Linear Thinking in the Governance of Emerging Technologies: An Analysis of the Emerging Epistemic Community of the Fourth Industrial Revolution Technologies in South Korea

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Abstract

Epitomized by Vannevar Bush’s linear model, linear thinking on the relations of science and technology (S&T) viewing science to have sequential impacts on technology and society is prevalent among policymakers despite its descriptive inaccuracy. This study explores the mode of linear thinking among scientific experts leading the discourse and policymaking on the so-called fourth industrial revolution (4IR). It first examines a new policy window for South Korean researchers of information & communication technology (ICT) opened with the widely televised AlphaGo match in March 2016. Through in-depth interviews of long-time advocates of frontier ICT, we track how Korean ICT experts have taken advantage of the AlphaGo shock and pushed their research agenda with various opportunities (notably the government’s mid- and long-term ICT development planning process). These interviews supplemented with documentary analyses of key policymaking moments reveal an emerging community of experts sharing common causal beliefs and assumptions as to the socioeconomic and ethical consequences of 4IR technologies. We then examine the pattern and degree of linear thinking among the ICT experts, especially in recognizing and formulating technical and social risks of 4IR technologies such as job displacement, human identity crisis, and ethical dilemmas. This analysis utilizes the survey of about 100 ICT and non-ICT experts and 500 lay citizens on the potential risks of 4IR technologies. Our preliminary results show a significant degree of linear linking in identifying and preemptively addressing key risks of 4IR technologies is most prevalent among ICT experts, followed by non-ICT experts, and citizens. As such this study reveals the serious limitations of the emerging epistemic community of ICT experts in understanding the co-production of technological risks and devising better anticipatory governance of emerging 4IR technologies.

Keywords: fourth industrial revolution, epistemic community, linear model, co-production, expert, ICT, anticipatory governance, South Korea

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1. Introduction

In South Korean, the Fourth Industrial Revolution (4IR) is in progress. Korean lawmakers introduce the framework act for “Promoting the 4IR” and developmental plan for "Intelligence and Information Society." The 4IR special committee was organized in August 2017 by a presidential order to converge the public’s opinions and integrate the private sector’s participation. The 4IR is more than catch praise or a popular word.

The concept of industrial revolution has been discussed for a long time. The Industrial Revolution refers the economic and industrial changes, including other changes in society, technology, and organization in 18 centuries Briton by Arnold Toynbee’s work in 1884 (Bezanson 1922). Characterized by factory system, capitalism, colonial economy, and class, the Industrial Revolution describes the industrialization of agricultural society (Houston and Snell 1984; Crafts 1996). The cotton, iron, and machinery industries arise with new technologies such as spinning machine and steam engine. The industries grow, and technologies are diffused, stimulating each other (Song 2017).

Since the second revolution is discussed, yet economic historians investigate the validity of revolution, focusing on technological changes (Mokyr 1998). Electricity, chemicals, and communication devices are featured in the second revolution, and automation, aircraft, and manufacturing control system are featured in the third revolution (Edgerton 2010). The historians prioritize the impacts of technologies differently. Fogel (1962) reinvestigate the contribution of train system to the American economy, finding that technological innovation is not the prerequisite for industrial growth (Rosenberg 1983). The historical view criticizes that productivity gains from technological progress are delayed in the era of the first industrial revolution (David 1990). The debates on "productivity paradox," which denotes the
doubtful result of capital investments and technological innovations are widened with the deliberation on information technology (Brynjolfsson and Hitt 1996; Macdonald, Anderson, and Kimbel 2000).

Information and communication technology (ICT) is on the forefront of the 4IR despite the disputable relationships between technological innovations and industrial revolutions. The government of South Korea announces the “Mid- and Long-Term Plan for Intelligent and Information Society” in December 2016. Targeting on artificial intelligence (AI) and big data R&Ds to catch up the leading edge technologies, the plan states the reformation of industries, education, and social welfare system. It intends to increase a societal adaptability to AI-driven-changes and prevent the risk of emerging technologies.

The epistemic communities (epicoms) of ICT experts in universities appear at this moment in South Korea. The government organizes the special committee composed of ICT experts, especially in AI research. They mainly position in academy unlike the world leading AI experts in the U.S., which are mainly in industry. ICT experts have shared the causal belief and technological imaginaries, voicing the rationale for societal change with the image of bright future.

This research confirms the epistemic characteristics of the ICT experts’ communities, the linear thinking of science and technology. Vannevar Bush (1945) asserts the linear model of science and technology, addressing the basic rationale for public funded R&D. The model explains the relationships between science, technology, and society. Scientific knowledge discovered in basic research is developed as a technology research. Technology is applied to diverse industrial fields, which is diffused to the entire society and progress the society. ICT epicoms blur the boundaries between basic, development, and applied research, conducting
convergence research and finding the channels for technology diffusing and method of commercialization. In this practice, the epistemic communities are distinguished from the technological determinism prevails in Korean society.

The communities understand the social construction of technology; however, they recast the linear thinking, which is not seemingly different from technological determinism after experiencing economization of R&D. They actively fit the research subjects to policy criteria requiring economization that is led by the government. Meanwhile, the communities participate in economization, they argue new economization, stating that private sector and universities become the principal agents of R&D, and the government is a system coordinator supporting innovation. Believing that AI will change the society regardless of the existence of the 4IR, epistemic communities remain in linear thinking, although they overcome the technological determinism.

The linear thinking of ICT epistemic communities limits the risk perception of emerging technologies in three aspects. First, the linear thinking limits the imaginaries of risks. Second, the linear thinking leads policy to rely much on a technological fix. Lastly, the linear thinking hinders the public making consensus on emerging technologies and risk governance. Jasanoff (2016) points that risk management of emerging technologies has a failed history due to uncertainty. In a sense, this research reflects the limitation of emerging epistemic communities in understanding the co-production of technological risks and devising better anticipatory governance of emerging 4IR technologies.

(Following section includes the literature reviews)
2. Literature Review

Fourth Industrial Revolution

How this concept spreads to South Korean society? World Economic Forum (WEF) suggests the definition of 4IR. Klaus Schwab (2016), the executive chairman of WEF said “Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last century. It is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres”. The principal agent utilizing the concept is manufacturing industry. They are international engineering firms handling equipment and machinery and data analysis firms forecasting the market.

In detail, the Industrie 4.0, German manufacturing innovation policy is the preliminary concept of 4IR. German Industrie 4.0 implements AI to achieve full automation by digitalizing the manufacturing practices to enhance operation control with advanced sensors. Other developed countries, U.S., Japan, and China, have a similar manufacturing policy, but rarely mentioning the “fourth industrial revolution.”

Schwab state some emerging technologies as leading forces of 4IR. They are AI, robots, internet of things (IoT), automated vehicles, 3D-printing, nanotechnology, biotechnology, material science, energy storage, and quantum computing. The leading technologies is a set of heterogeneous technologies. Some technologies are rather than products such as automated vehicles, but nanotechnology and biotechnology are research fields. Energy storage is a research domain but is a research goal or additional effects of technological development.

The government of South Korea (Related Ministries 2016) announces the “Mid- and Long-Term Plan for Intelligent and Information Society” in December 2016 to preemptively
response to technological change. It has been nine months after the go match between AlphaGo and Lee Sedol, the heroic go master of South Korea. Targeting on artificial intelligence (AI) and big data R&Ds to catch up the leading edge technologies, the plan states the reformation of industries, education, and social welfare system to increase a societal adaptability to AI-driven-changes and prevent the risk of leading technologies. The plan explains that the social change is originated from “technology → industry → society,” which is different from previous R&D policy that rationalizes public investment for fostering new industries (industry → technology → new industry). In a sense, the technological determinism is prevalent over the economization rationale considering S&T as inputs for economic growth (Berman 2014). The R&D budget for the Korean AI is newly planned for a one trillion won, which is the one thirteen of yearly R&D budget.

Media criticizes that the policy response has rash aspects. It is significant criticisms pointing the repeated issues of the Korean science and technology policy. R&D policy lacking long-term commitment easily leads to speculative projects and results in trustless relationships between agents and principles (Hong et al. 2015). Strong governmental leadership drives the 4IR as it does on other innovation policies. Media, however, prints the articles on the “fourth industrial revolution,” contributing to making the 4IR as a “social reality” in the Korean society (Hong 2017, 6), which is reflected in Figure 1. The 4IR has local popularity in the Korean society compared to the global trend in the Google search. The media reports cross the two phase for making 4IR as a major issue in society. It was 119 articles published in 2015. Including major press media, 44 media report the 4IR as an issue of World Economic Forum in January 2016. They could not drag the 4IR as a major topic in the next month. From 223 to 143, articles printed in the public media decrease. The go match between human
and AI reboots the 4IR news to 449 in March. The number of the articles constantly increases at the end of the year and becomes policy interest as the presidential election starts. For the five months after presidential impeachment passed in December of 2016, 17,177 news articles are published. All candidates of major parties refer the "fourth industrial revolution" and pledge the social reformation for upcoming 4IR and early response to perceived risk.

Public research institutes and National Assembly of South Korea open policy debates on 4IR. Ministries of Korean government manage policy seminar 168 times, and public research institutes publish more than 60 reports after the AlphaGo shock. The policy seminar held in National Assembly invite the Klaus Schwab emphasizing that technology convergence will rapidly change the society in 4IR age. He concludes that individual citizen, firm, and government should increase the adaptability to technological change.

Figure 1. Google Trend Search (2016-2017)

Note: This result is drawn from the world-wide trend of Google search. The “4차 산업혁명” is the Korean translation of fourth industrial revolution.
ICT Experts and Epistemic Communities

The epistemic communities of ICT experts appear when the scientists and engineers perceive the 4IR as a policy window. Their primary belief is that machine learning technique will shape the Korean society into the entirely different world. The belief they share shows up in public lecture, columns, televised show, and policy debates with confidences and concerns. Centering the machine learning on the debates and dealing with the application fields such as internet of things, big data, autonomous driving, security computing, etc., ICT experts care on emerging ICT, based on electronic engineering and computer science. Expert groups are composed of researchers in an academy and public research institute, unlike the U.S. where industrial scientists and engineers lead AI research.

“ICT” and “expert” become famous words in 4IR. Korea Press Foundation (2017) analyzes the related keywords around the 4IR. Listing the name of major presidential candidates as Figure 2 shows, the media articles are focused on particular technologies, which are ICTs such as "artificial intelligence," "internet of things," and "big data." The analysis shows that the "job" and "expert" are other important issues in the 4IR. Drawing the dissensus between scientific advisory in South Korea, this research confirms the communities' emergence and the epistemic characteristics of communities.

Korean researchers in universities have transformed their positions in the contextual change of policy. On the one hand, collaborating with industrial research and transferring technologies by patent, professors perform entrepreneurship in 90s’ democratization (Ryu 1998; Lee, Lee, and Pennings 2001). On the other hand, scientist and engineers in universities cooperate with the government, mobilizing political resource to drive Korean science and technology policy in Cold War (Kim 2008; Im and Choi 2017). They even become policy
entrepreneurs legislating brand new research domain in the middle of post-development debates (Shin 2017). In these days, Korea Advanced Institute of Science and Technology (KAIST), one of the top research university in South Korea, announces the responding plan for the 4IR as an academic practitioner in annual WEF meeting. Selecting ten patents as prospective technologies in the era of 4IR, KAIST holds public lectures explaining the technologies with promising visions.

Figure 2. Keywords Analysis on Fourth Industrial Revolution in South Korea

Source: Newspaper & Broadcasting May (Korea Press Foundation 2017, 117-118), Fig. 3. The title of the article is "The Fourth Industrial Revolution in News big data."

Note: Translating the source into English.

The scientists and engineers perceive 4IR as a policy window. The Korean Federation of Science and Technology (KFOST), the largest organization of scientists and engineers in Korea, survey its member’s recognition on the 4IR in May 2017 at the peak of popularity. The survey finds that majority members of KFOST think that the 4IR already starts. According to Hong (2017), the survey results reflect scientist and engineers’ perception of the
4IR in three ways. First, scientists and engineers expect positive future with the 4IR. They are more optimistic about science and technology. Second, although they realize the theoretical deficit of 4IR, considering this phenomenon is a something currently in progress. As a result, the scientists and engineers push the policy issues toward the 4IR they prioritize before.

The scientists and engineers’ issues on the 4IR policy are divided into two groups. The first group supports the institution reformation in general and second group supports the deregulation. Both of issues score a similar importance (27% v. 26%) as Figure 3 top shows. The first issue is related to the science policy in general, for instance, scientific communities’ autonomy on research fund, miscommunication between government agencies, and pressure on outcomes within a short term. The cases of the second issue are easing the evaluation process before and after the project and deregulating on technology transferring and commercialization. The former issue covers the scientists and engineers in general, and the latter issue is primarily relevant to researchers in development and application. In our interview, ICT experts prefer the deregulation rather than reformation. They recognize the broad emphasis and support of scientific communities on AI and related technologies as Figure 3 bottom reflects. The “education and innovation system” scores first in strategic field survey but interest groups prioritize AI based technologies heavier like “IoT,” “digitalization of manufacturing,” and “automation” follows.
The ICT epistemic communities appear in the policy window of 4IR. ICT experts are the major player of 4IR policy. Some of them speak the risk of technological changes. Stating that “robot replace 70 percent of jobs” in Korea (Choi 2015), the ICT experts concern the competitiveness will be “caught up by China” and should invest to digitalization of manufacturing to regain the superiority over those late comer countries (Sim and Kim 2016). They criticize the government intervention, education system failing to raise creativeness, and innovation practice in the industry. Policy rhetoric is mentioned to illuminate the urgency
of the 4IR, such as income polarization, population aging and labor force shortage (Park 2013). ICT experts assert the social reformation issue with the risk of AI technology. They warn that technological change will sweep the Koran society, but conclude their warning with the prospective forecasting on future; "human will think about what they will do after machine replaces their labor."

The epistemic communities are not dominated by technological determinism. They disagree with the crisis debates originated from 4IR. Believing that AI will change the society regardless of the existence of 4IR, the epistemic communities have confidence in their expertise. They overcome the technological determinism prevalent in Korean society. They demand institutional setting change, understanding that technology could not shape the society alone. These epistemic communities reflect that how the casual and principle belief of scientists and engineers shapes the policy domain (Haas 1992). The scientific advisory offers supporting knowledge to alliance party, suggesting the direction of policy in an objective tone. In this process, they form a coalition sharing belief and knowledge. Further, understanding and utilizing the structure influencing political agents, the coalition of scientists and engineers share "a common policy enterprise" (Haas 2015, 5). Insisting that uncertainty in the emerging technology could be mobilized for the policy enterprise, this research investigates the difference of perception between ICT experts and non-ICT experts. The perception gap between lay citizens and experts are also important, but we focus on dissensus in experts to examine the social construction of knowledge and politics of expertise (Bak 2013).
Linear Thinking and Risk Perception

The rising epistemic communities in ICT fields have reproduced and strengthened the linear model of science and technology policy. Linear thinking in ICT experts is different from technological determinism. It is more close to the economization of science and technology, which translates the scientific knowledge into political power. The linear thinking, however, limits the communities to deliberate the co-production of emerging technologies' risk and participate the anticipatory governance.

The early community of AI researchers did not label themselves majoring AI. Although they interacted with lay citizens by teaching them, the researchers concerned that public could have an unrealistic expectation on AI (Shin 2017b). They hope that AI technology progress in a linear way without fluctuation that U.S.’ AI researchers’ experienced. After machine learning dominates the AI research in these days, this normative behavior has been changed. Researchers actively reveal their major in AI, making collaboration with application fields.

The epistemic communities blur the boundaries between processes of R&D. The linear model of science divides the R&D into three steps; basic, development, and application. In our interview, one researcher thinks basic research in ICT is linked to commercialization directly via machine learning. In other words, one robot researcher explains that every step of R&D has own “market needs” as Figure 4 reflects. Conducting convergence research and finding the channels connecting S&T and society such as technology transfer, clinical test, patent transaction, they flexibly shift between the stages of R&D.
The communities understand the social construction of technology; however, they recast the linear thinking, which is not seemingly different from technological determinism after experiencing economization of R&D. The linear thinking and technological determinism have a similar feature, but they are different (Vermaas et al. 2011). Having various stages between science and society, the linear model permits the society to interact with S&T. In a sense, epistemic communities actively fit their research subjects to policy criteria requiring economization, which is led by the government. In their voice, epistemic communities state that private sector and universities become the principal agents of R&D and government should be a system coordinator supporting innovation. The communities’ vision on economization resonates with the critics on science, technology, and innovation policy.
insisting diverse agents should participate and lead innovation system (Song et al. 2004; Hong et al. 2015).

The linear thinking of ICT epistemic communities limits the risk perception on emerging technology in three aspects. First, the linear thinking weakens the imaginaries on technological risks. Nuclear power plants in the developmental era of South Korea show that technological imaginaries are shaped by expert groups. Thus public has limited imaginaries on the power plants (Jasanoff and Kim 2009). ICT experts and lay citizens do not contemplate the uncertainties of 4IR technologies in diverse aspects. Thus technological unemployment becomes the representative risk. Institutions like technological assessment screen opinions of lay citizens, but the assessments do not carry on debates for long-term (Ryu et al. 2010). Realizing the gap between experts and lay citizens and dissensus between experts, this research could contribute to extending the imaginaries. Second, the linear thinking leads policy to rely much on a technological fix. Technological fix undermines the governance of technology, which could deepen political risk on responsibility (Hutchings, Parker, and Jeffrey 2016). Personal data loss, for the case, is a potential risk engaged with the majority of the 4IR technologies, increasing the governance on convergence research. In preliminary interview, ICT experts dealing with data in biotechnology leans much on security computing for data protection. They consider data leakage risk will be spontaneously solved as technology progress, and has little relevance to their fields because the security computing is on charge. Lastly, the linear structure of expertise hinders the consensus on emerging technologies and risk governance of the public (Beck 2011). Jasanoff (2016) points that risk management of emerging technologies such as NBIC (nano-, bio-, information technology, and cognitive science) has failed history due to uncertainty. In a sense, the needs for
anticipatory governance developing consensus is grown because the governance could guide the society confronting risks of emerging technologies (Guston 2014). Our research investigates the public’ societal understanding of 4IR technologies and experts’ risk perception, suggesting evidence for the anticipatory governance of emerging technologies.

References


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