The Necessity and Future Challenges of Science, Technology, Society and Humanities Fusion Research in Korea

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ABSTRACT

Science, technology, society and humanities (STSH) fusion research is aimed at creating new research areas and methods that can resolve complicated issues in society that cannot be solved by a single academic discipline. This study identifies initiatives that can promote STSH fusion research in Korea. We review the definition and characteristics of STSH fusion research to analyze the necessity of STSH fusion research with a focus on the structural changes in the S&T environment. The emergence and diffusion of generic technologies, transition to post catch-up innovation mode, and the evolution of policy to the third generation innovation policy are identified as notable changes. This paper briefly reviews the status of fusion research underway and presents initiatives to promote STSH fusion research.

KEYWORDS: fusion research, science, technology, society and humanities (STSH), technology assessment, ELSI research

1. BACKGROUND

There has been growing interest in fusion research that encompasses science, technology, society and humanities (STSH) fields in Korea. Research is underway to identify new research areas and create new knowledge by converging science and technology with social sciences and the humanities. Examples of such convergence include brain science, cognitive science, and cultural technologies.

New research focuses on exploring the social implications of science and technology, and discusses how to adopt and implement new technologies. As a result, technology assessment and research dwelling on the ethical, legal, and social implications (ELSI) of technology are gaining wide attention

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these days. Fusion research has remained a peripheral issue in discussions on science, technology and innovation policies. However, it is now emerging as a major subject in the Science, Technology and Innovation (STI) policy agenda.

STSH fusion research is still faces challenges due to the closed structure of research fields and it is a recent move that STSH fusion research is materialized in various projects. This study identifies initiatives that can promote STSH fusion research. For this purpose, Chapter 2 reviews the definition and characteristics of STSH fusion research. In Chapter 3, the necessity of STSH fusion research will be reviewed with a focus on the structural changes in the S&T environment. Chapter 4 briefly reviews the status of fusion research underway while Chapter 5 presents initiatives to promote STSH fusion research based on the understanding that Korea needs STSH fusion research a local identity and characteristics.

2. THE CHARACTERISTICS OF STSH FUSION RESEARCH

2.1 Definition and Types of STSH Fusion Research

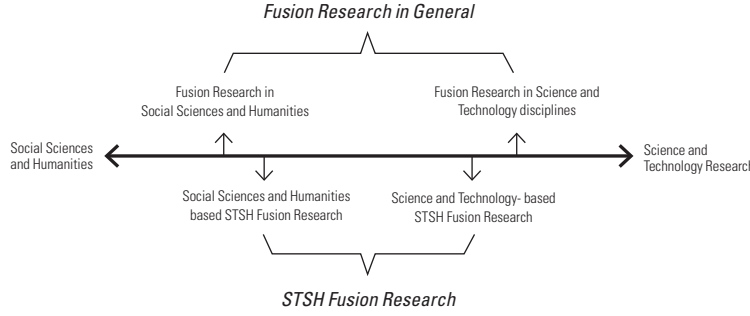
STSH fusion research is aimed at creating new research areas and methods to resolve complicated issues in society that cannot be solved by a single academic discipline. The objectives of STSH fusion research are to generate creative fusion with science, technology and society that can meet future different socio-economic needs and to build a science and technology system friendly to humans, society, and culture through a self-reflexive approach.

STSH fusion research can be classified into 'science and technology based fusion research' and 'society and humanities based fusion research'. Science and technology based fusion research creates new research fields and knowledge by combining S&T knowledge with society and humanities as in the cases of brain science, cognitive science, and cultural technology. In these research areas, creating new science and technology is emphasized through fusion. On the other hand, society and humanities based fusion research creates knowledge in the process of exploring social meanings of science and technology and understanding the process of the social embedding of new technology. In this type of fusion research, the focus is on the reflection and social acceptance of science and technology.

Depending on the degree of development, STSH fusion research is classified into two types. The first type of STSH fusion research is an early-stage fusion research creating new knowledge fields by combining existing individual academic disciplines. Though this type of fusion research is still lacking its identity as an independent research domain, it presents a potential development path as a new academic field. The second type of STSH fusion research is a more established state of fusion research. Examples of this type of STSH fusion research include, cognitive science combining psychology, philosophy, artificial intelligence, history of science and technology in addition to the sociology of science and technology. Since different types of STSH fusion research require different implementation approaches, it is necessary to take specific approaches when developing policies to promote fusion research.

Interdisciplinary fusion research of the National Research Foundation of Korea contains a detailed definition of STSH fusion research. According to this definition, STSH fusion research is one that meets national or social needs by fusing STSH, analyzes social issues caused by S&T development from a society and humanities perspectives, and solves issues by applying S&T research methods to society and humanities research.

FIGURE 1 Status of STSH Fusion Research



2.2 Technological Evolution and STSH Fusion Research

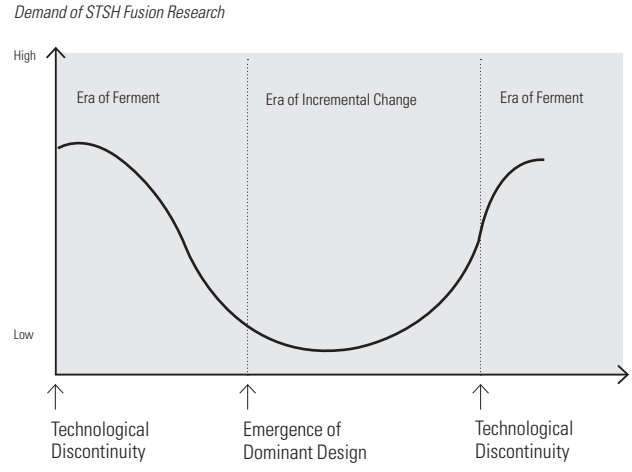
From the perspective of interactions between science, technology and society, STSH fusion research is activated when society pursues a new socio-technical system.

When society explores new industries based on new technologies, the society creating and utilizing the new technologies is in a flexible state. It is uncertain which technological options will be the dominant design or what institutions and markets are necessary for creating and utilizing these technological options (Tushman and Rosenkopf, 1992; Van de Van and Garud, 1993). For example, it is uncertain whether curing diseases using stem cell technology would be possible in the future. Even if curing diseases using stem cell technology becomes possible, it is still unclear what criteria are required for a safe and effective cure, what regulations are required, and whether a stem cell market can be supported.

Innovators who support certain technologies like industries, universities, and research institutes try to create institutions that support new technologies as well as develop technologies (Nelson, 1994; Lynn et al, 1996; Bijker and Law, 1992; Deuten et al, 1997; Geels, 2004). When new socio-technical systems emerge, the complimentary aspects between technologies and social systems become diluted and conflicts arise between the groups who support old versus new technologies. To overcome this situation, more knowledge and efforts are required at the entire society level. Interests in STSH fusion research intensify when the demand for knowledge on the interaction between technology and society increase.

Later when new socio-technical systems are stabilized, incremental innovation becomes possible and interests in STSH fusion research decreases. However, when a new technology emerges again, socio-technical exploration of new technologies takes off again, reactivating STSH fusion research.

FIGURE 2 Evolution of Technology and the Demand of STSH Fusion Research



Source: partial modification of Tushman and Rosenkopf (1992).

3. THE NECESSITY OF STSH FUSION RESEARCH IN KOREA

Behind this new phenomenon lies the structural transformation of science and technology innovation. This change requires more in-depth study and understanding of the co-construction of science, technology, and society.

3.1 The Emergence and Diffusion of Generic Technologies

The first notable change in this regard is the emergence and proliferation of such generic technologies as IT, biotechnology, and nanotechnology since the mid-1990s. A generic technology refers to a technology that constitutes the foundation of every type of human activity and has the potential to change economic and social activities in general (Perez and Soete, 1988; Caracostas and Mulder, 1998).

Amid the diffusion of these generic technologies, new lifestyles and work routines have begun to emerge. Active interaction between generic technologies and social institutions has given rise to a completely new type of socio-technical system. Society has become incomparably different from that of 20 years ago through the wide use of technologies such as the Internet and Smartphones. Through the World Wide Web, we have acquired a new way to make connections, developed new types of industries and services, and create new occupations.

Under these circumstances, it is only natural that research on future socio-technical systems assumes a central importance in STI policy studies. Research in this area requires systematic knowledge about the interaction among Science, Technology and Society. Without such knowledge, policymakers would have difficulty in determining what development trajectories generic technologies will take, which trajectory will be more beneficial to economic growth, employment, the environment and the quality of life, and finally what policy measures are necessary to select the most desirable trajectory (Geels, 2004).

3.2 Transition to Post Catch-up Innovation Mode

Another notable change is the shift of Korean companies away from catch-up innovation. Korean companies have traditionally pursued what is called the fast second strategy. Under this strategy, Korean companies enter new markets after first movers have established themselves. They capture the emerging markets based on their prowess in product development and large-scale production capabilities. This strategy has helped Korean firms avoid the trial and error process, while enabling them to grab the opportunities offered by rapidly growing markets.

The fast second strategy has helped Korean companies grow into world-class corporations. This strategy requires the ability to monitor the direction of technology development pursued by leading corporations. Its successful implementation also calls for the ability to make salient decisions, focus investment on certain areas, and drive managers and workers toward the given goals. It does not accept any mistakes, failures, or deviations in the implementation process (Kim, 1997; Lee and Lim, 2001). However, many Korean firms have reached a point where there are no more targets to imitate and benchmark (Hobday et al, 2004). For them, it has become difficult to maintain global competitiveness through the imitation strategy as firms in newly emerging nations are rapidly catching up using a similar strategy.

Under these circumstances, Korean companies have to blaze new trails through creative innovation activities that require an approach completely different from the fast second strategy since it means developing new products and services. Korean firms need to go beyond developing new technologies. They should be able to see how their new technologies interact with society. They need to figure out how their technologies create new markets, establish new institutions, and change individual lifestyles.

These efforts assume central importance in creative innovation activities. Recent developments in the cellular phone sector well demonstrate the importance of creative innovation. Korean companies have achieved global competitiveness in the mobile phone sector through the fast second strategy; however, they have had some difficulties in establishing dominance in the Smartphone business.

The emergence of the Smartphone has changed the mobile phone market; however, Korean companies were slow to understand the changes and respond to it. The main reason: their business strategy was based on old market development forecasts. The difficulties of Korean firms in establishing leadership in the Smartphone business was not due to their lack of technology or expertise, but due to their lack of the ability to understand the social implications of Smartphones and to visualize the future that this new mobile gadget offers.

Fusion research encompassing STSH can significantly contribute to improving innovators' ability to co-construct technology and society. It will ultimately enhance their ability to envision future socio-technical systems, and strengthen the ability to lead in a newly emerging industrial sector.

The efforts of Korean companies to go beyond playing catch-up and should involve a new approach with regard to technological risks. In the catch-up process, they faced low risks in technology development because they borrowed technologies from advanced nations. Moreover, it was easy to address the risks because they could use the safety rules and other countermeasures that were already in place in these countries.

Korean companies are now facing new problems as they are now in the post-catch up phase. In many cases, the concept of the technologies they intend to develop is not clear and there are not enough solutions to the safety issues occurring in the process of developing and using new technologies. In addition, new technologies appear in a society where relevant standards, safety rules, and other necessary norms are not yet defined. Korean companies which develop new technologies need

to think about how to establish new social systems that go with them. For instance, these days, cosmetics and home appliances are developed using nanotechnology. For their wider use, it is necessary to identify potential risks of nano-particles, discuss safety rules, and build a social consensus on how to ensure safety.

Fusion research involving STSH can play a crucial role in addressing new technological risks. Technology assessment and ELSI research aims to review technological risks that may arise in the innovation process, provide solutions to the risks, and suggest new directions for technology development. This can contribute to devising safety rules and resolving conflicts stemming from technological risks as well as facilitate future adoption and the utilization of new technologies.

3.3 The Evolution of STI Policy

The third structural change behind the rise of fusion research is the evolution of science technology innovation policies. In the past, STI policies focused on developing science and technology. Today the focus has shifted to resolving economic and social problems using science and technology. This new approach is called third-generation innovation policy or integrated innovation policy. Previous, STI policies concentrated on economic growth; however, the scope of third-generation STI policies has expanded to cover social issues, such as the environment, health and welfare, and safety (Edler et al, 2003, OECD, 2005).

TABLE 1 The Development of STI Policies

	First Generation Innovation Policy	Second Generation Innovation Policy	Third Generation Innovation Policy
Approach toward Innovation	linear approach	systemic approach	systemic approach
Policy Goals	economic development	economic development	economic development, quality of life, sustainable development
Areas of Innovation Policies	sectoral policies	policies involving several sectors	policies involving several sectors
Major Policy Interests	policies for science	· policies for innovation · innovation-friendly employment policies and financial policies	· innovation policies for resolving economic and social issues · integration of environmental and social policies with innovation policies
Major Players of Innovation Policy	science and technology sectors	science, technology, and economic sectors	science, technology, and economic sector as well as users and civil society

Source: Summary of Edler et al (2003); OECD (2005).

In Korea, the examples of such a shift include 'the Innovation Policy for the Enhancement of Quality of Life' announced by the National Science and Technology Council in 2007, 'the Public Welfare and Safety Research Project' initiated by the Ministry of Education, Science and Technology in 2010, and 'the Quality of Life Technology (QoLT) Development Project' promoted by the Ministry of Knowledge Economy in 2010.

STSH fusion research is designed to analyze how science and technology can contribute to resolving social problems. In this respect, fusion research makes innovation policies reflexive. It provides us

with a good platform to review the social functions, effects, and implications of the development of science and technology. For policymakers, fusion research offers a good opportunity to reflect on why innovations are promoted in the first place.

4. THE CURRENT STATE OF STSH FUSION RESEARCH IN KOREA

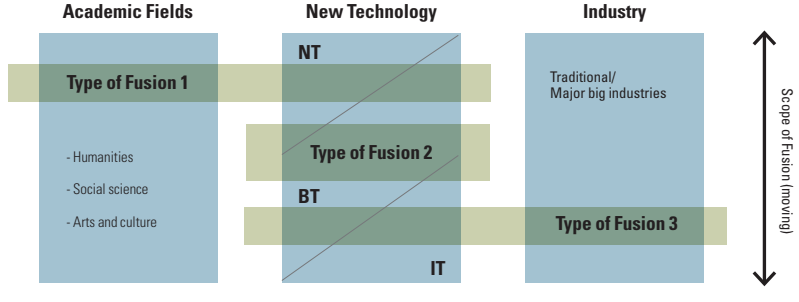
While the demand for STSH fusion research is growing, this type of research is only in its beginning stage in Korea. There has long been a clear division between liberal arts and science and engineering. Furthermore, high barriers exist between departments in each division. Under these circumstances, conducting research transcending the departmental boundaries is by no means easy. Even if young researchers are trained in fusion research, it is not easy for them to engage in it because under the current departmental system, they cannot find a research job in the first place unless they specialize in one of the existing disciplines. This causes problems in nurturing and utilizing a talented workforce.

It is against this backdrop that several projects have been launched to revitalize STSH fusion research. They are conducted not as a project affiliated with a large-scale science-technology or society-humanities research program, but as an independent project where STSH converge. Examples include a study on policies targeting the development of fusion technologies, research on technology assessment, and ELSI research.

4.1 Fusion Technology Development Project

Under the 'Basic Plan for National Fusion Technology Development (2009-'13)', STSH fusion research project is being conducted to promote inter-disciplinary fusion research. Since this project began two years ago, its goal and future direction are not yet clearly defined. It has been moving forward through trial and error. STSH fusion research carried out under this project aims to integrate science and technology with social sciences and humanities to create new knowledge.

FIGURE 3 Types of Fusion Research



Type 1: Fusion between new technologies and existing disciplines (humanities, social sciences, arts and culture) and fusion between science-technology and society-humanities. Examples: brain research, cognitive science.
Type 2: Fusion between new technologies. Examples: nano-bio materials research, IT- nano device technology.
Type 3: Fusion between new technologies and existing industries. Examples: intelligent vehicle technology and U-city technology.

Source: Basic Plan for National Fusion Techologies Development (2009-'13)

4.2 Technology Assessment and ELSI Research

Technology assessment and ELSI research aim at interpreting science and technology from a social sciences and humanities perspective. Technology assessment started 10 years ago but it has not yet developed to the point of attracting social attention. Technology assessment is an activity undertaken before the implementation of a new technology. It studies ways to maximize benefits from the new technology while minimizing its negative impacts. A wide range of experts participate in this process to assess the potential impacts of the new technology from diverse aspects (economic, social, cultural, ethical, and environmental) and come up with measures to reduce technological risks. In addition, the results are introduced to the public to enhance social learning about the new technology and its impacts.

Technology assessment in Korea has been conducted since the late 1990s and mainly led by civil society organizations in the form of 'consensus conferences' on issues such as genetically modified food and cloning technologies. Consensus conferences are intended to give ordinary people an opportunity to deliberate the benefits and risks of a technological development and reach a consensus about their possibilities and consequences. It is a technology assessment that relies on discussions and learning among civic society organizations rather than on expert opinions.

In 2003, the Korean government initiated its official technology assessment projects in accordance with the Science and Technology Basic Law. It assessed NBIT fusion technology in 2003, RFID technology in 2005, nanotechnology in 2005, stem cell research in 2006, climate change technologies in 2007, and infectious disease protection technology in 2008.

The outcomes of these technology assessments were passed on to the members of the National Science and Technology Council, but they have not drawn much attention due to the low awareness or understanding of technology assessment on the part of public officers, scientists, and engineers. In addition, it is difficult to conduct in-depth technology assessments due to the lack of preliminary studies and qualified experts on a wide range of subjects covered by technology assessment.

To address this problem, it is necessary to carry out research that reviews the potential, limitations and social influence of new technologies from a social sciences and humanities perspective. This will aid a knowledge base necessary for technology assessment and help nurture researchers. At the same time, science communication needs to be activated to increase the outcomes of technology assessment to civil society as well as the science community and induce social discourses on them.

ELSI research studies ethical, legal and social implications of new technologies; however, this field remains in its embryonic stage. Currently, ELSI research on the human genome project, brain science, and nanotechnology is underway at a small scale. The research focus is on systematically reviewing the research achievements of advanced nations and applying them to Korea. In addition, work is

TABLE 2 The Case of Technology Assessment in Korea

	Technology	Convening Organization
Civil Society led TA	GMO Food (1998)	UNESCO Korea
	Cloning Technology (1999)	UNESCO Korea
	Electricity Industry (2004)	People's Solidarity for Participatory Democracy
Government led TA	NBIT Fusion Technology (2003)	MOST
	RFID Technology (2005)	MOST
	Nanotechnology (2005)	MOST
	Stem Cell Research, UCT, and Nano-material (2006)	MOST
	Climate Change (2007)	MOST
	Infectious Disease Protection Technology (2008)	MEST

underway to finalize the Robot Ethics Charter needed to effectively respond to potential problems that may arise in using robots.

5. POLICY ISSUES FOR STSH FUSION RESEARCH

In order to promote STSH fusion research, it is necessary to launch independent research projects focused on fusion research. Interdisciplinary research remains on the periphery of science and technology R&D projects; it also tends to be ignored by researchers in the social sciences and humanities fields. STSH fusion research needs to go beyond the dimension of being conducted as an extension of existing research projects to the level of securing a solid foundation as an independent research area.

For this, the first thing that needs to be done is to launch a new type of national R&D project called the "Science, Technology, Society and Humanities Alliance Program". This program is intended to lay the foundation for STSH fusion research. It is a meta program designed to promote STSH fusion research, nurture a fusion research workforce, establish research infrastructure, and create research organizations.

In addition, it is necessary to implement a sub-project for the development of a fusion research roadmap and a fusion research model that helps predict the independent advancement of STSH fusion research. In this process, complicated relations and interfaces between different academic disciplines and technologies need to be checked on a regular basis and a research map needs to be developed to explore mutually beneficial fusion research between humanities, social sciences, arts and science and technology to ultimately present a future direction of fusion research. Along with this, the structure, process and issues of STSH fusion research should be analyzed and the modeling of fusion research types is also necessary. This means the entire cycle of planning, selection, evaluation and commercialization of fusion research projects should be reviewed to come up with knowledge and experience required for systematic research planning and management. In this process, a thorough review of success versus failure factors and facilitating versus hindering factors is also required.

Second, it is necessary to launch projects to assess the social and cultural implications of large-

scale national R&D projects. Through such assessments, we can ensure that national R&D projects develop in a way that is friendly to the environment, society, and culture. For large-scale national R&D projects, it is necessary to allocate a certain amount of research expenditures (about 2-3 percent of the total budget) for the assessment of their social and cultural implications. This mechanism could allow researchers in the humanities, social sciences, arts, and science and technology to jointly conduct STSH fusion research, deliberate the future direction of the R&D projects, and carry out social learning. At the same time, it is necessary to connect separate technology assessments and ELSI research projects for a more effective and wider utilization of research methodologies as well as information and knowledge created from each project.

Another necessary task is to strengthen the link between STSH fusion research and science-technology planning, management, and evaluation activities. Planning a national R&D project or making a technology roadmap requires a profound knowledge of the future developments in socio-technical systems; however, Korea is not yet capable of creating such profound knowledge. As a result, discussion on the future socio-technical systems tends to be based on the outlook and visions created by advanced countries. It is obvious that Korea needs a vision that is tailored to domestic social conditions and it is necessary to carry out STSH fusion research on the future development of domestic socio-technical systems prior to planning or creating a technology roadmap.

We also propose the establishment of a STSH fusion research center committed to the resolution of social problems. In order to resolve social and technological problems occurring in the process of technology adoption and application, we should establish a research center where social sciences and humanities scholars can conduct research jointly with scientists and engineers. The researchers will be able to carry out community-based research aimed at resolving social problems in a certain region. For instance, they may study countermeasures for social and environmental problems that may arise in a community following the wide distribution of renewable energy technologies or they may focus on the establishment of an energy recycle system in an industrial complex for small and medium-sized companies. The establishment of a preventive medicine system in rural areas could also be the subject of research for the center.

Along with this, it is necessary to develop programs to support "social entrepreneurs" who actually carry out the problem-solving activities based on the results of STSH fusion research. To solve social issues, social entrepreneurs lead social innovation in public sectors such as the environment, welfare, culture, and safety.

6. CONCLUDING REMARKS

Since STSH fusion research is a new research area in Korea, it is necessary to create an independent knowledge base as well as secure legitimacy by widely publicizing its social value and usefulness. However, given the clear division between liberal arts and science and technology, it would take quite some time before fusion research becomes the mainstream in the R&D sector. In this regard, recent efforts toward STSH fusion research can be seen as an experiment aimed at creating new research trends. To ensure that these experiments can proceed toward a strategic goal, policymakers as well as scientists and engineers need to create a vision for fusion research and chart its future direction.

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