Initiative Smart Factory, a non-profit research organization, in June 2005. Furthermore, German Research Institute of Artificial Intelligence, a research institute backed up by German government and industry, named the efforts of The Industry 4.0 in 2006. The German federal government announced the High-Tech Strategy 2020 as a technology policy in 2010. An action plan for this policy, the High-Tech Strategy Action Plan, which was an investment plan for 2012-2015, included the Industry 4.0 as one of the detailed policies.

Table 1 Target items of the High-Tech Strategy Action Plan of 2012

1. CO_2-neutral, energy-efficient and climate-adapted city ("future city")
2. Renewable energy resources as an alternative to oil
3. Intelligent restructuring of energy production
4. Combating illness with individualized medicine
5. Improving health through targeted preventive measures and nutrition
6. Independent living for senior citizens
7. Sustainable mobility
8. Internet-based services for the economy
9. INDUSTRIE 4.0
10. Secure identities

This action plan was announced at the Hanover Fair. However, the Industry 4.0 was more noticed than the main policy from the general public and international societies. The following policy of the German government was the establishment of the Platform Industry 4.0, announced in the 2013 Hanover Fair, an organization backed up by the federal government, industry associations, government research labs and big companies. The platform leads the development and support of the Industry 4.0 and the efforts of industries.

The definition of the Industry 4.0 is diverse, but has some common keywords: the preparation for the 4th industrial age (webpage of the Platform Industry 4.0); digital transformation of manufacturing, which the Industry 4.0 ultimately is (i-scoop, 2017); digitalization, connectivity, and growth opportunity by new manufacturing technologies; and the paradigm shift over the connection of machinery and products by the Internet (Schuh et al., 2017, Foreword). The main keywords of these definitions are digitalization, connectivity and smartization of manufacturing for the purpose of the preemption of the world market in the platforms of the Industry 4.0 (Han et al., 2016).

In the discourse on the Industry 4.0, it is not easy to find the term of the 4th Industrial Revolution, but only the nuance for a new age and new paradigm in manufacturing.

2. Ha and Choi

Ha and Choi (2015) defined the 4th Industrial Revolution as the 'everything super intelligence communication revolution' commenting: "mega transition to the Digital Planet Earth by the innovation of life style of mankind and the operation system of socio-economy" (p. 11). "Super intelligence means that something different substances from mankind and any living creature have intelligence close to that of mankind like a smart car." "The current era is the Internet era of mankind, but the coming 30 years are the era of super intelligence Internet era of everything." (p. 12) He also adds that the CPS (cyber-physical system) society will be realized in 2030 in the super intelligence Internet era (p. 13).

The technological core of the revolution, he said, is made up of three elements: digitalisation of the physical world, intelligence of the digital world, and the social road to intelligent systems such as smart city, and smart factory, etc. This will overcome the limits of the physical world since the limits will be covered by the cyber world.

The revolution is the holonic path and will follow the sequential revolutions such as the 1st of the way to nature, the 2nd of artificial, and the 3rd of cyber (p. 31). The revolution will last next 100 years with the smartizen of 10 billion people and also 10 billion subscribers of 5G communication.

3. Klaus Schwab

Although in Korea, the term of the 4th Industrial Revolution was introduced by Ha and Choi (2015), the term has become popular after the presentation of

Klaus Schwab at the Davos Forum. In his book (2016), Schwab suggested three rationales for a revolution: speed of changes, scope and depth of changes, and the shock to systems. The speed of change is characterized by the exponential speed rather than linear speed since changes can be easily transferred to other changes because of cross connectivity. For example, the speed of 50% spread of any innovation has been shortened: PC 20 years, wired broadcasting 15 years, VCR 12 years, and Internet 10 years. The scope and depth of changes make the transformation of personal, economy and society as the unexpected paradigm. Further, the changes go beyond how and what to 'who we are'. The previous revolution was the changes of how and what, but the current changes raise a question because of who mankind in the context of artificial intelligence. The current changes accompany the systemic shock in the relationship between countries, firms and societies, and also in the total systems.

Schwab describes the current revolution as the 4th with these technologies such as mobile, sensor and artificial intelligence following these flows: the 1st since the mid of 18th century by rail road and steam engine; the 2nd since the end of the 19th century and the beginning of the 20th century by electricity and mass production; the 3rd since 1960s by computer and digital revolution. He adds synthetic biology to the core technologies of the 4th. Therefore, he describes that the core of technologies is the interaction of physics, digital and synthetic biology.

He points out that there will be big impacts in all spheres of society, but the most realistic issues are from economic opportunity and labor crisis. He put emphasis on the growth opportunity against the trend of aging and low productivity. On the other hand, there will be a big crisis in employment and labor because of labor replacement by machinery and the emergence of new requirements by machinery.

IV. Evaluation by Existing Theories

1. Theory of Industrial Revolution

The starting time of the Industrial Revolution differs in many writings: Rider et al. (2007) put it around 1700, Perkin (1969) around 1780, Pollard (1981) in the 1760s, and Ashton (1948) between 1760 to 1830.

Key technologies started from textile manufacturing, metallurgy and steam power to other industries such as agriculture, mining, canals, roads and railways. The rise of these industries accompanied changes in labor such as labor conditions, factory and urbanization, child labor, and labor organization. In addition, these changes made social changes in factory system, family life and the role of each family, and quality of living etc.

This theory tells us some implications: the starting time is a matter of history, not the current time. Second, to be a technological or industrial revolution, a technological change brings the emergence of innovations in many technologies and further industries. Third, technological and industrial changes bring changes in labor, and in turn social changes.

2. Computer/ME/IT Revolution

The first commercial computer appeared in 1951, integrated circuit in 1959, and microprocessor in 1971. Further developments in these technologies made the function to cost cheap and spread into many areas. This change made the emergence of the term of the computer era (Dertouzos and Moses, 1979) and diverse revolution (Osborne, 1979). Mably (1980) and Forester (1981) used the term of the Microelectronics Revolution, or simply ME Revolution, based on the role of microelectronics. On the other hand, the Computer Revolution (Evans, 1979; Heitlinger, 1984), Micro-computer Revolution (Braun, 1981; Calhoun, 1981), or PC Revolution (Edwards, 2016) was used under the highlight of PC. Edwards (2016) picked out seven microprocessors to make the term of revolution; Intel 8080 (1974), Motorola 6800 (1974), MOS 6502 (1975), Zilog Z80 (1976), Texas Instruments TMS9900 (1976), Intel 8088 (1979), and Motorola 68000 (1979).

This era based on these technologies is called the IT era. Seol (2011) classified the IT era into 10-year periods: device era in the 1970s, information processing in 1980s, communication in 1990s, the convergence of information processing and communication in 2000s, and the emergence of a cyber society in 2010s. In addition, the IT era has been characterized by automation histories such as factory automation (FA), office automation (OA), and home automation (HA). This IT revolution becomes the IT economy recording 28% of the gross domestic products (GDP) in Korea. This development can be called as a real industrial revolution in an economic perspective.

Again, let us formulate a few questions: First, is the coming of IoT era far from the path of automation? Is it ill advised to add Internet of Things (IoT) to the next automation, and also Internet of Everything (IoE) after IoT? Second, if new series of technologies are added in the discourse of the 4^{th} Industrial Revolution, it is artificial intelligence. We accept that it is a real breakthrough technology, but is it quite far from the nature of ME or IT revolution? The third and most important factor is that, thanks to the technologies, which are the backbone of the discourse, can the economy be formed like IT revolution recording 28% of GDP? This is the economic meaning of industrial revolution. If possible, when is it possible?

3. Evaluation by the Techno-economic Paradigm

In the 1970s, there was a severe world economic depression due to the oil shock. This brought the theory about the crisis of capitalism and long wave. The long wave theory postulates that there are 50-60 year economic waves (Kondratiev, 1935) and the main reason is innovation (Schumpeter, 1939). The Neo-Schumpetrian (Freeman, 1982; Perez, 1983) revived the innovation wave theory.

What the theory of techno-economic paradigm among others says is that there are three characteristics of 1) continuous cost reduction, 2) limitless supply and 3) high applicability, and the pattern of development in three branches such as motive branches, carrier branches and infrastructures. Simply speaking, if a cluster of technological changes becomes a revolutionary wave over a small innovation wave, technology and economy should move together.

4. Evaluation by Other Studies

Peter Mash (2012) suggested the concept of the 5th revolution adding to the 4th computer revolution during 1950-2000. This revolution started in 2005 and will last until around 2040, and the impact will last until the end of the 21st century. In addition, new change will not be in the creative industry, but in manufacturing.

Jeremy Riffkin (2011) talked about the 3rd revolution based on the convergence of the Internet and energy technology, following the 2nd revolution since the first decade of the 20th century, which was the mix of electricity communication and internal combustion, that is oil. He emphasized the energy sector.

Brynjolfsson and McAfee (2014) coined the term of the 2nd machine age based on mental power. The 1st machine age was the industrial revolution based on physical power. They emphasized the sources of power. The machine intelligence of the 2nd age interconnects with the physical world.

Ray Kurzwell (2006) also said that there would be a real 4th Industrial Revolution since 2045, when the singularity is coming, which is the ultimate replacement of human intelligent labor by artificial intelligence. He insisted that the 1st to the 3rd Industrial Revolution were the replacement periods of the physical labor of mankind.

V. Evaluation by Industrial Activities

1. Highlights of Major Countries

1.1 Germany

The German government's effort is focused on the Industry 4.0, which is the digitalization of manufacturing. The main purpose of the Industry 4.0 is that 'leading of world market in the cyber-physical system and smart devices (Webpage of the Platform Industry 4.0).'

The propellers of the Platform Industry 4.0 are the united team of government, industry and research institute. Industrial associations for telecommunication, machinery, and electronics and electricity formed the organization in 2013, but the organization expanded to include scientific society, political parties, labor union and other association in 2015. However, the Federal Ministry of Education, big companies and the Fraunhoffer Institute under the support of the Federal Ministry of Economy and Energy lead the organization. The role of this organization is the study of future issues such as standards, security, legal framework, and work, education and training.

In addition, the German Science and Engineering Academy published the Industry 4.0 Maturity Index in April 2017 for the implementation strategy of manufacturing companies (Schuh et al., 2017).

1.2 USA

In June 2011, the Presidential Advisory Committee on Science and Technology pointed out the advanced technology for manufacturing. This brought government policies such as the Advanced Manufacturing Partnership and the National Network for Manufacturing Innovation. These activities might be stimulated by the German policies.

In industry, the Smart Manufacturing Leadership Coalition was formed by Rockwell Automation, 3M, GE, Emerson, GM and NIST in 2012, which now has 56 members representing companies, research institutes and universities. In addition, in 2014, GE, AT&T, Cisco, IBM, Intel to come up with the standards of industrial internet and IoT formed the Industrial Internet Consortium. Now the consortium has been expended to more than 200 companies.

1.3 Japan

The Abe government in Japan has joined lately the trend of the 4th Industrial Revolution because of government change. However, since 2015, the related policies have been included such as Robot New Strategy, and the creation of

IT country. The Robot New Strategy aims to lead the international standards in robot area where they have an international competitiveness and to get data from various technical fields. This policy linked to the establishment of the Robot Revolution Initiative where more than 300 companies joined.

Furthermore, the Japanese government announced the Super Smart Society, or simply Society 5.0. The Society 5.0 is the mixed policy of the Industry 4.0 and the connected society. The representative Industry 4.0 policy is a robot strategy and the latter is the setting up of 11 service platforms such as web data, human activity data, 3D geographical data, transportation data, environmental observation data, production and distribution data of manufacturing and agricultural produce.

2. Evaluation by Industry Response

Infosys and the Institute for Industrial Management (FIR) of RWTH Aachen (Aachen University) did the first survey of the Industry 4.0 in early 2015. The survey covers 433 representatives of manufacturing in five countries such USA, UK, France, China and German-speaking areas. The results are shown in Table 2 and 3. About half the companies were more than "partially implemented" in 2015, but 80% will get the same status in 2020. It is surprising that China, not old countries, is the leader in response to the trend.

Table 2 Responses to the Industry 4.0 (%)

	2015	2020
No awareness	15	7
Potential recognized	31	13
Partially implemented	39	32
Systematically implemented	15	48

Table 3 Responses to the Industry 4.0 by country (%)

	Follower	Early adopter
China	43	57
US	68	32
UK	74	26
German speaking	79	21
France	86	14

Source: Infosys and FIR of RWTH Aachen (2015)

In the survey of December 2016 by UK manufacturing companies association, EEF and Oracle, although 61% was using digital technologies, which is not the level of the Industry 4.0, 80% responded that the Industry 4.0 would be realized by 2025.

In the IDC estimation of April 2017, China and India will be the largest markets for the Industry 4.0 except Japan (i-scoop, 2017). The biggest users of the robot will be for fabrication and print 25% and mining 21%[2]. Also in the forecast of MarketsandMarkets in May 2017, the biggest markets for the Industry 4.0 is not the old economies, but Asia such as Japan, China, and Korea. By technology, industrial robotics will be the largest market followed by industrial Internet of things, cyber security and 3D printing (recitation from i-scoop, 2017)

In Korea, in the survey by the Korea Federation of SMEs in December 2016, only 11.4% responded that they know what the Industry 4.0 is.

3. Summary

Each leading country is preparing for the new trend focusing on their national strength such as manufacturing in Germany, independent technologies such as AI and industrial Internet in the USA, and robot in Japan.

In the industrial sector, only small firms respond to the potential of the new trend, and most of them are even not recognizing the trend. However, most investment will be done until 2025. Asian countries such as China, Japan and India will be the leader in investment.

VI. Discussion and Conclusion

1. Structure of the Expected Revolution

Schwab (2016) pointed out that core technologies are not only ICT, but also the interaction of physics, digital and biology. Ha and Choi (2015) said that it is the chorus of IBCA such as IoT, big data, CPS (cyber physical system) and AI.

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[2] http://www.idc.com/getdoc.jsp?containerId=prAP42234517

However, the technological structure is not so simple. The structure of the coming 4th Industrial Revolution will be expected as follows: 1) excellence science, 2) core + base technologies, 3) application + infrastructure, and 4) institutions.

Core technologies are IoT, AI, cloud, big data, robot and 5G communication. Base technologies are data security, sensor, new material and genome technologies. Applications are wearables, synthetic biological industry and all the smart products and industries such as smart car, smart factory, smart security, smart Medicare, smart defence, smart city, smart energy, etc. These application areas will accompany their infrastructures. Furthermore, these technologies should bring legal and institutional changes.

Table 4 Structure of the expected 4th Industrial Revolution

Area	Sector	Technologies/applications
Technologies	Science	
	Core	IoT, AI, cloud, big data, robot and 5G communication
	Base	Data security, sensor, new material and genome technologies
Applications	Products	Wearables, synthetic biological products
	Smart systems	Smart car, smart factory, smart security, smart Medicare, smart defence, smart city, smart energy
Institutions	Legal Institutional	Data properties, test and certification, guidelines for smart applications

This structure is just a forecast, but there are different responses from stakeholders. The stakeholders feel differently in view of the different impact of each technology. The impact of these technologies may have three different flows of impact.

The first flow of big impact is from the Industry 4.0 that is for manufacturing. Many people in manufacturing industries have interest in this topic. Germany and Japan have focused on this flow of impact.

The second flow of impact, but not significantly highlighted, is the connection between each field and thing, simply Internet of things. Two reasons may underlie the lower concern from the general public. One is that this is the consecutive flow from past. People are used to communication technologies such as Internet and mobile. The second is that these technologies work like infrastructure, so people only enjoy it, not with direct concern for how and for what.

The third flow of impact is the impact of AI, which is the biggest shock to the general population who is not a specialist in technology and industry. This shock may come from the close links from technology to usage. One example is the IBM Watson that has appeared as the replacement of experts group. In 2011, Watson won the very popular US quiz show, Jeopardy. After this event, IBM announced Watson's next challenge was cancer in 2012, and achieved the concordance rate of 81-96% by type in cancer diagnosis in 2017. This AI has been already adapted to practical diagnosis in many hospitals[3]. The third example, which has a big impact, is from Go. Google's AlphaGo won a historical match between artificial intelligence and one of the best Go players, professional 9 dan, Sedol Lee, in 2016. In addition, another system has been used in the legal area as an attorney and in stock trading.

These different flows produce different feelings and understanding about the future of the 4^{th} revolution. Some people think the Industry 4.0 is the current flow of the 4^{th} revolution that should be overcome first. Others think AI is the main issue of the revolution. Many people define the 4^{th} revolution with only a perspective, not the whole features, like an old joking about the description of the elephant.

The first manufacturing flow is expected to be realized in 2025 according to many surveys such as EEF and Oracle (2016) and Korea Federation of SMEs (2016). This means that now is the time for investment in manufacturing. If the total feature is being considered, the realization of the revolution needs more time. Ha and Choi (2015) says it will be the year 2030, Ray Curzweil (2006) 2045, Klaus Schwab 2050, and Michio Kaku (2011) 2100. In economic terms, we suggest that the industrial innovation should account for the main portion of GDP by 2030.

2. Nature of Industrial Innovation

If someone talks about the completed or whole features of future at present, we say it is a scientific fiction. Therefore, we should separate the flows by time. If we consider the near future, say for 10 years, the first era of the revolution, this may be called the industrial innovation of the revolution.

The first feature of industrial innovation is the speed of the spread already commented by Schwab (2016). The reason, if we may add, may come from 1) very speedy communication technologies such as SNS (social network service); 2) amazing mass production capabilities to support people's expectation; and 3)

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[3] https://sciencebasedmedicine.org/ibm-watson-versus-cancer-hype-meets-reality

recognition of people, firm and government for the merit of quick adaption of impactful technologies.

The second feature of industrial innovation is that industrial innovation is more important than technological invention at the moment, although some technologies such as AI are still developing and some technologies for manufacturing do not fully support the needs of the spot. In the industrial spot, technologies are evolving through merge and convergence of different technologies.

The third feature is that, although current industrial flow is the starting point towards the leading ability in the economy, the will of people and governments is stronger than the real economic possibility.

Table 5 Concerns on each revolution

	2017 for the 4th	1981 for the ME
Technology	15.8	21.4
Industry/economy	26.3	21.4
Labor/employment	3.6	14.3
Society	24.5	42.9
Education	19.1	
Policy	10.7	
Total	100.0 (392)	100.0 (42)

3. Pattern of Discourse

The distribution of articles by issue shows the pattern of discourse. We extract the references from Calhoun (1981) for the ME revolution and analyze the articles from the Korean academic DB, RISS for the 4^{th} Industrial Revolution like Table 5. The share of concerns about technology and economy are similar to each case with about 42%. The concerns for ME Revolution is more concentrated in labor issue than the 4^{th}. This fact may be interpretated as that labor issue is not yet in the problem at the moment. The 3rd feature of concerns of current Korea is found in education and policy.

Korean scholars give big emphasis on the preparation for the coming era in many areas; 19.1% in education as preparations in diverse sectors and 10.7% in policy as that for society.

4. Conclusion

This is an article about the ongoing complex issue which will last several decades, the 4th Industrial Revolution. Therefore, some discussions are based on the future forecasts, which could possibly be wrong. To overcome this, we tried to show the global forecast of major technologies and industries and the responses by major governments. However, forecasting the future is the basic limit of this article.

Nonetheless, we publish this article, as a specialist in future technology and technology policy, to introduce the proper innovation and innovation policy, beyond scientific fiction and unnecessary fear about the future. Every future has sequences of creation, innovation, being products and industry, societal change on time flows. Hence, the stepwise response and preparation is necessary with time flows.

References

Ashton, T.S. (1948) The Industrial Revolution (1760-1830), Oxford University Press.

Bijker, E., Hughes, T.P. and Pinch, T.J. (1987) The Social Construction of Technological Systems, Massachusetts: MIT Press.

Braun, E. and MacDonald, S. (1978) Revolution in Miniature: The History and Impact of Semiconductor Electronics, Cambridge: Cambridge University Press.

Calhoun, C.J. (1981) The microcomputer revolution? Technical Possibilities and Social Choices, 9(4), 397-437. DOI: https://doi.org/10.1177/004912418100900402

Curzweil, R. (2006) The Singularity Is Near, When Humans Transcend Biology, Penguin Books.

Dertouzos M.L. and Moses, J. (eds.) (1979) The Computer Age: A Twenty Year View, Cambridge, MA: MIT Press.

Dunham, Arthur Louis (1955) The Industrial Revolution in France, 1815-1848, New York: Exposition Press.

Edwards, B. (2016) 7 Microprocessors That Powered the PC Revolution, PCMAC, March 17. https://www.pcmag.com/feature/342957/7-microprocessors-that-powered-the-pc-revolution

Evans, C.R. (1979) The Mighty Micro: Impact of the Computer Revolution, Gollancz.

Foreign Affairs (ed.), (2016) The 4th Industrial Revolution.

Forest, T. (ed.) (1980) The Microelectronic Revolution, Oxford: Blackwell.

Forester, T. (1981) Microelectronics Revolution, MIT Press.

Freeman, C. and Perez, C. (1988) Structural crisis of adjustment, business cycles and investment behaviour", in Dosi et. al., Technical Change and Economic Theory, Pinter Publishers, ch.3, 38-66.

Freeman, C. (1982) Economics of Industrial Innovation, 2nd ed., London: Pinter.

Ha, W.G. and Choi, N.H. (2015) The 4th Industrial Revolution, Seoul: Contentshada, December (Korean).

Han, S.H. et al. (2016) How to Start The 4th Industrial Revolution, Seoul: Paper Road, November (Korean).

Heitlinger, L.J. (1984) The computer revolution in medical imaging systems, IEEE Potentials, 3(4), 10-13.

Infosys and RWTH Aachen, Industry 4.0: The State of the Nations, 2015.

Kaku, M. (2011) Physics of the Future: How Science Will Shape Human Destiny and Our Daily Lives by the Year 2100, New York: Anchor Books.

Kondratiev, N.D. (1935) The long waves in economic life, The Review of Economics and Statistics, 17, pp. 105-115.

Korea SMEs Federation (2016) A Survey on the SME Recognition and Response to the 4th Industrial revolution, December (Korean).

Kreis, S. (2017) Lecture 17, The Origins of the Industrial Revolution in England. Retrieved 18 August 2017. http://www.historyguide.org/intellect/lecture17a.html

Mably, C. (1980) The microelectronics revolution: An assessment of its significance for education and teacher education, Revue ATEE Journal, 3(1), 25-35.

MacKenzie, D. and Wajcman, J. (eds.) (1985) Social Shaping of Technology, Philadelphia, Buckingham: Open University Press.

Mash, P. (2012) The New Industrial Revolution, Yale U Press.

Moon, Y.H. et al. (eds.) (2014) White Paper on Future Technologies, Institute of Information Analysis, Korea Institute of Science and Technology Information.

Moon, Y.H. (2017) Core future technologies, presented at the Korea 4.0 Forum, May.

Moon, Y.H. (2017) The 4th Industrial Revolution and future industries, presented at the conference of Korea Society for Public Management, Seoul: President Hotel, November 11.

Osborne, A. (1979) Running Wild: The Next Industrial Revolution. Berkeley: Osborne/McGraw-Hill.

Park, H.G. et al. (2017) The 4th Industrial Revolution New Era of Manufacturing - How to Build Smart Factory, Seoul: Hoite Books. (Korean)

Perez, C. (1983) Structural change and the assimilation of new technologies in the economic and social systems, Futures, 15(5), 357-75.

Perez, C. (1985) Microelectronics, long waves and world structural change: new perspectives for developing countries, World Development, 13(3), 441-63.

Perez, C. (2002) Technological Revolutions and Financial Capital, the Dynamics of Bubbles and Golden Ages, Cheltenham: Elgar.

Perkin, H. (1969) The Origins of Modern English Society, 1780-1880, Routledge & K. Paul.

Pollard, S. (1981) Peaceful Conquest: The Industrialization of Europe, 1760-1970, Oxford University Press.

Reid, T.R. (1985) Microchips: The Story of a Revolution and the Men Who Made it, London: Pan.

Rider, C. (ed.) (2007) Encyclopedia of the Age of the Industrial Revolution, 1700-1920.

Schuh, G. Anderl, R., Gausemeier, J., ten Hompel, M. and Wahlster, W. (eds.) 2017, Industrie 4.0 Maturity Index - Managing the Digital Transformation of Companies, acatech STUDY, National Academy of Science and Engineering of Germany, April.

Schumpeter, J.A. (1939) (1982) Business Cycles, Philadelphia: Porcupine Press.

Schwab, K. (2016) The 4th Industrial Revolution, World Economic Forum.

Seol, S.S. (1986) The characteristics and economic meanings of IT technology, Hannam Review of Social Science, 6(8), 255-272.

Seol, S.S. (2011) Technological Innovation, Seoul: Bummunsa.

Seol, S.S. (2017) Smart factory in Korea, presented at the Korea 4.0 Forum, October.

Seol, S.S. et al. (2017) Korea 4.0 Vision, Daejeon: Korea 4.0 Forum, May.

Seol, S.S. and Moon, Y.H. (2017) An evaluation of the theories of the 4^{th} Industrial Revolution, presented at the ASIP 2017 Hanoi Conference, Asian Society for Innovation and Policy, September 21-23.

Toynbee, A. (1894) Lectures on the Industrial Revolution of the Eighteenth Century in England, Longmans, Green and Co., ISBN 1-4191-2952-X.