https://doi.org/10.7165/wtr17s1207.17

OPEN ACCESS

Role and Policies of STP in the Era of 4th Industrial Revolution from Triple Helix Viewpoint

Byung-Joo Kang*
Secretary General, World Technopolis Association
Professor, Hannam University, Republic of Korea

Abstract
This paper defines the role of the Science Park and makes policy recommendations for the "Era of 4th Industrial Revolution" from a Triple Helix viewpoint. The role of traditional science parks, and theory of Triple Helix and the 4th Industrial Revolution are reviewed, and strategies to cope with the 4th Industrial Revolution in a few advanced countries are analyzed. This paper finishes by suggesting strategies such as acceleration of networking, education to foster creative and innovative manpower and initiating capacity building projects for the advancement of Science Parks in the 4th Industrial Revolution.

Keywords
Role of science park; 4th Industrial Revolution; Internet of things; Big data; On-demand economy; Hyper intelligent and hyper connected; Transformed society

I. THE WORLD WE ARE FACING TODAY

We are already living in the era of the 4th Industrial Revolution. Manufacturing has reborn through the convergence of Internet of things (IoT), Big data, 3D printing, Cloud computing and Artificial intelligence (AI). Adidas produces five hundred thousand pairs of sport shoes per year with only ten workers. Chabot, a robot distributed by Amazon which recognize voices, and Google Now have become a smart home center that carry out cooking, sweeping and home watching. Mobile approval pay systems such as 'Apple Pay' and 'Samsung Pay' will lead a new commercial trade, where cash and credit card are no more necessary. Sharing Economy and On-demand Economy that are derived from Uber and Air B&B get a spotlight as a new pattern of the On-demand Economy. Artificial intelligence, like 'Watson' or 'Alphago,' is a powerful invention for the fashion, medical and financial areas.

What changed our society of today and what are the main drivers of change in the 4th Industrial Revolution? People say that advancement of science and technology is the driving force of societal change for the human beings as always. Technology was used for the invention of arrow, knife and pottery in the primitive era to bring social change and became a key driving force of agricultural, industrial and informational revolution. Now, science and technology have been creating a new civilized society with continuous invention of tools and appliances through vertical specialization and horizontal convergence.

*Correspondence to : Prof. Byung-Joo Kang
Secretary General of World Technopolis Association and Professor of Hannam University, Daejeon, Republic of Korea
E-mail : kbj20@hnu.kr

World Technopolis Review

Rapid development of science and technology triggers a huge disruptive innovation over entire industries. The first Industrial Revolution replaced human labor with machine labor through the invention of train, ship and spinning machine etc., which were manufactured due to a steam generator at the end of 18th century. Cities were built with factories nearby and a variety of manufactured goods were produced.

A common feature of economically prosperous regions is that they have science and technology that other regions do not have and they try to build and manage science and technology parks based on needs (Kang, 2014). Research institutes, universities, research oriented firms, science parks and the interaction among them has been emerged as the driving force of science based economic development for a long time. The science park originated as a repository for firms generated by the university which wanted to maintain the collaborative cord between university and firm. The role of the science park must change according to contemporary situations.

Society in the 4th Industrial Revolution will be led by an On-demand Economy, where economic activity will be created by digital marketplaces that fulfill consumer demand via immediate access to and convenient provisioning of goods and services.

Telecommunication systems, prototype and pilot production, testing facilities, tool development laboratories and calibration laboratories were the major occupants in the traditional science park. However as connection among people, things and cyber system is expected to be increased and many artificial intelligence such as robotics, the Internet of Things, autonomous vehicles and 3D printing are expected to be the center of our daily life, policy makers and managers of Science Park would want to know what roles Science Park should take in the transformed society.

II. STP, TRIPLE HELIX, AND 4th INDUSTRIAL REVOLUTION

1. Science and Technology Park

1) Introduction

Science and technology parks are the places where many facilities for R&D, start-ups and incubation, training, supporting function are located to conduct joint R&D projects and technology transfer for universities, public research institutes and private research labs to support high-tech industries and to accelerate regional economic development

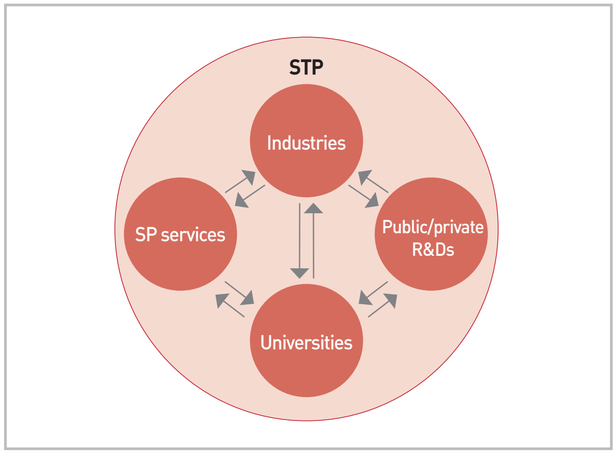

Fig. 1. Main actors and their relationships in the science park

Source: Kang, 2016

A science park is an organization managed by specialized professionals, whose main aim is to increase the wealth of the community by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions (IASP, 2002). To enable these goals to be met, the science park stimulates and manages the flow of knowledge and technology amongst universities, R&D institutions, companies and markets. It facilitates the creation and growth of innovation-based companies through incubation and spin-off processes and provides other value-added services together with high quality space and facilities.

Science parks are always directly or indirectly associated with the education sector through universities (the primary source of trained human and intellectual capital) or through public or private research institutes. They share common objectives such as providing a training ground for entrepreneurs and supporting technology-led entrepreneurship based on university or laboratory research results. In fact, universities and R&D institutions play an important role in science parks as drivers of education, new knowledge, and trained manpower. In particular, university students and faculty may collaborate with companies located in the science park through student internship programs and part-time jobs, company created by faculties, and research partnerships. (European Investment Bank et al., 2010)

The physical facilities and the services offered are expected to enhance the competitiveness of tenants (researchers, firms, start-ups) located in the science park.

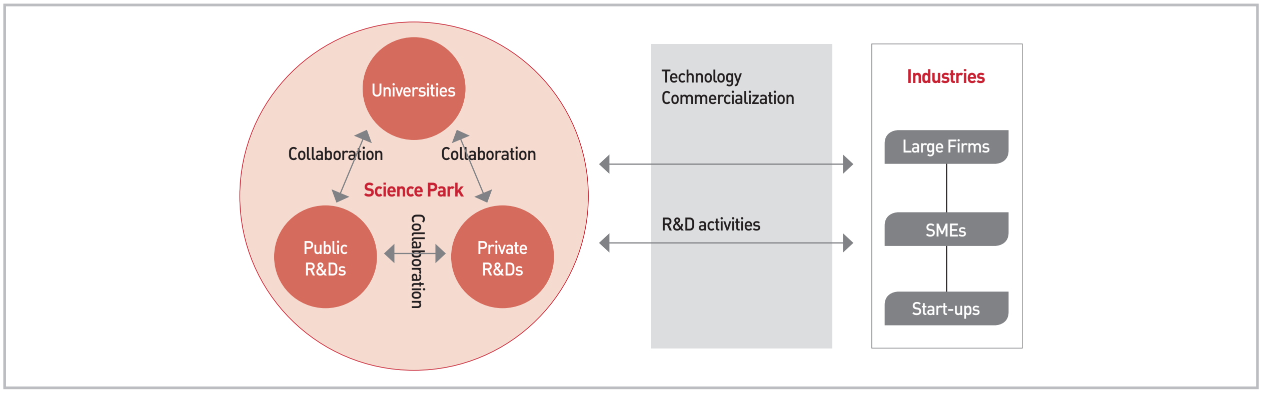

Fig. 2. Major activity links in the science park

Source: Kang, 2016

2) Industry-specific specialized infrastructure

Depending on the technological or industrial scope of the science park, the technical infrastructures may include advanced telecommunication systems, prototype and pilot production, testing facilities, tool development laboratories, calibration laboratories, and environmental testing. To attract leading players the planned infrastructure should incorporate the most recent technological advances in the industry. The decision about the range and quality of this kind of investment will affect the overall attractiveness of the science and technology parks (European Investment Bank et al., 2010).

3) Key support services

Science park clients include technology-intensive small and medium sized enterprises (SMEs) as well as large firms, all of which require a range of services. The range, quality, and cost effectiveness of services are a key positioning tool vis-a-vis prospective tenants. Support and advisory services are expected to include marketing, contractual, and legal issues related to technology management and collaborative projects such as below (European Investment Bank et al., 2010).

- Screening of new business opportunities, technology trends and foresight
- Management of collaborative projects, patenting and IPR
- Market development (business plans, road shows, international missions)
- Match-making between tenants and clients
- Easy access to project finance (grants, loans, equity financing)
- Training, seminars and workshops for capability building
- Facilitated recruitment from universities
- Networking events

4) Contents of activities in science parks

(1) Technology commercialization

Technology commercialization is defined by the incorporation of research results by private firms. It includes activities such as utilization of research results, development of new products and technologies, and transfer of technology. It also includes all the cooperative activities among universities, public and private research institutes that leads to technology commercialization. Technology commercialization is the most critical function of science and technology parks, and it plays a primary role in the "value chain" that connects innovation to markets.

By transferring and expanding research results through R&D activities and collaborative researches, regional innovation, economic development and technology commercialization can occur. Universities and research institutes continuously provide necessary research results and human resources to science parks. Public research institutes that are funded by the government, conduct R&D activities to promote the development of strategic industries with a long-range vision. Private research institutes, managed by private firms, conduct mid and short range vision strategic research projects for specific technologies in order to promote industrialization (Oh, 2011).

Universities and research institutes promote technology commercialization through collaborative researches. They contribute to the success of science parks through the innovation of technology, and the industrial growth and economic development of the region. Occupants of science and technology parks are firms, universities, public research institutes, and private research institutes (Oh, 2011).

(2) R&D activities

R&D in science and technology parks includes collaborative research among universities and private & public research institutes. The major contents of R&D in each kind of institute are such as below:

Universities (HEI) educate human resources capable of scientific research and conduct R&D activities with private & public research institutes. Public R&D institutes accelerate technology innovation and build R&D infrastructure through government led R&D activities. They also support private R&D activities of private firms with long-range vision.

Private R&D institutes or research institutes affiliated to firms conduct research in specific fields and put more focus on application of research results, manufacturing of new products. Collaborative research increases innovative capacities of science parks through partnerships among firms, universities, and private and public research institutes. Collaborative research is a key method to develop and expand technologies through the close collaboration among various organizations (Oh, 2011).

2. Triple Helix

1) Introduction

The triple helix was generated from an analysis of government's relation to university and industry in different societies and its various roles in innovation (Etzkowitz and Leydesdorff, 2000). Universities, firms, and governments each undertake the role of the other in triple helix interactions even if they play their own roles. The university undertakes the role of industry by stimulating the development of new firms from researches. Firms develop training to higher levels and share knowledge through joint ventures, acting like universities. Governments act as public venture capitalists while continuing their primary job regulatory activities. Triple helix focuses on the university as a source of entrepreneurship and technology as well as critical inquiry.

A triple helix coordinated entirely by the government only allows for a limited source of ideas and initiatives. Under these circumstances government may take initiatives without consulting others, indeed it may subsume the other institutional spheres and direct their activities (Etzkowitz, 2008). Conversely, if the government is absent from the innovation picture, then coordination, regulation and funding necessary to encourage improvements may be insufficient.

The growth of new firms from academic research and the location of science-based industry adjacent to universities is a manifestation of triple helix relations. Innovation increasingly takes form in triple helix relations and the new types of innovation actors that are invented through these interactions include incubators, science parks, and venture capital firms.

Innovation takes on a new meaning as the spirals of the triple helix intertwine. Even in its original sense of product development, innovation is no longer only the special province of industry. Knowledge producing institutions have become more important to innovation as knowledge becomes an increasingly significant element in new product development (Etzkowitz, 2008).

This expansion of the concept of innovation makes university and government significant actors in the innovation process, collaboratively as well as individually. The triple helix is a platform for "institution formation," the creation of new organizational formats to promote innovation, as a synthesis of elements of the triple helix. The triple helix captures this transformation of roles and relationships as intertwined spirals with different relations to each other (Etzkowitz, 2008).

2) Governance types in Triple Helix

The fundamental interest in Triple Helix is to analyze what kinds of relationships exist among innovation actors such as university, industry and government. Generally speaking, there are three types of governance structure in Triple Helix such as static model, laissez-faire model and normative model (e.g. Etzkowitz, 2008; Etzkowitz and Leydesdorff, 1997, 1998).

(1) Static model

In some countries, government is the dominant institutional sphere. Industry and the university are subordinate parts of the state. When relationships are organized among the institutional sphere, government plays the coordinating role. In this model, government takes the lead in developing projects and providing the resources for new initiatives. Industry and academia are seen to be relatively weak institutions that need strong guidance. The former Soviet Union, France, and many Latin American countries are a good example of this model (Etzkowitz, 2007).

The static model relies on specialized organizations linked hierarchically by central government. Translated into science and technology policy, the static model is characterized by specialized basic and applied research institutes, including sectoral units for particular industries. Universities are largely teaching institutions, distant from industry. A central planning agency was a key feature of the Soviet Union of the static

https://doi.org/10.7165/wtr17s1207.17

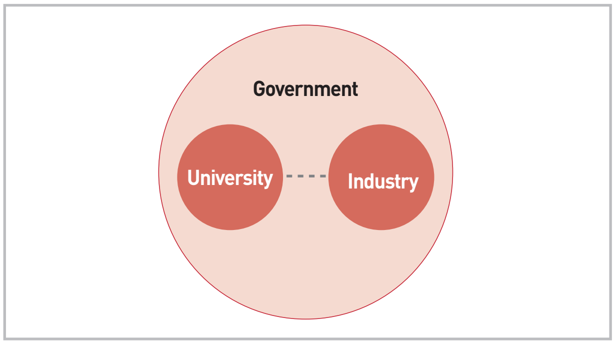

Fig. 3. The static model

Source: Etzkowitz, 2008

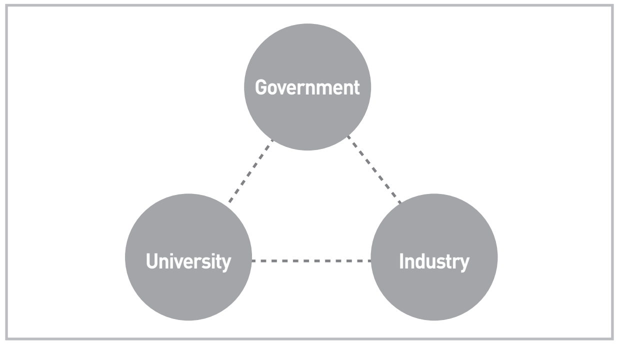

Fig. 4. The laissez- faire model

Source: Etzkowitz, 2008

model. A decision was required from the central planning agency to arrange implementation of institute research. Waiting on such a decision often became a block to technology transfer since the firms and the institutes could not arrange the matter directly (Etzkowitz, 2007).

(2) Laissez-faire model

In this model, the university is a provider of basic research and trained persons. Its role in connection with industry is to supply knowledge, mainly in the form of publications and graduates who bring knowledge with them to their new jobs. It is up to industry to find useful knowledge from the universities without expectation of much assistance. Industry is also expected to operate on its own, with firms linked to each other by the market relationships of buying and selling (Etzkowitz, 2007).

In the laissez- faire model, government is expected to play a limited role of regulation or of buying products but not necessarily in the military area where there is much closer linkage.

Government is expected to play a larger civilian role only when an activity cannot be provided by the market. No one is prepared to offer the function for sale or perform it, therefore it must be provided by government. It is on the basis of this argument of market failure that it is agreed that the government may provide funds to the university to supporters each because the market will not meet that need. Since it would not take place otherwise, it is accepted that there is a limited role for government (Etzkowitz, 2007; Etzkowitz, 2008).

(3) Normative model

A normative model is emerging in the transition to a knowledge based society, whereby university and other knowledge

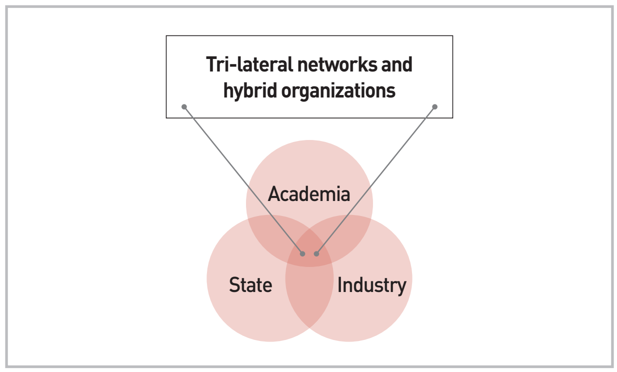

Fig. 5. Normative model

Source: Etzkowitz and Leydesdorff, 2000

institutions play an increasing role, acting in partnership with industry and government (Etzkowitz, 2008). The normative model offers the most important insights, as the best environments for innovation are created at the intersections of the structures. This is where creative synergies emerge and set in motion a process of “innovation in innovation”, create new venues for interaction and new organizational formats, as individual and organizational actors not only perform their own role, but also “take the role of the other” when the other is weak or under-performing (Etzkowitz and Leydesdorff, 2000; Etzkowitz, 2002; Ranga and Etzkowitz, 2013). Through this creative process, the relationships among the institutional spheres of university, industry and government are continuously reshaped in “an endless transition” to enhance innovation (Etzkowitz and Leydesdorff, 1998), bringing forth new technologies, new firms and new types of relationships in a sustained systemic effort (Ranga and Etzkowitz, 2013).

3) Triple helix circulation

Knowledge capitalization has various sources in industry, universities, and government institutes. When knowledge is transformed into capital, persons from any originating may be potential entrepreneurs and founders of firms. A triple helix in which each strand may relate to the other two can be expected to develop an "overlay of communications, networks, and organizations among the helices" (Etzkowitz and Leydesdorff, 2000; Etzkowitz, 2007).

Figure 6 depicts a triple helix circulation that occurs on "macro and micro" levels. Macro circulations move among the helices, while micro circulations take place within a particular helix. The former create collaboration policies, projects, and networks while the latter consist of the outputs of individual helices (Etzkowitz, 2007; Etzkowitz, 2008).

Lateral social mobility, introduction of expertise from one social structure to another, can stimulate hybridization, invention, and innovation of new social formats. Horizontal circulation is thus more likely to have a radicalizing effect than vertical circulation with its inherent conservative bias. Vertical circulation occurs through upward and downward movement of individuals within an institutional structure, typically through recruitment of new persons of talent from lower strata, revivifying an elite (Pareto, 1991; Etzkowitz, 2008).

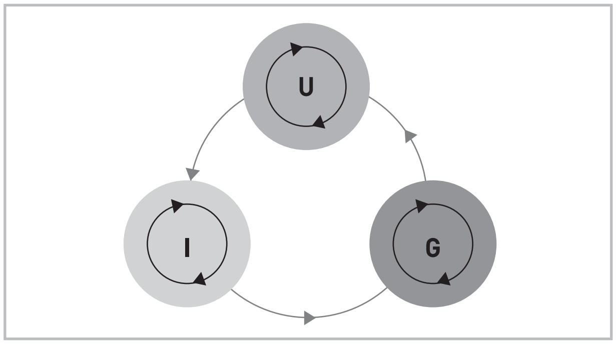

Fig. 6. Circulation of individuals in the triple helix

Source: Etzkowitz, 2008

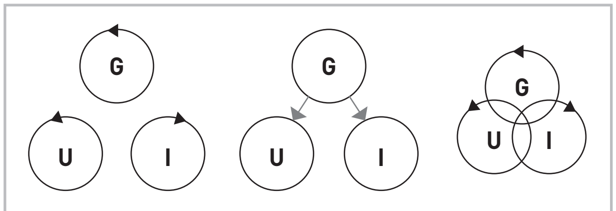

Fig. 7. Evolution of Triple Helix Model

Source: Etzkowitz, 2008

4) Evolution of university–industry–government relationships in Triple Helix

The triple helix is an analytical and normative concept derived from the changing role of government in different societies in relation to academia and industry. Interaction among university, industry and government as relatively independent, yet inter dependent, institutional spheres is the key to improving the conditions for innovation and sustainable development in a knowledge-based society. The triple helix is a spiral model of innovation that captures multiple reciprocal relationships at different points in the process of knowledge capitalization (Etzkowitz, 2002).This model as be seen in Figure 7 explains three stages of development in Triple Helix about transition of inter actions among university, industry and government in terms of knowledge production, exchange and use (Etzkowitz, 2002).

The first stage of the triple helix model is internal transformation in each of the helices, such as the development of lateral ties among companies through strategic alliances or an assumption of an economic development mission by universities.

The second stage is the influence of one helix upon another, for example, the role of the U.S. federal government in instituting an indirect industrial policy in the Bayh-Dole Act of 1980. When the rules of the game for the disposition of intellectual property produced from government sponsored research were changed, technology transfer activities spread to a much broader range of universities, resulting in the emergence of an academic technology transfer profession.

The third stage is the creation of a new overlay of trilateral networks and organizations from the interaction among the three helices formed for the purpose of coming up with new ideas and formats for high-tech development.

An example of this is Joint Silicon Valley which is a nonprofit organization established at the beginning of 1992 that include large firms, small enterprises, local governments and universities to cope with stagnation because of severe competition in semiconductor and computer industry.

These kinds of interactions create new organizations such

https://doi.org/10.7165/wtr17s1207.17

as incubator facilities, technology transfer office and science parks to achieve the goals which were set up through the networking among three innovation actors (Etzkowitz, 2008). These processes give influence to the role of university, industry and government that are belonged to innovation spiral and the influences are expanded to the whole society in the long run. Collaboration between knowledge generating actors related to innovation should be preceded to get development in triple helix.

Universities, industries and governments in a region may participate in discussion to enhance a local economy. Local governments may agree to speed up building-permitting processes to a new plant construction, universities may undertake to train more students in an area related to the local economy and firms may negotiate new supplies relationships with each other (Etzkowitz, 2007).

3. The 4th Industrial revolution

1) Introduction

The Fourth Industrial Revolution can be described as the advent of "cyber-physical systems" involving entirely new capabilities for people and machines. While these capabilities are reliant on the technologies and infrastructure of the Third Industrial Revolution, the Fourth Industrial Revolution represents entirely new ways in which technology becomes embedded within societies and even our human bodies. Examples include genome editing, new forms of machine intelligence, breakthrough materials and approaches to governance that rely on cryptographic methods such as the block-chain (Davis, 2016).

There were three industrial revolutions before the last one. The First Industrial Revolution is widely taken to be the shift from our reliance on animals, human effort and biomass as primary sources of energy to the use of fossil fuels and the mechanical power this enabled. The Second Industrial Revolution occurred between the end of the 19th century and the first two decades of the 20th century, and brought major breakthroughs in the form of electricity distribution, both wireless and wired communication, the synthesis of ammonia and new forms of power generation. The Third Industrial Revolution began in the 1950s with the development of digital systems, communication and rapid advances in computing power, which have enabled new ways of generating, processing and sharing information (Davis, 2016).

However, in many parts of the world aspects of the Second and Third Industrial Revolutions have yet to be experienced, complicated by the fact that new technologies are in some cases able to "leapfrog" older ones. The 4th Industrial Revolution is beginning to emerge at the same time that the third, digital revolution is spreading and maturing across countries and organizations.

Table 1. Major drivers of change for future society in each country

Classification	Major drivers of change
Germany	Big data, robot, self-driving car, smart supply chain, self-organization, etc.
UK	Bio and nano technology, future computer, virtual reality, hologram, 3D printing, etc.
USA	Cloud, automation technology, censor and communication skill, 3D printing, software, IoT, self-driving car, etc.

source: Dolphin, 2015; Talwar and Hancock, 2010

2) Characteristics of 4th industrial revolution

Hyper intelligent and hyper connected are the two key characteristics in 4th industrial revolution and society will be become intelligent because of those characteristics. We are already stepping into hyper-connected era. Rapid development and expansion in ICT area including internet of things and clouding exemplified connection between human and human, human and things, things and things and hyper-connected has exemplified through those process. It is expected that the number of internet platform subscriber by 2020 would be three billion and the number of smart device unit would be 50 billion. This statistics suggest that we are entering now hyper-connected society (Kim, 2016).

There is another characteristic, hyper intelligent, in the 4th industrial revolution. Technologies and industrial structure will be transformed to hyper intelligent due to linkage and conversion of artificial intelligence and big data which are one of the main drivers of change. We already experienced that we are living in the era of 4th industrial revolution in 2016. Go player Lee Saedol and artificial intelligence computer Alphago got several rounds of go play matches. It is expected that deep learning related market will be rapidly grown in the future.

3) Changes of society in the 4thIndustrial Revolution Era

Industrial structure will be changed and a new smart business model will be created through the convergence of technologies and industries in the 4th industrial revolution era in terms of technology/industrial point of view. A new industrial ecosystem such as smart factory that is based on Cyber Physical System would be established due to the characteristics of hyper connected and hyper intelligent. For an example, Cyber Physical System will change a main body of production. Traditionally, mechanical system was a main part in the production process, but parts are main bodies in production and mechanical system is used as an auxiliary production part in a new industrial structure.

Transition in industrial ecosystem already has begun because necessity of human labor became lower in manufacturing and phenomena of re-shoring appear in these days. Boston Consulting Group diagnose that US became suitable place for production at the 2013 Report as a reflection of this phenomena. General Electric Corporation moved manufacturing factories for laundry machine, refrigerator and heater from China to Kentucky and Google produces Nexus Q, media player at the San Jose California. Strategy of Cyber Physical System based Industry 4.0 is under proceed in advance by Germany after converging ICT and manufacturing for the prosperity and innovation of manufacturing industry at 2011.

Due to the advancement of platform technology based on hyper connection such as Internet of Things and Cloud, a new smart business model 'online to offline' will appear sooner or later. Sharing Economy and On-demand Economy will bring new types of industrial collaboration based on experience of consumer and data and a new smart business model based on ICT and hyper connection will be made.

4) Case study: Strategic policies to respond the 4thIndustrial Revolution

Existing industrial structure and societal system will be totally changed in the 4th Industrial Revolution Era because a group of disruptive technologies such as Internet of Things, Bag data, Cyber Physical System and artificial intelligence, etc., would be dramatically evolved. What would be the industrial structure in the 4th Industrial Revolution if we accept the transformed industrial structure mentioned above? We may find common features from 'industries 4.0 of Germany', the industrial internet of U.S.A, and 'new robot strategy of Japan'. Common features are convergence between products and services, linking hardware and software, and consolidation of network and real world. Various policies and strategies to cope with the 4thIndustrial Revolution are under creation in many developed countries such as Germany, US and Japan.

① Germany

Germany leads the 4thIndustrial Revolution. Germany pronounced Strategy of 'Industry 4.0' through 'high tech 2020' that converging ICT and manufacturing industry together as one of the key national projects at November 2011. 'Industry 4.0' means the 4thIndustrial Revolution to survive at the era of Internet of Things, Big Data and Service.

The strategy of Germany is to utilize current manufacturing ecosystem which collaborate large firms and SMEs in one hand and to generate fundamental innovation over the entire manufacturing industries through the establishment of intelligent and automated Cyber Physical System that connect all the things together and converge computer and physical world.

Germany made a plan of establishing a system of producing multiple sort with proper amount through efficient product development and production process, and optimal supply and acquiring standardization by expanding their system over the world. Major companies such as Siemens and Volkswagen are affirmatively participating in governmental plan that Germany want to lead world manufacturing industry by enhancing export competitiveness and high technologies.

> In Germany, government and industry has defined a plan for smart factory development with the Industry 4.0 program. The smart factory concept means that manufacturing processes will be organized in a different way compared to the traditional standards. In the era of intelligent manufacturing, the entire production chain, including suppliers, logistics and product life cycle management will be connected across corporate boundaries.
>
> In the factory of the future, all individual steps included in the production process will be fully connected and integrated. Some of the processes to be impacted are factory and production planning, logistics product development, enterprise resource planning and manufacturing execution systems. Also, in a smart factory, the plant machinery and equipment will enable the improvement of the production process through self-optimization and autonomous decision making. (Tomás, 2016)

Germany is trying to lead global standards of manufacturing industry in the early 2020s through "industry 4.0"by establish-

https://doi.org/10.7165/wtr17s1207.17

ing and operating an innovative manufacturing industry platform based on number one data base in the world. The data created from individual factories and products are shared between devices, factories and industries and high-performance production equipment located industrial sites perform necessary jobs. This model aims at building a manufacturing ecosystem in where every factory in the country operating as a virtual factory.

② U.S.A.

The President's Council of Advisors on Science and Technology pronounced an evaluation report "The Network and Information Technology Research and Development" on R&D in eight ICT areas in August, 2015. The council suggested pushing ahead eight areas preponderantly in fiscal year of 2017. Those eight areas are cyber security, IT and health, big data and data intensive computing, IT and physical world, cyber human system, and high performance computing.

United States try to build an industrial internet platform that is composed of cloud service extension in scope and structure like a big firm such as General Electric, etc. Information on the internet, production facilities and parts of the real world are collected and systematically stored on the cloud server, and artificial intelligence handle those date with many sorts and the administrators of the production site conduct appropriate measures. In this case, the production facilities at the factory are cheap devices that perform their jobs under the orders of cloud server. This is an industrial model that preoccupy new industrial ecosystem by taking use of internet platform capacity and expand their business areas into autonomous cars, self-operating robot, etc. The strategy of business expansion of Google and Amazon is expansion and re-production of cloud-based industrial system that emerging from network into real world.

Private firms are actively participating in implementing governmental policies. General Electric suggested industrial internet as a new industrial revolution model through the linkage of Internet of Things, Cyber Physical System, Big Data and artificial intelligence. This is a platform strategy to secure stabilized income and to merge service industry and manufacturing industry through the sophisticated big data analysis after collecting various data from industrial sensor attached machineries. American Industrial Sector established Industrial Internet Consortium in 2014 and GE, IBM and Intel participated in this project as major actors and about 258 firms and groups are participating as of December 2016.

The industrial Internet refers to smart devices, smart systems, and smart decision-making. This technology helps to optimize the industrial process with the real-time application of big data generated by industrial equipment.

The industrial Internet of Things involves the sensors and devices fitted in industrial equipment that provides large quantities of data. The basic concept of the industrial Internet rests on the premise that the entire world can be connected through any device.

③ Japan

Japan revealed the 4th Industrial Revolution Policy "Japan Revitalization Strategy 2016" which is established based on IoT, Big Data, AI, and Robot. Japanese government suggested 'New Robot Strategy' as a 4th industrial revolution platform policy based on already existed robot technologies to solve the problems of low fertility and aging society. This strategy aims to compete with Industrial Internet Strategy of USA and Strategy of Industry 4.0 of Germany through acquisition of international standard in manufacturing industry by utilizing Japan's advantage robot technologies

Table 2. Strategies of enhancing industrial competitiveness

Country	Main contents
Germany	- Industry 4.0' was announced to lead in manufacturing industry - Converging ICT and manufacturing industry, Proceeding smart factory through standardization
USA	- Advanced manufacturing partnership, establishment of national strategies for high tech manufacturing industry. - Enhancement of national competitiveness through the innovation in high tech manufacturing industry, creation of jobs, economic prosperity
Japan	- Strategy of industrial prosperity in Japan, Law for competitiveness enhancement - Excavation of competitive industries, Generation of new market, Regional innovation

source: Summary of publications from each country.

III. ROLE IDENTIFICATION AND POLICY RECOMMENDATION FOR STP

1. Role identification

Traditionally, the main roles of science parks were technology commercialization, conducting R&D activities and providing facilities for start-ups and incubation. However new roles of science parks for the 4th Industrial Revolution Era should be changed. It is necessary to invent and foster new growth engine of a country from convergence of ICT, manufacturing and service industry for the 4th industrial revolution because hyper connection is one of the key characteristics of the 4th industrial revolution era.

The first role of science parks in the 4th Industrial Revolution could be an acceleration of networking as a growth engine of regional development. The 4thIndustrial Revolution or Industry 4.0 is the idea of smart factories in which machines are augmented with web connectivity and connected to a system that can visualize the entire production chain and make decisions on its own. In this fourth Industrial Revolution, we are facing a range of new technologies that combine the physical, digital and biological worlds. These new technologies will impact all disciplines, economies and industries, and even challenge our ideas about what it means to be human. These technologies have great potential to continue to connect billions more people to the web, drastically improve the efficiency of business and organizations and help regenerate the natural environment through better asset management.

The second role of science parks in the 4th industrial revolution could be carrying out new education programs or capacity building projects to cope with hyper intelligence, which is another key characteristic of 4th Industrial Revolution. It is necessary to utilize strategically the “Internet of Things” to prepare the coming workforce for the challenges ahead in the 4th Industrial Revolution Era.

There are different opportunities available that will shape the role which can be undertaken by science parks in the 4th industrial revolution era.

2. Policy recommendations

The World Economic Forum considers that re-skilling and retraining will be a priority and that governments should incentivize this trough lifelong learning. Other priorities include reshaping education curriculums to meet future needs and collaboration between business and government to meet skills and employment needs.

1) Acceleration of networking

Networking ability of a science park is fundamental factor in the era of the 4th industrial revolution. Competitive science parks need to create an organizational context in which networking among tenants, universities and companies outside the park is encouraged and reinforced. The competitive advantage of science parks relies on the development of business and technological alliances, partnerships and opportunities with similar science park organizations, research centers and firms located around the world (European Investment Bank et al., 2010).

The competitive positioning of parks is usually carried out through an analysis of the international market structure and the science park’s skills and infrastructures. However, parks also have to position themselves with respect to existing national and international park networks. It is necessary to bear in mind that (European Investment Bank et al., 2010):

- The science park network is based on relationships with the central government, local governments, universities, large and medium-sized firms, venture firms, and associated institutes (endogenous networking). Cooperative networking between the local government and the park management helps to enhance the park’s performance;
- Such international collaboration is a strong axis of the park’s positioning strategy. This can strengthen the technological innovation capacities of the local area as science parks often seek skills and resources beyond national borders. Such international collaboration (exogenous networking) can take place through bilateral collaboration with one or more parks with the same sectoral focus, through participation in other parks’ scientific or collaborative research projects, or through multilateral industrial development initiatives.

2) Education to foster creative and innovative manpower

It is necessary to foster manpower that has capabilities to adapt actively and can lead changes of future society on the ground that the key factor in the 4thIndustrial Revolution is human being. To respond and to enhance utilizing capability future technologies, it is necessary to expand and intensify software education based on information and communication technology and to create an environment of smart education. UK has undertaking education of 5~16 year old students as a duty after designating 2014 as ‘the year of code’ and curricu-

https://doi.org/10.7165/wtr17s1207.17

lum of computer science for the K-12 students is under operation in USA.

An education innovation plan, Connect ED (2013) Program is under operation by utilizing super speed internet and high technology based learning tools in USA and 'Education Cloud Program' is under operation to provide students global level IT infrastructure. In case of Europe, establishing IT based education environment by accelerating 'Opening up Education (2014)' to enhance creativity on information and communication technology for the elementary and middle school students is a general trend.

3) Initiating capacity building projects

It is necessary to adopt capacity building centered education system to foster workers who have creative and converging capacity by escaping from traditional education system because society will demand people who are ready for the 4th Industrial Revolution. Some advanced countries including US already initiated new education system to foster student for the future. New types of university such as 'Minerva School' has established and under operation in US and new types of educating method such as 'Massive Open Online Course' is being introduced in a few famous universities such as Harvard and M.I.T. Traditional education system put focus on gaining knowledge but new education system put focus on creative and converging capacity building and on capacity building to solve problems. Stanford University put focus on increasing student's capacity for the sake of creativity and innovativeness enhancement by operating 'D-School at Stanford' that combine knowledge on science and technology and ideas for design. Under this situation, it is necessary to transform education system based on knowledge expansion to education system based on fostering creativity and convergence oriented capacity building in the field of science and technology.

IV. CONCLUSIONS

If the 4th Industrial Revolution is reviewed from industrial aspect, Sharing Economy and On-demand Economy is emerging due to the development of technology-based platform that connect the supply and demand, and starting-ups would be relatively easy because variety of services and business models that utilize technology-based platform will be increased.

Support policies such as improving labor market flexibility, revising education system and fostering basic science etc. are necessary to respond to the 4th Industrial Revolution. A few categories of policies are recommended here.

Firstly, policies such as retraining existing human resources, improving flexibility of education system and carrying out joint programs among industry, academia and research institute are needed to meet a highly skilled jobs on demand.

Secondly, policies such as making high value-added, enhancing technological competitiveness and fostering materials and parts industries through the increase of investment efficiency in R&D are recommended.

Thirdly, a few policies such as fostering new growth engine industries, conversing manufacturing and service industries and re-shoring of domestic industries which are currently located in foreign countries are necessary to cope with the restructuring of global industries.

A science park is basically a real-estate development, ideally located next to a university. Its purpose is to house two types of research oriented firms: companies that grew out of the university and want to maintain close ties, and firms that want to locate an R & D unit to a quasi-academic site (Etzkowitz, 2008). The former type of firms need to develop business alliances, partnerships and opportunities with similar firms located around the university, because hyper-connected is one of the characteristics of 4th industrial revolution and this type of firms have a good position in this. The latter firms often wish to pursue multiple objectives, including closer collaboration with academic researchers and the ability to invite potential recruitment candidates to work in the firm. This type of firms need to train firm employees by university professors and to carry out joint research projects by university professors and firm employees, because the person who is transferring knowledge from university to firm is the person that firm want to hire.

Science parks have been playing a key role in leading national economic development and working as a growth engine in advanced countries for a long time. Science parks over the world are now facing a new trend so called "the 4thIndustrial Revolution" with no strategies to cope with this new wave. Since individual science park may stand on a different position, no unified strategies could be identified, some strategies such as acceleration of networking, education to foster creative and innovative manpower and initiating capacity building projects will be necessary to all the science parks.

REFERENCES

Davis, N. (19 Jan 2016) "What is the fourth industrial revolution?", World Economic Forum. Available at: https://www.weforum.org/agenda/2016/01/what-is-the-fourth-industrial-revolution/

Dolphin, T. (2015) *Technology, Globalisation and the Future of Work in Europe*, Institute for Public Policy Research (IPPR). Available at: https://www.oxfordmartin.ox.ac.uk/downloads/academic/technology-globalisation-future-of-work_Mar2015.pdf

Etzkowitz, H., and Leydesdorff, L. (1997) *Universities and the Global Knowledge Economy: A Triple Helix of University-Industry-Government Relations*, London: Pinter.

Etzkowitz, H., and Leydesdorff, L. (1998) "The Endless Transition: A "Triple Helix" of University-Industry-Government Relations", *Minerva* 36(3): 203-208.

Etzkowitz, H. and Leydesdorff, L. (2000) "The Dynamics of Innovation: From National Systems and 'Mode 2' to a Triple Helix of University-Industry-Government Relations", *Research Policy* 29(February): 109-123.

Etzkowitz, H. (2002) *MIT and the Rise of Entrepreneurial Science*, London: Routledge.

Etzkowitz, H. (2007) "University-Industry-Government: The Triple Helix Model of Innovation", *Proceedings of 51st EOQ Congress* (Pargue, 22-23 May 2007), European Organization for Quality.

Etzkowitz, H. (2008) *The Triple Helix: University-Industry-Government Innovation in Action*, New York: Routledge.

European Investment Bank, the World Bank, Medibitikar, and City of Marseille (2010) *Plan and Manage a Science Park in the Mediterranean: Guide book for Decision Makers*. Available at: http://www.eib.org/infocentre/publications/all/plan-and-manage-a-science-park-in-the-mediterranean.htm

International Association of Science Parks (IASP) (2002) "Definitions: A glossary of some key terms and definitions from the industry of science and technology parks and areas of innovation", (IASP International Board, 6 February, 2002). Available at: http://www.iasp.ws/Our-industry/Definitions (Accessed at May, 2017)

Kang, B. J. (2014) "Exploring Governance Models of Science & Research Parks and Related Organizations", *World Technopolis Review* 3(1): 39~54. DOI: 10.7165/wtr2014.3.1.39

Kang, B. J. (2016) "Governance Structures to Facilitate Collaboration of Higher Education and Science & Technology Parks", *World Technopolis Review* 5(2): 108-118.

Kim, J. H. (2016) "Seeking strategic responses to future social change in the era of the Fourth Industrial Revolution", *KISTEP Inl* 15: 45-58.

Oh, D.-S. (2011) "Academia, Industry and Government Cooperation in Science & Technology Park: Case of Daedeok Innopolis, Korea", *Technopolis Review* 12th Issue: 28-40.

Pareto, V. (1991) *The Rise and Fall of Elites: An Application of Theoretical Society*, New Brunswick, NJ: Transaction Publishers.

Ranga, M., and Etzkowitz, H. (2013) "Triple Helix Systems: An Analytical Framework for Innovation Policy and Practice in the Knowledge Society", *Industry and Higher Education* 27(4): 237-262.

Talwar, R., and Hancock, T. (2010) *The Shape of Jobs to Come: Possible New Careers Emerging from Advances in Science and Technology (2010-2030)*, Fast Future Research.

Tomás, J. P. (March 28, 2016) "Smart factory tech defining the future of production processes", *RCR Wireless News.* Available at: https://www.rcrwireless.com/20160328/internet-of-things/smart-factory-tech-defining-future-production-processes-tag23-tag99

Received November 19, 2017
Revised December 03, 2017
Accepted December 07, 2017