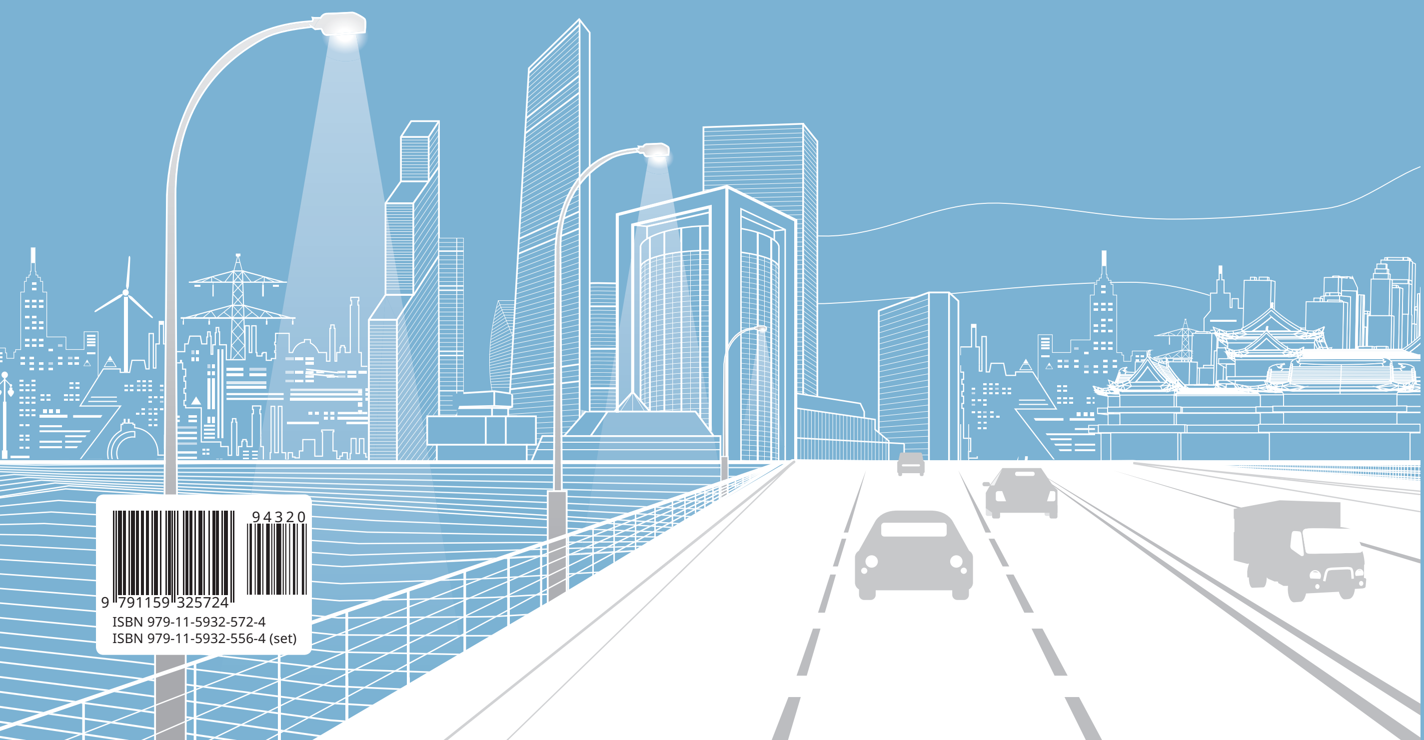
Ministry of Economy and Finance (MOEF)
Sejong Government Complex, 477, Galmae-ro, Sejong-si 30109, Republic of Korea
Tel. 82-44-215-7746
www.moef.go.kr

Korea Development Institute (KDI)
Namsejong-ro, 263, Sejong-si 30149, Republic of Korea
Tel. 82-44-550-4114
www.kdi.re.kr

Knowledge Sharing Program (KSP)
www.ksp.go.kr



ISBN 979-11-5932-572-4
ISBN 979-11-5932-556-4 (set)

2019/20 KSP Policy Consultation Report

Strengthening the Innovation Capacity toward the Era of Industry 4.0 for the Visegrad Group Countries

Ministry of Economy and Finance

Presented by the MOEF, Republic of Korea

Knowledge Sharing Program

2019/20 KSP Policy Consultation Report

Visegrad Group

Strengthening the Innovation Capacity toward the Era of Industry 4.0 for the Visegrad Group Countries

Ministry of Economy and Finance

KDI Korea Development Institute

Government Publications Registration Number
11-1051000-001038-01

Knowledge Sharing Program

2019/20 KSP Policy Consultation Report

Visegrad Group

Strengthening the Innovation Capacity toward the Era of Industry 4.0 for the Visegrad Group Countries

Ministry of Economy and Finance

KDI Korea Development Institute

2019/20 KSP Policy Consultation Report

Project Title	Strengthening the Innovation Capacity toward the Era of Industry 4.0 for the Visegrad Group Countries
Prepared for	Visegrad Group (Czech Republic, Hungary, Republic of Poland, Slovak Republic)
In Cooperation with	Czech Republic, Ministry of Industry and Trade (MIT), Tomas Bata University in Zlin Ostrava technical university Hungary, Ministry of Foreign Affairs and Trade (MFA), Budapest Business School Szechenyi Istvan University Republic of Poland, Ministry of Economic Development World Economy Research Institute at Warsaw School of Economics (WERI, SGH) Slovak Republic, Ministry of Economy (MOE), Slovak Innovation and Energy Agency (SIEA)
Supported by	Ministry of Economy and Finance (MOEF), Republic of Korea
Prepared by	Korea Development Institute (KDI)
Project Director	Sanghoon Ahn, Executive Director, Center for International Development (CID), KDI
Project Manager	Sanghoon Ahn, Executive Director, CID, KDI
Project Officer	Miyeon, Lee, Senior Research Associate, CID, KDI
Senior Advisor	Hyunghwan Joo, Former Minister of Trade, Industry & Energy, Republic of Korea
Principal Investigator	Sungchul Chung, President, The Wonjung Institute
Authors	Chapter 1. Sungchul Chung, The Wonjung Institute Laszlo Csonka, Budapest Business School Laszlo Vasa, Szechenyi Istvan University and the Institute for Foreign Affairs and Trade, Hungary Chapter 2. Seung Jong Oh, KEPCO International Nuclear Graduate School (KINGS) Martin Hromoda, Tomas Bata University Vladimir Kebo, Ostrava Technical University Chapter 3. Siwook Lee, KDI School of Public Policy and Management (KDIS) Marzenna Anna Weresa, Professor, WERI, SGH Arkadiusz Michal Kowalski, Associate Professor, WERI, SGH Marta Mackiewicz, Assistant Professor, WERI, SGH Chapter 4. Youngsoon Chang, Myongji University Artur Bobovnicky, Slovak Innovation and Energy Agency (SIEA)
English Editor	Korea Institute of Culture and Arts Translation

---

Government Publications Registration Number 11-1051000-001038-01
ISBN 979-11-5932-572-4
979-11-5932-556-4 (set)

2019/20 KSP Policy Consultation Report

Strengthening the Innovation Capacity toward the Era of Industry 4.0 for the Visegrad Group Countries

Preface

Knowledge is an essential ingredient in a country's economic growth and social development. Of particular importance is government capacity to formulate and implement policies. The global society is making various efforts to promote knowledge sharing between countries and improve their policy capacity to tackle development issues and enhance global prosperity.

Indeed, knowledge laid the foundation for Korea's unprecedented transformation from a poor agro-based economy into a modern industrialized nation with an open and democratic society. Technology transfer from abroad and educational investment helped expand the domestic knowledge stock and made this transformation possible. The Korean government could also accumulate invaluable practical lessons not found in a conventional textbook through the course of development.

The Ministry of Economy and Finance (MOEF) of Korea introduced the Knowledge Sharing Program (KSP) in 2004 to share Korea's development experience with the international community through joint research, policy consultations, and capacity-building activities. Since its inception, the program has played a vital role in supporting socio-economic development of partner countries around the world.

Korea Development Institute (KDI) has participated in the KSP since the program's launch and has been working with more than seventy foreign countries and organizations. KDI, Korea's leading think-tank with an extensive experience in policy research, has provided solutions to the challenges that partner countries face in a variety of fields, ranging from industrial development to public-sector reform. In the 2019/20 KSP, KDI carried out policy consultation and capacity-building projects with twenty-two partners including three new participants—Belarus, Serbia, and the ASEAN Secretariat.

Among these meaningful projects for mutual learning, this one was initiated by the Ministry of Planning and Investment (MPI) of Vietnam with the aim of "Solving Issues of Technical Barriers to Trade within the Framework of the World Trade Organization and Free Trade Agreement ." Upon the request of the MPI, the MOEF and KDI organized a research team consisting of Vietnamese and Korean experts. The team conducted in-depth analysis of internal and external policy environments, identified Vietnam's key development challenges, and offered policy recommendations and action plans.

The COVID-19 pandemic has affected the project this year, as it has done every aspect of our lives. Despite the unprecedented challenge, the project was successfully completed thanks to devotion from the teams from both countries. Throughout the process, I witnessed how collaborative efforts can lead to overcoming hardship, and learned the importance of knowledge-sharing as more and more countries seek to learn how others have dealt with challenges.

On behalf of KDI, I would like to express my deepest appreciation to the Government of Vietnam and the Department of Planning and Investment (DPI) of the MPI for their collaboration in the project. In particular, I would like to extend my profound gratitude to His Excellency Minister Nguyen The Phuong , Mr. Ton Nu Thuc Uyen, Director General, Ms. Nguyen Van Khoi, Deputy Director, and Ms. Nguyen Anh Duong, Officer at the DPI for their unwavering support. The completion of this project would not have been possible without their devotion. I also wish to thank the KSP consultation team—Senior Advisor Dr. Dae Hee Yoon , Principal Investigator Professor Duk Geun Ahn , researchers Professor Yong Jun Jang and Professor Heejin Lee , and local consultants Mr. Ton Nu Thuc Uyen, Mr. Le Quoc Bao and Ms. Nguyen Van Khoi —for producing this report.

This project benefited greatly from many others both inside and outside the Vietnamese government, including Ms. Nguyen Thi Linh Huong, Director at National Center for Socio-Economic Information and Forecast, Mr. Pham Huu Loc, Professor at Ly Tu Trong Technical College and Mr. Dang Minh CEO at DoLISA. I would like to extend my sincere thanks to all who have made valuable contributions to a successful completion of the project. I am also grateful to the Center for International Development of KDI, in particular Executive Director Dr. Sanghoon Ahn, former Executive Director Dr. Youngsun Koh, Project Manager Dr. Changjae Lee, and Project Officer Ms. Seungju Lee, for their hard work and dedication to the project.

I firmly believe that the KSP will serve as a stepping stone to further elevate mutual learning and economic cooperation between Vietnam and Korea, and hope it will contribute to their sustainable development.

Jeong Pyo Choi
President
Korea Development Institute (KDI)

Contents

Chapter 2
Smart Energy Systems in Safe Society 4.0

Chapter 3
Policy Instruments Supporting Innovation in Services: Policy Implications for Korea and V4 Countries

Contents

Contents | List of Tables

Contents | List of Tables

Contents | List of Figures

Contents | List of Figures

Chapter 4

2019/20 Korea-Visegrad Group Knowledge Sharing Program (KSP)

Miyeon Lee (Korea Development Institute)

2019/20 Korea-Visegrad Group Knowledge Sharing Program (KSP)

Miyeon Lee (Korea Development Institute)

The Visegrad Group (V4) is a regional cooperation group comprised of the Czech Republic, Hungary, the Republic of Poland, and the Slovak Republic. It was established through a summit meeting between the three countries of Czechoslovakia, Hungary, and Poland in 1991. However, after Czechoslovakia was dissolved into the Czech Republic and Slovakia in 1993, the V4 remains as a cooperative relationship among the four countries. All four countries were successfully transformed into market economies in the 1990s and are now members of the Organization for Economic Cooperation and Development (OECD) and the Development Assistance Committee (DAC). They are particularly strong in basic sciences, with high education levels and good infrastructure. Further, these countries are supported by the geographical advantages of Europe, which are considered to entail high potential for economic cooperation and growth. The V4 has grown rapidly since joining the European Union in 2004, and has been participating in various projects and operational programs (Ops) that facilitate national development strategies through the EU Fund. The national development strategies of the four countries follow EU policy strategies and key principles, with priority being given to R&D, SMEs, innovation, and infrastructure sectors, especially during the 2014-2020 program. Although the V4 has achieved a relatively stable transition and economic growth, it faces challenges in the areas of strengthening the competitiveness of SMEs, commercializing science and technology, promoting innovation and entrepreneurship, and revitalizing the labor market.

In line with the recent expansion of economic and political cooperation between the Republic of Korea and the V4, the Knowledge Sharing Program (KSP) with the V4 was launched to promote sharing of economic development experiences and knowledge as well as to strengthen the ties between the two sides. In consultation with the four countries in 2015, we analyzed the demand for sharing experiences in “Innovation Policy”, an area which all countries put high policy priorities and have various mutually beneficial experiences. On the 3rd of December 2015 at the first summit meeting, the leaders of the Republic of

Korea and the V4 reaffirmed their intention to work together within the KSP framework. Accordingly, the 2016/17 Korea-V4 KSP was launched in July, 2016. Through this first year of cooperation, Korea and the V4 completed joint research on 1) The National Innovation System of Korea and Visegrad Group Countries; 2) National R&D Projects and Methods of Program Evaluation and Monitoring Mechanisms; 3) Promotion of Technology Transfer and Revitalization of R&D in the Private Sector (Public Policies Supporting Technology-Inspired Start-ups and Their Outcome); and 4) Robotics in Factory Automation.

Based on the results of the 2016/17 KSP, the V4 proposed subtopics for the 2017/18 Korea-V4 KSP, under the overarching topic of “Innovation Policy for SMEs in the Era of Industry 4.0” according to the policy priorities of each country. These subtopics were: 1) R&D and Innovation Policies to Enhance Energy Security (Czech Republic); 2) Fostering Innovation SMEs: With a Focus on Technology Transfer (Hungary); 3) Policy Incentives for R&D and Innovation in SMEs: Accomplishments and Issues (Poland); and 4) Promotion of Smart Production Systems for SMEs: Robotics and Automotive Industry (Slovakia). In the first year of the study, the researchers and policy practitioners determined that the V4 countries are highly dependent on Foreign Direct Investment (FDI) and that the share of SMEs in the national economy is very large. However, they also found that the value-added created by and the innovation performance of the local SMEs are low and that FDI is not closely linked with local companies. Given these structural characteristics and current status, Korea and the V4 partners concluded that innovation policy and institutional improvement are needed for improving SMEs’ technological innovation capacity to facilitate sustainable growth of the V4.

In line with the overall theme of “Innovation” in the area of cooperation between Korea and the Visegrad Group, research was launched to study the S&T system of Korea and Visegrad Group countries in the 2016/17 KSP. Based on the first year’s results of the KSP, researchers from five countries focused on Innovation Policy for SMEs in view of their large share in the national economies of the V4. As the last project of three years of multilateral cooperation, the 2019/20 Korea-V4 KSP has been launched with the overarching topic of “Strengthening the Innovation Capacity of Visegrad Group Countries” according to the policy priorities of each country. The following are the areas of focus: 1) New Role of Higher Education Institutions in an Innovation-based Economy (Hungary); 2) Smart Energy Systems in Safe Society 4.0 (Czech Republic); 3) Policy Instruments Supporting Innovation in Services: Policy Implications for Korea and V4 Countries (Hungary); and 4) Next Generation Policy for Digital Transformation of SMEs in Slovakia (Slovakia). In the first year of cooperation, researchers investigated the ground strategy regarding Science and Technology and Innovation Policy; for the second year, the research was focused on how V4 member countries could support local SMEs in their efforts to expand their innovation capacity. For the last project, the Korean research team drew approaches to enhance the innovation capacity of the V4 countries in the era of Industry 4.0.

Sub-topics	Researchers	Local Consultants
New Role of Institutions of Higher Education In an Innovation-based Economy (Hungary)	Sungchul Chung (President, The Wonjung Institute)	Laszlo Csonka (Senior Research Fellow, Budapest Business School, Hungary) Laszlo Vasa (Research Professor, Szechenyi Istvan University and the Institute for Foreign Affairs and Trade, Hungary)
Smart Energy Systems in Safe Society 4.0 (Czech Republic)	Seungjong Oh (Professor, KEPCO International Nuclear Graduate School)	Martin Hromoda(Tomas Bata University), Vladimir Kebo(Ostrava Technical University)
Policy Instruments Supporting Innovation in Services (Poland)	Siwook Lee (Professor, KDI School of Public Policy and Management)	Marzenna Anna Weresa Arkadiusz Michał Kowalski Marta Mackiewicz (World Economy Research Institute at Warsaw School of Economics)
Next Generation Policy for Digital Transformation of SMEs in Slovakia (Slovakia)	Youngsoon Chang (Professor, Myongji University)	Artur Bobovnicky (Director of the Department of Innovation and International Cooperation, Slovak Innovation and Energy Agency)
• Senior Advisor: Hyunghwan Joo (Former Minister of Trade, Industry & Energy, Republic of Korea) • Project Manager: Sanghoon Ahn (Executive Director, Center for International Development (CID), Korea Development Institute (KDI)) • Principal Investigator: Sungchul Chung (President, The Wonjung Institute)		

For the first official phase of the 2019/20 Korea-V4 KSP, the Korean delegation headed by Hyunghwan, Joo, Former Minister of Trade, Industry & Energy, Republic of Korea, visited Prague, Czech Republic from October 24 to 25 for the KSP launching seminar and High-level Meeting. The launching seminar was conducted on October 24 at the Ministry of Industry and Trade of Czech Republic. Policy practitioners, academicians, and experts visited Prague (Capital of Presidency Country) to participate in the launching seminar. They listened to Korea's experiences in supporting the country's industrial innovation and presented the specific research requirements based on their policy demand and priority. Apart from the launching seminar, participants attended a separate meeting for each topic (countries) on narrowing down the topic, discussing the division of labor, finalizing the title of each topic, and planning future schedule. Furthermore, Former Korean Minister of Industry and Trade, Dr. Hyungwhan Joo had high-level meeting with the Minister of Industry and Trade of Czech Republic, Mr. Karel Havlicek. Through this meeting, Dr. Hyungwhan Joo notified the Czech Minister that the 2019/20 Korea-V4 KSP had been launched successfully, and requested his continuous support for the KSP project. Mr. Karel Havlicek welcomed the KSP consultation team and shared his opinion and expectations regarding the Korea-Visegrad Group cooperative relationship and further economic cooperation.

For the second stage, the Korean researchers visited each country of V4 to attend KSP Policy Seminar, meet various professionals, and visit related organizations and private companies regarding each research topic.

Sub-topics	In-depth study Institute/Agency
New Role of Institutions of Higher Education in an Innovation-based Economy (Hungary)	• Ministry of Foreign Affairs of Hungary • National Research and Development Institute (NRDI) • Budapest University of Technology and Economics, Center for University-Industry Cooperation • University Technology and Knowledge Transfer Forum • University of Debrecen • 77 Elektronika Kft.* • Szent Istvan University
Smart Energy Systems in Safe Society 4.0 (Czech Republic)	• Ministry of Industry and Trade of Czech Republic • Thomas Bata University • Technical University of Ostrava • Energy Security Platform • CNS*
Policy Instruments Supporting Innovation in Services (Poland)	• Ministry of Economic Development • World Economy Research Institute at Warsaw School of Economics
Next Generation Policy for Digital Transformation of SMEs in Slovakia (Slovakia)	• Ministry of Economy • Slovak Business Agency • Office of the Deputy Prime Minister of the Slovak Republic for Investments and Informatization • Industry 4UM (forum of Slovak IT companies)

Note: * Private Company.

The Korean researchers visited Hungary, Czech Republic, and Slovakia to have an in-depth study within 2019. The visit to Poland was scheduled in March 2020. Owing to the unexpected outbreak of COVID-19 in late January, every kind of travel to foreign countries was restricted. Therefore, an in-depth study with Poland was conducted by video conference with polish experts. Even though there were limitations to these online meetings with various professionals and companies, the Polish experts were all professional researchers at university level with various experiences and knowledge of Poland's service industry, and this helped to cover and manage certain limitations of virtual cooperation.

The outbreak of the COVID-19 pandemic since January 2020 has affected the world as a whole. Many countries, including Korea and the Visegrad Group countries, have implemented emergency measures to tackle the pandemic. Facing the COVID-19 pandemic, we are working not only to protect citizens from the virus and develop a vaccine, but also experiencing limitations of global travel, trade, etc. Until now, globalization, free trade, and global supply chain were considered a given condition universally. The COVID-19 pandemic has also affected the timely progress of the 2019/20 KSP. Despite the difficult circumstances, we have been committed to minimizing uncertainties and achieving the initial objective of our project. In this regard, we have devised alternatives to proceed with our joint research. As the third stage of the KSP, colleagues from V4 will be invited to attend the Interim Reporting Seminar and Policy Practitioners' Workshop to be held in Korea. The Seminar and Workshop will provide opportunities to share the interim results of research and allow the V4 delegates to have meetings with research-field-related organizations, companies, and experts in Korea. Since we are facing limitations in global travel because of COVID-19, researchers have suggested that we may present an interim report in writing instead of "Interim Reporting Seminar".

For the last stage of KSP, the Senior Policy Dialogue, and Policy Practitioners' Workshop was organized by on-line means. Given the inconvenience of holding real-time video conferences between five countries with seven hours of time differences, separate Workshops were organized for each country on three different dates.

Date	Country	Sub-topics	Contents
Aug 13 (Thu)	Slovakia	Next Generation Policy for Digital Transformation of SMEs	• Final Reporting Seminar • Policy Practitioners' Workshop
Aug 19 (Wed)	Czech Republic	Smart Energy Systems in Safe Society 4.0	• Senior Policy Dialogue • Final Reporting Seminar • Policy Practitioners' Workshop
	Hungary	New Role of Institutions of Higher Education in an Innovation-based Economy	
Aug 26 (Wed)	Poland	Policy Instruments Supporting Innovation in Services	• Final Reporting Seminar • Policy Practitioners' Workshop

Considering the restrictions presented by the COVID-19 pandemic, the Interim Reporting Seminar was conducted in writing to share researchers' ideas, while the Policy Practitioners' Workshop was postponed. Given that the purpose of the Workshop was to offer an opportunity for direct meetings between researchers from V4 and research-field-related organizations in Korea, both sides agreed to wait until global travel can be safe within the project schedule. While several countries have eased the restrictions on global travel, the COVID-19 situation is still serious and therefore it was not possible to postpone the Policy Practitioners' Workshop anymore. Hence, the Workshop was planned back to back with the Final Reporting Seminar as a special seminar session by external experts in research fields.

With the Czech Republic, the Senior Policy Dialogue was planned between the Senior Advisor, Dr. Hyunghwan, Joo, Former Minister of Industry and Trade, and Mr. Martina Tauberova, the Vice Minister of the Ministry of Industry and Trade of the Czech Republic. As the Presidency country of Visegrad Group in 2019/20, Czech Republic successfully hosted the Launching Seminar and High-level Meeting of the 2019/20 KSP and arranged the Senior Policy Dialogue between the Minister of Industry and Trade of the Czech Republic and the Senior Advisor, Dr. Hyunghwan, Joo, Former Minister of Industry and Trade of Korea. Since an official high-level meeting was held in the first stage of the project, a Senior Policy Dialogue was arranged between Mr. Martina Tauberova and Dr. Joo for sharing the final result of the 2019/20 Korea-V4 KSP and discussing avenues for further cooperation between Korea and Visegrad Group.

This year's project was the last phase of the multi-year, multi-lateral KSP. As the third-year project, it has been a continuation of collaboration on the issues of technology and innovation of SMEs, focused on diverse aspects of the SME sector. Through the whole project period for three projects, researchers from the five countries shared their professional knowledge, experiences, and perspectives in the research field. The KDI is grateful for the sincere cooperation and facilitation from the Ministry of Industry and Trade, Tomas Bata University, and Ostrava technical university of the Czech Republic; the Ministry of Foreign Affairs and Trade and National Research Development Innovation Office(NRDI) of Hungary; the Ministry of Economic Development and World Economy Research Institute at Warsaw School of Economics of Poland; and the Ministry of Economy and Slovak Innovation and Energy Agency (SIEA) of Slovakia. We would also like to place on record our appreciation for the Korean Embassies in the Visegrad Group countries.

Executive Summary

Sungchul Chung (The Wonjung Institute)

Executive Summary

Sungchul Chung (The Wonjung Institute)

In 2016, Korea and V4 countries launched a three-year KSP with a joint examination of their national innovation systems with a view to identifying the focus areas for sharing of knowledge in the policy domain. The review found, among many others, that Korea and V4 countries need to address the problems stemming from structural duality of the industrial innovation systems, in which an extremely large number of non-innovative Small and Medium Enterprises (SMEs) coexist with a very small number of highly innovative Large global Enterprises (LEs). The source of the problem is that it is difficult for SMEs and LEs to engage in mutually beneficial technological interactions, mainly because of the wide gaps in technological capability between the two, which, in many cases, leads to the polarization of the economy, deterring the dynamic and sustainable growth of industries. Korea and the V4 countries shared the view that SMEs' weakness in innovation posed one of the major challenges to the countries on their move toward an innovation economy, and that it was necessary to design and implement a comprehensive set of policy programs, for which a thorough understanding of the underlying issues was a prerequisite.

It was from this perspective that Korea and V4 countries agreed to focus their knowledge sharing activities on the issues related to SMEs and innovation. Accordingly, the subjects of V4-Korea KSP have been centered round the derivatives of SMEs and innovation, with specific issues selected to cater to the needs of individual countries.

The 2019/2020 KSP with V4 tackled the following issues:

- Hungary: New Roles Played by Higher Education Institutions in an Innovation-based Economy;
- Czech Republic: Smart Energy Systems in Safe Society 4.0;
- Poland: Policy Instruments Supporting Innovation in Services: Policy Implications for Korea and the V4 Countries;
- Slovak Republic: Next Generation Policy For Digital Transformation of SMEs in

Slovakia.

Each of the V4 countries teamed up with a Korean research partner and worked together in analyzing the state of the issues, comparing policy experiences, and exploring possible options for policy actions. What follows are the summaries of the collaborative studies and policy implications:

1. Hungary: New Roles Played by Higher Education Institutions in an Innovation-based Economy

Korea and Hungary place high policy priority on the issues of industry-university cooperation, and offer diverse policy programs to promote industry-university interactions so that they can work out new business ideas and technologies to vitalize economic activities. The rationale is simple: if the generators and users of knowledge/technologies work together, it would be easier to translate the knowledge/ technologies into applications that generate social/economic values. The analyses of the policy programs for university-industry cooperation and their performances in the two countries show that there have been noticeable developments in industry-science interface, but there still remain huge rooms for improvement. Each of the countries may find lessons to learn from the strengths and weaknesses of the policy systems and their achievements of the other countries.

Based on the analyses and comparison of the policy experiences of the two countries, the following recommendations are presented for the promotion of industry-university cooperation:

- Make universities more attractive as a source of knowledge for the business sector: (1) improve the infrastructure, human capacity and knowledge base of universities, and (2) make universities more industry-friendly.
- Strengthen incentives and supports for researchers in higher education institutions to encourage their engagement in cooperative activities with industries.
- Improve policy assistance to SMEs so that they can build research, innovation and entrepreneurial capacity based on a clear understanding of their technological problems and take advantage of the scientific and technological opportunities that universities can offer.
- Promote mutual mobility between HEIs and industries. Knowledge flow and cross-fertilization between these sectors may narrow the gap between supply and demand, viz. what universities can offer and what industries need in order to remain

internationally competitive.

- Give sufficient time to policy programs. (1) A policy program requires time to take effect. (2) Very frequent changes in policy programs may hurt the predictability of policy.
- Encourage and support informal channels for industry-university cooperation. They may work better as they need less of third-party involvements and are based more on spontaneity and mutuality of the parties involved.

2. Czech Republic: Smart Energy Systems in Safe Society 4.0

Energy security and support for the digital transformation of SMEs are very important as stated in the EU directives. The notion of energy security encompasses both the traditional definition of securing energy (minimal dependency on foreign influence) as well as resilience to intermittent energy supply that can be effectively secured by adopting smart energy systems.

Building smart energy systems requires new transformational technologies, necessitating not only heavy investments in technology development but also careful examination of the social and economic impacts of the new systems. In this sense, smart energy systems (smart grid, smart city, electric car) may play the role of test beds to examine the impact of Industry 4.0 on energy security. In building smart energy systems, the study emphasizes that a broad range of issues–technological as well as legal and social–should be addressed. These include the following considerations: (1) Digital capability is critically important to building energy security systems; (2) In utilizing big data on customers' energy use, it is crucial to identify ways to handle and manage personal information, and to build a system for knowledge integration and predictive analysis; (3) To employ the cloud and energy platform (test bed) approach, appropriate technical and/or institutional measures may be taken to ensure cyberspace security, technology resilience, and networks optimization; and others.

The above suggests that Korea and the Czech Republic have much to offer to each other in terms of mutually beneficial R&D cooperation as well as policy planning in the areas of energy and security. Sharing of R&D and deployment experiences will make it easier for the two parties to prepare for the emerging era of Industry 4.0. Based on the cooperation, the two countries may be able to take a step further to establishing a bilateral working committee on digital economy and Industry 4.0.

3. Poland: Policy Instruments Supporting Innovation in Services: Policy Implications for Korea and V4 Countries

Tertiarization–the structural shift of an economy toward the service sector–has been arguably one of the most salient features for the global economy over the past several decades. There has been an overall increase in the share of services in GDP since the 1970s. The trend is expected to continue in the future, given the various socio-economic factors, such as higher income elasticity of the demand for services relative to that for manufacturing goods, the ongoing rapid population aging, higher rate of women's participation in the labor market, the advent of the 4th Industrial Revolution, etc.

The 4th Industrial Revolution, in particular, means transformative changes in production and consumption processes, which are becoming more intelligent and closely interfaced. This in turn has led to increased complementarity between the manufacturing of goods and the provision of services. Together, these imply that innovative capacity in services will play a critical role in shaping industrial competitiveness of an economy in the future. Recognizing that higher innovation is connected closely with a stronger role of service sectors in an economy, Poland's Strategy for Responsible Development (2017) highlights the importance of knowledge-based service sectors in enhancing overall competitiveness. Even though Korea belongs to the world-leading group in terms of R&D expenditure with a GERD/GDP ratio of over 4.5% (2017), Korea's innovation activities have been extremely biased toward manufacturing, with innovation in services left more or less unattended.

This study examines the current states of the service sectors in both countries, with a focus on Knowledge-Intensive Business Services (KIBS). The major obstacles to the development of these sectors have also been identified for each country. Based on these analyses, this study explores effective policy options to boost service innovation.

It has been found that the services sector in Poland and Korea, particularly the knowledge-intensive services, is still less developed and less innovative in comparison with the average for EU countries. The major issues include: (1) a lack of appropriate financial system; (2) regulatory burden; (3) policy bias in favor of the manufacturing sector; and (4) the lack of qualified personnel. It is thus recommended that the governments of the two countries redress the policy measures that are biased against the service sector, improve access to finance for service firms, ameliorate regulatory burden, and promote digitalization.

4. Slovak Republic: Next Generation Policy for Digital Transformation of SMEs in Slovakia

The 2030 Strategy for Digital Transformation of Slovakia is a framework cross-sectional government strategy that defines the country's policy and priorities in the area of digitalization. With a view to realizing a data economy similar to the level of the European Union, the Slovak government is pushing to strengthen technological capability in such areas as artificial intelligence, block chain, data analysis, data security, high performance computing, and IoT.

The problem, however, is that industries have neither the capability to deal with the processes nor technological knowhows to implement the new system. Furthermore, they not only lack resources (financial, human, technological, etc.) but are yet to establish specialized organizations and action plans to promote and facilitate the digital transformation of SMEs.

To explore possible solutions to the problems Slovakia is facing, this study looked into how Korea had taken advantage of digitalization to overcome the Asian financial crisis that hit the Korean economy hard around the end of the 1990s. Korea, being a latecomer, had to take an approach tuned to maximizing digitalization (in terms of the level of digitalization and the number of companies digitalized) at the lowest cost within the shortest time period possible. To implement the strategy, the Korean government established special agencies and made large investments so as to support the digitalization of as many firms as possible. Furthermore, the policy programs were customized to the needs of industries, and focused on manufacturing and IT companies together to facilitate digitalization. Owing to these efforts coupled with high awareness of the Korean society on the importance of digitalization, Korea was able to emerge as an IT power within a short period of time.

The study finds that Korea's approach, if contextualized to the local needs, may be applicable to Slovakia. The suggestions are: (1) Create an organization mandated with the implementation of the policy programs for digital transformation of SMEs; (2) Customize policy programs to industries' needs; (3) Make bold initial investments to showcase success models; and (4) Promote and encourage interactions between large enterprises and SMEs.

01

CHAPTER

New Role of Higher Education Institutions in an Innovation-based Economy

Sungchul Chung (The Wonjung Institute)
Laszlo Csonka (Budapest Business School)
Laszlo Vasa (Szechenyi Istvan University and the Institute for Foreign Affairs and Trade)

Keywords
Industry-University Cooperation, Technology Transfer, Commercialization, Research and Development (R&D), Innovation

New Role of Higher Education Institutions in an Innovation-based Economy

Sungchul Chung (The Wonjung Institute)
Laszlo Csonka (Budapest Business School)
Laszlo Vasa (Szechenyi Istvan University and the Institute for Foreign Affairs and Trade)

Summary

The role of universities worldwide has been changing in fundamental ways with the emergence of innovation economy where research and innovation take place in a much more complex context that involves diverse players as well as processes including inter-sectoral and international cooperation and competition. In an innovation economy, university-industry linkages are particularly emphasized as both players have much to offer each other for mutually beneficial cooperation in research and innovation. Diverse forms of university–industry collaboration have been emerging in recent years in response to the changing technological and economic environments, such as: (1) the emergence of new scientific and technological fields; (2) the increasing science and technology intensiveness of industrial production; (3) growing need for new sources of funding for research at universities; and (4) government policies that necessitate raised economic returns for government-funded research. This is also related to the implications of the term "the third mission" of universities, which is to apply and utilize knowledge for economic and social development. Thus, the third mission of higher education institutions is linked to "engagement with the wider world" through enhanced education and research.

Hungary has a centuries-long, strong tradition in higher education. The country's modern system of higher education has made huge contributions to the world's scientific and intellectual heritage, although the period of socialist regime in the second half of the 20th century made serious disruptions in the development of Hungary's higher education system as it became separated both from the research capabilities and the industrial sector. After the transition into a market economy, adjustments were made in the higher education system to enable the country rejoin the international communities. The most urgent question today is how to fully utilize the scientific and technological assets of the higher education institutions for the promotion of the competitiveness and innovativeness of the

Hungarian industries–especially of Small and Medium Enterprises (SMEs)–that lag behind the industries of the European Union (EU). The Hungarian government has recognized the urgency of the issue and has been taking a series of actions to reorient universities so that they serve as forward-looking institutions capable of utilizing knowledge assets for economic and social development.

Unlike Hungary, Korea has a very short history of working with the Western system of higher education. The growth of higher education was largely fuelled by the Korean people's desire for education, and accelerated by the industrialization of the Korean economy that in its wake created huge demand for highly educated manpower. Thus, the role of the universities in the early stage of development was confined to meeting the rapidly growing demand for industrial manpower. It was only in the 1980s that Korea began to pay serious attention to research. Two decades of efforts to promote indigenous R&D brought about remarkable changes to Korea's R&D and innovation landscape. Such developments presented yet another level of challenge for the institutions of higher education and public sector R&D organizations–the demand that public-funded R&D should make contributions to social and/or economic developments. Universities have been pressed to work with industries as a means of commercializing the results of the publicly supported R&D. The government responded to the demand by taking a variety of policy actions–legal measures, subsidies, R&D and other support programs for the promotion of industry-university cooperation.

Despite the differences in the social and economic backgrounds, Hungary and Korea share the same policy issue of how to promote university-industry cooperation as a means to strengthen the competitiveness of their industries. Both countries are placing high policy priority on measures to address this issue and have been making diverse policy efforts to put the two key players of innovation together so that they can work out new business ideas and technologies to vitalize economic activities. The rationale is simple: If the generators and users of knowledge/technologies work together, it would be easier to translate the knowledge/technologies into outputs that generate social/economic values. The analyses of Korea and Hungary's policy programs for university-industry cooperation and their performances show that there have been noticeable developments in industry-science interface, but there still remain huge rooms for improvement in both countries. Each of the countries may find lessons to learn from the strengths and weaknesses of the policy systems and their achievements of the other country.

Korea is a late-comer in both modern higher education and industrialization, which means that Korea has had to take a more comprehensive approach toward promoting university-industry cooperation that includes policy actions for not only strengthening the cooperative capabilities of universities and private businesses but also fostering a favorable social and economic environment, such as physical, organizational and financial infrastructure.

Korea's strengths are based on the comprehensive policy approach based on policy plans: coordinated implementation of the policy programs (by the National Committee on Industry-University Cooperation chaired by the Prime Minister); relatively well-developed infrastructure that includes the information system and financial programs for technology transfer, technology licensing offices, industry-university cooperation centers, etc.; and active patenting activities of university researchers. On the other hand, Korea faces several challenges, such as: (1) low mobility between industries and universities, in particular in research manpower; (2) low attractiveness of universities as a source of technologies and business ideas-industries in Korea tend to rely more on in-house R&D rather than look to universities for technical solutions or new business ideas; (3) the wide gap between what industries need and what universities can offer; (4) insufficient incentives for university faculty members to work with industries; (5) rarity of entrepreneurs who can identify market opportunities that existing technologies may offer and link them to commercialization; and (6) excessive dependence on government policies for the promotion of industry-university cooperation.

Hungary is well known for the long, strong history of its higher education system and rich accumulation of scientific achievements. However, Hungarian industries have been struggling to overcome the problems inherited from the Soviet period and catch up with the progress made by neighboring European countries. As a means to upgrade the innovation capabilities of private industries, the Hungarian government has been taking various policy actions that include the promotion of industry-university cooperation. Yet, the policy measures have been tuned more to promoting cooperative R&D and innovation activities and less attention has been devoted to establishing and strengthening the basic capabilities to facilitate such activities. The business sector has been receiving an increasing amount of public funding for research and innovation but this support has not been linked to increased collaboration with universities. On the other hand, the recent decline in public funding for university R&D has stimulated Hungarian universities to seek increased collaboration with industries, as they need to make up for the decreases in financial supports from the government. Therefore, Hungary's strengths and weaknesses in the area of university-industry cooperation differ very much from those of Korea.

Hungary's strengths can be summed up as follows: (1) strong policy will of the government to promote industry-science interface cooperation–the government reformed the Hungarian Academy of Sciences as a measure to enhance social and economic relevance of scientific activities; (2) the attractiveness of universities as a source of knowledge and ideas, based on which many Foreign Direct Investment (FDI) companies seek cooperation; and (3) strong commitment of universities to industry-university cooperation for financial and other reasons.

Yet there is a huge room for improvement, too, such as: (1) insufficient infrastructure; (2) the short time frame of policy programs–most of the policy programs in the past two decades were short-term in nature and not sufficient to foster long-term commitments of universities and industries for sustainable relationships; (3) support programs that are heavily biased toward research collaboration while missing out on strengthening of basic capabilities and attitudes (e.g., openness towards collaborations); (4) relatively poor patenting activities of universities; and (5) limited Research, Development and Innovation (RDI) capacities and access of local SMEs to the technological opportunities that universities offer.

The above comparison shows that the key challenge for Korea is to find ways to make universities more attractive to industries as a source of ideas and technologies, while Hungary needs to do more to better utilize the existing infrastructure and develop an environment for industry-university cooperation that provides more opportunities for SMEs to take part in research and innovation activities.

1. Introduction

The traditional role of universities as the dominant producers of knowledge has been facing strong challenges, as the rise of innovation economy has brought diverse players into the process of not only the generation but also the dissemination and utilization of knowledge. In an innovation economy, research and innovation take place in a much more complex context that involves diverse players as well as processes including inter-sectoral and international cooperation and competition. University-industry linkages are particularly emphasized not only from a practical perspective but also from policy aspect as the two players have much to offer to each other for mutually beneficial cooperation in research and innovation. This trend has been discussed under the “Triple Helix Model” that offers insights into the mechanisms through which the complex process of innovation can be broken down into constituents. It puts into focus the commercialization of research results and thereby the knowledge-based growth of regions, for which the three elements of the helix–universities, businesses and governments–collaborate with each other. In the process, they develop themselves and help each other develop. The members of the helices take on tasks previously attributed to the other partners, blurring the boundaries between and among themselves in the process. However, the theory was based originally on Western European and U.S. experiences and the practice seems to suggest that such kind of collaboration and partnership, viz. the operation of the Triple Helix is not so prominent in the economies of Central and Eastern Europe, like in Hungary (Leydesdorff and Etzkowitz 1998, Pique *et al.* 2018). In addition to the changes in the context, in which universities operate as an innovation player, there may be country-specific issues that call for stronger industry-university linkages. The global financial crisis and the economic recessions that followed the crisis in some countries brought about reductions in public funding of university activities, including education and research, making it inevitable for universities in those countries to look more to private industries in seeking additional funds for research and education.

Diverse forms of university–industry collaboration have been developing in recent years in response to the changing technological and economic environments, such as: (1) the newly emerging scientific and technological fields; (2) the increasing science and technology intensiveness of industrial production; (3) increasing need for new sources of funding for research at universities; and (4) government policies that necessitate better utilization and therefore improved economic returns for government-funded research. Universities that are active in technology transfer and promoting other forms of cooperation with industries are characterized as "entrepreneurial" universities (Etzkowitz, 1983). Entrepreneurship and innovation in universities go beyond mere promoting of business start-ups and technology transfer. The notion includes inter-disciplinary linkages, role of students in education and research, partnerships with industries to raise relevance and impact of research and education conducted at universities, supports for nascent entrepreneurs and so on. This is related to the implications of the term "the third mission" of universities, which is to apply and utilize knowledge for economic and social development. Thus, the third mission of higher education institutions is linked to "engagement with the wider world" through enhanced education and research (OECD 2017).

Hungary has a centuries-long, strong tradition in higher education.[1] Hungary's modern system of higher education, which took shape in the early 20th century, has since made huge contributions to the world's scientific and intellectual heritage.[2] The Hungarian higher education system has gone through diverse changes, both positive and negative, one of the most significant of which was its integration into the Soviet system after WWII. Since

1 The first Hungarian university was established in the town of Pecs in 1367 with faculties of law and medicine.

2 The first Hungarian-educated Nobel scientist was Philipp Lenard who won the prize for his work on Cathode rays, and the most recent Nobel Prize winner is Avram Hershko (2004).

its exit from the Soviet system, Hungary has implemented extensive efforts to integrate its system into the EU. These efforts have been focused on resetting the mission of the higher education institutions, which is still largely based on the traditional model characterized by teaching and learning, and research. The most urgent issue is to find ways to fully utilize the scientific and technological assets of the higher education institutions for enhancing the competitiveness of the Hungarian economy that lags behind the EU-average. The Hungarian government has recognized the need for and urgency of better knowledge utilization by the industrial sector, and has been paying serious policy attention to the improvement of the third mission of the higher education institutions over the recent years. In this regard, the government has adopted a series of actions to reorient universities toward serving as forward-looking institutions capable of utilizing knowledge assets for economic and social development.

Public policy has played an important role in introducing entrepreneurship, innovation and the third mission to Hungarian higher education for better utilization of knowledge. Another important driver at the university level has been the need to generate additional financial sources to compensate for stagnating/decreasing public funding. Accordingly, Hungary's approach to the third mission leans more toward promoting the commercialization of university-generated knowledge for the support of local economic development. The policy efforts have created positive effects by putting universities closer to industries. However, the outcomes are far from satisfactory. It has been assessed that industry-university partnerships tend to be very short-lived and their sustainability seems to be questionable in the absence of government-support. Another issue is that only a handful of local SMEs have been able to take advantage of the policy (Inzelt and Csonka, 2016).

Unlike Hungary, Korea has a very short history of working with the Western system of higher education. It was brought to Korea by missionaries around the end of the 19th century, but it was only after the WWII that the system of higher education in Korea achieved significant growth.3 The growth was largely fuelled by the Korean people's desire for education,[4] and further accelerated by the industrialization of the Korean economy that has created huge demand for highly educated manpower. Accordingly, the role of universities in the early stage of development was confined to meeting the rapidly growing demand for industrial manpower. It was only in the 1980s that Korea began to pay serious attention to research. Two decades of efforts to promote indigenous R&D have brought about remarkable changes in Korea's R&D and innovation landscape. Such developments

3 Korea got independence in 1945.

4 The Korean culture has been heavily influenced by the Confucian tradition that places the highest value on education and scholarship.

presented yet another level of challenge to the institutions of higher education and public sector R&D organizations–the demand that public-funded R&D should make contributions to social and/or economic developments. Universities have been pressed to work with industries as a means to commercialize the results of the publicly supported R&D. The government responded to the demand by taking a variety of policy actions–legal measures, subsidies, R&D and other support programs. There have been enormous efforts on the side of the government to promote industry-university cooperation, with special emphasis on technology transfer and commercialization. The policy efforts have been rewarded with increased technology transfers between public sector institutions and industries. A very positive outcome of the policy efforts appears to be the formation of a common understanding that innovation can hardly flourish without active interactions and cooperation among the innovation players. Yet, there remain diverse issues and challenges for Korea to overcome in order for the country to transform the institutions of higher education into bona fide innovation players and have them engage with other players for active innovation.

As discussed above, despite the differences in the history of higher education systems and the context of social and economic development, the two countries face the same challenge: how to better engage the higher education institutions in the national efforts for innovation and economic development. The objective of this study is to analytically review and compare the two countries' policy experiences to promote industry-university cooperation for mutual policy learning and to derive policy suggestions that may be applicable to the partner country.

This report was created by joint efforts of the Hungarian and Korean experts. The report starts with a brief discussion on the emerging issues related to the 'third mission' of higher education institutions, followed by an analysis on the role of universities in Hungary within the national innovation system. The next section presents the Korean policy experiences and derives policy achievements and issues. The Hungarian and Korean experiences are combined and compared in the next section for mutual policy learning. The final section concludes the report by making a summary and putting forward policy recommendations for Korea and Hungary.

2. Toward the "Third Mission" of Higher Education Institutions: New Trends

2.1. HEIs as Innovation Partners

Higher Education Institutions (HEIs) play a critical role in innovation and socio-economic development in several ways. HEIs train and develop human capital, which is the key driving force behind economic development. Investment in higher education provides high social returns from the accumulation of human capital and economic spillovers, which justify public support for HEIs. The most important factor is the role of the manpower that HEIs produce – a mediating role between capital and labor in economic growth. Without such manpower, technology- and/or knowledge-intensive machines or processes can hardly be utilized for productive activities. HEIs are one of the key players in public research, both fundamental and applied. The ways HEIs are organized and operated determine the efficiency of research activities, which in turn affect the quality and quantity of knowledge stock, the very source of technological progress. In many OECD countries, HEIs carry out roughly half of the public research activities, indicating the importance of HEIs as an innovation player (OECD 2019).

HEIs matter because they are in a position to help local economic development through the so-called 'third mission' that refers to HEIs' engagement in community development. In other words, the third mission of HEIs encompasses entrepreneurial and financial activities, their social and cultural relevance, and knowledge transfer. The term refers to activities of knowledge exchange in science and technology policy, while within the education community, the term is used more frequently to refer to HEIs' role in local development.

As such, the idea of the 'third mission' is not new – both knowledge transfer and local engagement are actually traditional characteristics of HEIs in many of the advanced countries. The concept has been highlighted recently as a means to stress the accountability of HEIs toward the community. Simply put, the third mission may include the following:

- Informal engagement with industries;
- Consulting and advisory activities;
- Inputs in public policy-making processes;
- Nurturing entrepreneurship skills among students and researchers;
- Economic and social utilization of research outcomes;
- Linking university education to vocational training;
- Contribution to community development through education, such as classes for non-students, etc.

The notion of the third mission, therefore, is a reflection of the local priorities and is, in most cases, an unfunded mandate and expectation placed on HEIs. Locally generated knowledge and its spillovers tend to be geographically confined even though some of the knowledge may be codified and diffused globally. This may be why so many countries are interested in promoting the third mission of HEIs, in particular, industry-university cooperation.

University-industry interactions and collaborations are an issue of high priority for policymakers worldwide (Estrada *et al.*, 2016), and have thus received increasing policy attentions and supports in diverse forms in the recent years (Cohen *et al.*, 2002). The policy trends are global in nature, and Hungary and Korea, even though they are far apart geographically and culturally, face the same policy challenge to promote industry-university cooperation as a means of strengthening the innovation capabilities of their economies. Therefore, HEIs in Hungary and Korea have been constantly pressed and encouraged by the governments and other stakeholders to adjust themselves to the changing realities.

2.2. Transforming Channels between Universities and Industry

Interactions between universities and firms take place through various formal and informal channels (Bekkers & Bodas Freitas, 2008; OECD, 2019). However, the channels have undergone continuous changes and transformation in response to the needs of economies, society and environment.

2.2.1. Formal Channels

Collaborative research refers to research activities carried out jointly by industry and university researchers. The projects can be partially or fully funded by industry and range from small- to large-scale initiatives. Research services are often provided to solve concrete problems of industries and develop new technologies/knowledge in line with the specifications of sponsoring companies. Research activities in this case are generally more application-oriented.

Japan's flagship project A-STEP (Adaptable and Seamless Technology Transfer Program through Target-driven R&D)1 is a good example of how governments can support university-industry collaborative research. This program provides supports for joint R&D based on the results of high-quality basic research (research output, intellectual property rights, etc.) to translate the results of such research into outcomes of social/economic values. Depending on the R&D phase and the objectives of each project, A-STEP sets the optimal R&D funding and period to enable seamless pursuit of medium- to long-term R&D. Through this approach, the program aims to bridge the gaps between academic research results and industrial needs and to realize highly effective and efficient innovation.

Intellectual property (IP) transactions refer to the licensing and/or selling of IP, such as patents and other forms of intellectual properties generated by universities, to industries. For instance, as one of Singapore's leading innovation agencies, the Intellectual Property Office of Singapore (IPOS) proactively develops a vibrant IP ecosystem by keeping its regime robust and policies up-to-date in line with the industry's demands.

Research mobility: Research mobility is important, as researchers act as "knowledge brokers" or "boundary spanners" between universities and industries, as these experts are knowledgeable about both the university and industry sectors (Rosli *et al.*, 2018). As such, these professionals can be important channels or links that create better relations and interactions between university and industry partners.

<Table 1-1> Policy Initiatives to Promote Mobility of Researchers: Selected Examples

Country	Name of initiative	Mechanisms	Financial subsidy	Networking	Share of salary subsidised	Averagd duration of subsidy	Mobility destination	
		Guidelines and information					HEIs or PRIs	Private firms
Canada	Mitacs - Elevate	Yes	Yes	Yes	>80%	>18 months	No	Yes
Colombia	Integration of PhDs into Colombian companies	No	Yes	No	>80%	>18 months	No	Yes
France	Vade-Mecum of Public-Private Linkages	Yes	No	No	-	-	Yes	Yes
Korea	3rd Basic Plan for Nurturing S&T Human Resources	Yes	No	Yes	-	-	Yes	Yes
Norway	Reserch-Based Regional Innovation	No	Yes	No	40-80%	6-18 months	Yes	Yes
Peru	Article 86 of the University Law 30220	No	Yes	No	40-80%	6-18 months	Yes	No
Thailand	Talent Mobility	No	Yes	Yes	>80%	6-18 months	No	Yes
United Kingdom	CASE Studentship	No	No	Yes			Yes	Yes

Note: HEIs = higher education institutions; PRIs = public reserch institutes.
Source: STIP Compass database (retrived in July 2018), considering only policy initiatives active in 2017.

Academic spin-offs are the business entities that university researchers (or graduates) create as means to commercially exploit the knowledge and/or technologies they developed. A new trend in the spin-off scene is the involvement of students in university entrepreneurial and spin-off activities. Scholarship or fellowship programs are increasingly being offered to talented and motivated students so that they can realize their innovative ideas. For example, ETF Zürich's Pioneer Fellowship[5] is awarded to one or two individuals who intend to independently develop a highly innovative product or service. It is worth highlighting that eight of the 25 new ETH Zürich spin-offs were founded by Pioneer Fellows in 2016.[6]

Labour mobility refers to university graduates who join industry. This channel is often deemed to be among the factors that have the greatest impact on the industry, particularly in some disciplines and industry sectors, based on the share and numbers of students who graduate every year. Labour mobility is a key channel of science-industry knowledge transfer, particularly in some disciplines and industry sectors. New evidence based on surveys of labour force has provided insights into the contributions of social scientists to industry. Evidence shows that graduates in social sciences (which include economics, political science, sociology, geography, business studies and law) contribute to innovation in a wide range of service sectors, including highly dynamic ICT sectors (OECD, 2014).

2.2.2. Informal Channels

Research publications are academic writings presented in academic journals and other specialized media. Science-intensive sectors such as biotechnology and pharmaceuticals have strong complementarities with basic academic research and the R&D of firms in this sector tends to be utilized in research publications (Perkmann & Walsh, 2007).

Research centres are created to produce both innovative approaches/technologies and academic publications, resolving the inherently conflicting goals between university and industry partners that have not been fulfilled satisfactorily by other institutions, such as academic departments, firms and research institutes (Gulbrandsen *et al.*, 2015). Such research centres have also been established in Norway, such as the "Centres for Environment-friendly Energy Research" (FME – Forskningssentre for Miljøvennlig Energi) and "Centres for Research-based Innovation" (SFI – Sentre for Forskningsdrevet Innovasjon), which are two of the most prestigious schemes in Norway.

5 http://ethz.ch/industry-and-society/entrepreneurship/pioneer-fellowship.html

6 http://sciencebusiness.net/news/77373/Record-year-of-spin-offs-for-ETH-Zurich

Conferencing and networking facilitate the interaction between researchers and industry representatives. These interactions can take place in formal conferences or dissemination events, but also in more informal settings such as meetings with and having contact with former classmates employed in universities and industry (OECD, 2019). These networks are recognized as important for developing and maintaining university-industry collaborations (Steinmo & Rasmussen, 2018).

Within the broad context of networking, alumni organizations are increasingly assuming more important roles in the field of university-industry collaboration. For instance, the Texas Tech Alumni Association (TTAA) established the Tech Hub Entrepreneur Alumni Network to provide entrepreneurial scholarships for students and alumni and connect them with the university in a meaningful way to support the university's entrepreneurship and innovation initiatives. The Hub Network provides opportunities to recognize alumni's contributions to the entrepreneurial ecosystem and innovation system.[7]

Geographic proximity often allows networking and informal interactions between university and industry researchers. These informal encounters may be facilitated by locating science parks near university campuses, by establishing firms' laboratories within university campuses or by using the university facilities for a firm's research (OECD, 2019). Collaborative research is often conducted locally (D'Este & Iammarino, 2010), as well as in more peripheral regions (Johnston & Huggins, 2016), which implies the importance of having research institutions in close geographical proximity to industry. A large database of patent applications in 35 OECD countries and China from 1992-2014 shows that 50% of all industrial inventive activity occurred within 30 kilometres of a university (OECD, 2019), which indicates the important role universities play in the economic growth of their nearby regions (Mueller, 2006).

Facility sharing refers to the sharing of infrastructure such as laboratories and equipment between university and industry partners. It is often expensive to build up a lab; thus, universities often establish labs that could be used for both the training of students and carrying out research for industry. A Norwegian example is the High EFF Lab, an advanced research facility to be hosted by SINTEF and NTNU, built with a price tag of approximately 50 million NOK. The High EFF centre was built to fulfil two important goals: to enable a reduction in specific energy use and a reduction in greenhouse gas emissions generated by Norwegian industry (Claussen, 2019).

Training includes courses and continuing education provided by universities to firms,

7 http://www.depts.ttu.edu/research/research-park/techhublaunchparty/php

but may also take the form of lectures delivered by industry employees at the university. Training is also linked to labour mobility, and for firms there are also possibilities to engage with students during their education. The dual system of higher education, widely practiced and popular in Germany, serves as a model worldwide. The effectiveness of such training, successfully combining the development of theoretical knowledge with the practical activities of students, has been proved by validity in real life over a long period of time. The indisputable advantages of this system include its ability to respond quickly to the challenges of globalization and transformation in the professional world.

University-industry interaction takes place through a mix of formal and informal channels. The importance of the university-industry channels is found to differ across science fields and industry sectors (De Fuentes & Dutrénit, 2012). Thus, policies should be tailored in response to the specific needs of industry and university actors (OECD, 2019).

2.3. Universities' Contribution to Innovation and Societal Change

2.3.1. Cross-border Public-private Innovation Partnerships

Public-Private Partnerships (PPPs) within innovation and R&D are gaining ground as an effective approach to fostering long-term international university-industry collaboration with a focus on priority areas (European Commission, 2018). Examples of international PPPs include the European Innovation Partnerships (EIP), such as the European Active and Assisted Living Programme (AAL), the EIP-Water, the EIP on Agricultural Productivity & Sustainability (Agri.), the EIP on Raw Materials and the EIP on Smart Cities and Communities (SCC). Many PPP programs tend to operate with large budgets, by concentrating resources in a limited number of centers that cater to a larger group of beneficiaries over a relatively long period of time. It is worth mentioning that a growing volume of research and innovation activities is expected to be carried out within the context of international PPPs and EIPs. This adds another layer to university-industry partnerships, a complexity that HEI researchers must deal with in the future.

2.3.2. Focus on Global Mission-oriented R&D Initiatives

The transition from the United Nations Millennium Development Goals (MDGs) to the Agenda 2030's Sustainable Development Goals (SDGs) altered the prospects of economic and societal development – it is now a universal/global challenge, not only an issue for developing countries alone. The MDGs have already had a considerable impact on national R&D and innovation agendas, and are bound to have profound effects on the research and educational agendas of universities.

Another by-product of the same trend is a change in aid-financing, in which there is increasing support for multilateral financing mechanisms rather than country-specific programs. This implies a stronger role for STI co-operation in developing and implementing international aid programs with a view to contributing more effectively to specific SDG. These transitions increasingly blur the traditional divide between R&D for international development and R&D for national purposes. National STI policies now tend to include more of an international role than ever, and there are visible tendencies and attempts toward improved cooperation and coordination for joint financing at a global level (Remøe, 2019). Such global collaboration includes sharing of research data and outputs, research evidence, knowledge, digital tools and technologies relevant to achieving the SDGs.

2.3.3. Role of Socio-economic Paradigms and System Transition Policies

With the advent of the 21st century, global challenges such as climate change, the need to pursue sustainable economic growth, digitalization, population ageing, etc. have necessitated new types of innovation policy thinking. In this context, the policy challenge is how to minimize the destructive nature of new innovations and reduce the social costs associated with the technological transitions (Stiglitz & Greenwald, 2014). This new line of policy thinking is therefore not only concerned with the good governance of national and regional systems of innovation, but it also addresses the questions as to how transitions between various socio-technical systems occur or should occur. An example is the ongoing transition from carbon-based to carbon-free technological trajectories. Such large-scale socio-technical transitions call for a better understanding of the broader societal interactions beyond the conventional domains of R&D and innovation policy. Moreover, whereas science and technology-based innovation policies prioritize R&D support, and innovation system policies focus on networks, clusters, and industry-university collaborations, etc., the new policies for mission-oriented and socio-technical transitions acknowledge the need for broader participation of the society in innovation (Fagerberg, 2017).

Another strand of international literature that provides numerous evidences on the changing role of HEIs in the innovation system and on the changing nature of institutional linkages is focused on the "Triple Helix model." This model identifies university, industry and government as the main actors of the innovation system in a knowledge-based economy. They not only influence each other, but through their very interactions, they evolve constantly. This leads to blurring institutional boundaries when these actors extend their activities. (Etzkokwitz and Leydesdorff [1996], Pique *et al.* [2018]) In the Triple Helix model, HEIs are a key player in the innovation system in that they have to go beyond their traditional role as a knowledge-generator and become more and more involved in distribution and utilization of knowledge. These tasks are most efficiently served through industry-university collaborations or through various interactions with the broader social and economic environment (that is, the third mission).

2.3.4. Increasing Importance of Universities' Management of the Talent Pipeline

University-industry collaboration requires careful management in order to bring optimal benefits. These include a two-way flow of ideas: research and training results flow out to industry and there can also be in-bound questions and requirements that fuel research initiatives. For example, sometimes technical problems experienced at the cutting-edge of practice lead to new questions for science.

Industrial collaboration of this type can also be an important means of diversifying funding sources for fundamental research. However, universities may need to modify their incentives and arrangements for staff – including tenure and promotion criteria – if they are to reap the rich rewards from such extensive collaboration.

In certain fields of technology, universities may face brain-drain if they do not collaborate proactively with industry. An example is the keen interest of industry in recruiting academic experts in fields like artificial intelligence, data science and other hot technologies.

2.4. Responses to the New Trends: Hungary and Korea

2.4.1. Hungary

Hungary has been an important player in the development of higher education in Europe, making remarkable contributions to the development of science worldwide. Throughout its long history, Hungary's higher education system has undergone diverse changes, both positive and negative, the most notable of which was its integration into the Soviet system after WWII. The Soviet system is known to have been state-centered and heavily focused on education and training that can hardly fulfill the diverse expectations placed on HEIs under the new political and economic environment. Since its exit from the Soviet system, the Hungarian HEIs have had to make continuous efforts to reset their roles so as to meet the new demands.

Diverse factors have prompted Hungary to reset the mission of HEIs in the country. What stands out is the need for building the innovation capacity of private companies, especially the local SMEs that belong to the lower end of the EU27 in terms of innovation activities at both in-house and organizational level. The SMEs lack not only internal resources for innovation but also access to external sources (loans, venture capital, public support etc.), while in contrast, Hungary's HEIs continue to enjoy an internationally strong reputation for their excellence in science and research. This suggests that the scientific research capabilities of HEIs have not been fully exploited for social and economic development, due to the systemic failure in bringing HEIs and industries together in the pursuit of innovation.

Therefore, of the diverse roles of HEIs that the third mission suggests, industry-university cooperation has attracted the most attention of Hungary's policy-makers at all levels (regional and national). The government has been striving to improve the legal and institutional framework for industry-university cooperation, while expanding financial and other forms of supports to strengthen industrial R&D and innovation. In order to facilitate industry-university cooperation, policy measures have been taken to promote the mobility of people and resources between businesses and academia, industry-university collaboration in R&D and innovation, and various forms of interaction between the two players.

2.4.2. Korea

The roles of HEIs in Korea have evolved with the country's economic development, suggesting that the roles of HEIs have been adjusted in response to the changing demand of the society and economy. In the early stage of development (1960s and 1970s), the role of universities was almost confined to producing manpower required for industrialization, and it was only in the 1980s that Korea started to pay attention to research and development as a major function of universities, emphasizing the linkage of education to research. In the mid-1990s, the Korean society's demand for university services began to diversify into "contribution to industries." In order to facilitate university-industry cooperation at a regional level, in 1994, the government initiated the program of "Regional Research Centers (RRC)," which allowed regional industries to access and use research facilities, and work together with university researchers for technical solutions and/or commercialization of R&D results.

Entering the 2000s, Korea emerged as a global player in R&D (6th in the world in terms of R&D expenditures), and such a development presented yet another level of demand to the HEIs and public sector R&D organizations – demand that the R&D community should do more to translate the R&D results into outcomes of social and/or economic values. More specifically, they faced the demand to work with industries in order to commercialize the results of the publicly funded R&D. The government responded to the demand by amending the Promotion of Industrial Manpower Training Act (1963) into the Promotion of Industrial Manpower Training and Industry-University Cooperation Act (2001), which mandates the Ministry of Education to coordinate inter-ministerial collaboration to draw up and execute an "Action Plan for the Promotion of Industrial Manpower Training and Industry-University Cooperation" (plan period: five years). In addition, the Promotion of Technology Transfer Act (2001) was also revised in 2007 to include articles on "Commercialization of Public R&D Results." As such, in the 2000s, technology transfer and commercialization have become an important role the Korean society demands of HEIs.

3. Role of Higher Education Institutions in the National Innovation System of Hungary

3.1. Higher Education Institutions in the Hungarian Innovation System

3.1.1. Structure of the Economy

Hngary is a small open economy whose performance is largely dependent on foreign-controlled enterprises, in terms of both economic growth and innovation. There are a large number of foreign controlled enterprises in the economy (the number of foreign controlled enterprises in 2017 was the fifth largest among the 28 EU member states after Germany, Romania, UK, and France) although the number has been decreasing slightly since the beginning of the 2010s. In the manufacturing industry, the share of these foreign-controlled enterprises' R&D expenditures in value added amounted to 2.2% (2017) which was lower than those in most other EU countries, such as the Czech Republic (3.4%), Germany (7.0%), France (9.1%) or UK (15.0%) (Eurostat Online Database). On the other hand, the foreign-controlled enterprises finance more than 58% of all business expenditures on R&D (BERD) and employ almost 46% of all R&D personnel in Hungary's business sector (2018; KSH 2019). The share of foreign value-added in gross exports of Hungary is one of the highest among OECD countries (OECD, 2016). Despite the above-mentioned influential role of foreign-owned multinational enterprises, the Hungarian business sector is still characterized by a slightly above-the-EU-average share of micro- and small enterprises. This group of economic actors is less competitive in international markets and less growth-oriented compared to their counterparts in other European economies or other larger economic actors in Hungary.

3.1.2. National R&D and Innovation Structure

Since the transition to a market economy, the RDI governance system has changed a number of times within the government. For a large part of the past three decades, R&D and innovation policy was supervised by a State-secretary, and on the operational level, a governmental agency was responsible for the implementation of policy programs. The actual form and political power of the organisation also changed from time to time in these three decades. Currently, the field is governed by the Ministry of Innovation and Technology (MIT) that supervises the National Research, Development and Innovation Office (NRDIO), the main governmental actor responsible for the implementation of strategies, support programs, etc.

Hungary's public sector science system consists of two main groups of actors: a) the Lorand Eotvos Research Network (LERN, formerly the research institution network of the Hungarian Academy of Sciences), and b) university research centers. Both groups include diverse entities, making the public research system fragmented. LERN is engaged mainly in basic or discovery research. University research centers are focused partly on applied research largely due to their collaboration with the business sectors. The annual research expenditures of universities have reached approximately €237m (2018) after a dynamic increase in funding since 2016, following a period of decreased funding between 2011 and 2016 (www.ksh.hu). In addition to these, there are a few other public research centres acting as background organisations of various ministries. There is also the main applied research center network, the Bay Zoltan Non-profits Ltd. for Applied Research.

Hungary's business R&D has increased in terms of both expenditures and research manpower over the past few years, but its performance still lags behind the EU-28 average. An important feature of the Hungarian R&D funding system is that public (government) support for business R&D (BERD) is high compared to other EU member states. It accounted for 0.13% of the GDP in 2017, which was the highest among all member states, whereas the EU average for the same year was 0.07% (Eurostat Online Database). Unfortunately, this does not lead to proportionately higher collaborative activities between the public and private sectors.

R&D activities in the business sector are concentrated in and dominated by large corporations, mainly multinationals, and the largest share of the Business Enterprise Expenditure on R&D (BERD) is accounted for by large companies. Enterprises with more than 250 employees represented 58% of BERD in 2018, while enterprises with 0-9 employees accounted for only approximately 7%. (KSH 2019) While the share of innovative companies in the largest size category (250+ employees) was around 56% (CIS 2016), the share was around 25% among small companies (10-49 employees), which made the national average 29%, one of the smallest among EU member states (Eurostat Online Database). Countries with lower share include Bulgaria (27%), Poland (22%), and Romania (10%) (Eurostat Online Database). It is therefore a major challenge for the Hungarian economy to motivate SMEs to engage in RDI activities. According to the EIS 2019 dataset, Hungarian SMEs are among the five lowest in the EU-28 in terms of in-house innovation activity. However, if the current growth rate is maintained, Hungary may soon catch-up with the EU average (of the recent years).

Hungarian SMEs' innovation performance is just marginally better among the low performing countries in the EU, if measured by their collaborative activities -- eighth from the bottom among the EU member states. Their performance may be better evaluated if broader types of collaborations (R&D and other types of cooperative activities) are taken into account. The share of SMEs engaged in collaborative innovation is only half of the EU-28 average and the growth rate of the share points to the likelihood of a further decline in the near future. A potential explanation for this situation is that the moderately increasing business R&D funding is used mainly for in-house R&D, and only 6% of university R&D is funded by the business sector (OECD MSTI database).

3.1.3. R&D Resource Base

Hungary could not significantly improve the performance of its innovation system in the past decade. Measured by the EU's Summary Innovation Index, Hungary's performance remained at around 67% of the EU-28 (27) performance or the 22nd among the EU28 in 2019 (EC, 2020).

A. Research Manpower

The decline in the number of R&D units and in the total number of R&D personnel started in 2013 and continued until 2016. During the period, the number of R&D units decreased by 2.6%, and the headcount of R&D personnel also reduced by 2.8%– although the number of researchers grew by 1.3% compared to the previous year (KSH, 2017). This trend was reversed in 2016 and in the following two years, the number or R&D units grew by 14% and 12% respectively each year compared to the previous year and the total number of R&D personnel grew from 54,000 to over 66,000, a number never achieved before. The number of researchers also kept growing after 2016 by 10% and almost 8% yearly (KSH, 2019).

B. Structure of Research Funding

It should be noted that past growth in R&D expenditures was mainly fuelled by the increase in business R&D expenditures. While the business R&D expenditures grew from approx. 0.7% to almost 1.2% of GDP between 2010 and 2018, the public sector R&D expenditures declined from approx. 0.5% to below 0.4% of GDP -- one of the lowest among EU member states. This trend, if continued, may lead to the weakening of the local knowledge base. The business sector funded 52% of the Gross Domestic Expenditure on R&D (GERD) in 2018 (€978m or HUF340b), while the government funded 32% or €604m (HUF212b), and foreign sources – including direct and indirect EU funds - 15% or €277m (HUF96b). The share of the domestic non-profit sector was negligible (0.5%). The business sector's share in GERD reached its peak at 56% in 2016, but since then public R&D funding has grown more than business funding for R&D (KSH, 2019).

3.1.4. University R&D and Innovation System

Currently (2020), the university system consists of 65 institutions: 38 universities, of which 27 are state universities and 9 private or church universities. State institutions include 21 universities, 5 universities of applied sciences and 1 college. The private institutions include 7 universities and 2 universities of applied sciences. In addition, there are 29 colleges, only one of which is state-run and the remaining 28 are small private or church colleges. Universities employ 36% of the total research manpower of the nation (approx. 24,000) at 1,333 research units.[8] Almost half of the research units and more than one third of the researchers belong to social sciences and humanities (HCSO, 2019) .

R&D resources: HEIs are important actors in the R&D system, spending almost 13% of GERD, with the public research organizations spending less than 11% of GERD. Over the recent years, private contribution to university R&D has increased, accounting for 9.0% of university R&D expenditures in 2014 and 9.6% in 2016, which is higher than the EU-28 averages of 6.4% and 6.5% respectively for the same years (OECD MSTI database). The share of business- funded university R&D dropped to 6.1% in 2017 below the EU average of 6.9%. Unfortunately, the increases in private funding were accompanied by decreases in public funding, reducing the total university R&D expenditures as a percentage of GDP from 0.23% in 2010 to 0.19% in 2018.[9] Parallel to this, government R&D expenditures (GOVERD) declined slightly from 0.21% in 2010 to 0.17% in 2018. This latter number was just slightly below the

8 However, it is interesting to note that, according to the higher education statistics, there were 1,935 research positions in the sector in the 2017/2018 academic year (www.oktatas.hu, Higher Education Statistics).

9 The national statistics on R&D funding are aggregate and do not reveal the number of scientific organizations that utilize private sector funding, but it can be assumed that the funding is only received by some of the organizations.

EU average, but the level of university R&D was less than half of the EU average. A recent peer review of the Hungarian research and innovation system highlights the gross underfunding of the public research system (EC, 2016b). The declining public funding creates significant challenges for HEIs to find complementary funding, which leads to deteriorated research environments. Under the current situation, HEIs can hardly meet the society's potential demand for technology development. Even though public funding increased over the last two years, it is far from sufficient to totally solve the problem. Out of the government R&D funds, 32% are going to HEIs, 28% to public research organisations and 38% to private business sectors. Furthermore, university R&D funds are extremely concentrated at the large state universities, worsening the situation.

Major areas of research: In terms of the areas of research in higher education, funding for engineering and humanities increased, whereas funding for natural sciences and medical research declined (KSH, 2016). In 2018, almost 26% of all higher education R&D fund was allocated to social sciences and humanities, 23% to engineering, 21% to natural sciences, and another 21% to medical sciences. Almost 60% of the government funds were spent on basic research and 30% on applied research, while the overall share of basic research reduced to 19% and that of applied research to 23%, and the lion's share was devoted to development research.

Efforts for a transition toward the "Third Mission": Most of the Hungarian HEIs have not been able to adjust their roles to pursue the 'third mission', taking only very modest steps towards transforming into 'entrepreneurial universities' (indirectly supported by the government). The slow adjustment has partly to do with the insufficient pressure from both inside and outside as well as the lack of strong demand from the business sector. Of course, there are several cases of meaningful industry-university cooperation involving a few universities in certain areas, but even those cases did not last long enough to establish a tradition. Furthermore, even the increasing flow of resources from industries to universities has not brought about active industry-university cooperation. Based on data from the Community Innovation Survey (CIS, 2016), the percentage of innovative companies cooperating with higher education institutions stands at 12.2% in comparison to 13.8% of the EU-28 (or 11.7% of EU-27). However, this exaggerates the real picture because the proportion of Hungarian business companies that have implemented either product or process innovations is very small compared to those of other EU countries. Also, there is a major difference between companies in their collaborative efforts by firm size. While 30% of firms with more than 250 employees collaborate with HEIs, only 10.0% of SMEs (with 10-49 employees) do so, and 11.9% of medium-sized companies are involved in such collaborations. All of these shares lag behind the corresponding figures for EU-27 (Eurostat

Online Database).

3.2. Promotion of a New Role of HEIs: Industry-University Cooperation Policy and Performance

Collaboration between industry and university sectors has attracted the attention of policy-makers at all levels (regional, national and EU) as they have recognized its importance as a driver of economic development. The interaction can take place by formal and informal channels as the flow of researchers, entrepreneurship training, technology transfer and the commercialization of R&D results. The Hungarian government has adopted measures to improve the legal and institutional framework to provide supports for universities as innovation players to effectively carry out their roles, while at the same time promoting interactions among the players through various initiatives that nurture and upgrade industry-university partnerships. Yet, Hungary is at an early stage of development in terms of industry-university cooperation. The benefits of industry-university cooperation are still not fully recognized by either side, the key barriers being the lack of capabilities and awareness of the usefulness of cooperative activities, coupled with institutional bureaucracy and limits of business funding.

3.2.1. Legal and Institutional Framework

The Hungarian HE system has undergone a number of reforms since the country's transition into a market economy. The main stages of these reforms took place around 1993, 2004 and 2015. Each of the reforms added new elements to the HE system as part of efforts to strengthen the research and other activities of HEIs. After the transition, the first wave of legislation added research as an integral task of HEIs. The Act XXXVIII of 2005 on Higher Education aimed to broaden the opportunities for HEIs and business partnerships and facilitate the commercialization of knowledge produced by HEIs. This law regulated the activity of university spin-off companies, and required them to introduce the technology transfer function and establish internal regulations on intellectual property matters (the ownership of research results, sharing of financial returns and engagement with third parties). This law created better legal conditions for the commercialization of research results produced by HEIs (in line with Bayh-Dole type legislation). The Act CCIV of 2011, the next major modification to HEI-related laws, abolished some of the achievements of the previous legal regulations (e.g. the Economic Councils) but did not abandon the intention to further improve collaboration between the two sectors. The latest modification to the HEI-related laws in 2015 introduced a five-member council, an advisory body on strategic and economic issues of HEIs. Based on this Act, the University of Applied Research was created (by merging the previous colleges).

Parallel to the above changes, the strategy “A Change of Pace in Higher Education” was launched (adopted in 2016), placing policy focus on the following: development of innovation competences in tertiary education; the long-term provision of human resources for RDI; the renewal of the RDI infrastructure; and the strengthening of the industrial relations of higher education institutions. One of the most important consequences of this strategy was the introduction of a new operational model for HEIs. The first pilot case was the Corvinus University of Budapest. The core element of this model has been that the HEI will no longer be supervised by the ministry but by a public foundation. The Government provides the initial capital for the foundation, and this foundation will finance the operation of the university subsequently. Therefore, the HEI will become a ‘private’ organisation free from state bureaucracy, and remain more flexible and independent. According to the government, this new operational model will help the organisation(s) to be competitive internationally in all three missions and be part of the best European and global HEIs. After the first pilot project, the scope of this model is being broadened in 2020, and five new HEIs will be ‘privatized’ this way.

3.2.2. Policy Tools

The Hungarian government launched various initiatives to nurture and upgrade industry-university partnerships.

The major changes in the funding system for R&D and innovation activities in the early 2000s facilitated the launching and implementing of diverse policy programs and direct and indirect policy measures for university-industry interaction. Beyond the National Research, Development and Innovation Fund (from now on NRDI Fund, and previously known by the name Research, Technology and Innovation Fund [RTIF]), which continues to be the major national source for R&D support programmes, EU Structural Funds as well as the direct research funding from various EU programs (most notably the former Framework Programmes, currently Horizon 2020) became available as important funding sources for RDI after the Accession. The EU Structural Funds are actually larger sources of economic and RDI development compared to the NRDI Fund. Both public funding sources are allocated to each of the programs through a bidding process.

In addition, tax deductions are provided to companies engaged in R&D collaboration with public organizations. The specific form and rate of deduction have changed several times; the latest regulations (2012) offer a deduction from the tax base if the company has an R&D contract with a public research organization and performs research jointly with the company. In this case, 300% of the contract amount can be deducted. Another specific form was introduced in 2014: the 'Higher Education Supporting Agreement' that offers a tax deduction if a firm supports HEIs for at least five years. In this case, the company can deduct 20-50% of the total amount of supports from its tax base.

The available public funding allowed the launch of various government initiatives with relevant measures for academia-business partnerships. Various policy programs to promote industry-university cooperation have been implemented since 1999, and since then the policy commitment to industry-university cooperation has been further strengthened. The main purpose of these programs is to improve the innovative performance of the economy by encouraging private industries to participate in government-financed projects or cooperation arrangements. The policy programs have changed during the past two decades in their rationale, focus, and approach, even though there have not been any formal analyses or evaluation of the impacts generated by the programs.

The earlier programs implemented before 2016 (or closed programs) were more or less focused on supporting industry-university cooperation in R&D and innovation, and therefore were favourable to large companies capable of utilizing the opportunities to work with universities for research and technology development. On the other hand, the programs launched in 2016 and thereafter (the current programs – new breed policy initiatives) aim at to tackle a broader range of policy issues related to industry-university cooperation.

<Table 1-2> Closed Programs (1999-2015)

Program	Fund source	Period	Description
Cooperative Research Centers (CRCs I) CRC II	NRDI Fund (RTIF) EU Structural funds	1999-2004	The funding was aimed to ensure sustainable partnerships and was provided for HEIs for three years, supporting R&D and curricula development. The first call funded five centers and the second added fourteen CRCs at HEIs and PROs.
Regional University Knowledge Centers (RUKC)	NRDI Fund (RTIF)	2004-2006	The support was available for consortia led by HEIs collaborating with various partners (small-large companies, government) and achieving high-level R&D and innovative activities for the benefit of their regional environment. The three calls established eighteen RUKCs in total with fourteen HEIs. Funding was provided for three-to-four years.
R&D Centers ("Development poles")	EU Structural Fund	2007-2009	The program supported the survival ofprevious CRCs and/or RUKCs with the following specific aims: a) market utilisation of product/process innovations; b) RDI services for the business sphere; and c) the creation of new workplaces (mainly for PhDs and postdocs) either at the HEIs or at the firms. The 3+2 year calls supported thirteen R&D centres in total for three years.

<Table 1-2> Continued

Program	Fund source	Period	Description
National Technology Platform	NRDI Fund (RTIF)	2007-2009	This was the first initiative that placed the business actors in the lead role. The Centers were required to lead strategic partnerships between the business sector and research organizations realizing commercially relevant R&D-based innovations and ensure the participation of PhDs and young researchers in the projects. Support was available for periods of one or four-to-five years for the ninety-eight projects in the five targeted sectors.
Regional and Sectoral HEI Collaboration	EU Structural Fund	2012-2014	This program was supporting the HEIs to improve their services and integration into the regional/sectoral economies by enhancing collaborations and collaborative capacities at the HEIs. Nine institutes benefited from the fifteen supported projects. The funding period was up to two years.
R&D Competitiveness and Excellence Contract	NRDI Fund (RTIF) EU Structural Fund	2012-2015	This is a top-down initiative for the creation of projects with substantial R&D and industrial results improving the national competitiveness. Eight industry-led projects were awarded the contracts both in 2013 and 2015. Projects' length is up to four years. The continuation of this program has been realized from a different funding source since 2015.

Source: Modified and Extended based on Inzelt and Csonka (2016).

<Table 1-3> Current Programs (2016-Present)

Program	Fund source	Period	Description
HEI-Industry Cooperation Centers	NRDIO Fund	2016-	- This is a large -scale project to supportHEIs' building infrastructure andrelated capacity - The project supports not only R&D but also training and education (soft skills, etc.)
Competence Centers (Development of research infrastructure)	NRDIO (National Research, Development and Innovation Fund Office) Fund	2019-	- To support the establishment and operation of market-oriented RDI centersas bases for sustainable industry-university partnerships
University Innovation Ecosystem	NRDIO Fund	2019-	- To build a result-oriented innovation ecosystem that facilitates the utilization ofuniversity knowledge stock, and tostrengthen entrepreneurial mindset in theacademic society - To improve the system of technology transfer and innovation management
Indirect Support: Regional Innovation Platforms	NRDIO Fund	2019-	- Strengthening linkages among regionalstakeholders
Science Parks (Technology and Innovation Park)	NRDIO Fund	2019-	- To support university-based organizationsand facilitate collaboration with localindustries for technology transfer and the generation ofinnovations, and tonurture a business-friendly institutionalsystem

Source: Modified and Extended Based on Inzelt and Csonka (2016).

In addition to the above, there are programs that are indirectly related to the promotion of industry-university cooperation, such as:

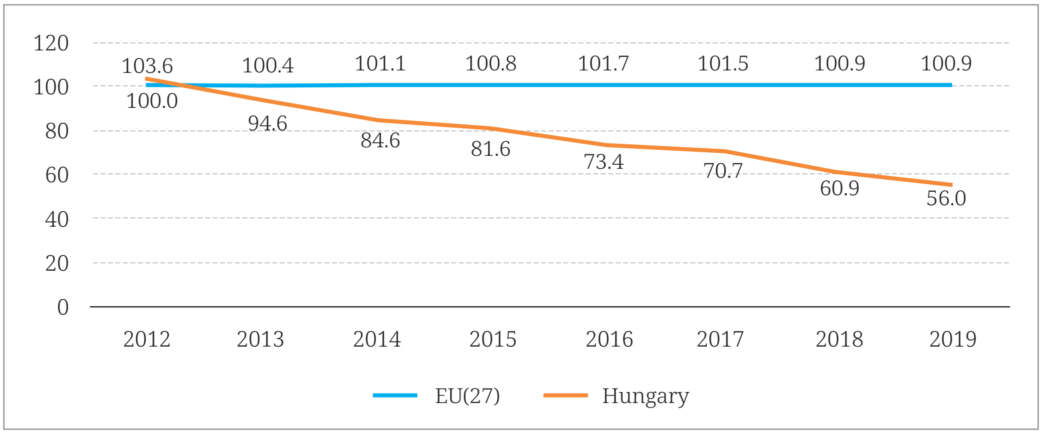
- The RDI Strategy (2014-2020) and the Shifting of Gears in Higher Education Mid-Term Political Strategy (2016-2020) that puts forward the vision for the development and presents a comprehensive review of the state of the innovation system, including industry-university relations. The strategies offer programs to encourage and promote new start-ups based on university knowledge stock;
- Support Program for Better Utilization of Intellectual Property (2015 onwards), Innovation Voucher Program (2015), Support for the Establishment of Start-up and Spin-off Companies (2015/2017).

3.2.3. Performance

3.2.3.1. Flow of Resources between Industries and Universities

The situation has been improving partly because of the increasing flow of private R&D funds into universities and partly because of the strengthened policy measures of the government to promote industry-university cooperation (Havas, 2015). Despite the various governmental programs listed in the previous section and other direct and indirect governmental tools to support university-industry linkages, the share of private co-funding for public R&D is decreasing. [Figure 1-1] shows a significantly declining interest of the private sector in the knowledge/technologies generated by HEIs in Hungary. In contrast, the EU average remains stable, possibly indicating a stable relationship between public research organisations and industries.

[Figure 1-1] Private Co-funding of Public R&D Expenditures (% of GDP)



Note: Data shows the relative performance compared to the EU 2012 level.
Source: EIS (2020).

3.2.3.2. Industry-University Cooperation

Systematic data on industry-university cooperation in Hungary are almost non-existent or scarce. The Industry-University Joint Centers, which are formal platforms for industry-university cooperation supported by the government, are mostly dominated by large enterprises, in particular, FDI companies. Information on systematic technology transfer is almost unavailable. There are well-known success cases that were partly made possible by the policy programs, but it seems they owe more to the informal channels between university researchers and business communities for the successes.[10]

One of the very successful organizations is the Budapest University of Technology and Economics (BME), which managed to establish a number of common research labs with leading industrial organizations in various technological fields, launched major public funded RDI collaboration projects and established and continues to maintain many other forms of university-industry linkages (including education).

- BME is actively engaged in cooperation in the areas of ICT, energy, automobiles, bio-technology, nanotechnology, and disaster prevention technologies with global enterprises such as NOKIA, SIEMENS, RG, and MVM.
- BME recently established the "University-Industry Cooperation Center" to promote and manage cooperative activities with industries and toward that end, launched the "BME Research, Innovation and Development Gateway (Bridge) Program." The University also operates an on-campus technology park as a platform for industry-university cooperation.
- BME is still in an early stage of developing organizational infrastructure for industry-university cooperation and thus the achievements so far have been largely made possible through informal contacts between individual researchers and industries.

Another success case: The Széchenyi István University (Győr) has created an almost symbiotic relationship with the local subsidiary Audi Hungaria Zrt and with the local government, which resulted in the involvement of the company in course development, establishment of new departments, funding of infrastructure and also common research projects.

In addition to the above, the Szent Istvan University, Gödöllő presents a successful case of industry-university cooperation at a regional level. The Szent Istvan University is a top institution in the area of agriculture with a high reputation for its excellence in horticulture,

10 This was learned from the discussions during the field study carried out in Budapest in December 2019.

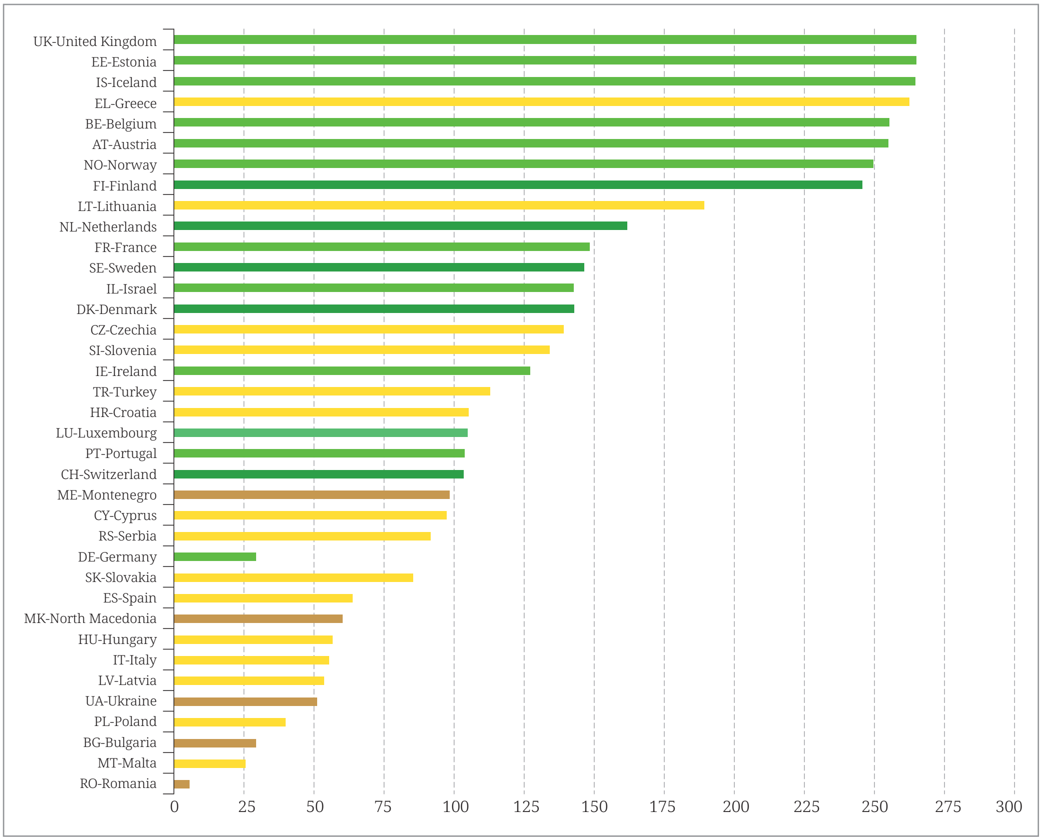
food, landscaping and mechanical engineering. Based on the excellence, the university has been able to make remarkable contributions to the development of the regional economy by working closely together with the food industry, chemical industry, and pharmaceutical industry of the region. The Szent Istvan University relies heavily on personal relationships for the development and implementation of cooperative programs with industries.[11]

As indicated by the above cases, several universities are seeking to work with industries, while at the same time promoting inter-university cooperation to jointly explore effective ways to strengthen mutually beneficial relationships with industries. The University of Debrecen, which pioneered industry-university cooperation in the areas of medical science and life science in Hungary, initiated the organization of the "Inter-University Network for Industry-University Cooperation" as a means to combine forces in strengthening institutional infrastructure for industry-university cooperation.

Unfortunately, however, almost all the cases described above are about cooperation with large enterprises. As shown in [Figure 1-2], Hungary belongs to a low-performing group among EU states in terms of the proportion of SMEs engaged in cooperation with other players that include customers, suppliers, universities, and public or private research institutes. The Eurostat Database (based on the Community Innovation Survey) provides data on the extent of collaboration between innovative enterprises and universities. Only 10% of the innovative SMEs (with 10 to 49 employees) collaborate with universities or other higher education institutions. This number is only slightly lower than the EU average (11%). Mid-sized Hungarian enterprises (from 50 to 249 employees) are somewhat more active in such collaborations (12%) but this is also behind the EU average of 17%. Data also show that enterprises tend to prefer cooperation with other enterprises, customers or suppliers over working with HEIs (Eurostat Online Database).

11 Professor Istvan Szabo, Vice Rector of the Szent Istvan University, emphasized that personal contact is much more effective than formal channels in developing cooperative relationships with industries. (Interview conducted in December 2019).

[Figure 1-2] Innovative SMEs Collaborating with Others



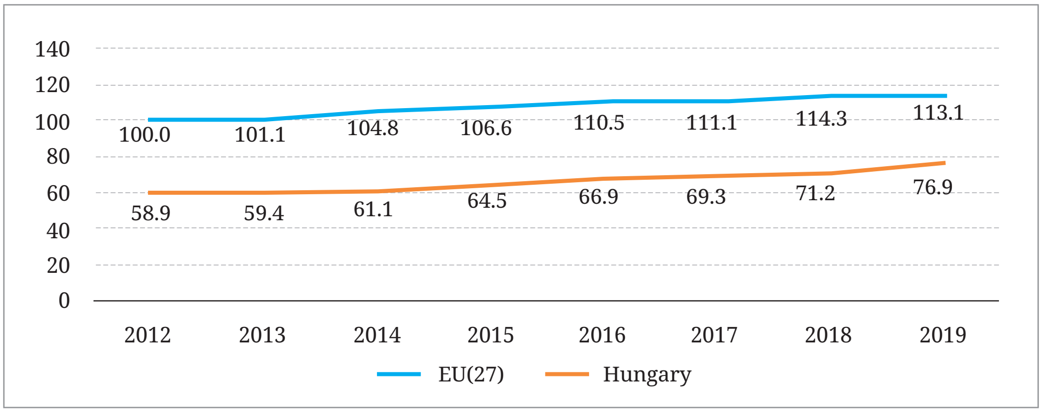
Source: EIS (2020).

Industry-university R&D: Industry-university cooperation appears to be focused on R&D and innovation, which may be attributed to the R&D and innovation-oriented policy programs. For example, the HICC Program is very much focused on supporting R&D cooperation between universities and large enterprises that are already capable of working with universities on a par. Thus, it is safe to infer that industry-university cooperation in Hungary is very much R&D-oriented and favorable to large enterprises. The earlier government programs paid less attention to building broad-based internal capacity so that universities could respond to technical and non-technical problems for which SMEs need solutions. This may explain why SMEs have not participated actively in the programs for industry-university cooperation, contributing to the low proportion of SMEs cooperating with other innovation players. Fortunately, the current programs (launched in 2016 and onward) have been made more attractive to SMEs by taking into account what these entities want to gain from working with universities. This may change the attitudes of SMEs toward the government programs for industry-university cooperation and attract SMEs to participate in the programs.

Joint publications: Industry-university cooperation in R&D leads to scientific publications and/or patents. Scientific publications indexed in the Elsevier Scopus database show that, during the period between 2003 and 2013, the share of industry-university joint publications in Hungary remained almost unchanged at 1.3%, while the share was 2.8% for EU-28 (2008-2013). According to the EIS 2019 data, the level of public-private co-publications in Hungary is lagging behind the EU average although a modest increase can be identified in the data.

[Figure 1-3] Public-private Co-publications per Million Population

(Unit: % of GDP)



Note: Data shows the relative performance compared to the EU 2012 level.
Source: EIS (2020).

Technology development: The number of joint patents filed in Hungary is negligible, mainly due to the tradition that does not attach much importance to patenting in research career. According to the Knowledge Transfer Study (Arundel *et al.*, 2013), Hungary used to produce the smallest number of patents granted (0.8) per 1,000 research personnel among EU countries. In the past couple of years, foreigners have shown a growing interest in the Hungarian economy as measured by the slightly growing EPO (European Patent Office) patents validated in Hungary (HIPO, 2020). At the same time, the year 2019 saw more than 72 thousand patents registered with the EPO from the 28 EU member states. Among these, 100 were of Hungarian-origin, which represents a 15% decrease compared to 2018. This also means that there were 10.2 patents per million Hungarian inhabitants, which is among the smallest of the EU member states (22nd of EU-28). Austria had 265.2, Finland 306.6, Czech Republic 18.5, Greece 13.1, and Poland, 12.2 but Slovakia had even less with 7.7, and Bulgaria with 4.8 and Romania with 1.9 were also found lagging behind (EPO website).

Technology transfer and commercialization: Formal information on technology transfer and commercialization is almost non-existent. Hence, it is practically impossible to assess formally the impacts of the policy programs on technology transfer and commercialization activities in Hungary. However, there are success cases that demonstrate how universities and industries worked together to translate university knowledge/ideas into market values. Elektronika Kft is a company in Hungary that showcases a success case based on the commercialization of university technologies. The company, founded by two people in 1986 based on a medical technology transferred from a university, has grown to be a dynamic tech company with a sales revenue of over €100 million and manpower of over 600 workers. The founders of the company obtained technologies from a university through their personal channels, conducted additional joint research for commercialization, and succeeded. This is a case where a business company has successfully translated new ideas/technology of a university into market value through collaborative processes, including joint research for commercialization. Since this company was founded before the Hungarian government launched the policy programs to promote industry-university cooperation, it may not be appropriate to cite this success case as a result of the policy programs. However, this case study exemplifies the role of informal channels in industry-university cooperation in Hungary, which, in a certain sense, has now taken root as part of Hungary's culture. The impacts of the policy programs are yet to be seen. It may take time for the recent policy programs to make visible impacts. Regarding university spin-offs (and start-ups), the law provides a clear policy direction, but the framework conditions have not matured enough to induce the growth of spin-offs and start-ups. The latest revision of the law mandates the government to improve the situation but its impact is yet to be seen.

3.3. Overall Assessment and Policy Issues

3.3.1. Overall Assessment

Hungary has made encouraging achievements through the policy endeavours over the recent decades, providing a springboard for higher and broader levels of industry-university cooperation. Even though sufficient information/data are is not available to formally assess the effectiveness of the policy programs, there are success stories showcasing the benefits of industry-university cooperation, technology transfer and commercialization. The strengths of the Hungarian system may be summed up as follows:

- Strong scientific base of universities: It appears that the strengths of the current Hungarian system stem from the scientific excellence of the universities, which attracts industries to work with them.
- Active technological interactions between large enterprises and universities: The R&D-focused programs offer excellent opportunities for enterprises to take advantage of the world-renowned scientific and technological potentials of the Hungarian universities, thereby facilitating industry-university interactions, in particular

between large enterprises and top universities. These exchanges allow Hungarian companies to improve their innovative capabilities while the universities could reinforce their infrastructure for innovative services and improve the mindset of faculty members. Collaborations have also made university education more demand-oriented.

- Role of informal channels in industry-university collaboration: Even though Hungary is at an early stage of building infrastructure for industry-university cooperation, interactions and cooperation between the two players have been made possible through informal contacts and channels, which appear to be a widely accepted and well-functioning mode of operation in Hungary. Such a mode of cooperation may be one of the strengths of the Hungarian system that needs to be further encouraged and maintained.
- Flexible policy adjustment: The current programs (launched in 2016 and thereafter) have been adjusted to respond to the broader needs of industries, thus providing a springboard for SMEs to pursue higher and broader cooperation with universities. The programs facilitate the building of partnerships and support many joint R&D and innovation efforts, contributing to the creation of an ecosystem for SMEs-university cooperation.

Success or failure of a program is not a simple 'yes or no' question: even if the programs did not perform perfectly as originally planned, they might have had positive effects on initiating new linkages, and in this sense, the government programs deserve credits for building a foundation for self-sustaining industry-university partnerships. Programs based on a step-by-step approach may do better in attracting more companies to engage in serious and productive collaboration.

3.3.2. Issues and Challenges

Despite the strengths and achievements of the policy programs, there remain several issues and challenges to be tackled:

- How to further improve university infrastructure and its attractiveness as a major source of knowledge for industries: One of the most important measures that government can take to promote university-industry cooperation is to provide institutional infrastructure that makes it easier for the players to approach each other. This may include information system (on patents, new technologies, new processes, etc.), financial system, and internal organizations that manage and facilitate the interactions between the parties.
- The time horizon of programs (mostly 3-4 years) needs to be extended: Even though

the Hungarian government has launched diverse programs to foster and promote cooperative linkages between institutions of science, higher education and business since the early 2000s, they have been amended so often – especially during the first decade of the new millennium - that the key players have had difficulties in comprehending and adopting them in their own business plans. It takes a long time for policy programs to achieve the intended outcomes, but the lifespan of the programs in Hungary tends to be too short (3-4 years) to bear fruits and contribute to the strengthening of strategic thinking among stakeholders.

- Industry-university cooperation biased toward joint research: The broad policy mix that the government has used over the past 15 years as a whole lacks initiatives to strengthen the basic capabilities for effective industry-university cooperation. For example, the government programs rarely offer supports for SMEs that are generally weaker in technology and management. The government programs' main focus has been to encourage high-end collaboration, such as joint R&D. This approach has been effective in strengthening cooperation between entities that have had previous interactions, accumulated mutual trust and built linkages. However, it has seldom worked among those who have had no previous linkages or at least some degree of interaction.
- How to motivate SMEs to pursue innovation and strengthen their capacity for R&D and innovation: In order for SMEs to engage in active cooperation with universities, a necessary condition is that they desire to cooperate with universities. Further, in order for the cooperation to bear fruit, they need to have the capacity to work with universities.
- How to make universities industry-friendly: A more open university culture may be required to make industries, especially SMEs, feel welcome to engage in cooperation.

4. Role of Universities in Innovation: Industry-University Cooperation in Korea

4.1. Growth of the Higher Education Sector

As of 2014, 3.2 million students were enrolled at 408 Korean HEIs, of which 189 are four-year universities, 10 four-year education universities, 2 industrial universities, and 139 two-year vocational colleges, 1 institute of long-distance education, and others. The number of university students accounted for an overwhelming 51.5% of the population aged 20-29 in the same year.

The growth of HEIs in Korea has been as phenomenal as the economic growth. During the period from 1960 to 2000 that represents the high-growth stage of the Korean economy, the number of university students grew more than 30 times from a mere 101 thousand to 3,130 thousand, making Korea a leading country in terms of university enrollment rate[12]. Two factors explain this phenomenal growth: one is the Confucian tradition[13] that places the highest value on education and scholarship, and the other the high rates of return on investment in HE due to the rapid industrial growth. As [Figure 1-4] shows, overall, the growth pattern of universities looks very similar to that of GDP, but it is notable that universities grew faster than the economy in the early phase of economic development. This may be explained as the influence of the expected rate of return on investments in HE and also the Confucian tradition[14].

There were only seven national universities in Korea of the early 1950s, which means that the modern system of HE in Korea is just a little older than 60 years. The expansion of HE in Korea started during the period between 1960 and 1980 when Korea began to link higher education to economic growth, as marked by the creation of an institution for advanced education and research in science and engineering (the Korea Advanced Institute of Sciences: KAIS in 1971) and the establishment of two-year vocational colleges. The expansion continued in the 1980s, during which the number of university students increased by 30%, and also in the 1990s when the legislation (1995) made it easier to establish new universities.

The question is how Korea managed the financial aspect of the explosion of demand for HE. Simply put, Korea has been able to expand the HE system without increasing fiscal burdens by relying heavily on the private sectors. In Korea, private universities account for approximately 80% of the university enrollments, the highest among OECD countries. Simultaneously, public spending on HE remains at about 0.6% of GDP, which is the lowest among OECD countries (OECD, 2010). On average, private universities in Korea derive 73.6% of their revenues from tuitions, 13.8% from donations and contributions, 8.7% from transfers from foundations, and the remaining 3.9% from government subsidies and/or grants (IPEDS 2009, KEDI). Thus, the role of government in HE has been more focused on

12 The university enrollment rate was 68.2% in 2014, which is one of the highest in the world.

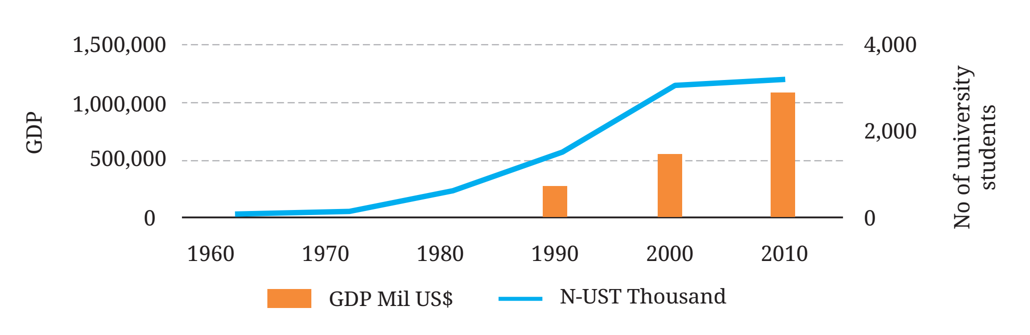
13 The Confucian philosophy governed the Korean society for more than 500 years since the late 14th Century, serving as the political, economic, and legal reference frame of the society during the period of Yi Dynasty (1392-1897). Even though the influence of the Confucian teachings on the Korean society has been tapering off rapidly with the demise of the Dynasty and the massive influx of new ideas, most importantly the Western culture, the Confucian values still remain a key factor in inter-personal relationships and social order. Most notable of the many unique features of the Confucian society was that scholastic ability determined one's social mobility and thus social status, which still fans the desire for education among Koreans.

14 However, the Confucian and economic factors conflict with each other in that the Confucian tradition emphasizes moral attributes, while in contrast, the rate of return on investment in education is determined by the skills valued in employment and economic activities.

setting rules and controlling the system rather than providing financial assistance.

Korea's approach to promoting HE in response to the growing demand in the early stages of development was very much tuned to expanding the supply capacity of the HE system rather than enhancing and ensuring the quality of education.

[Figure 1-4] Growth of GDP and Universities: 1960-2010



Source: KOSTAT.

4.2. Changes in Demand for University Services

During the period of Korea's development, almost all the sector policies were geared to promoting and facilitating industrialization and economic development. HE policy was not an exception: it was integrated into the national development strategy to meet the human resource requirements of various sectors. Therefore, education policy, Science, Technology and Innovation (STI) policy, and industrial development policy have been closely interlinked in a mutually reinforcing manner as shown in <Table 1-4>.

<Table 1-4> Policy Linkages for Economic Development

Policy Linkage	1961-1980	1981-1999	2000-
Economic development goal	Industrialization Development of Heavy Machinery Industries (HMI)	Structural transformation to hi-tech industries	Transition toward an innovation-based economy
STI requirements	Technological learning: Imitation	Indigenous R&D: Development of strategic technologies	Creative research
HR requirements	Technological learning capacity Engineering capacity	R&D capacity Development capacity	Creative thinkers Abstract thinkers Creative minds
Education policy	Production of fast learnersUniversalization of secondary educationVocational education	Expansion of university education Strengthening graduate programs Linking education to research	Creativity education Research orientation of education Linking education to the market

<Table 1-4> Continued

Policy Linkage	1961-1980	1981-1999	2000-
Higher education policy	Quantitative expansion	Promotion of research universities	Promotion of industry-university linkage Promotion of the commercialization of research results

Source: Author.

4.2.1. Responding to Increasing Demand for Technical Manpower: 1960s-1970s

The role of Korean universities in the early stage of development was tuned to producing fast learners capable of understanding, absorbing and operating technologies brought in from foreign sources for industrialization. At this stage, the HE policy was tuned to expanding the quantitative supply capacity to meet the rapid increases in demand for new skills. Concurrently, the government created the Government R&D Institutes (GRIs) to help industries in identifying, acquiring, and assimilating foreign technologies for local application. Therefore, the role of universities, at this stage, was almost confined to teaching. During the period between 1960 and 1980, the number of university students increased more than six times from 101,000 to 621,000. The growth of the HE system at this stage owes much to the growth of the two-year vocational colleges, which were first established in 1965 in order to nurture technical manpower required at production sites. In 1980, vocational colleges accounted for 24.5% of the university students.

While promoting the expansion of the HE system, the government put into action a plan to improve graduate education. In 1971, the government created the Korea Advanced Institute of Science (KAIS, currently the Korea Advanced Institute of Science &Technology or KAIST), a graduate school for advanced education and research in science and engineering. KAIS brought in the US graduate education system that links education to research to nurture research-oriented scientists and engineers in Korea. This indeed was a farsighted policy action of the government to meet the human resource requirements more than a decade ahead when Korea would move toward a stage of indigenous R&D for structural transformation of the economy. Later, many local universities adopted the KAIS model in making a transition toward research universities. In parallel with KAIS, the government created the Korea Science and Engineering Foundation (KOSEF; currently, the National Research Foundation, NRF) in 1977 to fund university research.

4.2.2. Transition toward Research Universities: 1980-2000

The 1980s marked an important milestone for Korea's STI and HE policy. In the early

1980s, the government shifted the STI policy focus from promoting acquisition of foreign technologies to promoting indigenous R&D, to facilitate the structural transformation of the economy from a low-/mid-technology-based industrial economy into a high-technology-based one. For this, the government launched the national R&D program aimed at developing the strategic technologies required for the transformation, while offering fiscal and financial incentives to stimulate R&D and innovation in the private industrial sectors at the same time.

As part of the policy shift, the government started to increase financial support for university research and launched initiatives such as the "Scientific Research Center (SRC)," "Engineering Research Center (ERC)," "Medical Research Center (MRC)," and "National Core Research Center (NCRC)".[15] Those programs were designed to facilitate the formation of centers of excellence in science and engineering research where university researchers can work together, and thereby to promote the transformation of the formerly teaching-oriented universities into research-based or graduate program-oriented universities. The government also launched the Korea Brain 21 (BK-21) Program devoted to supporting graduate studies and research, around the end of the 1990s. The policy shift of the government was accompanied by rapid increases in research funds that enabled the expansion of the graduate programs in science and engineering. Government R&D funds for universities increased from KRW 25.9 billion (approx. US$ 24 million) in 1980 to KRW 244.3 billion (US$ 222 million) in 1990 and to KRW 1.56 trillion (US$ 1.42 billion) in 2000. As a result of these measures, graduate programs at Korean universities grew remarkably in both quantity and quality. During the same period, the number of graduate students increased rapidly from 33,939 in 1980 to 229,437 in 2000, and in the year 2000, 15,754 MS's and 2,175 Ph.D.'s in science and engineering graduated from Korean universities.

<Table 1-5> The Growth in the Number of Graduate Students: 1980-2000

Year	Total	National universities	Public universities	Private universities
1980	33,939	11,133	0	22,806
1985	68,178	19,155	207	48,816
1990	86,911	25,042	384	61,485
1995	112,728	33,902	1,081	77,745
2000	229,437	68,841	2,657	157,939

Source: KEDI (2005).

It was around the mid-1990s that the Korean society's demand for university services began to diversify into 'contribution to industries.' In order to facilitate university-

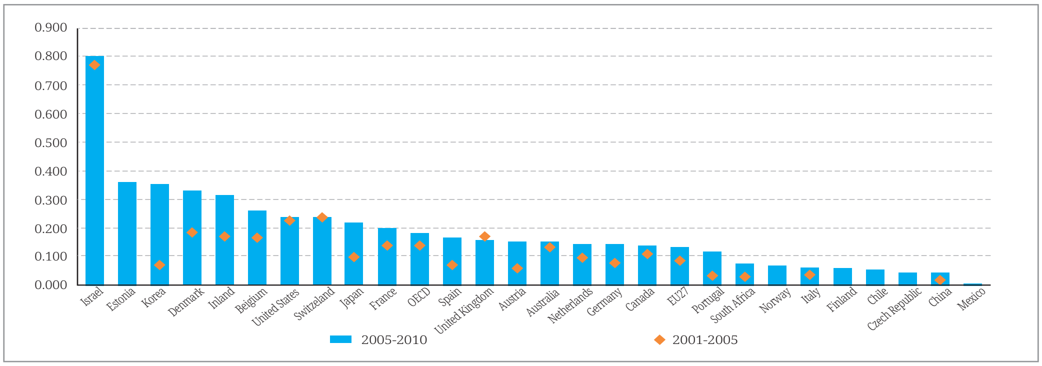
15 SRC/ERC was launched in 1990, MRC in 2002, and NCRC in 2003.

industry cooperation at a regional level, in 1994, the government initiated the program of "Regional Research Centers (RRC)," which allowed regional industries to access and use research facilities, and work together with university researchers for technical solutions and/or commercialization of R&D results. In 2006, RRC was merged with the "Technology Innovation Center (TIC, 1995)" of the Ministry of Industry, Trade and Energy (MITE) to form the "Regional Innovation Center (RIC)."

4.2.3. Universities as Innovation Players: 2000-present

Two decades of efforts to promote indigenous R&D brought about remarkable changes in the R&D and innovation landscape of Korea. In the early 2000s, Korea emerged as a new player on the global stage of science and technology, spending 2.5% of GDP on R&D (2002), and joining the leading countries in terms of the number of patents registered (Korea obtained 4,004 US patents in 2002, seventh in the world in terms of patent count). The source of the dynamism was the business sector that accounted for more than 75% of the nation's R&D investments and hired 60% of the research manpower (2000). The dynamism may be better explained by the growth in the number of industrial R&D centers that exploded from a mere 46 in 1980 to 7,110 in 2000. These industrial R&D centers led the innovation activities in Korea, from R&D to commercialization. Universities also made a remarkable progress in scientific research, elevating Korea to the 15th place worldwide in terms of the number of SCI (Scientific Citation Index) publications (2000). In addition, increased university R&D led to the expansion of patenting activities. Universities accounted for 5.18% of the total patent applications at the Korea Industrial Properties Office (KIPO) in 2014, which is deemed high relative to the patent performances of universities in other countries. An international comparison of the patenting performances of universities by the OECD finds that Korean universities fare better than their counterparts in most of OECD countries (OECD, 2014) (see Figure 1-5).

[Figure 1-5] Patents Filed by Universities: PCT Applications per $billion GDP (ppp)



Source: OECD (2014) p. 100.

Such developments presented yet another level of challenge to the HEIs and public sector R&D organizations – the demand that the R&D community should do more to translate the R&D results into outcomes of social and/or economic values. More specifically, they faced the demand to work with industries in order to commercialize the results of the publicly supported R&D. The government responded to the demand by amending the Promotion of Industrial Manpower Training Act (1963) into the Promotion of Industrial Manpower Training and Industry-University Cooperation Act (2001), which mandates the Ministry of Education to coordinate inter-ministerial collaboration to draw up and execute an "Action Plan for the Promotion of Industrial Manpower Training and Industry-University Cooperation" (plan period: five years). In addition, the Promotion of Technology Transfer Act (2001) was also revised in 2007 to include articles on "Commercialization of Public R&D Results." The law also requires the Ministry of Trade, Industry and Energy (MOTIE) to work together with other ministries and agencies in developing policy plans to achieve what the law stipulates: the Basic Plan for the Promotion of Technology Transfer and Commercialization. As such, in the 2000s, technology transfer and commercialization have become an inexorable function of universities demanded by the Korean society.

Today, the roles of universities in the NIS of Korea are three-fold: (1) producing high-quality manpower; (2) conducting scientific research; and (3) facilitating industrial innovation through industry-university collaboration. Currently, there are 147 universities that are considered to be research-oriented, employing more than 100K researchers or 21% of the total R&D work force of the country. However, the share of universities in GERD (Gross Domestic Expenditure on R&D) remains at 8-9%, more than 50% of which are taken by the top 20 universities, suggesting that the majority of the universities are still heavily teaching-oriented.

4.3. Promotion of Industry-University Cooperation, Technology Transfer and Commercialization: Policy and Performance

4.3.1. Policy System

The National Committee on Industry-University Cooperation (NCIC, launched in 2018, chaired by the Prime Minister) is responsible for setting policy directions and coordinating policies related to industry-university cooperation under the auspices of ministries and agencies. The Committee is mandated by the law to formulate and coordinate the implementation of the "Basic Plan for the Promotion of Industrial Manpower Training and Industry-University Cooperation".

A. Legal Frame

Many laws and regulations are concerned in one way or another with the issue of industry-university cooperation in Korea. Of diverse laws and regulations that deal with the issue of industry-university relationships, the major one is the Promotion of Industrial Manpower Training and Industry-University Cooperation Act that stipulates the measures the government should take for the promotion of industry-university cooperation. This law mandates the government to formulate and implement "the Basic Plan for Industrial Manpower Training and Industry-University Cooperation" that lays out the policy direction of the government for the promotion of HRD, technology transfer and commercialization and new technology start-up of universities, and the development of infrastructure for those activities. The Plan is reestablished with appropriate changes every five years.

In addition, the Promotion of Technology Transfer and Commercialization Act (Technology Transfer Act, in short) stipulates that the government should take policy actions to: (1) develop infrastructure for technology transfer; (2) provide financial support for technology transfer; and establish (3) a technology evaluation system; and (4) technology trust system. The Technology Transfer Act focuses more on promoting technology transfer and commercialization.

The above laws are further augmented by (1) the Promotion of R&D Special Zone Act that provides supports for the trade, transfer, and commercialization of the technologies developed within the zone; (2) the Special Law for the Promotion of New Start-up Businesses, and others.

B. Policy Plans

There are two plans that establish specific policy programs for industry-university cooperation, technology transfer and commercialization. One is the Basic Plan for the Promotion of Industrial Manpower Training and Industry-University Cooperation (2019-2013) that contains action programs to help create an ecosystem conducive to active industry-university interactions and cooperation. To achieve the goals, the Plan sets out programs geared to promoting and supporting: (1) diversification of industrial manpower training, placing emphasis on market- or demand-oriented education; (2) transfer and commercialization of university-developed technologies with market potential, including the "Buy (R&E results) and Develop (for commercialization)" program for enterprises; (3) supports for start-ups, including education, funding, institutional support and others; and (4) improvement of infrastructure for the promotion of industry-university cooperation. This Plan was formulated through inter-ministerial and inter-agency consultation coordinated by

NCIC (Office of the Prime Minister, 2018).

The other is the Sixth Plan for the Promotion of Technology Transfer and Commercialization (2017-2021), which is also an inter-ministerial plan coordinated by the Ministry of Trade, Industry and Energy (MOTIE). This plan is more focused on the promotion of technology transfer and commercialization, while the previous one (MOE plan) is geared more toward promoting industry-university linkages in a broader sense. The current Plan provides directions for fostering an open innovation system, in which universities and industries find it more beneficial to work together for technology development and innovation.

C. Roles of Ministries

Various ministries and agencies are involved in diverse programs set through inter-ministerial consultation under the coordination of NCIC for the promotion of technology transfer and commercialization. The specific programs of the individual ministries are subject to change, but overall, each of the ministries pursues the following objectives through their own programs. The specifics are as shown in <Table 1-6>.

<Table 1-6> Roles of Ministries and Agencies in Industry-University Promotion

Policy Subject	Contents	Ministries Involved
R&D for commercialization	- Support for commercialization of R&D - Prototype development, etc.	MOTIE, MSS, MSIT
	- Engineering of the technologies transferred from public sectors	MSIT, MSS
Support for technology transfer and technology trade	- IP management strategy and consulting services - Technology trust system, technology information system, etc.	MOE, MOTIE, MSS
	- Technology evaluation system, feasibility of commercialization, etc.	MOTIE, MSS
Organizational network and infrastructure building	- Nurturing experts on technology transfer (TT) and commercialization, and support for organizations for TT and commercialization (TLO, etc.)	MOTIE, MOE
	- Support for the development of experts' networks	MSIT, MOTIE, KIPO
Laws and regulations	- Preferential treatment in public purchase for products based on public R&D - Technology and product certificates	MOTIE, MSS
Financial support	- Creation of funds, and provision of financial supports	MOTIE, MOE, MOC, MSIT

Note: MSIT: Ministry of Science and ICT; MOE: Ministry of Education; MOTIE: Ministry of Trade, Industry and Energy; MSS: Ministry of SMEs and Startups; KIPO: Korea Industrial Properties Office; MCST: Ministry of Culture, Sports and Tourism.

Source: Author.

4.3.2. Institutional Infrastructure

Two levels of infrastructures are required to promote and facilitate technology transfer and commercialization: one is a set of institutional systems that provide not only rules and regulations but also platforms for interactions between labs and markets; the other is a set of internal organizations to deal with and manage the processes of technology transfer and commercialization. With regard to building infrastructure for technology transfer and commercialization, the law requires the development and operation of the following:

A. Policy Planning System

NCIC is responsible for formulating and coordinating the implementation of the Basic Plan for the Promotion of Industrial Manpower Training and Industry-University Cooperation, the first (2019-2023) of which was drawn up and put into action in 2019. In addition to this, the law mandates the MOTIE to develop action plans to promote technology transfer and commercialization every five years based on the policy inputs of individual ministries. Currently, the sixth plan is being carried out.

B. Information System

The National Tech-Bank (NTB, ntb.kr) provides an integrated comprehensive information system that links technology users and providers. KIBO (Technology Finance Corporation, kibo.or.kr) has been operating the Tech-Bridge that offers diverse services, including information on technology demands.

C. Technology Trust System

The government is mandated by the law to establish a technology trust system that manages the processes of technology transfer and commercialization on behalf of the technology owners who, in many cases, are not equipped with the knowhow/resources to deal with the legal, commercial and technological issues involved in the processes. KIAT (Korea Institute for the Advancement of Technology) was first designated as a technology trust agency, and currently there are four technology trust agencies including KIAT.

D. Financial System

With a view to facilitating technology transfer and commercialization, the government provides financial and technical assistance such as the START-up Fund, the Fund for the Development of New Growth Engines, Technology Loan Guarantee by KIBO, etc.

E. Technology Licensing Office (TLO)

It is mandatory for public R&D organizations to set up and operate TLOs as a window for technology transfer and commercialization.

F. Industrial Relations Office

The Promotion of Industrial Manpower Training and Industry-University Cooperation Act encourages universities to set up and operate "Industry-University Cooperation Centers (IUCC)" that play the role of linking university R&D to industrial uses. The MOE provides financial and other forms of incentives for the establishment of IUCC. As of 2017, over 84% of the Korean universities and professional colleges (353 out of 418) operate IUCC's.

4.3.3. Policy Programs[16]

Diverse programs are being implemented by various ministries and agencies within the framework of the Basic Plan for the Promotion of Industrial Manpower Training and Industry-University Cooperation. The overall structure of the current programs is as follows:

Diversification of university education to meet the demands presented by industries:

- Capstone design: Training students to apply what they learn at universities to the real-world problems–strengthening problem solving capabilities;
- Contract programs: Degree programs customized to the needs of the business enterprises and industries;
- Customized curriculum: Curriculum customized to the particular needs of a business enterprise, organization or local community, such as the Leaders in Industry-University Cooperation Plus (LINC+) program of the MOE;
- Education programs to meet the needs of new industries: Supports for interdisciplinary and future-oriented programs, such as the BK21 program designed to upgrade graduate education (MOE), development of high-caliber industrial manpower programs (MOTIE), development of S/W manpower programs (MSIT), etc.

Commercialization of intellectual properties of public sector institutions:[17]

- Support for industrial technology development based on public sector R&D results: Linking business R&D to university research, such as the BRIDGE (Beyond Research, Innovation and Development for Good Enterprises) program (MOE) that

16 The programs and systems discussed in the section on infrastructures are also important parts of the policy programs for the promotion of technology transfer and industry-university cooperation.

17 For the programs related to information system, financial supports, and technology trust system, refer to the section on infrastructure.

provides supports for the development of prototypes and/or additional R&D for the commercialization of technologies with high industrial potential developed by universities.
- Translating results of basic scientific research into industrial technology: supports for industry-university collaboration in translational research.
- Supports for the capacity-building of Technology Licensing Offices (TLOs) of public R&D institutes, the industrial-university cooperation centers (IUCCs) of universities and university technology holding companies.

Promotion of start-ups:
- Support for start-up education: "Start-up Class 100" (National Research Foundation), "K-MOOC" (MOE), "KAIST K-School" (entrepreneurship education, special degree program on start-up management, etc.)
- University start-up funds: Co-funding by the MOE, universities, students, alumni, industries.
- Promotion of technology holding companies as business organizations to promote and manage university technology-based start-ups.
- Promotion of and support for 'student start-up club' and start-up contests, etc.

Building infrastructure for industry-university cooperation: Refer to section 4.3.2. Infrastructure.

4.3.4. Industry-University Cooperation: Performance

4.3.4.1. R&D Collaboration

According to the analysis of the national R&D programs (2017), of the total of 51,789 R&D projects (KRW 16.6 trillion) analyzed, 11,857 projects (22.8%) worth KRW 6.6 trillion (39.8%) were conducted jointly by multiple organizations in the form of collaborative or commissioned research. In terms of the number of cooperative R&D projects, industry-university cooperative research accounted for 43.5% (or 5,163 sub-projects) of the total number of cooperative sub-projects, followed by industry-industry cooperation (11.9%) and industry-GRI cooperation 9.7% [Figure 1-6]. However, in terms of the size of funds, the share of university-GRI cooperation projects turned out to be greater (25.7%) than those of industry-university cooperation projects (24.0%) and industry-GRI cooperation projects (9.8%) as shown in [Figure 1-6].

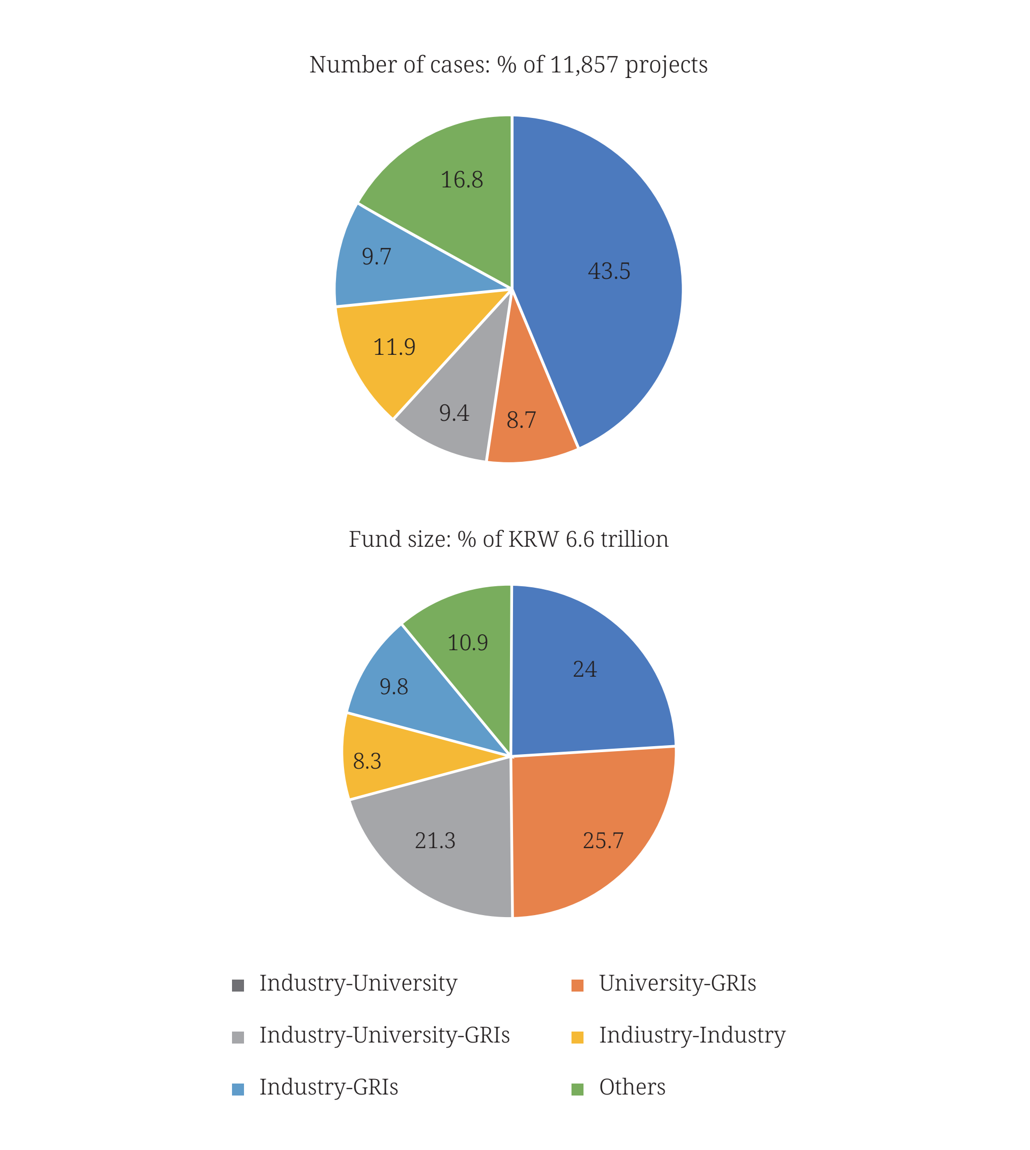
The vast majority of the cooperative projects were for technology development (17,588 projects or 87.7%), and only a small portion (150 projects or 0.8%) was for technology transfer and commercialization. Notable is the trend of the declining number of cooperative R&D projects for technology transfer and commercialization over the recent years from 378 in 2015 to 470 in 2016 and to 150 in 2017 ([Figure 1-7]). This may have something to do with the declining share of industry-funded university research observed over the recent past years ([Figure 1-8]).

There are indications that industry-university cooperation in R&D and innovation has been weakening over the recent years, such as:

- The shares of industry-funded research at universities and GRIs have declined significantly (see Figure 1-8)
- Of the R&D funds flowing out from industries, the proportion bound to universities has been declining continuously since the early 2000s, which may be an indication that the importance of universities as a partner for R&D and innovation is diminishing from the perspective of industries.

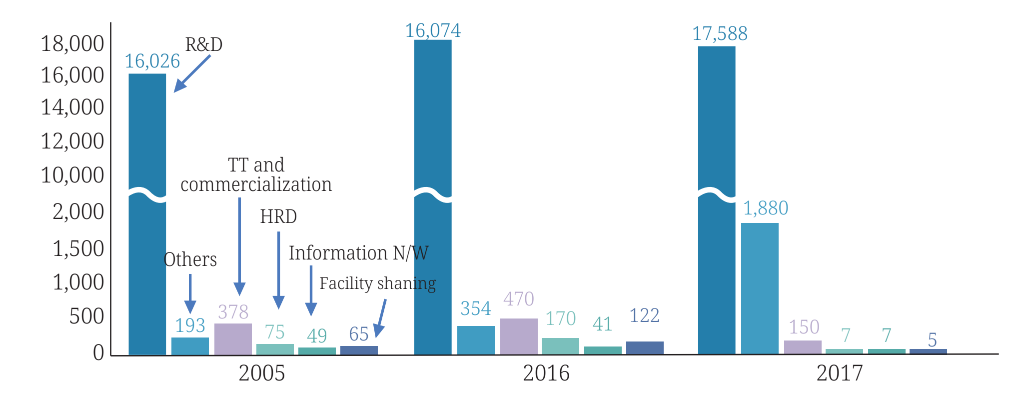
As indicated in [Figure 1-8], the flow of funds from industries has declined gradually but continuously since the early 2000s. However, the share of industry-funded R&D at universities in Korea (11.2% in 2014) is still much higher than those in the US, the UK, Japan, France, and the OECD average, which was around 6% in 2011.

[Figure 1-6] Structure of R&D Cooperation between Innovative Players-2017



Source: KISTEP (2018).

[Figure 1-7] Cooperative Projects by Objectives: Number of Cases



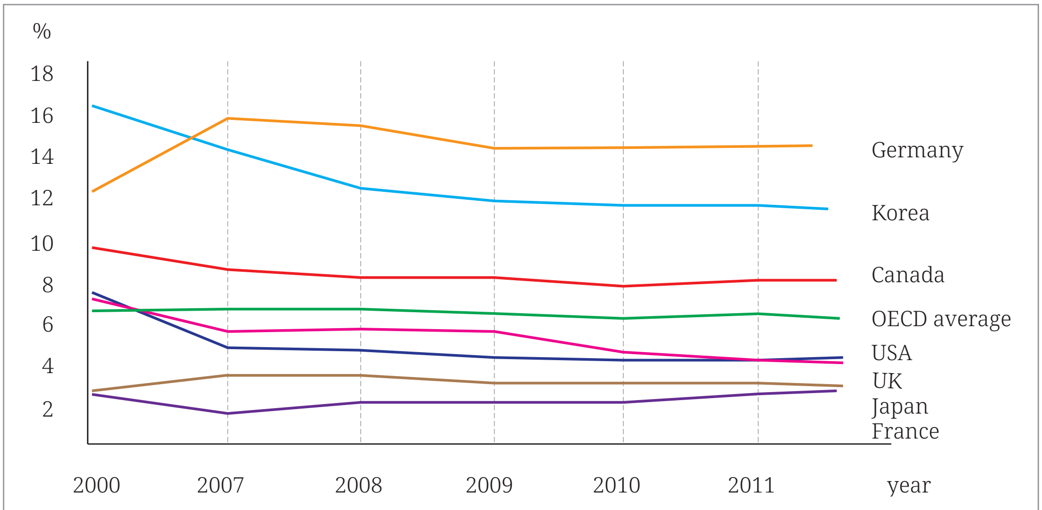
Source: KISTEP (2018).

<Table 1-7> Flow of Funds between GRIs, Universities and Industries (As percentage of the recipient's total R&D funds: 2014)

		To		
		GRIs	Universities	Industries
From	GRIs	0	6.0%	1.0%
	Universities	0.2%	0	0.03%
	Industries	3.0%	11.2%	0

Source: Based on the 2014 Survey of Research and Development in Korea.

[Figure 1-8] Share of Industry-funded R&D at Universities



Source: OECD (2014).

However, there is another indicator that points in the opposite direction: university-industry co-patenting activities have increased steadily over the recent years. In 2000, the share of joint patent applications (between university, GRIs and/or industries) in the total patent applications filed at the Korea Industrial Properties Office (KIPO) was only 0.4% but the share more than tripled to 1.58% in 2012 (KIAT, 2015). The share of university-industry co-application increased even more remarkably from 0.1 % in 2000 to 0.95% in 2012. Interestingly, however, the share of university-industry co-applications in the total university patent applications declined during the same period from 25.6 % to 18.3% (KIAT, 2015). This suggests that university-industry cooperation increased over the period but not so much as the innovation activities of the universities themselves. The proportions of university-industry, GRI-industry, GRI-university and GRI-university-industry joint patent applications were 0.95 %, 0.4%, 0.2% and 0.02% of the total patent applications at KIPO, respectively, in 2012 (KIAT, 2015). It is also notable that Korean industries do not cite university patents as much as industries do in other OECD countries (OECD, 2014b). The above seems to concur with the assessment of the Global Competitiveness Report 2016-2017, which gives Korea a score of 4.4 (1-7 scale) in university-industry collaboration, or 29th among the countries assessed (WEF, 2016).

4.3.4.2. Technology Transfer

A. IPs generated by Universities

The rapid increases in university R&D have resulted in equally remarkable increases in Intellectual Industrial Properties (IPs) of universities. Over the recent five years, the number of IPs generated by universities has almost doubled from 50,890 in 2012 to 99,283 in 2016. Most notable is the growth of international patents: while the number of domestic patents has grown at an annual rate of 17.7%, the number of international patents has more than doubled during the same period, which may indicate the improvement in the quality of the patents owned by Korean universities (see Table 1-8).

<Table 1-8> IPs Owned by Universities: 2012-2016

Year	# Univ.	Domestic patents	Foreign patents	Utilities	Design	Trade-marks	S/W	Copy-right	Total
2012	277	34,857	3,016	417	1,878	2,246	6,256	2,220	50,890
2013	273	43,373	4,026	462	2,004	2,127	8,640	1,745	62,377
2014	276	57,749	5,494	445	2,469	2,443	10,965	1,753	81,318
2015	275	62,259	5,606	376	2,938	2,743	12,075	2,901	88,898
2016	273	66,946	8,324	304	3,192	2,875	14,379	3,263	99,283
Annual growth rate %	-	17.7	28.9	-7.6	14.2	6.4	23.1	10.1	18.2

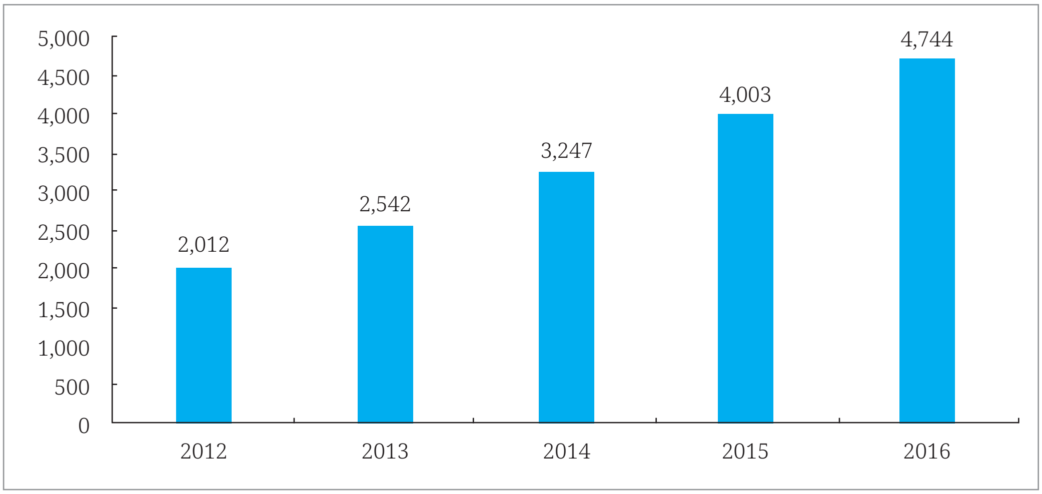
Source: NRF.

Another notable feature is the distribution of IPs among universities: the Top 10 universities account for 42.6% of domestic patents and 70.1% of foreign patents, which reflects an extremely high concentration of IP ownership and the high concentration of R&D activities in the top universities (NRF, 50% in 2014).

B. Trends of Technology Transfer

The increase in the number of IPs has resulted in an almost equal increase in the number of technologies transferred. During the period of 2012-2016, the number of technology transfer cases grew from 2,012 to 4,744, recording an average annual growth rate of 23.9% ([Figure 1-9]). According to the MOTIE, the overall ratio of technologies transferred has also increased rapidly from 19.5% in 2012 to 25% in 2016. Further, the increase has been more significant in the case of GRIs–from 34.9% to 60.3% (<Table 1-9>). On the other hand, of the technologies developed by universities in a year, only 12.8% were transferred to industries in the same year. The ratio was even lower for GRIs at 8.6% (MOTIE, 2017). Out of the cumulative number of technologies that universities own, only 6-7% are transferred (MOTIE, 2107) in a year, while GRIs have been transferring about 10% of their stocks of technologies in a year <Table 1-9>. Hence, it can be said that GRIs have performed better in terms of technology transfer.

[Figure 1-9] Growth of Technology Transfer from Universities[18]



Source: NRF.

18 There exist discrepancies between the data of MOTIE and NRF, possibly because of the differences in the definition of technology. However, the overall trends are in the same direction.

<Table 1-9> Ratio of Technologies Transferred* (%)

Year	Total	Universities	GRIs
2012	27.1	19.5	34.9
2014	31.7	25.4	39.3
2016	38.0	25.0	60.3

Note: Ratio of technology transferred = (number of technology transferred in the year/number of technologies developed in the same year)

Source: MOTIE.

C. Technologies Transferred by Area

IT (Information Technology) accounts for more than 36% (4,441 cases) of the technologies transferred, bio/health technologies 21.9%, machineries 16.1%, and electronics 9.2. The data clearly reflects the structure of R&D in Korea, which is heavily focused on ICT and bio/health technologies. According to the MOTIE, GRIs were the major source of IT (3,607 cases), while universities were the major players in transferring of bio/health technologies (1,593 cases out of 2,693 cases) (Table 1-10).

<Table 1-10> Share of Technologies Transferred by Areas (2017)

Machinery	Electronics	IT	Chemistry	Bio/health	Others
16.1	9.2	36.1	3.3	21.9	13.4

Source: MOTIE.

D. Mode of Technology Transfer

Contracts for technology transfer between industries and public sectors are made through diverse modes–licensing, ownership transfer, free transfer, free licensing, and others, of which the share of licensing was dominant at over 65.6% in 2017 (in the case of industry-university contract, 57.7% in the same year).[19] Please see <Table 1-11>.

<Table 1-11> Number of Technology Transfer Contracts by Type

Year		Ownership transfer	Free transfer	Licensing	Free licensing	Option contract	Others
2011		330	-	2,759	178	5	148
2014		718	419	4,098	639	0	107
2017	Total	1,466	282	4,905	278	0	546
	GRIs	266	234	2,553	178	0	170
	Univ.	1,200	48	2,352	100	0	376

Source: MOTIE.

19 In the case of the GRIs, the share of licensing was even higher at 74%.

E. Recipients of Technologies

Small and medium enterprises are absolutely the dominant beneficiaries of the technology transfer, receiving more than 91% of the technologies from both universities and GRIs. This may be because large enterprises in Korea are the dominant players in R&D and innovation, accounting for over 54% of the gross expenditures on R&D or 72% of the nation's business expenditures on R&D, and thus far less reliant on external sources for technologies. Many of the large enterprises are global players in the areas of their business and highly self-reliant in technology development.

<Table 1-12> Recipients of the Technologies

Year		Transferees (enterprises by size)					
		Small	Medium	Mid-large	Large	Foreign	Others
2011		90.4%			5.8%	-	3.8%
2014		44.6%	42.9%	3.2%	5.3%	-	3.9%
2017	Total	56.4%	33.8%	2.2%	3.3%	0.8%	3.5%
	GRIs	76.3%	15.1%	2.4%	2.9%	0.8%	2.5%
	Univ.	50.6%	41.4%	1.7%	2.4%	0.8%	3.1%

Source: MOTIE.

4.3.4.3. Commercialization

The mechanism of technology commercialization that leads to new products/processes and businesses is a complex, adaptive system that operates under risky and uncertain conditions. This means that success in commercialization hinges upon numerous factors that affect the behaviors of market participants. In many cases, the transferred technologies may not reach the market in the form of new products or processes because of technological or managerial and/or other reasons. The same holds true about new technology-based start-ups: new business may not succeed for similar reasons. Thus, it is practically very tricky to define "commercialization". Does commercialization refer to a state where the technologies are accepted by the market and thus generate reasonably significant revenues or the stage where initial steps are being taken by technology users to utilize the market potential of the technologies? This issue has been discussed recently in several innovation studies (for example, Sloek-Madsen, Ritter and Sornn-friese, 2015).

Despite the complexity of the process, commercialization of technology is, in general, achieved through two channels: (1) transfer of technology to users; or (2) starting a new business using the technology(ies). Therefore, commercialization performance is usually assessed in terms of the metrics that measure the economic returns from technology transfer and new technology-based start-ups. The MOTIE also employs the metrics to evaluate the commercialization performance of the public sector institutions, including universities in Korea.

A. Commercial Utilization of the Technologies Transferred

According to a survey conducted in 2017 by the MOTIE, of the 16,241 cases of technology transfer contracts between public sector institutions and industries that remain effective, 1,760 cases (10.8%) have generated revenues or cost-savings and 5,069 cases (31.2%) were still at the stage of additional research or investment for production or application. As for the remaining 9,392 (58%), they were either not in use or their whereabouts were unknown. If commercialization were defined as the state where actions are being taken for commercial utilization of the technologies, it may be fair to say that 42% of the technologies transferred have been commercialized, of which only 25% are from universities (MOTIE, 2017). Overall, GRIs are ahead of universities in terms of commercialization performance (see Table 1-13).

<Table 1-13> Whereabouts of the Technologies Transferred from the Public Sector, Including Universities

Whereabouts of the technologies transferred to industries	Number of contracts (%)	
	From public sectors	From universities
Revenue was generated or cost-reduction took place – new products or processes	1,760 (10.8%)	457 (6.4%)
At the stage of additional investment and/or research for actual application to production	5,069 (31.2%)	1,383 (19.3%)
Not in use currently	1,389 (8.6%)	525 (7.3%)
Whereabouts unknown	8,023 (49.4%)	4,814 (67.1%)
Total contracts (effective as of 2016)	16,241 (100%)	7,179 (100%)

Source: MOTIE.

Another way of measuring commercialization performance is to compare the revenues derived from the technology transferred. The annual revenue data for the year 2016 show that universities collected KRW 68.7 billion (or about US$ 62.5 million) as royalties for 143 cases of technology transfer (including liquidation of equities), while GRIs earned KRW 109.5 billion (US$ 100 million) from the 135 technologies transferred. Here again, GRIs outperformed universities.

B. Technology-based New Start-ups

As of the end of 2016, 795 new start-ups based on technologies of public institutions were in operation. Of them, 518 were created based on university-owned technologies and the remaining 279 on GRIs' technologies. Further, 730 of them were launched by the researchers and/or institutions that developed the technologies, and 65 by external transferees of the technologies from universities or GRIs. The business performances of the start-up companies varied widely; only 32 companies (12 owned by universities, 19 by GRIs and 1 by the private sector) have achieved annual sales of US$ 3 million or more. In 2016, a total of 266 new start-ups were launched: 225 by the researchers and/or the institutions that developed and own the technologies and 41 by external technology transferees.

<Table 1-14> New Technology-based Start-ups

Launched by	Number of new start-ups (end of 2016)		
	Total currently in operation	Created in 2016	Companies that achieved sales volume of US$ 3 million or greater
Universities+ GRIs	730	225	31
Technology transferee	65	41	1
Total	795	266	32

Source: MOTIE.

4.3.5. Financial Returns

4.3.5.1. Revenues from Technology Transfer and Commercialization

The statistical picture of the technology transfer and commercialization activities of the Korean universities and GRIs looks pretty encouraging: the number of technology transfers and technology-based start-up businesses has been increasing, and so have the revenues from such activities. The revenues that universities and GRIs collected from technology transfers reached approx. US$ 165 million in 2016 – about US$ 40 million smaller than the revenues of the previous year (2015). Universities' share of the revenue was about 39% at US$ 64 million (see Table 1-15).

Of the 278 organizations surveyed, 44 collected revenues of over US$ 1 million (21 universities and 23 GRIs) in the year 2016. Notable is the trend that the share of universities has been increasing continuously over the past decade, starting from a mere 14.4% in 2007 to 38.6% in 2016 (see Figure 1-10).

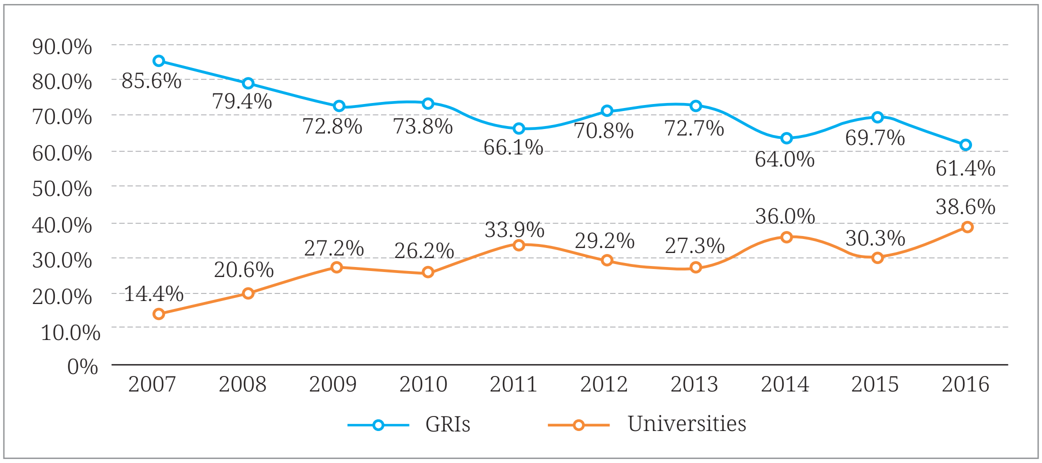
<Table 1-15> Revenues from Technology Transfer

(Unit: US$ Million)

Organization	2010	2012	2014	2016
GRIs	85.8	109.3	83.8	101.7
Universities	30.5	45.0	47.0	63.8
Total	116.3	154.3	130.8	165.5

Source: MOTIE.

[Figure 1-10] TT Revenue Shares of Universities and GRIs: Trends



Source: MOTIE.

4.3.5.2. Efficiency

Taxpayers may ask: “Do universities and GRIs deserve the tax money they spend on R&D?” or “What are the returns to the investments in R&D and innovation?” GRIs and universities in Korea spent almost US$ 11.7 billion on R&D in 2016: GRIs about US$ 6.6 billion and universities US$ 5.1 billion. In the same year, they collected about US$ 165 million or 1.41% of the R&D money they spent during the year. GRIs collected 1.54% of the R&D money they spent in 2016 as revenues from technology transfer, and universities 1.24% (MOTIE). However, in terms of trend, the ratio of the revenues from technology transfer to R&D expenditures of universities has been rising consistently over the past decades (from 0.83% in 2009 to 1.24% in 2016), while in contrast, the trend for GRIs has been somewhat in the opposite direction (Figure 1-11).

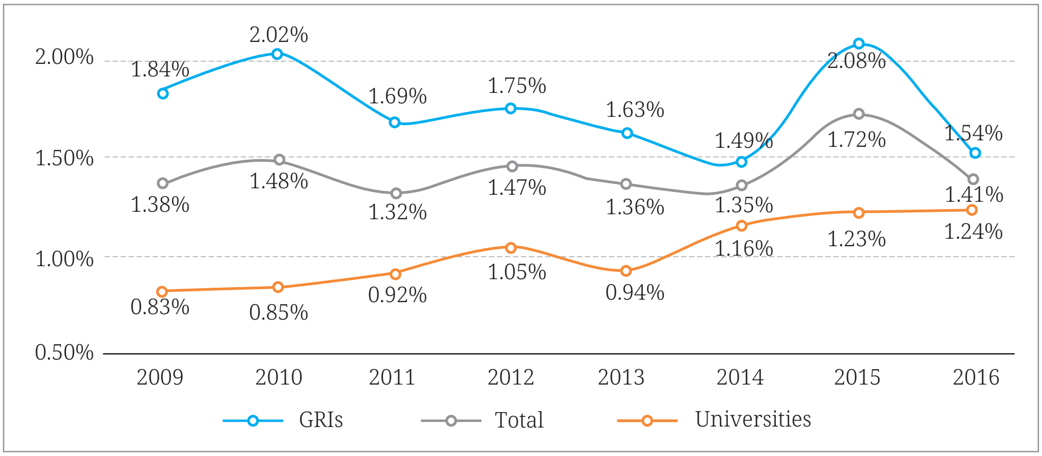
The problem is that it is difficult to justify the R&D investments by the revenues they derive from technology transfer and commercialization. The ratio of the revenues to R&D expenditures is lower than the market interest rate, and far lower than the ratio they achieved in the United States (4.15%, KSTEP). Of course, in order to assess the efficiency of R&D investments, it is necessary to take into consideration the societal benefits of the technologies, which are much bigger than the direct benefits. Even so, international comparison implies that R&D investments have not been as efficient as they could be in Korea. In view of this, many experts suggest that something more has to be done to utilize the results of R&D for the benefits of the society.

<Table 1-16> R&D Expenditures and Revenues from TT and Commercialization

Organization		2010	2012	2014	2016
Total	R&D exp. (a), US$ million	8,385	11,258	10,398	12,602
	Revenues (b), US$ million	125	165	140	177
	Ratio (b/a), %	1.48	1.47	1.35	1.41
GRIs	R&D exp. (a), US$ million	4,543	6,672	6,025	7,089
	Revenues (b), US$ million	92	117	90	109
	Ratio (b/a), %	2.02	1.75	1.49	1.54
Universities	R&D exp. (a), US$ million	3,842	4,584	4,372	5,513
	Revenues (b), US$ million	33	48	51	68
	Ratio (b/a), %	0.85	1.05	1.23	1.24

Source: MOTIE (2018).

[Figure 1-11] Ratio of Revenues from TT over R&D Expenditures



Source: MOTIE (2018).

4.4. Summary and Policy Issues

4.4.1. Overall Assessment

Systematic policy efforts for the promotion of industry-university cooperation began in the early 2000s when the Korean government first put into action the Action Plan for the Promotion of Technology Transfer and Commercialization (2001-2005). Since then, there have been enormous efforts on the side of the government to promote industry-university cooperation, in particular, for technology transfer and commercialization, the achievements of which may be summarized as follows:

- Building infrastructure for industry-university cooperation: Legal and policy framework, educational programs, information system, financial support system, internal capacity to manage technology transfer and commercialization (TLO, IUCC, etc.), and others.
- Significant increase in university-industry R&D collaboration in the recent years: From 4,591 cases (KRW 1,393 billion) in 2015 to 5,163 cases (KRW 1,580 billion) in 2017.
- Rapid increases in intellectual properties and technology transfer from universities to industries: During the period of 2012-2016, university-generated intellectual properties increased from 50,890 to 99,283. This rise has been linked to the equally rapid increase in technology transfer to industries from 2,012 cases (2012) to 4,744 cases (2016). Of the 16,241 technologies transferred from public sectors to industries (cumulative number of cases surveyed in 2017 by MOTIE), 1,716 cases (10.8%) have achieved cost reductions or sales revenues.
- University start-ups: As of the end of 2016, the number of start-ups created and owned by universities was 518, of which 204 were launched in 2016. Twelve of the start-ups have achieved sales revenues of US$ 3 million or greater.
- Revenues: Universities collected US$ 68 million from technology transfers in 2016, which is about 1.2% of their R&D expenditures in the same year. Some critics cite this seemingly low ratio as evidence against public R&D investments.

In a nutshell, universities in Korea have been able to generate large numbers of IPs based on R&D, which has led to rapid increases in technology transfers to industries. Yet, only limited cases of the technologies transferred have reached the stage of full commercialization, which seems to suggest that the progresses so far owe more to the policy stimulants than the resourcefulness of the players involved.

4.4.2. Issues and Challenges

Technology transfer becomes meaningless if it is not linked to actual utilization for social and economic development. Thus, the effectiveness of industry-university cooperation should be judged based on the extent to which the relationship contributes to industrial innovation through technology commercialization or other means. Given this criterion, it is hard to evaluate the effectiveness of Korea's policy on industry-university cooperation. However, the Korean government may claim credit for building the institutional infrastructure to promote and facilitate industry-university cooperation, such as policy system, information system, financial programs, education programs, TLO, IUCC, etc. The policies have also been effective in promoting the generation of IPs and technology transfer, but the policies do not seem to work beyond this stage, because commercialization or actual utilization of technologies entails additional costs and risks that are not within the government's scope to mitigate.

The low rate of commercialization of transferred technologies may be partly due to the deceasing effectiveness of policy measures at the stage of commercialization and beyond, and partly derive from:

- Weakness of universities in understanding and meeting the technological needs of industries;
- Weakness of industries, in particular SMEs, in specifying their technological requirements;
- Weakness in universities' capacities to implement technology transfer and commercialization; and
- Rarity of entrepreneurs capable of linking new technologies/ideas to market values.

Yet, the most serious barrier to productive industry-university cooperation derives from the technology strategy in the early stage of industrial development in Korea, which was focused on promoting learning from foreign technologies, where universities did not have any significant roles to play. All industries wanted from universities was a steady supply of young engineers with superb learning capacities. Industries in those days seldom considered universities as a source of technologies. Therefore, in the course of the structural transformation, private industries focused on in-house R&D for the development of new technologies rather than looking to universities for the acquisition of technologies. This was particularly so in the case of large enterprises in Korea, which are today global players in R&D. This may have created a tendency among private industries to stick to in-house R&D for the acquisition of new technologies, not leaving much of a space for open innovation to breathe and grow in the Korean innovation system. Perhaps, this may provide a partial explanation why Korean industries invest so heavily in in-house R&D instead of relying on universities and/or public sector research organizations.

In addition to the above, there exist various hurdles along the way toward promoting technology transfer and commercialization, such as:

- Low mobility of innovation resources (human, financial and information) across sectors that leads to lower productivity of resources;

- An evaluation system that gives higher credits to academic achievements than industrial contributions such as technology transfer and commercialization;
- A university system shielded from the market -- inability of universities to respond to changes in the market.

5. Comparison of the Policies and Performances

5.1. Policy Environment

5.1.1. Hungary

Hungary has a centuries-long, strong tradition in HE that has made huge contributions to the world's scientific and intellectual heritage. The Hungarian HE system had once been integrated into the Soviet system after WWII. While Hungary has implemented extensive efforts to align its HEIs back with the Western system, the most pressing issue has been to find ways of linking the scientific and technological assets of HEIs to the competitiveness of the Hungarian industries. The Hungarian government responded to the pressure by taking a series of policy actions to reorient HEIs toward serving as forward-looking institutions that engage in cooperation with other sectors of the society to utilize their knowledge assets for economic and social development, a role tagged as the "third mission" of HEIs.

Public policy has played an important role in introducing entrepreneurship, innovation and the third mission to Hungarian higher education institutions, while an important driver at the university level has been the need to generate additional financial sources to improve R&E and innovation facility. Therefore, Hungary's approach to the third mission has been focused on promoting industry-university cooperation to utilize the knowledge stocks of the universities for the benefit of the economy.

5.1.2. Korea

Unlike Hungary, Korea has a very short history of working with the Western system of HE. However, since the 1960s, Korea's HE has grown at an unprecedented rate in terms of both quantity and quality. The growth was fuelled by the Korean people's desire for education, and accelerated by the industrialization that created huge demand for new skills. Thus, the role of Korea's HEIs in the early stage of development was confined to meeting the rapidly growing demand for industrial manpower. It was only in the 1980s that Korea began to pay serious attention to research as a major role of HEIs. Two decades of efforts to promote indigenous R&D have elevated Korea to the ranks of leading countries in terms of R&D expenditures.

The situation of university-industry collaboration and R&D in Korea has given rise to a question: Are the R&D expenditures of universities justifiable? Universities have been pressed to work with industries as a means to commercialize the results of the publicly supported R&D. There have been enormous efforts on the side of the government to promote industry-university cooperation, in particular, for technology transfer and commercialization. The policy efforts have been rewarded with increased technology transfers between public sector institutions and industries. Yet, there remain diverse issues and challenges for Korea to overcome in its drive to transform the institutions of higher education into bona fide innovation players and engage them with other players for active innovation.

5.2. Policy Systems and Programs

5.2.1. Policy System

A. Korea

Korea is taking a very integrated policy approach that involves diverse ministries and agencies whose policies and programs are coordinated and overseen by the National Committee on Industry-University Cooperation (NCIC, chaired by the Prime Minister).

B. Hungary

The Ministry of Innovation and Technology and the National Research is in charge of policy formulation while the National Research, Development and Innovation Office (NRDIO) is responsible for implementation regarding the issues of industry-university cooperation, technology transfer and commercialization. The two organizations are working closely together to achieve success in the field of RDI.

5.2.2. Legal Frame

A. Korea

There are two laws that exclusively deal with industry-university cooperation, technology transfer, and commercialization. The laws contain provisions and mandates for the government and other players to follow in promoting industry-university cooperation, technology transfer and commercialization. Among many others, the laws mandate the government to formulate and implement five-year plans for the promotion of industry-university cooperation, technology transfer, and commercialization.

B. Hungary

Hungary's policies on industry-university cooperation, technology transfer and commercialization are based on the two laws governing higher education and innovation policy. The former contains regulations focusing on HEIs and their responsibilities to create structures and mechanisms for collaboration with industry and society. The latter creates a general supportive environment for activities in the domain of science, technology and innovation.

5.2.3. Policy Programs

A. Korea

In accordance with the provisions of 'the Basic Plan for Industrial Manpower Training and Industry-University Cooperation,' the policy guides programs on: (1) development of industrial manpower; (2) promotion of technology transfer, commercialization, and start-ups; and (3) development of institutional infrastructure to facilitate industry-university cooperation and commercialization. Various programs under these categories are formulated and implemented by diverse ministries and agencies.

B. Hungary

Majority of Hungary's programs (1999-2015) in the past were more or less focused on supporting industry-university cooperation in R&D and innovation, while the current programs (starting 2016, such as the Higher Education Industry Cooperation Centers or the recent University Innovation Ecosystem program and the Territorial Innovation Platform) offer broader supports including an on-line platform for information service, knowledge transfer, networking, etc. There are dedicated support programs for development of intellectual property, for the establishment of technology transfer mechanisms and also for the improvement of research infrastructures that can be utilized by the business sector as well. Programs that offer indirect supports for industry-university collaborations include the RDI Strategy (2014-2020) and the Shifting of Gears in Higher Education Mid-Term Political Strategy (2016-2020).

5.2.4. Funding System

A. Korea

Each of the ministries and agencies provides funds to support the programs under its purview. In addition to the public funds, industries have access to private financing, through entities such as the National Tech-Bank (NTB), Korea Technology Banking Corp (KIBO, provision of credit guarantee for industries), etc. that provide financial services for industry-university cooperation.

B. Hungary

There are three major sources: The National Research, Development and Innovation Fund (NRDI Fund) which is the major government fund for R&D and innovation, and the EU Structural Funds and direct EU Funds, such as the Horizon 2020. Hungary combines the first two sources for the promotion of industry-university cooperation. Other foreign (private and public) sources may also be available for industry-university collaborations apart from indirect measures (such as tax allowances) that are part of the government's policy mix.

5.2.5. Information System

A. Korea

The laws mandate the government to construct a system where industries and universities can access information on the availability of and demand for technologies, and avail other information on research, technology and innovation. The National Technology Information Service (NTIS) provides detailed information on national R&D programs, inputs and outputs of the programs, researchers, etc. The National Tech-Bank (NTB) operates an information system that links the potential users and suppliers of technologies, and the Korea Technology Banking Corporation (KIBO) runs the 'Technology Bridge' program.

B. Hungary

Information systems are developed and operated by individual universities with the government's support. The University Innovation Ecosystem Program and the Territorial Innovation Platform provide support for universities to build and operate information systems for the benefit of industries seeking cooperation with universities. Currently, the NRDIO also provides services customized to the needs of enterprises engaged in innovative activities or seeking to be innovative.

5.2.6. University Infrastructure

A. Korea

The laws encourage universities and R&D organizations to establish internal organizations for managing and facilitating cooperation with industries, in activities such as technology transfer, joint research, educational programs for industries, etc. Currently, 353 out of 418 universities and professional colleges are operating Industry-University Cooperation Centers that function as technology licensing offices in some cases.

B. Hungary

By 2019, most of the universities and public research organizations with significant research efforts have set up Technology Transfer Offices (TTO). However, these offices are often too small and almost invisible (hidden in various places of the universities' organizational structure) to the business sector. In addition to TTO, the University Innovation Ecosystem program and the Territorial Innovation Platform provide supports for the strengthening of university infrastructure for industry-university cooperation, technology transfer and commercialization. It is notable, however, that they depend more on personal connections than formal channels for exchange of technology information, technology transfer and other forms of industry-university cooperation.

5.3. Policy Performances

5.3.1. Industry-funded University R&D

A. Korea

The proportion of industry-funded university R&D expenditures in Korea has been declining since the early 2000s from over 16% in 2000 to 11.2% in 2014. The decline owes more to the greater increases in public-funded university R&D expenditures rather than a decline in the flow of industrial funds itself. On the contrary, the flow of business R&D fund to universities increased in absolute amount, but the increase was much lower than that of the public funds. Reflecting this trend, the share of industry-university patent co-applications in total patent applications at the Korea Intellectual Property Office (KIPO) rose from 0.1% in 2000 to 0.95% in 2012.

B. Hungary

The share of industry-funded university R&D expenditures was 6.1% in 2017 (but 9.6%

in 2016), which was below the EU-28 average of 6.9% (2017). Unfortunately, while the R&D expenditures of businesses have been growing constantly in the past few years, this did not come with an increase in the level of public-private collaborations, partly because funding of public R&D was decreasing in the meantime until 2016 and started to increase again only lately. Therefore, university R&D expenditures amount only to 13% of GERD (in 2018) which represents stagnation in terms of the percentage of GDP. Additionally, this level of cross-funding is lagging behind compared to the performance of most EU member states. If universities wish to broaden their involvement in these activities, they would have to find additional sources of funding, one of which is the business sector. However, currently the innovativeness of local SMEs is lagging behind the EU average and therefore the demand for university knowledge is very limited within the business sector; only a very small share of firms can be mobilized as active partners in industry-university collaborations.

5.3.2. Technology Transfer, Commercialization, and Start-ups

A. Korea

Korean universities have made remarkable achievements in terms of technology transfer, at least quantitatively. The number of cases of technology transfer more than doubled during the period of 2012-2014 from 2,012 to 4,744.

- Recipients: SMEs were the predominant beneficiaries of the transfers (92% of the technologies transferred), with only 4.1% of the technologies transferred to large enterprises (2017).
- Technologies transferred: Technology transfers were highly concentrated in several technologies–IT accounted for 36.1% of the technologies transferred, bio-technologies 21.9%, and electronics 9.2% (2017).
- Commercialization: As of 2016, of the technologies licensed out to industries, 10.8% realized sales revenues or cost reductions, and 31.3% were at the stage of additional R&D or investment for actual application to industrial use. This means that about 60% of the technologies transferred have not been actually utilized for some reasons.
- Technology-based start-ups: Korean universities have not been so active in linking their technologies to new businesses as suggested by the number of their IPs. As of 2016, 518 start-ups based on university technologies were in operation, of which 12 companies achieved sales revenues of over US$ 3 million.

B. Hungary

Industry-university cooperation in Hungary appears to be focused on R&D and innovation, which may be attributed to the orientation of policy programs to some extent, leaving the development of skills and capabilities unattended in a broader sense. Early policy measures somewhat neglected the fact that only a small number of Hungarian companies are prepared for advanced RDI collaboration with universities, since most of the companies, especially SMEs, did not have the experiences, knowledge, human resources, and strategic orientation for such partnerships. Even the current HEICC program is very much focused on supporting R&D cooperation between universities and large enterprises that are already capable of working with universities on a par.

There are very few data available on the extent of technology transfer activities between HEIs and business organizations. However, this by no means suggests that universities are seldom engaged in technology transfer; many of the industry-university interactions in Hungary take place through informal channels that are not counted in formal data. It may be assumed that RDI collaborations provide opportunities for businesses to access new technologies, trade secrets and, in limited cases, IPs, while universities take the opportunity to obtain additional funds for R&D, the results of which can be published. It seems that the government's approach is currently shifting toward addressing issues related to infrastructure and capacity-building, which have been somewhat neglected so far.

- Joint publications: During the period between 2003 and 2013, the share of industry-university joint publications in Hungary remained almost unchanged at 1.3%, while the share was 2.8% for EU-28 (2008-2013). Between 2013 and 2019, the number of public-private co-publications had been increasing at a faster pace than the EU-average, rising slightly closer to that level.
- Technology development: The number of joint patents filed in Hungary is negligible, mainly due to the tradition that does not give much credit to scientists for patenting. The situation is slightly better if we take into account the number of (Hungarian) inventors instead of applicants. Many multinational subsidiaries collaborating with Hungarian HEIs are filing patents at their headquarters.
- Other forms of technological partnerships (e.g. technology transfer, start-up companies etc.): According to the scarcely available statistical data, Hungary's figures are lagging behind the European average. However, it should be noted that many of the activities take place through informal channels, which cannot be detected in the formal data.

6. Conclusion: Policy Issues for Mutual Learning

Despite the stark differences in the tradition, history and development trajectories of the HEIs of the two countries, Korea and Hungary share very similar problems in adjusting the roles of HEIs in response to the new demands of the society. As discussed in the previous sections, the governments of the two countries have been making serious policy efforts to enhance industry-university cooperation. Hungary's strategy has been to facilitate industry-university linkages mainly through joint R&D and innovation, while Korea places greater weight on technology transfer as a means of industry-university cooperation. Even though the policy efforts of the two countries have made positive and encouraging impacts on engaging the two players in mutual cooperation in the form of joint R&D, technology transfer, and so on, the achievements so far have been far short of what the countries need in order to meet the challenges presented by the paradigmatic changes in technology and industries. Hence, how to further strengthen industry-university cooperation and how to reorient HEIs to fulfill the new, extended roles in an innovation economy still remain key items on the policy agenda.

Deriving implications from the discussions in the previous sections, it can be said that the current weaknesses in the industry-university relations in both of the countries are not solely the result of unresolved issues in the higher education policy. Both countries have been engaged in efforts to develop HEIs and adjust the mode of operation to cope with the emerging challenges. Still, there are environmental constraints that could hardly be relieved by such policy actions, such as the university culture, traditions that define inter-sector relationships, and so on. In a way, the problems on the side of SMEs, viz. weak motivation for innovation, weak R&D capability, and inability to specify their technological problems, might have been the major obstacles to active cooperation between SMEs and universities. The implications are that policies focused solely on resetting the roles of HEIs can hardly succeed in bringing the two players to the same playing ground, and that equal policy emphasis should be placed on strengthening SMEs' motivation and capacity for innovation, and more broadly, on making the social and economic environment conducive to inter-sector cooperation for innovation.

6.1. Policy Achievements and Issues: A Summary

6.1.1. Korea

Korea has made relatively encouraging developments in promoting industry-university cooperation, technology transfer and commercialization by: (1) taking a comprehensive policy approach based on a legal system that mandates the formulation and implementation of plans for the development of demand-orientated curricula at universities; and (2) building institutional infrastructure for industry-university cooperation, technology transfer, commercialization and start-ups. (3) Furthermore, the policy programs have been effective in promoting patenting activities of universities which facilitated technology transfer.

Despite the achievements, problems still remain: The most serious barrier to productive industry-university cooperation derives from the technology strategy Korea adopted in the early stage of industrialization; it was focused on acquisition of learning from foreign technologies, in which universities did not have any significant roles to play. Industries in those days seldom considered universities as a source of technologies. Therefore, in the course of the structural transformation, private industries focused on in-house R&D for the development of new technologies rather than look to universities for the acquisition of the technologies. This was particularly so in the case of large enterprises in Korea, which are today global players in R&D. This may have created a tendency among private industries to stick to in-house R&D for the acquisition of new technologies rather than seeking collaboration with other external players, leaving not much of space for open innovation to breathe and grow in the Korean innovation system.

More specifically, the following factors constrain active and productive interactions between industries and universities: (1) low mobility between industries and universities in terms of both human and financial resources; (2) low attractiveness of universities as a source of technologies and business ideas: large enterprises tend to rely more on in-house R&D rather than look to universities for technical solutions or new business ideas; (3) a gap between what industries demand and what universities can supply: weakness of universities in understanding and meeting technological needs of industries, and weakness of industries, in particular SMEs, in specifying their technological needs; (4) lack of incentives for university researchers to work with industries: academic credits are far more important in career development as university faculty than contribution to industrial relations; and (5) rarity of entrepreneurs who can identify market opportunities of existing technologies and link them to commercialization.

6.1.2. Hungary

Hungary has also made encouraging achievements through the government's policy endeavours over the past years. There are success stories showcasing the benefits of industry-university cooperation, technology transfer and commercialization, in particular, between the major universities and MNEs operating in Hungary. The achievements have been made possible by: (1) strong policy will of the government to promote industry-science; (2) scientific and technological strengths of the Hungarian universities, for which global companies are seeking cooperation; (3) informal (personal) channels/contacts that facilitate industry-university cooperation without formal processes that are bureaucratic, more time-consuming and costlier; and (4) greater commitment on the part of universities to cooperate with industries for financial sources to improve R&D facilities.

Yet, many problems still remain to be solved and/or mitigated: (1) Weak business demand for university knowledge: The majority of Hungarian SMEs are not innovative and therefore they are not actively seeking knowledge generated at local HEIs; (2) Time horizon of programs: The Hungarian government programs have been amended so often that the players have difficulties in comprehending the changes and adapting their business plans. Short-lived collaborations in most cases could neither attract a critical mass of partners nor sustain partnerships and make durable impacts. Fortunately, the current programs offer much longer policy commitments; (3) Heavy bias of industry-university cooperation toward joint research: The programs implemented over the past 15 years on the whole lacked initiatives to strengthen the fundamental capabilities necessary for successful industry-university cooperation. For example, the government programs rarely offer supports for SMEs that are in general weaker in technology and management. The government programs' main focus has been to encourage high-end collaboration such as joint R&D; (4) Organizational structure of HEIs: Many businesses complain about universities' bureaucratic, slow way of doing things. HEIs traditionally operate in a longer time horizon, while firms prefer collaborations with promises of quick results. In some cases, this disharmony even jeopardizes the success of the collaboration; and (5) Insufficient infrastructure that may include information system, financial system, and internal organizations that facilitate and manage the interactions between industries and universities.

6.2. Conclusion and Policy Recommendations

Korea and Hungary place high policy priority on the expansion of industry-university cooperation, and offer diverse policy programs to promote industry-university interactions so that they can work out new business ideas and technologies that vitalize economic activities. The rationale is simple: if the generators and users of knowledge/technologies work together, it would be easier to translate the knowledge/ technologies into outcomes of social/economic values. The analyses of the policy programs for university-industry cooperation and their performances in the two countries show that there have been noticeable developments in industry-science interface, but there still remain huge rooms for improvement. Perhaps, each of the countries may find lessons to learn from the strengths and weaknesses of the policy systems and their achievements of the other country.

Korea is a late-comer in both modern higher education and industrialization, which means that Korea has had to take a more comprehensive approach toward promoting university-industry cooperation. This included policy actions for not only strengthening the capabilities of universities and private businesses to cooperate but also fostering a social and economic environment favorable to the cooperation, such as physical, organizational and financial infrastructure.

Unlike Korea, Hungary is well known for the long, strong history of its higher education system and rich accumulation of scientific achievements. However, the Hungarian industries have been struggling to overcome the problems inherited from the Soviet period and catch up with the economies of neighboring European countries. As a means to upgrade the innovation capacity of private industries, the Hungarian government has been taking various policy actions that include the promotion of industry-university cooperation. Yet, the policy measures have been tuned more to promoting industrial innovation activities than stimulating universities' engagement, as evidenced by the allocation of public R&D funds to private industries and the decline / stagnation in R&D funds allotted to universities. Ironically, this motivated Hungarian universities to seek increased collaboration with industries as a means to make up for the limited financial supports from the government.

The analyses and comparison of the policy experiences of the two countries have led to the following recommendations for the promotion of industry-university cooperation:

- Make universities more attractive as a source of knowledge for the business sector: current and past efforts need to be continued to improve university infrastructure, human capacity and knowledge base in order to strengthen their positions as important sources of new ideas and technologies in the national innovation systems. Furthermore, measures have to be taken to improve the industry-friendliness of HEIs, and specifically the industry-university programs.
- Strengthen incentives and supports for researchers in HEIs to encourage their engagement in cooperative research with industries. This may require modification of the current evaluation and promotion system in HEIs, by introducing incentives for patenting, technology transfer, commercialization, consulting, and start-ups.
- Improve policy assistance to SMEs so that they can build research, innovation and entrepreneurial capacities. These may help them to better understand and articulate their technological problems and take advantage of the scientific and technological opportunities that the universities can offer. Support needs to cover human resource

development not only in the technological field but also in management, such as strategic planning. This may contribute to improving the awareness of the critical role innovation has in promoting economic competitiveness in a broader segment of the economy.

- Promote mutual mobility between HEIs and industries. Knowledge flow and exchanges between these sectors may narrow the gap between the supply and demand: what universities can offer and what industries need in order to remain internationally competitive. This inter-sectoral mobility should apply to both people and resources. These activities can contribute to the development of a common understanding between the two spheres in various technological fields and establish a forum where industries and universities match their knowledge and share common interests.
- Give sufficient time to policy programs. Two factors have to be taken into consideration in setting the time frame of policy programs: (1) A policy program requires a certain amount of time to take effect; and (2) Very frequent changes in policy programs may hurt the predictability of the policy environment. Thus, the time frame of a policy program should be set in such a way as to ensure effective implementation, improve predictability and also enable stakeholders to adapt to any policy changes. A predictable policy environment makes it possible to make strategic planning, and thus allows universities and industries to make a longer-term commitment to industry-university collaboration.

The new role, or the third mission of HEIs, includes a wider variety of interactions between HEIs and their (local) communities. Policy programs, in general, focus on formal channels (e.g., joint R&D, technology licensing, etc.), but, in many cases, informal channels may work better since they involve less third-party intervention and are based more on spontaneity and mutuality of the parties involved. Thus, informal channels for industry-university also deserve support and encouragement. As the sphere of activity shifts closer to the market, informal cooperation may work better than formal channels.

References

Aris Kaloudis, Arild Aspelund, Per M. Koch, Thomas A. Lauvås, Marius Tuft Mathisen, Øivind Strand, Roger Sørheim, Torgeir Aadland, *How Universities Contribute to Innovation: ALiterature Review-based Analysis,* Norwegian University of Science and Technology, 2019.

Arundel, A and Es-Sadki, N and Barjak, F and Perrett, P and Samuel, O and Lilschkis, S, European Commission, *Knowledge Transfer Study 2010-2012*, Publications Office of the European Union, Luxembourg, 2013.

Bekkers, R. and I.M. Bodas Freitas, *"Analysing Knowledge Transfer Channels between Universities and Industry: To What Degree do Sectors also Matter?"* Research Policy (37), 1837-1853, 2008.

Bruneel, J., D'Este, P., & Salter, A., *"Investigating the Factors that Diminish the Barriers to University–Industry Collaboration,"* Research Policy (39), 858-868, 2010.

Claussen, I. C., National Laboratories for an Energy Efficient Industry for Improved Utilization of Available Industrial Surplus Heat and a Reformation of the Efficiency in Various Industry Processes [Online], 2019,https://www.sintef.no/projectweb/highefflab/ [downloaded 03.05.2020].

Cohen, W., Nelson, R. R., & Walsh, J. P., *"Links and Impacts: The Influence of Public Research on Industrial R&D,"* Management Science (48), 1-23, 2002.

Cornell University, INSEAD, and WIPO, *The Global Innovation Index 2017: Innovation Feeding the World,* Ithaca, Fontainebleau, and Geneva, 2017.

De Fuentes, C., & Dutrénit, G., *"Best Channels of Academia–Industry Interaction for Long-term Benefit," Research Policy* (41), 1666-1682, 2012.

D'Este, P., & Iammarino, S., *"The Spatial Profile of University-Business Research Partnerships,"* Papers in Regional Science (89), 335-350, 2010.

Dőry, T., L. Csonka, M. Slavcheva, RIO Country Report 2017: Hungary, EU, 2018, doi: 10.2760/970708

EC, European Innovation Scoreboard, 2020, http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_hu.

EC, P*eer Review of the Hungarian Research and Innovation System, Horizon, Policy Support Facility,* Luxemburg, 2016.

EPO Statistics, Last accessed 1 July 2020, www.epo.org.

Estrada, I., Faems, D., Martin Cruz, N., & Perez Santa, P., *"The Role of Inter-partner Dissimilar ities in Industry-University Alliances: Insights from a Comparative Case Study,"* Research Policy (45), 2008-2022. 2016.

European Commission, *Mission-oriented Research and Innovation: Inventory and Charac terisation of Initiatives.* Final Report, European Commission, Directorate General for Research and Innovation, Brussels. 2018.

Eurostat Online Database, https://ec.europa.eu/eurostat/data/database

Fagerberg, J., Mission (im)possible? The Role of Innovation (and Innovation Policy) in Sup porting Structural Change & Sustainability Transitions, *TIK Working Papers on Innovation Studies,* TIK Centre, University of Oslo, 2017.

Gulbrandsen, M., Thune, T., Borlaug, S. B., & Hanson, J, *"Emerging Hybrid Practices in Public–Private Research Centres,"* Public Administration (93), 363-379, 2015.

HIPO, *Facts and Figures 2019*, Budapest, 2019.

Inzelt, A., L. Csonka, *Public-Private Interactions under Fluctuating Public Support Programs in: Knut Koschatzky, Thomas Stahlecker (eds.) Public-Private-Partnerships in Research and Innovation: Trends and International Perspectives,* Fraunhofer ISI, pp. 129-158, 2016.

Kim, H. and Kim, H., Technology Commercialization Policy Trends, KISTEP *Technology Policy Trend Brief 2019-8,* Seoul: KSITEP (Korean), 2019.

Leydesdorff, L., H. Etzkowitz, *Triple Helix of Innovation: Introduction, Science and Public Poli cy,* vol. 25, nr. 6, pp. 1-16, 1998.

KEDI (2005) Statistical Yearbook of Education, Seoul: KEDI

KSH (2018), Kutatás és Fejlesztés, *Research and Development, 2017,* Budapest, 2017.

KSH (2019), Kutatás és Fejlesztés, *Research and Development, 2018,* Budapest, 2018.

MOTIE, *2017 Survey Report on Technology Transfer* and Commercialization, Sejong: MOTIE (Korean), 2017.

MOTIE, *2018 Survey Report on Technology Transfer* and Commercialization, Sejong: MOTIE

(Korean), 2018.

MSF, *2016/2017 Knowledge Sharing Program with Hungary: Enhancing Governmental Promotion Policies for Economic Development,* Ministry of Strategy and Finance, Seoul, 2017.

Mueller, P., *"Exploring the Knowledge Filter: How Entrepreneurship and University–Industry Relationships Drive Economic Growth,"* Research Policy (35), 1499-1508, 2006.

NRF, *2017 Industry-University Cooperation, Survey Report,* Daejeon: NRF (Korean), 2018.

OECD, *Review of Tertiary Education, Korea,* Paris: OECD, 2009.

OECD, *Education at a Glance, Paris: OECD,* 2010.

OECD, *Industry and Technology Policy of Korea, Paris: OECD,* 2014.

OECD, Supporting Entrepreneurship and Innovation in Higher Education in Hungary, 2017, http://www.oecd.org/industry/supporting-entrepreneurship-and-innovation-in-higher-education-in-hungary-9789264273344-en.htm

OECD, University-Industry Collaboration: New Evidence and Policy Options, OECD Publishing, Paris, 2019, https://doi.org/10.1787/e9c1e648-en

OECD, Main Science and Technology Indicators Database, Last accessed: 4 July 2020, https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB.

Pique, J.M., Berbegal-Mirabent, J. & Etzkowitz, H., *"Triple Helix and the Evolution of Ecosystems of Innovation: the Case of Silicon Valley,"* Triple Helix vol. 5, nr. 11, 2018.

Perez, C., *Technological Revolutions and Financial Capital,* Cheltenham, UK/Northampton, MA, USA: Edward Elgar, 2002.

Perkmann, M., & Walsh, K., "University–Industry Relationships and Open Innovation: Towards a Research Agenda," International Journal of Management Review (9), 259-280, 2007.

Remøe, S-O., *Oslo Workshop on International Collaboration in Science, Technology and Innovation for Global Public Goods: The Chair's Statement,* Statement from the OECD Workshop on Global Public Goods in Oslo, 2019.

Rosli, A., De Silva, M., Rossi, F., & Yip, N., *"The Long-Term Impact of Engaged Scholarship: How Do SMEs Capitalise on Their Engagement with Academics to Explore New Opportunities?"* International Small Business Journal: Researching Entrepreneurship (36), 400-428, 2018.

Steinmo, M., & Rasmussen, E., *"How Firms Collaborate with Public Research Organizations: The Evolution of Proximity Dimensions in Successful Innovation Projects," Journal of Busi ness Research (69),* 1250-1259, 2016.

Stiglitz, J. E., & Greenwald, B. C., *Creating a Learning Society: A New Approach to Growth, De velopment, and Social Progress*, Columbia University Press, 2014, https://stip.oecd.org/stip.html

Sleok-madsen, Ritter, and Sornn-friese, *The 14 Faces of Commercializatio*n, DRUID Academy, 2015.

WEF, *The Global Competitiveness Report,* Geneva, 2018.

https://www.jst.go.jp/tt/EN/univ-ip/a-step.html

02

CHAPTER

Smart Energy Systems in Safe Society 4.0

Seung Jong Oh (KINGS)
Martin Hromoda (Tomas Bata University)
Vladimir Kebo (Ostrava Technical University)

Keywords
Smart Energy System, Energy Resilience and Security, Industry 4.0, Energy Research & Development Plan, Energy Cooperation.

Smart Energy Systems in Safe Society 4.0

Seung Jong Oh (KINGS)
Martin Hromoda (Tomas Bata University)
Vladimir Kebo (Ostrava Technical University)

Summary

This is one project within the 2019/20 Korea-V4 KSP. It has been conducted under the title of “Smart Energy Systems in Safe Society 4.0”. One approach to achieve the EU mandate of reducing carbon emissions is to adopt renewable energy sources. However, with the present level of technologies, introduction of renewables in electricity supply tends to cause issues of intermittency. The term “smart energy system” in this study refers to various efforts to overcome this issue. Smart energy systems include electricity, gas, production and supply of heat, petroleum and its products. Intermittency affects electricity supply and demand the most. In this study, the KSP Team will limit our topics to electricity application. Hence, within the scope of the present study, smart energy systems shall include smart grids, smart homes, smart demand management and related technologies.

The term “safe society” in the title suggests the importance of energy security in relation to the “Digitalization of Society”. Digital solutions such as communications systems, artificial intelligence, smart energy systems or quantum technologies can enrich our lives in many ways. However, the benefits arising from digital technologies do not come without risks and costs. This leads to the necessity of establishing measures to ensure physical and cybersecurity (European Commission, 2020).

EU Green Deal and Green New Deal by the Korean government call for increased use of renewable energy. The Renewable Energy 2030 policy of Korea aims to source 20% of the total electricity consumption from renewables by year 2030. Since smart energy system is one way to solve the issue of intermittency, R&D on smart energy systems has been pursued actively in Korea. Relevant R&D areas include smart grids, smart home, big data analysis, and cybersecurity. Most of the R&D conducted was on technology development. Field demonstration projects on smart grids and smart homes are ongoing since 2019. The current

4th R&D Plan includes field application and commercialization to move toward practical use by consumers. To reach the goal of practical application and commercialization, it is necessary to develop a roadmap with gap analysis. It is also recommended that the gap analysis considers technical as well as nontechnical elements such as legal and social issues.

In this regard, it is of interest to nurture and promote SMEs. The EU's directive calls for the support of digital transformation in SMEs. On the other hand, most elements of smart energy systems require further applied research and demonstration before commercialization. This is an area where government policy and support would be helpful. KEPRI and Korean government have strong SME support programs in smart energy systems; this includes R&D funding for necessary steps such as field demonstration, venture incubation program, technical information services, product qualification services and annual exhibitions. For innovative SMEs to be successful, commercialization and development of a healthy customer base are critical. In order to meet this goal, the successful implementation of smart grid and smart demand management with electricity pricing based on time of use are necessary.

The main purpose of this study was to provide a platform for both Korean and Czech researchers to exchange R&D information and ideas on how to utilize the recent development of Industry 4.0 (big data, IoT). The research team focused on identifying collaboration topics and researchers to move toward successful information exchange and collaboration. The R&D plan of Korean government and SME support program are examined in subsequent sections of the study report. Research on smart energy systems, performed at universities of both countries, is identified for future information exchange. Platforms for information exchange between SMEs of both countries will be useful for any joint projects conducted in the future as well. The annual Korea Industry Technology R&D Exhibit would be one such platform. It is the desire of both parties that this effort would lead to broader collaboration between the two countries in the area of research regarding the application of Industry 4.0 features to the energy area.

1. Introduction

As a part of the 2017/18 Knowledge Sharing Program with the Visegrad Group, researchers of Czech Republic and Korea examined R&D and Innovation Policies to Enhance Energy Security (KDI, 2019). Researchers from both countries recognized the need for de-carbonization in energy use and acknowledged the importance of renewable energy. They also exchanged notes on the importance of energy security with the introduction of variable renewable energy supply and the possible role Industry 4.0 can play. As a continuation, the authors decided to examine the role of smart energy systems and chose the title "Smart Energy Systems in Safe Society 4.0".

Considering the need to mitigate global warming, the importance of transitioning to carbon-free energy resources cannot be overemphasized. In this regard, there has been much research focus on renewables such as solar and wind. One of the shortcomings of the renewables is the issue of intermittency. Electricity requires instantaneous and continuous balance between supply and demand. The intermittency issue challenges the grid resilience and stability. It is one of key issues that require solution before wider use of variable renewable energy.

The term "smart energy system" broadly refers to the energy systems that would alleviate this challenge using various tools that are part of Industry 4.0. Smart energy system includes electricity, gas, production and supply of heat, petroleum and its products. Meeting the supply and demand for electricity is the crux of the problem and most active area for Industry 4.0 applications. Considering the scope of the study, this research team will limit the discussions to electricity applications among the candidate smart energy systems. Resolving grid intermittency is the key for electricity application. Smart grid, energy storage and management of the demand side such as smart homes and smart cities are key focus areas for R&D efforts to resolve the grid intermittency issues. Hence, R&D based on Industry 4.0 technologies in these areas is of interest to this research team.

The intermittency issue adds several challenges to achieving energy security. The term "safe society" in the title suggests the importance of energy security in relation to the "digitalization of society". The EC wants a European society powered by digital solutions that are strongly rooted in the common values of the EU, and enrich the lives of all people. Businesses need a framework that allows people to start up, scale up, pool and use data, to innovate and compete or cooperate on fair terms. Furthermore, Europe countries need to have choices and pursue digital transformation in their own way. The President of the EC stressed the need for Europe to lead the transition to a healthy planet and a new digital world. This twin challenge of efforts to simultaneously pursue a green and digital transformation has to go hand-in-hand. Digital solutions such as communications systems, artificial intelligence, smart energy systems or quantum technologies can enrich our lives in many ways. However, the benefits arising from digital technologies do not come without risks and costs (European Commission, 2020).

Distributed generation such as solar power and the wider use of electric vehicles are two disruptive challenges to the stability of electric grids. Distributed generation, smart charging of electric vehicles and smart energy systems are introduced at the level of distribution. Transmission systems connected to these distribution centers require real-time management for balancing of supply and demand of electricity. It would require two-way communication on the grid, which necessitates serious consideration of cyber and physical security. Big data analytics would aid the real time balancing of electricity supply and demand. However, analysis of big data requires additional challenge to cybersecurity since protection of personal data is necessary. These are important issues that need resolution for the wider application of digital transformation and Industry 4.0. R&D in this area promotes the applications of Industry 4.0 and is focused on means to better prepare for the wider use of Industry 4.0 technology in other areas. Researchers of the Czech Republic performed a SWOT analysis as shown in <Table 2-1> to determine the perspectives and focus of common activities of the KSP V4 (KDI, 2019). As the strengths of the Czech Republic's energy capabilities, the researchers noted high quality, reliable energy supply, transformation of the production base to electricity-based systems, and the public's acceptance of nuclear energy. As weakness, the research team noted the aging of highly educated human resources, limited potential to adopt wider use of renewable sources and the need to fulfill the binding targets of the EU's climate and energy policy. As opportunities, the team noted the position of Czech Republic in the energy commodity network in Central and Eastern Europe, enhancing technical education in energy field and participating in international energy research programs. As threat, it pointed out the uncoordinated deployment of capacities within EU (countries surrounding Czech Republic), and highlighted the urgency of ensuring safe and reliable power supply even under the demands of an emergency situation.

In Korea, the government promotes the use of renewables to meet the challenges presented by global warming. In a previous study, Jin Gyu Jang examined R&D and Innovation Policies of the Korean government (KDI, 2019). Digitalization, renewable energy, and management of the demand side with improved efficiency are just the few of the focus areas of the R&D strategy. With the focus on introducing more renewables, and improving energy efficiency with full utilization of digitalization, the R&D policy is still relevant. As an effort to increase usage of renewables, R&D on smart grid and electricity distribution is being pursued actively in Korea. A smart city demonstration project is in the planning stage as a way to apply Industry 4.0.

Smart energy systems and associated R&D applying Industry 4.0 would be beneficial for proactive response to future demands. Both the Czech Republic and Korea have keen interest to conduct research in smart energy systems (use of Industry 4.0 in the energy area) and enhance technical education. In this regard, as recommended by Jin Gyu Jang (KDI,2019), further collaboration between the Czech Republic and Korea would be beneficial to both parties in strengthening human interaction first in the area of energy technologies and designing short-term and mid to long term projects based on priority setting. This year, researchers from both Korea and CR focus on identifying collaboration topics and researchers so that this project moves toward a concrete step of information exchange and collaboration. In Section 2, the electricity use of both countries is examined. Following this, the transformation of the electric industry utilizing digital technology is discussed with the definition of the term ‘smart energy system’. In Sections 3 and 4, R&D activities in the smart energy system and cybersecurity are examined with the goal of identifying topics of mutual interest and collaboration. Section 5 examines the SMEs’ status in the smart energy system area.

<Table 2-1> SWOT Analysis (CR Participants)

Strengths	Weaknesses
• High-quality, reliable energy supply. • The transformation of the production base to electricity systems has started in order to preserve stability and sufficient capacity. • The public’s acceptance of nuclear energy. • Extensive heat energy supply systems. • Relatively favourable import energy dependence indicator. • Full self-sufficiency in electricity and heat generation. • Extensive know-how in building complex technological units.	• Market distortions and distorted investment signals. • Aging source base and networking infrastructure. • The aging of highly educated human resources. • Limited potential for higher extensions of renewable sources. • High share of local residents using low-grade fuels with high emission of pollutants into the air, in particular in densely populated areas. • High proportion of municipal landfilling waste. • Expecting a selfishly high standard of quality and reliability • Currently fulfilling the binding targets of EU climate and energy policy, contrary to the principle of technology neutrality when meeting decarbonisation commitments, which has caused disproportionate financial costs to the state budget and economy of the CR.

<Table 2-1> Continued

Opportunities	Threats
• Transit roles of the network infrastructures for energy commodities in Central and Eastern Europe. • Conceptual recycling and utilization of secondary raw materials, including recovery of energy waste. • Use of alternative fuels (electricity, CNG, etc.) in urban, suburban and railway transport. • Reducing the energy performance of buildings and increasing the energy efficiency of technological processes in industry. • Czech research and academic entities engaging in international energy research programs. • Enhancing the level of technical education and employment opportunities for graduates in the energy science and research fields. • Development of intelligent networks. • Restructuring the source base towards modern high-performance technologies and fuels. • Development of unconventional mining methods for hydrocarbons worldwide and in the EU (for example, in Poland).	• Uncertainty of the legal framework. • Unilateral and uncoordinated capacity deployment within the EU, especially in the countries surrounding the CR. • Limited disposable reserves of brown coal and the associated security of heat supply for the population. • The time-intensive nature of projects for building modern, high-capacity resources as a substitute for existing resources. • Safe and reliable power supply in an emergency situation against the backdrop of a gradual implementation that is organizationally and economically demanding. • Deteriorating operational reliability of the power system due to massive development of intermittent RES without introducing additional measures. • The risk of non-compliance with the adequacy parameters of production capacities (generation adequacy) due to the shutdown of the aging, high emission sources and sources without a collateral supply of coal. • The continuing dynamic development of intermittent RES in Europe, which is uncoordinated with the appropriate development of network infrastructure.

Source: KDI (2019).

2. Electricity Use, Smart Energy Systems and Energy Security

2.1. Current state of the Electricity Use

Energy security, traditionally, means producing energy domestically and relying less on foreign sources. For Korea and Japan, this would mean offsetting the scarcity of domestic resources through diversification and trade. In U.S., it means wider use of domestic energy resources. Efforts to achieve energy security require consideration of the energy mix and dependency on the resources.

With wider use of renewable energy, especially electricity, energy security also means the stable operation of the grid, while meeting the electricity demand. This requires technology solutions based on Industry 4.0. However, one has to realize that these R&D initiatives, though pursued vigorously, need time for fully successful implementation. The practical use of various energy supply and storage systems and management of the demand-side require agreement among multiple stakeholders. Decision-making in the electric utility sector involves many stakeholders. Furthermore, it requires solutions to ensure security for the use of personal data and to determine electricity pricing based on the time of use. For these reasons, it is expected that transformation of the grid to meet the intermittency challenge would progress slowly. At present, maintaining base-load electricity source is both cost effective and necessary. A MIT study examines the role of nuclear energy with various combinations of renewable energy in a carbon-constrained world, and illustrates the importance of nuclear energy as a cost-effective method to reduce carbon emissions (Buongiomo, 2018). In planning future energy mixes, the nuclear option needs to be carefully considered. In summary, both Korea and the Czech Republic face the challenge of increasing renewable energy use while both rely presently on stable base load systems such as nuclear and fossil plants. To realize the benefit of Industry 4.0 in the electricity market without disrupting supply, a two- pronged approach is recommended: sound electricity supply planning with sufficient base load; and the introduction of smart grids and renewables.

2.1.1. Czech Republic

The Czech Republic's electricity generation is 88TWh as of 2018. In this total output, 51.2% of electricity was generated by fossil plants while 34% was generated by nuclear plants and 11% by renewables. From 2006, the electricity market has been opened and three utilities, CEZ, E_ON, and PRE are the major suppliers. The transmission grid is connected with the neighboring countries, Germany, Poland, Slovakia, and Austria. Trading between the countries in 2018 was as follows: Poland (Import: 3771.2GWh, Export 635.3); Germany (Import: 7580.8GWh, Export: 4902.8GWh) Austria (import: 112.6, Export: 10864.1); Slovakia (Import 108.9, Export: 9078.2).

Czech Republic has six nuclear reactors in operation, generating 1/3 of its total electricity demand. Recognizing the carbon-free nature of the generation source, the country announced the plan to move forward with a bid invitation process to build a 1~1.2GW reactor in Dukovany.

The goal is to increase the domestic generation (at least 80% in 2040). The challenge is to reduce coal-fired plants to meet the EU recommendations. Additionally, grid operation under trading between neighboring countries is both an opportunity and a challenge.

2.1.2. Republic of Korea

The electricity is 570TWh as of 2018. In this, 41.8% of electricity was generated by fossil fuel while 23.4% was generated by nuclear plants. LNG (Liquefied Natural Gas) plants supplied 26.8%. Korea has 24 nuclear reactors in operation and four nuclear reactors under construction. The government promotes renewable energy. Renewables supplied 6.2% of the total energy output in 2018. Renewable energy added 4319 MW generating capacity in two years since December 2017, which is 77% of the total increased capacity. KEPCO is the sole entity supplying electricity in Korea. The transmission grid is isolated. The challenge is to reduce coal-fired generation while increasing the use of renewable energy. The peak load (summer) has been increasing 5% per year.

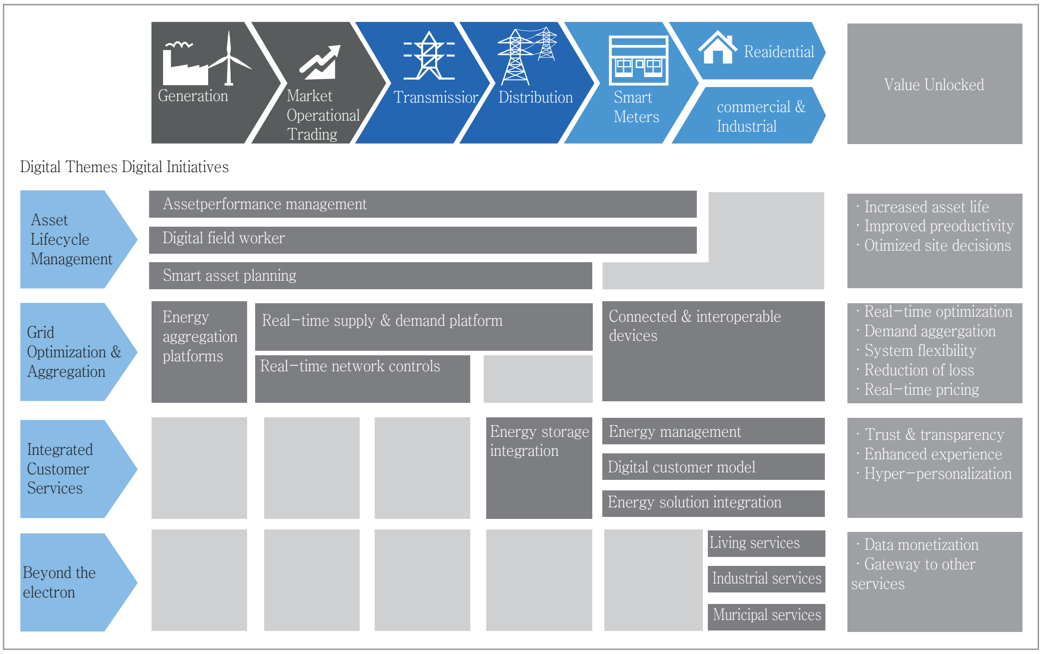
The government set the policy to promote renewables, distributed energy supply and management of demand side. The government has introduced measures to promote wider use of high efficiency motors and boilers and encourage energy efficiency in buildings. Additionally, ESS and penetration of AMI are promoted.

2.2. Smart Energy System and Industry 4.0 (Digitalization)

Both the Czech Republic and Korea aim for larger penetration of Variable Renewable Energy (VRE). In Korea, the Renewable Energy 3020 policy aims to have 20% of electricity coming from renewables by year 2030. A major challenge to this goal is the wide variations of renewable energy based on the time and place of the generation source. Once the supply by VRE reaches 3-13%, the transmission grid feels the impact; thus, to go over the 13% threshold, transmission flexibility to handle uncertainty and variability is required (Song Eunsuk, 2010).

Digital transformation is a key element of Industry 4.0. Based on a study of the digital transformation of industries, the World Economic Forum (WEF) listed asset life cycle management, grid optimization and aggregation, and integrated customer services as the factors driving the transformation of Electricity Industry, as shown in [Figure 2-1] (World Economic Forum White Paper, 2016). This white paper examines the impact from generation, transmission, distribution and consumption. Digital transformation enables real-time, predictive maintenance to extend the life cycle and operating efficiency of the generation, transmission or distribution assets. It enables grid optimization through real-time load balancing, network controls and end-to-end connected markets. Further it supports the connection of assets, machines, and devices, and provides advanced monitoring capability. Integrated customer service can be provided utilizing digitally enabled products and services relating to energy generation and consumption (demand side management). Based on the broad definition of smart energy systems as stated in the Introduction, grid optimization and integrated customer services are areas of interest for this project. Demand side management including smart homes and flexible grid operation are the outgrowth of digital transformation in these two areas.

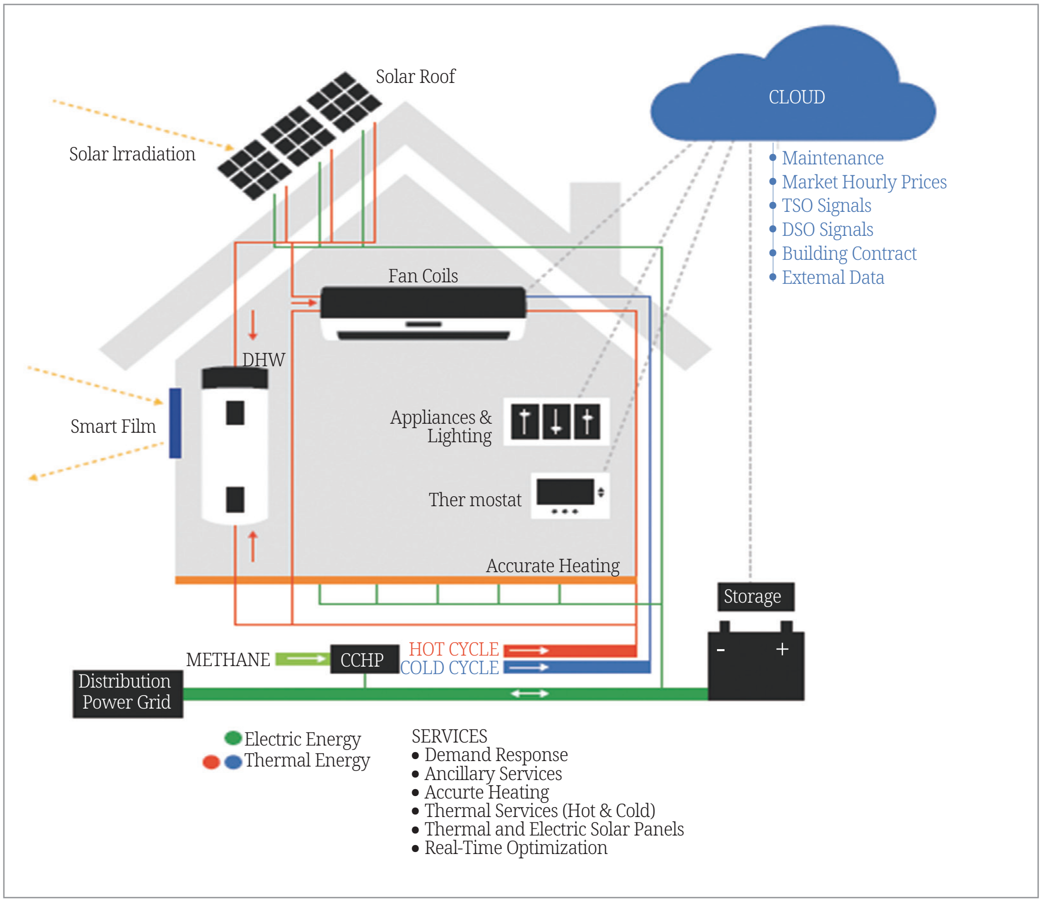
[Figure 2-1] Digital Themes and Initiatives Applied to Electricity Industry



Source: World Economic Forum White Paper (2016).

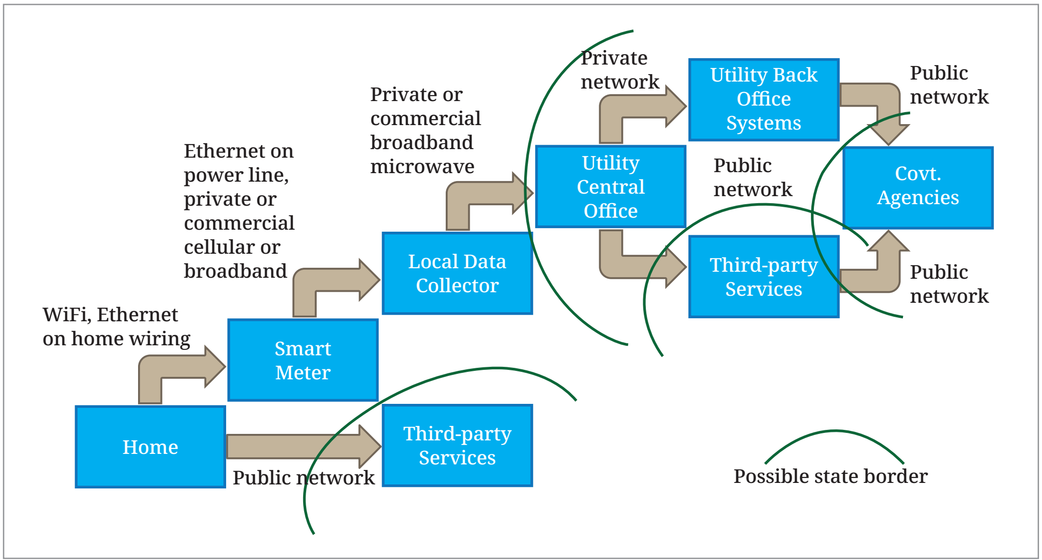
To better understand the desired outcomes of the digital transformation drive, a smart home envisioned with the full use of digital transformation functionalities is examined. [Figure 2-2] shows the arrangement of a smart home as an idealized but achievable smart energy system (MIT Energy Initiative, 2016). In the figure, it is shown as a residential building, but it can be replaced with an industrial or commercial building or a collection of buildings. The key enabling technologies are the widespread use of ICTs and abundant distributed resources. Devices embedded with internet-enabled chips provide the data for cloud-based computation. The aggregators would work as a broker representing these building users in interactions with transmission or distribution operators. This building is equipped with thermal and electric solar panels, electric and thermal storage, and a combined cooling and heating power unit. These are connected to a cloud-base data management and computation system with Internet of Things. Optimization algorithms would guide the operation of these equipment as well as purchase and sale of electricity. The cloud-base data management and computation system will be shared with the grid (transmission) operator so they can plan the supply of electricity. Large volumes of data are stored and transmitted throughout the system in support of system operations, as shown in [Figure 2-3].

[Figure 2-2] Smart Homes: An Idealized Smart Energy System



Source: MIT Energy Initiative (2016).

[Figure 2-3] Data Flow for a Smart Energy System



Source: MIT Energy Initiative (2016).

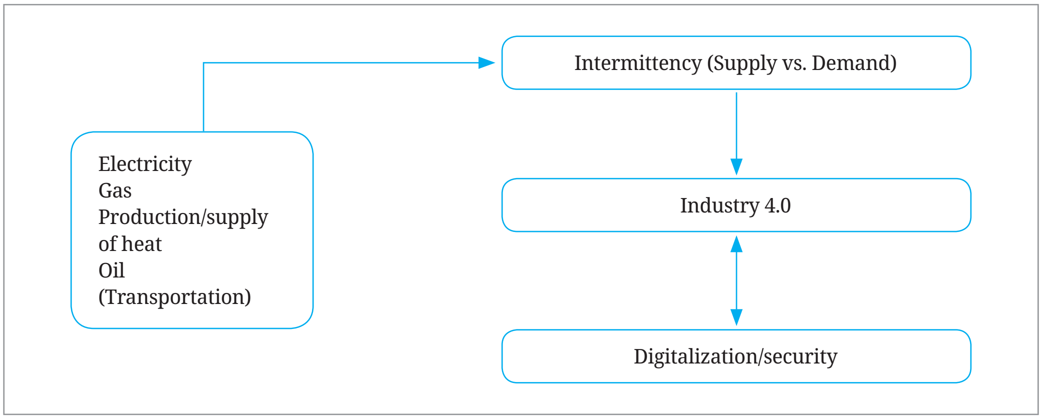
For this scheme to be realized (deployment & application phase of R&D), there are many technical and social/legal issues to be resolved. In this study, the KSP research team focuses on the various ongoing R&D elements related to those issues. From the perspective of grid optimization, smart grid is the mandatory element. It enables bi-directional flow and control of electricity. Advanced Metering Infrastructure (AMI) and Phasor Measurement Unit (PMU) are required for smart grid operations. To use the data generated, development of software tools based on big data analytics is necessary. In order to support demand side management, active application of Internet of Things to home appliances is necessary. These smart appliances would be the basic elements for demand side management.

These items are in various stages of development at present, and will be examined in Section 3. Smart grid and micro grid are in demonstration and application stages respectively. In Korea, Jeju Island's testbed for smart grid operation has been operated for 42 months successfully now. Smart meters have been installed in half of the target homes/buildings. Installation of PMUs is in progress. Smart home application is being used widely in the U.S. However, penetration is still less than desired in Korean homes. Data collection scheme and data analytics are in the development phase.

There are social and legal elements such as electricity pricing mechanism, data privacy and cybersecurity that need resolution. Social and legal frameworks are way behind the real application. These non-technical elements are difficult to solve given the large numbers of stakeholders and the impact on society. However, these non-technical elements must be included in any roadmap to reach the final solution. For a country to start taking full advantage of digital transformation, all the above elements need to reach demonstration/application phase.

In summary, smart energy systems can resolve intermittency (imbalance between supply and demand) issues by utilizing Industry 4.0 technologies driving digital transformation (see Figure 2-4). In electricity sector, this is the key issue to be resolved in order to achieve higher penetration of variable renewable energy. Both countries are strongly interested in R&D in this area. Accordingly, investigators from both countries are of the view that the exchange of information and joint R&D would be mutually beneficial.

[Figure 2-4] Digitalization: One Way to Solve the Problem of Intermittency



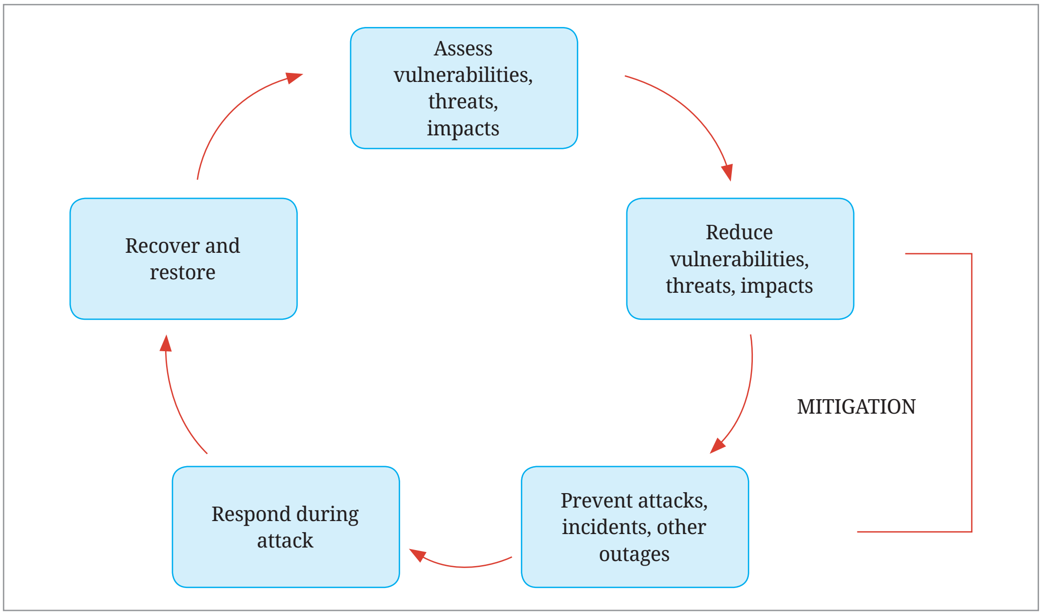
Source: Authors.

2.3. Considerations for Energy Security

Electricity and gas transmission are interconnected following the energy strategy of the European Union. The EU has a strong interest in maintaining resilience and security in energy supply. One of the efforts in this direction is the construction of the Southern Corridor pipeline and liquid gas hubs to improve the resilience of gas supply. The Czech Republic participates in this effort as a member of EU.

Energy security is one of the key considerations for the Czech Republic, since there are concerns of disruptions to large scale supplies of electricity, gas and heat. Relevant legal, institutional and organization tools are necessary to ensure the required level of energy security. Important legal regulations that are presently in force are listed in Appendix A. The approach follows the five step security life cycle as shown in [Figure 2-5]: (1) Assess vulnerabilities, threats, impacts; (2) Reduce vulnerabilities, threat, impacts; (3) Prevent attacks, incidents, other outages; (4) Respond during attack; (5) Recover and restore (Kassaian, 2011).

[Figure 2-5] Categories of Cybersecurity



Source: Kassaian (2011).

For each area, critical infrastructures are identified (Government Regulation No. 432/2010), and for each critical infrastructure, potential crisis situations and set of measures are specified. For power and electricity systems, the goal is the fastest possible restoration of electricity supply to all customers in full. The procedures, principles and measures adopted should make it possible to (KDI, 2018):

- Activate crisis management authorities;
- Analyse the situation and implement the appropriate crisis management measures (both own and contractual);
- Ensure the existence of the forces and resources necessary to address the crisis situation;
- Secure the supply of electricity for priority customers;
- Perform necessary repairs on electrical equipment;
- Restore electricity;
- Analyse the causes of the crisis situation and implement measures to strengthen the resistance of the power system.

Given the island grid configuration, energy security and especially a strong electricity supply system are of critical interest to Korea. The approach is to maintain a balanced energy mix with a view to securing fuel and to ensure resilience with sufficient margin. Korea imports oil, gas and coal for electricity generation. With the longer fuel cycle, nuclear power is less vulnerable to disruptions of foreign supply. A rolling five-year electricity supply plan is developed every two years to ensure sufficient installed power. Additionally, KEPCO establishes the plan to address shortages in electricity supply, including special electricity supply contract, and rolling blackout plan. This is crucial given the increasing frequency and magnitude of natural disasters. The country has investigated the impact of large disruptions to generation due to natural disasters such as earthquake and typhoon. Coping strategies were also examined as a part of the investigation (Kang Sang-gyun et al, 2017). With the introduction of renewable energy (Intermittent Energy Supply) and smart grids, the challenge to meet electricity security becomes multi-faceted and more complex. Now, transmission and distribution grid are as important as electricity supply in ensuring energy security and resilience.

3. Research and Development on Smart Energy Systems

3.1. Introduction

The main goal of this year's program is to promote information exchange and collaboration among the researchers and developers of both countries. In this section, the research team reviews the overall R&D program related to energy in Korea. Based on the review, we would narrow down the R&D activities appropriate for collaboration. Considering the interest toward deployment and application of technologies, projects being conducted at KEPRI are reviewed in detail. Based on the prospects for near-term collaboration, we examined candidate centers linked to the R&D divisions of universities. The candidate R&D centers for near-term collaboration are documented for future activities.

To meet the challenges presented by global warming, energy efficiency and use of renewable energy are important. In this regard, energy efficiency and demand side management have been advancing rapidly with the advent of Industry 4.0. However, use of renewable energy and electric vehicles are two disruptive inputs to electric grid. For stable operation of grid, utilities adopt PMUs (Phasor Measurement Unit) and AMIs (Advanced Metering Infrastructure). These require new R&D and development of standardization and communication protocols for interoperability. Furthermore, big data analysis (Industry 4.0) is required to manage the large volume of data being generated.

Integrated approach to solve the problem of intermittency has led to the development of smart grid technology and smart energy system. In this regard, the introduction of electric vehicles poses challenges to grid operations. In the interests of stable system operation, it is necessary to discourage EV charging at peak times. Smart energy system considers the integrated use of EV batteries as one ESS option.

In Korea, the promotion of renewable energy has increased the generating capacity of renewables. As the next step, the issue of intermittency due to renewables needs to be resolved for further increase in the use of renewable energy. One way to alleviate the intermittency issue is the adoption of smart grids. Korea presently has several demonstration projects for micro grids. However, the adoption of smart meters and PMUs are in the early stage. To adopt the smart energy systems, transmission and distribution networks need upgrades. Furthermore, the issue of cybersecurity related to personal data on energy use requires resolution. Hence, in summary, there have been significant R&D efforts in smart energy systems in Korea, but still deployment and real application require further effort.

3.2. The Fourth Energy R&D Basic Plan of the ROK

The Research, Development and Innovation Investment Policy of the Korean government and the earlier R&D plan were described in detail by Jin Gyu Jang (KDI, 2019). The Korean government's policy is to promote the transition into the low-carbon energy system by boosting economic development through stable domestic supply of energy and the cultivation of new energy industry. Five R&D investment directions were developed based on the policy: technology for supply of clean energy; higher efficiency of power transmission and distribution; innovation for energy consumption; creation of energy platform business; and verification R&D for global leading-edge energy technology. Three R&D areas chosen under the R&D directions are directly related to smart energy systems: ESS, smart grid, and demand management. The Korean government established the 2030 renewable energy strategy plan, with a goal to produce 20% of electricity from renewables by 2030. The intermittency problem related to renewables is one of the important issues being addressed by the R&D efforts.

In Korea, the top level energy R&D plan is updated every four years. Since the reporting by Jin Gyu Jang (KDI, 2019), the new R&D plan, the Fourth Energy R&D Basic Plan, has been established (Kim, 2019). Energy R&D has received about 800 billion Korean won worth of yearly support by the Korean government since 2010. Korea ranks fifth in energy R&D funding after U.S., Japan, France, and Germany. R&D funding to small and medium enterprises has increased steadily. This systematic support has led to the establishment of several SMEs that are competitive worldwide. Technology development has been successful and comparable to that of other world class R&D organizations. However, it is less than the desired level from the perspective of commercialization. The reasons for the lack of commercialization are lack of field applications, regulatory limitations, and lack of interaction with end users. Based on the review and analysis, the new plan embodied following improvements: (1) Focus on key R&D related to energy transition; (2) Develop flagship, mid-long term projects; (3) Promote collaborative R&D matching the technology needs; and (4) Support demonstration projects & qualification test bed infrastructure.

The new R&D plan selected four R&D topics and sixteen key technical areas. Out of the total funding, 90% will be targeted to these sixteen technical areas. The four key R&D topics are energy transition, energy efficiency, clean and safe energy, and distributed energy system as shown in <Table 2-2>. The sixteen key technical areas are also shown in <Table 2-2>. All four key R&D topics are related to energy transition. Based on the definition of smart energy system, digital transformation, energy efficiency and distributed energy system along with an enabling technology for optimum use of variable renewable energy are the most important topics of interest. Further, the impact of digital transformation is the greatest for the following three technical areas: big data, smart grid and cybersecurity.

<Table 2-2> 16 Key Energy R&D Areas

Key R&D Topics	Energy Transition	Energy Efficiency	Clean and Safe Energy	Distributed Energy System
Technical Area	- Solar power - Wind power - Hydrogen - New material in energy	- Industrial - Building - Transportation - Big data	- Nuclear - Clean fossil - Energy life-cycle safety system - Natural resource survey using ICT - Renewable and Recycling	- Smart grids - Energy storage - Cybersecurity

Source: Kim (2019).

To remedy the shortcomings of previous R&D results, the following plans will be applied: demonstration tests, commercialization, big data platform for energy, and regulation/system modification to support the technology use.

Realizing the importance of the socio-economic aspect, two other areas are included in the R&D plan, the study on the socio-economic impacts of the introduction of these technologies and support for SMEs operating in this area.

In summary, the Fourth Energy R&D Basic Plan supports the energy transition and the development and deployment of smart energy systems. It includes focused efforts for demonstration tests and application for smart grids and big data platform and the regulatory aspect, which would be crucial elements for realization of the smart energy system.

3.3. R&D on the Smart Energy Systems of ROK

<Table 2-3> shows the yearly R&D budget on smart energy systems in Korea since 2011. R&D into smart grids and smart home received stable funding of roughly 200 billion Korean won and 120 billion Korean won respectively. Budget for cyber-security R&D has grown from 37 billion Korean won in 2011 to 105 billion Korean won in 2020. Overall, the R&D in smart energy system has been funded steadily. As stated in the 4th R&D plan, there will be an emphasis on field application and commercialization.

<Table 2-3> Yearly R&D Budget Related to Smart Energy System

(Unit: 100 million won)

Year	Smart Grid	Smart Home	Cybersecurity	Intelligent Grid Platform
2011	1,880	1,040	370	21.25
2012	2,160	1,200	520	20.53
2013	2,010	1,190	530	41.5
2014	1,960	1,000	410	26.5
2015	2,080	1,040	630	11.45
2016	1,890	1,300	920	7.24
2017	1,530	1,340	790	1.57
2018	1,620	1,490	840	
2019	1,730	1,350	940	14.38
2020	1,490	1,250	1,050	6.72

Source: Authors' calculations.

R&D on smart grids is the first focused effort to respond to the introduction of variable renewable energy. The Jeju Island Smart Grid Demonstration Project was conducted from 2009 to 2013. The First Basic Plan for Smart Grid, a comprehensive R&D plan, was established and executed from 2012 to 2016. Currently, the Second Basic Plan that covers the period from 2018 to 2022 is in place. [Figure 2-6] provides the top-level description of the Second Basic Plan for smart grid. Two smart grid demonstration projects are ongoing: Mecca Gwangju Project and Seoul Smart Energy Community. The Mecca Gwangju Project is to serve 8,000 households in Gwangju through a smart grid. The grid serves multi-family housing such as apartments and townhouses and uses renewable energy such as solar power plants.

The Seoul Smart Energy Community project is to serve 3,000 households through a smart grid. Both projects started in October 2019 and will end in September 2023. There are 231 ongoing smart grid projects in 2020 with a total budget of 148 billion Korean won. The number of projects under applied research is 32 and the budget is 34 billion Korean won for 2020. The portion dedicated to technology development is 77%. Since 2019, the Smart Grid Demonstration Program is in place. The budget for the Demonstration Program was 6.75 billion Korean won for 2019 and it is 8.1billion Korean won for 2020. The Demonstration Program is an effort to move toward practical application.

The R&D budget for smart home is 125 billion Korean won in 2020. This is an area where commercialization is progressing actively. Smart home demonstration projects with IOT appliances are being implemented since 2019 to promote practical application. The R&D budget was 3.3 billion Korean won in 2019 whereas a budget of 4.4 billion Korean won has been allocated for 2020.

There are 171 ongoing projects in cyber security in 2020 with 105 billion Korean won. The number of projects under applied research categories is 29 and the budget is 25 billion Korean won. In this category, cybersecurity of digital I&C in nuclear power plants is one of the active research topics. An example of smart grid related topics in the basic research category is titled 'Multi-level Optimization-based Defense Algorithm to Mitigate the Impact of Cyber-attack on Volt-VAR Optimization and Service Restoration in Smart Distribution Grid'. An example of applied research is "SW Based ICT Network Security System for Safety-grade Industrial Network". Again, the research is fragmented with a large portion devoted to individual basic research elements.

Big data R&D has been active in Korea since early 2000. Big data R&D has wide applications, and smart grid and demand side management constitute a portion of the large effort. It is difficult to characterize the topics specific to smart energy systems. This study team selects one topic that is directly related to smart energy system: the development of a big data platform for transmission grid and application of AI (Intelligent grid platform). The budget for development of the big data platform is 672 million Korean won in 2020. A project titled 'Development of Cybersecurity Technology for Cloud-based Big Data Platform in Smart Grid' is being pursued in direct relation to smart grid and smart energy system. Two successful commercialization projects in energy big data are: "VRF Energy Analysis Service Based on Big Data Analysis" and "Monitoring of Factory Energy Use for Big Data Application". From the perspective of the practical application of smart energy systems, this is the area where the largest gap exists between the desired applications to the current state. Development of the E-Big Data Standards, similar to the Green Button in U.S., is in progress.

The key projects would be: "Collection of Energy Use Data and Interface", "Platform for Big Data Analytics", and "Big Data Application Service Model and Field Verification" (KETEP, 2020).

In summary, the study on smart grid and smart homes has reached the most advanced stage. As reported by KETEP in its review of the current R&D status, most of the projects are small and geared toward technical development. The authors consider a flagship project including integrated demonstration and qualification essential to reach the goal of practical application and commercialization of smart energy systems. In designing the flagship project, gap analysis and a roadmap are desired as the starting point. It is recommended that the gap analysis be conducted to include technical as well as nontechnical elements such as legal and social issues.

[Figure 2-6] The Second Basic Plan for Smart Grid (2018-2022)

Revise 1st Smart Grid Plan	Promote AMI Infrastructure → Utilizing AMI Information, Focus on Creating Services Manufacturing-centered Development → Customer- centered Service Testbed
	+
Climate Change	Expanding Renewable Energy, a Flexible Power Market through Technological Innovation, Transforming into a New Market Ecosystem Expansion of Infrastructure with Smart Power Grid for Renewable Energy
	↓
Director of the 2nd Plan	Creation of a Consumer-Oriented Power Market Ecosystem Energy Transition
Policy Goal	1. Activating New Services of Smart Grid 2. Create Experience for Smart Grid 3. Expansion of the Smart Grid Infrastructure(AMI, ICT infra) 4. Promote Smart Grids in Industry

Source: authors.

3.4. R&D Program at KEPCO Electric Power Research Institute

KEPCO (Korea Electric Power Corporation) Electric Power Research Institute (KEPRI) is the R&D arm of KEPCO, the sole electricity transmission and distribution company in Korea. R&D at KEPRI is unique in that it focuses on the technical needs of KEPCO. It covers the areas where the R&D results are well into development so that the outcomes can be applied to real world problems. The yearly R&D budget for KEPRI is about 1.3 trillion Korean won. KEPCO's internal funding provides 1.05 trillion Korean won annually. Detailed description of KEPRI's R&D work can be found in (KEPRI, 2018), (KEPRI, 2019). Considering the strong interest of the Czech Republic's researchers in nurturing SMEs, KEPRI's R&D projects related to smart energy systems are examined. Relevant ongoing R&D projects (KEPRI, 2018) are:

- A 28MW Battery ESS integrated test facility: Establishment of 28MW ESS battery as part of ESS Infra and development and stabilization of southwest offshore wind power output. The 28MW ESS management system is constructed at Gochang Power Testing Center. It is connected to a 60MW southwest offshore wind farm and operated.
- A common platform for Microgrid SW solution (for key information, communication, control, security, data management): The common power system and operating platform for smart grid is developed with IEC 61850 standards. It will be tested for microgrid application.
- PMU based big data analysis: Big data analysis based on PMU is used to assess the power system situation. The project is used to predict abnormal state of the power system by analysis of big data using PMU and hi-speed communication network. Further, a wide area grid monitoring and control system is constructed with 40 PMUs and 28 transformers and utilized. (see [Figure 2-7]),
- Improved AMI architecture and design of the operation system (encryption, smart meter gateway, AMI platform): One project in this category is the development of an advanced metering server package and GIS solution. In response to the expanded use of AMI (10 million customers in 2020), the server package is developed to provide application services to the utility and a mobile app 'PowerPlan' to customers. The app will be used to manage real-time power usage (see Figure 2-8).
- Development of Smart city integrated energy operation system
- Development of Optimal Urban Energy Mix Design Program for the Smart City: This program examines the energy resources and demands of the smart city and optimizes the energy mix (electricity, and heat). The goal is to minimize the cost of energy resources and carbon emissions while maximizing energy efficiency. The output is an optimum energy supply plan for the city.
- Smart city energy platform development
- Optimization of building energy use based on machine learning
- Development of gateway communication technology for multi wireless communication of IoT sensors: A self-communication network between devices and gateways is developed by combining Wi-Sun and LoRa communication technologies. It adopts LWM2M standard technology.
- Development and demonstration of block chain-based electric vehicle charging and peer-to-peer power trading system: With wider use of electric vehicles, small-scale electricity trade has become important. Peer-to-peer electricity trade and EV charging system are established with blockchain technology.

The topics of interest for collaboration would be: smart grid; use of AMI and PMU; ESS; smart city integrated energy operation system; and gateway communication technology for multi wireless communication of IoT sensors. The smart city demonstration project is in early stage of detailed planning. It involves various organizations of Korea, which has been the main reason for delays. In relation to smart energy systems, IoT and demand side management are the relevant elements for integration. The KEPRI R&D program covers these two areas.

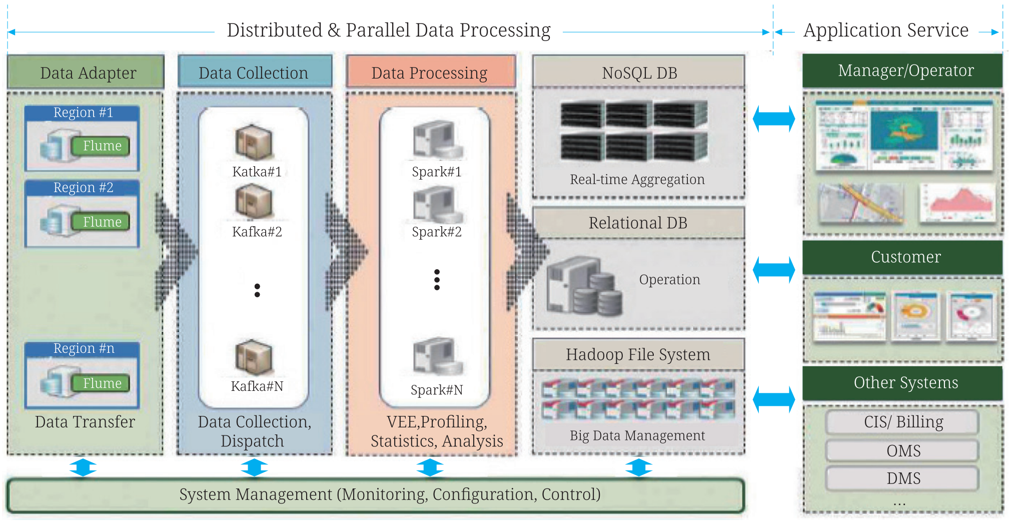
KEPRI has a program to promote innovations in SMEs and provide technical supports to SMEs. It promotes the formation of venture firms by KPERI researchers, and operates KETIS (KEPCO Technologies Information Support System) to provide technical support to SMEs. It has also established an equipment qualification center for SME products. This would be an area of interest for information exchange regarding SMEs.

[Figure 2-7] Wide Area Grid Monitoring and Control System

▲ Operating state of K-WAMAC

Source: KEPRI (2018).

[Figure 2-8] Advanced Metering Server Package



▲Architecture of big datd distribution and parallel process

Source: KEPRI (2018).

3.5. R&D Program in Czech Republic

The topics of interest for future potential projects are as follows: Electrical substation security utilizing digitization and innovation of security technologies; Effect of distributed resources and IoTs on energy infrastructure; and blackouts.

A. Electrical Substation Security (TSO)

- Use of “smart cameras”, the use of RADARs and LIDARs, the use of VR or AR (3D reality creation) and training to simulate typical situations;
- The issue of robotics security surveillance in electrical station conditions ("self-propelled/autonomous monitoring of vehicles, possibly supplemented with drones”),
- The possibility of using digital satellite imaging in support of remote security surveillance (link to Galileo) or the use of IoT, for example, for personal protection and occupational health and safety at electrical substations.

B. Energy Infrastructure and IoT and Industry 4.0

- Use of distributed resources to increase safety and security of supply;
- Influence of energy storage systems on system stability;
- On-gird/off-grid operation for the stability and security of energy and critical infrastructure;

- Method of optimization for energy infrastructure management with the application of artificial intelligence;
- Prevention, detection, response and minimizing the influence of the combined threats of physical and cyber security on the energy infrastructure;
- Specification of physical security solution for energy resources, transmission and distribution systems including substations.

Co-authors of the Czech Republic provided detailed list of projects, as shown in Appendix B. As shown in Appendix B, CTU/FTS (Czech Technical University/ Faculty of Transportation Sciences) established a doctoral study program for conducting research on smart cities. In order to pursue advanced studies in cybernetics and AI, the National Competence Canter was established. The focus of the projects is on smart city application and cyber/physical security. It is desirable for researchers in Korea to review the areas of study and identify topics of mutual interest.

3.6. R&D Program in Universities

In Korea, KEPCO is the sole electric utility and its R&D organization, KEPRI, is leading the effort of development/deployment of new research results. Czech Republic does not have a counterpart organization that can interact with KEPRI. However, R&D efforts at universities are active and there would be room for collaboration with Korean universities. University R&D serves two functions from the deployment and commercialization perspective: gatekeeper and incubator for venture companies. As a gatekeeper, it surveys and evaluates development of promising technologies. The successful R&D at universities leads to the formation of venture companies to provide commercial solutions. In this section, the KSP team introduces the R&D at Technical University of Ostrava and that at Korea University, considering the areas of common interest. The authors are of the view that university R&D efforts are the most promising areas for collaboration in near term.

ENET Centre at Technical University of Ostrava (http://cenet.vsb.cz/) has an active program in the areas of smart grid and renewable energy. The research covers microgrids (off-grid power system), electrical vehicles (to/from grid), diagnostics of electrical insulation, and reliability of electrical network. Some of their work is summarized below.

3.6.1. New Components of Electrical Networks: Increasing the Reliability and Safety of Electricity Supply

Power grids are a critical infrastructure from the point of view of safety/security and reliability with great social and economic importance. New features and technologies for electricity networks are under development at the ENET Centre. Examples are distribution networks using the latest power electronics (e.g. new technology for compensation of faults in distribution networks, resolution of electricity quality, management of output flow and electrical protection), and diagnostic procedures ensuring an increase in network flexibility, safety and reliability with the development of related systems for management and control of instrumentation.

3.6.2. Control, Monitoring and Protection of Power Grids Including ICT

The research deals with the increased demand added to the power grid due to the greater share of distributed and intermittent sources of energy. The objective is to develop technologies (critical infrastructure) for next generation power grids. In this regard, R&D activities focus on development of new algorithms for control, monitoring and protection of electrical networks including development of related information and communication technologies. The development of adaptable systems for protection and monitoring of networks is a key element. The system would handle a high share of distributed power generation, with secure communication technology for smart grids and optimization of transmission operations and distribution networks.

Performance of these activities requires application of the latest knowledge from the fields of power electronics technologies, extensive sensor networks (instrumentation), systems for control and management, and communication technologies.

3.6.3. New Technologies for the Effective Integration of Decentralised Electricity Sources into the Distribution System

This activity of the ENET Centre builds on previous activity and in particular utilizes new technologies for the effective integration of decentralised electricity sources into the distribution system. The main emphasis is on optimization of handling energy produced in particular using renewable sources (residential photovoltaic sources).

Within the context of the expected energy development, a significant part of electricity produced will be from photovoltaic power stations located on the roofs of buildings. This production will cause overflow into the electricity network, in particular during specific periods of time that could complicate the management of electricity networks (concurrence of excess electricity produced).

Optimization will resolve maximisation of the value of electricity produced in the cost-to-benefit ratio of the solution. Several alternatives are theoretically possible – storage of electricity in batteries, time management of appliance consumption, storage of heat in water or in underground bores, combination with a heat pump etc. The activity is focused on development of optimum solutions for various types of sources and consumption.

3.6.4. Storage of Electricity

The ENET Centre also deals with the issue of electricity storage in distribution networks with a high share of decentralised sources where electricity production is difficult to predict. Activity is focused on electricity storage on an electrochemical basis (battery systems). Research activities of the ENET Centre address both electrical equipment for systems and also prediction of lifespan and power management algorithms.

In Korea, the Advanced Power System Research Center at Korea University (lead by Prof. Gilsoo Jang) is active in the research on the dynamics and controls of power systems, and integration of renewable energy. From 2000, this group has focused its research in the field of power systems along with more than 100 research projects performed in these fields. The group has very a strong collaboration network with research institutes and companies. The lab operates real-time simulators to analyze grid-connected power electronics equipment and simulate wind farms in Jeju Island. Current projects of interest are:

Medium voltage DC connection for distribution: Utilization of medium voltage DC connection improves operation efficiency of systems, and enables additional connection of renewable energy sources within the DC grid. This would contribute to voltage stabilization of distribution networks through reactive power control.

Flexible frequency operation: Separate grid by power quality. By separating the grid based on the power quality needed, flexible frequency operation of the grid is achieved. The grid is grouped into three categories: regular frequency range 60+-0.5Hz, premier frequency range 60+-0.1Hz, and rough frequency range 60+-1 Hz. This is one solution to frequency disturbances due to high renewable penetration (Suh Jaewan *et al.,* 2017).

Renewable to grid: This project works on the development of a dispatch-able substation. This dispatch-able substation is used between variable generation resources and grid to handle intermittency issues.

Further information can be found at http://pel.korea.ac.kr.

4. Cyber and Physical Security

Protection of the energy supply network is critical to the well-being of public. Disruptions to the energy supply network have a huge impact on the economy. Hence, physical protection and cybersecurity of energy production and supply networks have been tasks for which the government takes responsibility. Detailed strategy and plan are not available to public due to the negative impact once such information is released to the general public. For this reason, information exchange on detailed strategy between the Czech Republic and Korea requires involvement of various government entities.

With the introduction of Industry 4.0 and smart energy systems, interaction between the energy supply network and communication network has become a necessity. This introduces cyber security issues that are typical to data networks such as online banking systems. This is one of the key barriers that need to be resolved before wider application of Industry 4.0 in energy area.

The data communication requirements would grow exponentially with the advancements in grid technology. Use of AMI (Advanced Metering Infrastructure) and PMU (Phasor Measurement Unit) are two examples. In Korea, KEPCO plans to install 22 million smart meters that are the key elements of AMI, in addition to 220 PMUs. The goal is to introduce Time-of-Use (TOU) pricing on electricity. TSOs (Transmission System Operators) need to balance electricity supply and demand continuously all the time. Mismatches may lead to frequency fluctuation and blackout. Accordingly, the integration of consumer data is necessary for full realization of a smart energy system. This requires careful consideration of the challenges to data communication networks and cybersecurity. Special care should be given to the protection and use of consumers' electric usage data as well as the processed data. [Figure 2-3] shows the complexity of the data structure. Furthermore, physical security considering control over grid hardware and facilities needs to be considered.

Cybersecurity requires consideration of all approaches taken to protect data, systems and networks from deliberate attacks and accidental compromise. It ranges from preparedness for recovery from:

- Loss of grid control (disruption of electricity supply over a wide area);
- Consumer-level problems (incorrect billing, interruption in service via tampering of smart meters);
- Commuting disruptions for EV (breach of recharging station);
- Breaches of data confidentiality (identity theft, physical security threats, terrorist

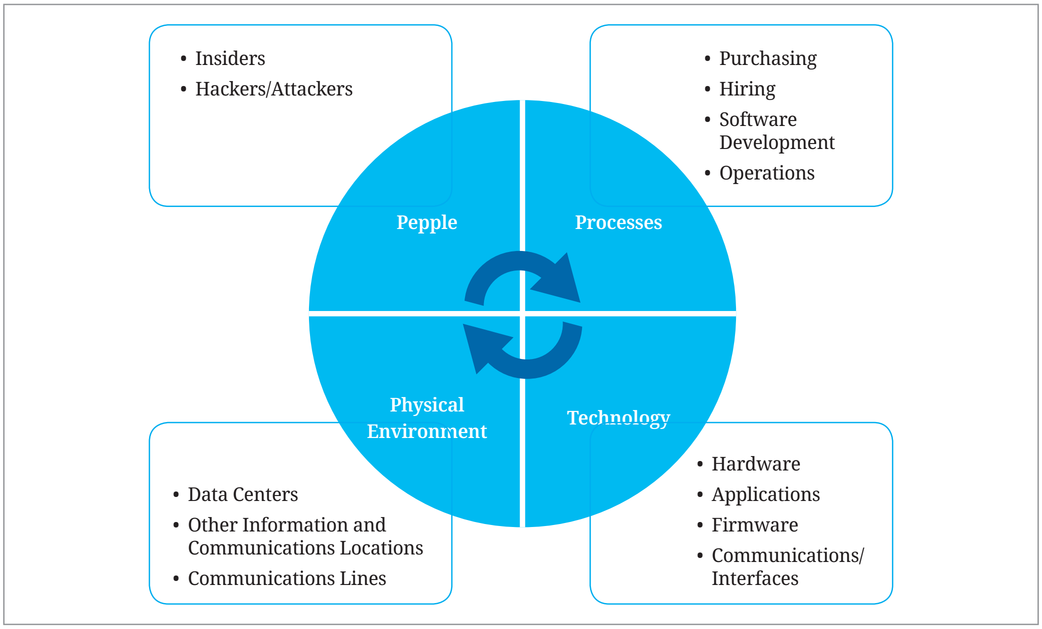
activities).

Given the ever-expanding connectivity and the evolving threats, making the grid completely invulnerable to cyber events is impossible. Furthermore, as shown in [Figure 2-9], people are the most vulnerable points in the chain. Hence, a holistic approach is necessary. Improving resilience to attacks and reducing the impact would be the goals of cybersecurity measures.

Research on technology is more active at this time. As discussed in section 3.3, R&D budget in cybersecurity in Korea has grown from 37 billion to 105 billion Korean won in a span of ten years. Again, the focus is on technology development. Handling the people element in the cybersecurity category seems to be the most difficult task. Field testing and application are necessary next steps. In cybersecurity, regulations on how to use personal data must be in place. In Korea, three laws governing information protection are in force at presented. In the EU, the General Data Protection Regulation is in effect. However, detailed interpretation and application of the regulations are necessary. Investments into cybersecurity are difficult to justify from the perspective of utility since it is not easy to quantify the return on investment. This is one of the areas that need policy level attention.

In this section, the KSP Team covers the topics on which researchers at both countries can collaborate. More specifically, the R&D topics discussed are focused on cyber security for transmission and distribution networks. The information exchange on field application and commercial use would be valuable for policy level discussion.

[Figure 2-9] Cybersecurity Categories



Source: Kassaian (2011).

4.1. R&D in Korea

In Korea, the government is in charge of the overall cybersecurity response system. Basic R&D is performed at universities and KEPRI. There are active research projects at several universities.

One program at Suncheon-hyung University focuses on the security of electrical networks (http://homepage.sch.ac.kr/security/). The Cyber-Physical System Security Lab (at Soonchunhyang Univ.) is conducting research and development on security policies and security technologies in the fields of smart grid, Nuclear Power Plant (NPP), and Smart City.

- Development of smart grid security guidelines;
- Development of security systems for smart grids and microgrids;
- Research on anomaly detection technologies using AI of power generation control systems;
- Development of security measures for Distribution Automation System (DAS);
- Development of security architecture for power control systems such as HVDC (High Voltage Direct Current);
- Development of technology for vulnerability analysis of NPP I&C (Nuclear Power Plant Instrumentation and Control) systems;

- Research on anomaly detection technology for renewable energy systems;
- Further, the current status of R&D projects in South Korea is as follows;
- Development of smart grid security systems;
- Development of core security technology for smart grids (AMI targeted);
- Development of security technologies for power control system;
- Development of microgrid security system;
- Development of security architecture for NPP I&C systems;
- Development of NPP I&C system security (such as detection of intrusion, authentication and encrypted communication, etc.).

KEPRI focuses on the topics related to electricity transmission and distribution. The following four topics from KEPRI R&D program are of interest to the present KSP project:

- Smart algorithms for prediction of and response to natural hazards (typhoon);
- A tool based on big data technology to support prediction of/response to transmission system events under natural hazards such as earthquake and typhoon;
- Development of security device for real-time surveillance and abnormality detection;
- Detecting unauthorized abnormal activities by adopting machine learning function.

4.2. R&D in Czech Republic

The authors from Czech Republic provided an extensive list of cyber and physical security research projects as shown in Appendix C. The list covers a wide range of topics, encompassing all facets of cybersecurity. This section introduces samples of projects that are closely related to electricity transmission and energy security.

- Methodology for protection of critical infrastructure in the areas of production, transmission and distribution of electricity [This project is to develop a certified methodology for ensuring protection of the critical infrastructure elements in the area of generating, transmitting and distributing electricity and for strengthening the security of information. The proposed project will be implemented in the form of applied research with the objective of covering the missing methodological and system solutions for the protection of the critical infrastructure];
- RESILIENCE2015: Dynamic Resilience Evaluation of Interrelated Critical Infrastructure Subsystems [The project is to study the dynamic correlation of the EU's significant sectors (energy, transport, ICT) and their elements],
- Resilience of the distribution system during national grid blackouts to improve safety of the public [To minimize the non-acceptable risks associated with the currently not-

very-probable, but possible crisis situations in the electric power supply],

- SESAMO – Methods and processes of developing computing platforms related to safety-relevant embedded systems for security and protection of critical infrastructure [To develop a component-oriented design methodology based upon model-driven technology, which jointly addresses safety and security aspects and their interrelation within networked embedded systems].

In cybersecurity area, Masaryk University and Tomas Bata University are active in research. They are engaged in research associated with the C4e center and CONCORDIA project (See Appendix C). The CONCORDIA project is related to EU's Horizon 2020, and started from January 2019. Again, the R&D subject covers all areas of cybersecurity. Collaboration with the counterpart researchers in Korean Universities would be beneficial.

4.3. Response to Blackouts

Researchers of the Czech Republic expressed strong interest in the strategy to prevent and cope with blackout. The following are the suggested topics of interest.

- Prevention and subsequent response during blackout situation;
- Development of use cases regarding events and scenarios for events with a negative impact;
- Development of Business Continuity Plans;
- System support for creating and maintaining plans;
- The DRP development of systems supporting rapid recovery (e.g. automated overhead deployment configurations);
- Construction of backup locations based on methods such as cloud solutions;
- Addressing cyber security for various types of communication networks within the energy distribution channels linked to the physical security of controlled devices and access to them.

Among the various topics, the strategies to address the top five requirements are developed and in place. Korea Power Exchange is the responsible organization. As discussed in section 2.3, with an island grid configuration, the Rolling Five- year Electric Supply Plan is the key to maintain margin and resilience in Korea. The last two topics are directly related to smart grids and smart energy systems. These are included in the R&D areas discussed in section 4.

5. SMEs in Smart Energy Industry

According to Chung (KDI, 2018), central and southeastern European countries made a successful transition to a new economic system in the 1990s and achieved significant growth. The challenges facing these countries are to continue national development under the legacy of the socialist system while abiding by the conditions set by EU. The key challenge is to move/connect university R&D to industry. Small and medium enterprises could play a key role in this. The active R&D efforts in universities and education systems in both countries are encouraging. A major task ahead is to move to applications.

Visegrad 4 countries have a keen interest in strengthening the innovation capability and competitiveness of their SMEs. As such, the title of the 2017/18 KSP was 'Innovation Policy for SMEs in the Era of Industry 4.0'. The national development strategy of V4 countries focuses on R&D, SMEs, and infrastructure development. These countries show strong desire to strengthen the competitiveness of SMEs, commercialize science and technology, and promote innovation. The share of SMEs in the national economy of V4 countries is very large. However, it is found that value created by and the innovation performance of the local SMEs are low. The linkage between large enterprises and local SMEs is less than the desired level, partly due to some large enterprises' dependencies on foreign direct investment (KDI, 2018).

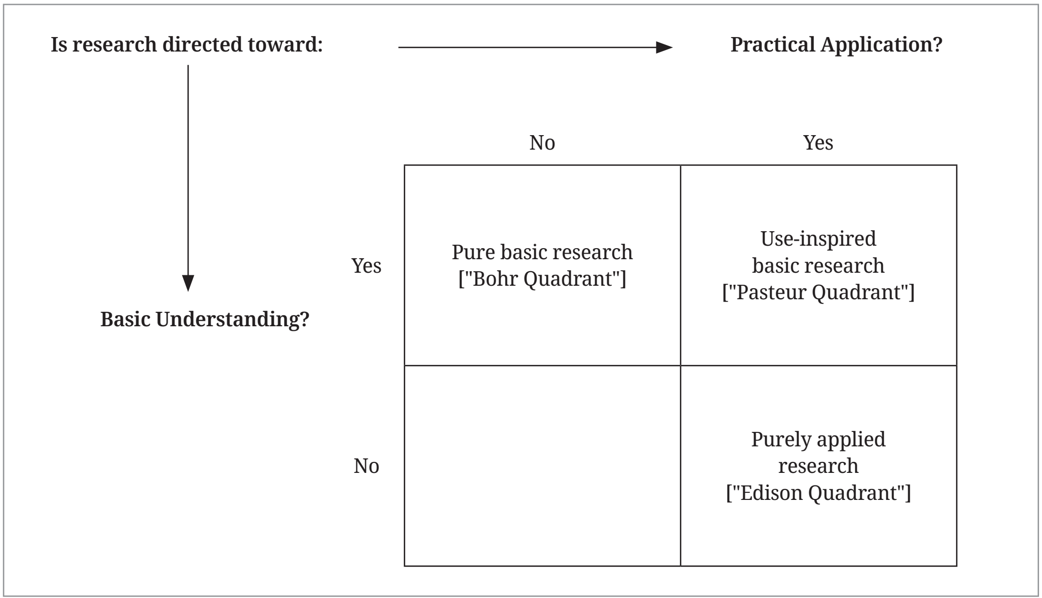
The researchers of Czech Republic expressed their desire to continue the topic of nurturing/promoting SMEs working in the domains of Industry 4.0 and smart energy. In this section, the KSP team will examine the general approach to nurture SMEs with new innovation technology. Following this, the efforts by the Korean and European governments and industry will be introduced. Finally, with the goal of future information exchange and collaboration, several SMEs from Czech Republic and Korea are introduced. Nurturing innovative SMEs is a difficult task and there are no clear cut answers as to the right steps to follow. The exchange of the success stories between the two countries will be useful in supporting SMEs' growth in the future.

Digital communication, social media interaction, e-commerce, and digital enterprises are steadily transforming our world. They are generating an ever-increasing amount of data, which, if pooled and used, can lead to completely new means and levels of value creation. It is a transformation as fundamental as that caused by the industrial revolution. Industry 4.0 refers to this transformation. Smart energy industry means the transformation of energy industry with the adoption of Industry 4.0 technologies enhanced by digitization. Industry 4.0 is one the strongest challenges and drivers for innovation of the society and future. There are key problems and questions connected to the cooperation and interconnection of SMEs and people with Cyber Physical Systems (CPS), as well as the interconnection between the Internet of Things (IoT), Internet of People (IoP) and Industrial IoT (IIoT). All smart systems and the entire smart society need energy resources to keep the key infrastructure alive—they need to be connected! The adoption/application of Industry 4.0 requires global vision, interdisciplinary collaboration among researchers and the awareness of the social impact created by social-digital transformation.

Unlike previous transformation, SMEs play active roles in the adoption of Industry 4.0, especially in the U.S. and Europe. Germany is leading the way in producing successful SMEs utilizing digital transformation (Meffert Jurgen and Swaminathan Anand, 2017). In the U.S., this is one area where a large number of venture companies are formed. One example in the U.S. is devices and software related to smart buildings. Development of smart building appliances is occurring at a rapid pace. Utilizing IoT devices with internet, the control and monitoring of energy use and home appliances are performed through Apps. This can be applied to public buildings as well as individual living in a smart home. One example is the U.S. ADT Pulse (Meffert Jurgen and Swaminathan Anand, 2017). In the U.S., Amazon, Google, and Apple are actively promoting smart home applications. In Korea, telecommunication companies such as SK Telecom are providing similar services. This led to SMEs providing a variety of smart home appliances.

For innovative SMEs to prosper, anticipating and meeting the customers' need is essential. Since smart energy systems are still under development, it is important to understand the R&D cycle: from conceptual study, development, deployment and application. The key challenge for all R&D efforts lies in successful deployment and application. In this regard, the estimation and understanding of needs raised by real industrial and business spaces and infrastructure are important. Deutch and Lester (Deutch and Lester, 2004) examine the taxonomy of R&D and innovation and the role of the government in promoting the adaptation of R&D to real requirements. Traditional linear models start from idea, and proceed through development, manufacturing and application (cost). As shown in [Figure 2-10], a two-dimensional Stokes' research and development matrix examines the process based on the needs for basic understanding and practical application. Practical application requires consideration of cost and customers' needs. The role of the government is somewhat limited for the Edison quadrant since the private company is the entity to commercialize and apply the research outcome to the real world problem. The work in the smart energy area lies in the Pasteur Quadrant and moves to the Edison Quadrant. To be successfully moving from the Pasteur/Edison domains, three factors are important: consortia of government and private companies; strong education programs (an example would be the European Platform for Digital Skills and Jobs); and university-industry cooperation (Deutch and Lester, 2004). For new technologies such as those associated with Industry 4.0, formation of enterprises based on university-industry has been quite successful in the U.S. This is one model that policy makers of the CR and Korea could consider.

[Figure 2-10] Stokes' Research and Development Matrix



Source: Deutch and Lester (2004).

5.1. Korea

Science, technology, and innovation play critical roles in the social and economic development of countries (KDI, 2018). The growth of industrial innovation capacity in Korea is a combined result of (1) private enterprise's response to market pressure; (2) the growing technology-intensiveness of industries; and (3) the aggressive investment strategy adopted by the chaebol companies and the government's policy actions (top-down). In the recent years, a more U.S.-like venture capital approach has been utilized especially in the IT area, and university-industry collaboration has become active. In Korea, the government considers healthy SMEs important to national well-being. The Ministry of SMEs and Startups was established in 2017. This Ministry sets up the government policy and supports formation of technology venture companies and financial funding. Hence, the Ministry of SMEs and Startups is the right organization for collaboration regarding the overall policy in promoting SMEs. In this section, the KSP Team focuses on SME development in smart energy systems, especially from the perspective of moving from the Pasteur Quadrant to the Edison Quadrant (or development, field trial to commercialization). As discussed in Chapter 3, as a part of the energy R&D roadmap, the Korean government has established a program to promote SMEs in the domain of energy transition. KETEP provides funding for development of promising technologies in energy area and supports field application phase for successful projects. Dasangng, one of the SMEs introduced in section 5.4, is such a case. Furthermore, KEPRI has been supporting the growth of SMEs in Korea, and has established programs to support SMEs and commercialization of research products (KEPRI, 2019). Examples are KETIS (KEPCO Technology Information Support System) for technology transfer of products developed by KEPRI, certification of new products, and provision of technical support for new products developed by SMEs. KEPRI has been active in providing technology transfer and information services to SMEs, and also provides financial support for incubator programs related to promising R&D products by KEPRI.

In the smart energy system area, there are efforts by the government as well as KEPCO to provide support for field applications. For these SMEs to be commercially successful, a customer base needs to be established. The successful deployment of smart grid and Time-of-Use electricity pricing is necessary in this regard.

5.2. Europe

Technological sovereignty here is not defined against anyone else, but focuses on the needs of Europeans and of the European social model. The Commission focuses on three key objectives to ensure that digital solutions help Europe to pursue its own way towards digital transformation.

5.2.1. Technology that Works for People

The term "technology that works for people" means development, deployment and uptake of technology that make a real difference to people's daily lives. Further, it unfurls along with a strong and competitive economy that masters and shapes technology in a way that respects European values.

Europe must invest more in the strategic capacities that allow countries and communities to develop and use digital solutions at scale and achieve interoperability in key digital infrastructures. Connectivity is the most fundamental building block of the digital transformation. It is what enables data to flow, people to collaborate wherever they are, and to connect more objects to the Internet, transforming manufacturing, mobility and logistic chains in the process.

Europe needs to invest in connectivity, deep tech and human capital, as well as in smart energy and transport infrastructures. However, this presents a problem: the more interconnected we are, the more we are vulnerable to malicious cyber activity. To tackle this growing threat, it is necessary to work together at every stage: setting consistent rules for companies and stronger mechanisms for proactive information-sharing.

Improving education and skills is a key part of the overall vision for digital transformation of Europe. European companies need digitally savvy employees to thrive in the global technology-driven marketplace. In turn, workers need digital competences to succeed in an increasingly digitalised and fast changing labor market.

5.2.2. A Fair and Competitive Economy

A fair and competitive economy necessitates a frictionless single market, where companies of all sizes and in any sector can compete on equal terms, and can develop, market and use digital technologies, products and services at a scale that boosts their productivity and global competitiveness, and consumers can be confident that their rights are respected.

Data has become a key factor of production, and the value it creates has to be shared with the entire society providing the data. This is why the EU needs to build a genuine European single market for data - a European data space based on European rules and values.

Many European companies–and SMEs in particular–have been slow at taking up digital solutions, and therefore have not benefitted from the digital advances and missed opportunities to scale up. The EC will seek to address this issue with a new EU Industrial Strategy that will set out actions to facilitate the transition towards a more digital, clean, circular and globally competitive EU industry. It will also include a strategy to enable SMEs, a vital part of the European economy, often hampered by lack of available skills, gain access to finance and markets. SMEs need a frictionless single market, unhampered by diverging local or national regulations that increase administrative burdens for smaller companies in particular. They need clear and proportionate rules that are effectively and uniformly enforced across the EU.

Ensuring fairness in the digital economy is a major challenge. In the borderless digital world of today, a handful of companies with the largest market share get the bulk of the profits based on the value that is created in a data-based economy. Those profits are often not taxed where they are generated as a result of outdated corporate tax rules, further distorting competition.

5.2.3. An Open, Democratic and Sustainable Society

An open, democratic and sustainable society is built upon a trustworthy environment in which citizens are empowered in how they act and interact, and of the data they provide both online and offline. This is considered the European way to digital transformation that enhances democratic values, respects fundamental rights, and contributes to a sustainable, climate-neutral and resource-efficient economy. What is illegal offline must also be illegal online. While it is not possible to predict the future of digital technology, European values and ethical rules and social and environmental norms must apply also in the digital space.

As powerful enablers for the sustainability transition, digital solutions can advance the circular economy, support the decarbonisation of all sectors and reduce the environmental and social footprint of products placed on the EU market. For example, key sectors such as precision agriculture, transport and energy can benefit immensely from digital solutions in realizing the ambitious sustainability targets of the European Green Deal.

Digital solutions, and data in particular, will also enable a fully integrated life-cycle approach, from design through sourcing of energy, raw materials and other inputs to final products until the end-of life stage. For example, by tracking when and where electricity is most needed, it is possible to increase energy efficiency and use fewer fossil fuels.

5.3. The International Dimension

The European model has proved to be an inspiration for many other partners around the world as they seek to address policy challenges, and this should be no different when it comes to digital transformation. A strong digital presence in the EU's drive toward enlargement, neighbourhood and development will enable growth and drive sustainable development, including the uptake of green ICT in partner countries and regions, in accordance with Europe's commitment to the 2030 Agenda for Sustainable Development.

Many countries around the world have aligned their own legislation with the EU's strong data protection regime. Mirroring this success, the EU should actively promote its model of a safe and open global Internet. In terms of standards, European trading partners have joined the EU-led process that successfully set global standards for 5G and the Internet of Things. Europe must now lead the adoption and standardisation process of the new generation technologies: block-chain, supercomputing, quantum technologies, algorithms and tools to allow data sharing and data usage. The European Union is and will remain the most open region for trade and investment worldwide, provided that anyone who comes to do business here accepts and abides by the EU's rules.

The data-agile economy and its enormous transformative potential will affect all the world and Europe stands ready to make full use of the advantages it is bound to bring. Yet, for this digital transformation to be fully successful, we will need to create the right frameworks that ensure secure and trustworthy technology and give the SMEs businesses the confidence, competences and means to digitalise.

5.4. Examples of SMEs from Both Countries

The KSP Team is interested in promoting interactions between SMES in Czech Republic and SMEs in Korea. In this section, a few examples of SMEs in the smart energy industry (application of Industry 4.0) are discussed. KETEP in conjunction with the Korean government organizes Korea Industry Technology R&D Exhibit annually. Last year, it was held from 13-14th of December at COEX, Seoul. SMEs of Korea introduced in this section are chosen from the businesses that participated in the Exhibit. These businesses are introduced as samples of SMEs active in the smart energy system area. The authors do not endorse or recommend any specific SMEs. We recommend that interested personnel, R&D planners and SMES from the Czech Republic attend this Exhibit. It would be a worthwhile platform for promoting collaboration between the two countries.

ELCOM in the Czech Republic has been working closely with the University of Ostrava. This is an example for close collaboration between universities and SMEs. DAWON DNS received support from Yangcheon-gu office for field application. Further, Dasangng received funding from KETEP for development and field application.

5.4.1. CNS (Czech Republic)

CNS was established in 1999, and provides services in IT technology and consulting. Presently, the company provides services related to cybersecurity, such as secure data transfer. Key products are Safety4Transfer, S4T-Pro, and NOTEBAR as described in Appendix E. It provides services in the U.S. through its office in Pittsburgh.

Safety4Transfer: The value of a trusted relationship, whether in a private conversation, a critical moment of need, or protecting assets, cannot be underestimated. We develop relationships and communicate in a unique way; secure data is very much akin to this. When a user transfers data, it must be as safe as a precious cargo. If a peer to peer relationship is established with a toolset that guarantees secure file transfer, it would be possible to substantially protect files and data. Imagine a cyber-approach where the user can increase protection in five minutes, one where the user establishes a trusted peer relationship and extracts files from a trusted place for both parties. The mechanism operates like an armored truck.

Safety4Transfer is a data encryption and transfer application that relies upon a secured, peer-to-peer virtual network that allows users to confidently exchange data with anyone in their network. The client-side software manages four layers of security. From 1) Initial Encryption 2) HTTPS Transport 3) Public Key Infrastructure to 4) Peer Authorization, every file is secure from the moment of release to the moment of acceptance. A simple client install provides the first best step for cyber threats.

In addition, the CNS just finished a development of two new products in cooperation with Technical University of Brno. Both of these projects received partial grant support from the EU funds and the Ministry of Interior of the Czech Republic. Currently, the company is in the commercialization phase with: S4T-Pro-S4T-Pro adds a new layer of security with encryption method NOTEZA based on the Vernam cypher into the current Safety4Transfer infrastructure. With this new method, senders can choose multiple transfer grants for encryption purposes. This guarantees an unbreakable transfer.

NOTEBAR is a technology solution for archiving of electronic documents; it enables secure and long-term archiving of these documents. The application provides 100% security for archived documents against unauthorized access, by entities including storage operators and providers. Furthermore, the application ensures reduction to the risk of individual failure through the cooperation of more than one person. This in turn necessitates the definition of the minimum number of people necessary to access the archived document, and in particular it increases the possibility of obtaining a duplicate of a damaged (destroyed) electronic document. The technology for archiving is, again, based on the unbreakable Vernam Cypher and CNS' our encryption method NOTEZA.

The NOTEBAR solution focuses on protecting the most sensitive documents that contain companies' know-how. The potential loss or misuse of these documents could negatively affect the profitability, reputation and market position, and in case of government organizations even the security of states and citizens.

5.4.2. ELCOM (Czech Republic)

ELCOM is one of the innovation leaders in the Czech Republic. It is a technology solutions provider with more than 30 years of experience. The company provides premium, highly specialized comprehensive services in the field of electrical power measuring technology and industrial automation with an international scope. Thanks to a globally recognized team of specialists and superior experts in electrical engineering, engineering and SW development, ELCOM offers tailor-made solutions to meet specific needs of the customers. A key advantage the company possesses is the complete understanding of the issues surrounding material engineering, electronics, data management and process engineering. ELCOM provides integration of all core competencies with future technology development, working with virtual and augmented reality and IoT, and providing the company's own unique technology for acoustic vibration, haptic testing, visual inspection, power quality metering and analysis and applications based on power electronics.

ELCOM guarantees maximum efficiency in the cost and performance of managing the entire order process from design to complete implementation. The company implements projects completely in-house in accordance with its integrated process management policy.

Thanks to the company's comprehensive understanding of the issues and global focus, ELCOM ranks among the most experienced teams in the Czech Republic and abroad. ELCOM's long-term knowledge and experience gained through the implementation of unique projects enable the company to be the European leader in automotive applications and a world leader in testing systems. ELCOM is a proud member of the worldwide National Instruments Alliance program and the only Czech company to gain access to this program. The company has reached the level of the Gold Alliance Partner.

The main products of the company are:

- Testers and Vision Systems: ELCOM is one of the foremost manufacturers in the field of test systems, as confirmed by dozens of the company's long-term partners from the world's leading technology companies. ELCOM's product testing solutions are largely tailor-made according to customer specifications and usage. ELCOM prepares testers and vision systems for full compatibility with the customer's equipment, which allows maximum flexibility and range of measurement.
- Power grid Monitoring: ELCOM is long-term supplier of state-of-the-art power grid monitoring systems. The portfolio of products and knowhow ranges from global Phasor Monitoring Systems (WAMS) covering, for example, Central Europe, through

metering and comprehensive evaluation of the quality of supplied electricity across the country, up to the detailed monitoring of industrial plants' energy usage at the level of individual machine consumption. The company has been developing special measuring instruments, central software and comprehensive deliveries for over 25 years, and is at world-class level in this field with successful deliveries to almost all continents.

- Test Beds and Drives: ELCOM is the foremost Czech manufacturer and supplier of Test Beds for electrical machines, especially within the implementation of their complete technical equipment, which the company supplies from the source part up to control software. The company focuses mainly on output testing rooms, in-operative and type test beds.
- Power Electronics: ELCOM capitalizes on the experience gained by designing and developing power supplies in the implementation of special, universal, auxiliary and back-up power supplies and line conditioners, in which the company cooperates with renowned global brands.
- Software Engineering, Design and Production: An integral part of the company's work is the design activity for power electrical engineering, software development for production lines and monitoring of solar power plants and production of low voltage switchboards. Accumulated experience enables the company to provide premium services in the field of heavy-current electrical engineering (metallurgical works, mines, the chemical industry, engineering industry, waterworks, testing facilities, improvements and development in the field of electrically powered mobility, etc.)

5.4.3. KSIGNCo.LTD (Korea)

KSIGNCo. LTD (IoT security convergence services, www.ksign.com): KSIGN is an IT security company founded in 1999 and specializes in encryption technology, a security-based technology. Personal information encryption is one of the key competencies of KSIGNCo. Recently, the company performed a project on 'Integrated Authentication and Authorization Management Platform'. Key components are authentication, authorization, ID management, key exchange and management, reliability and reputation management as defined in the IoT-Architecture project (http://open-platforms.eu/standard_protocol/iota-architectural-referenc-model/)(Biannual NEW TECHNOLOGIES OF KOREA, 2019)

5.4.4 DAWON DNS (Korea)

DAWON DNS (IoT analysis platform service, www.dawondns.com) DAWON DNS was founded in 2007 and specializes in surveillance, cloud service and interwork with smart phones on electricity use. The company provides care service for elderly utilizing smartphone-based IoT technology and has set up an AI power manager for Yangcheon-Gu office.

5.4.5 DASAN GNG (Korea)

Dasangng (www.dasangng.co.kr) started as a software company in 2000. Since then, the company has expanded its services to home IoT, building energy management and communication network area. It performed a project titled 'Development and Verification of Smart Home-based Demand Response System and Business Model' with funding from the government from December 2016 to September 2019. Currently, Dasangng is participating in a smart home field application project. It is, in the view of the authors, one of the success stories of the government's SME support efforts.

Clearly, smart energy systems and Industry 4.0 applications are areas where SMEs can play a major role. The challenge for the government and R&D sponsors such as KETEP and TACR is to establish programs that nurture the SMEs while not overly restricting their endeavors. The impact of Industry 4.0 is not limited to technical regime but to wider social and legal regimes as well. At a minimum, it is necessary to establish a consensus and regulation on the treatment of personal information and personal data related to energy use. For the SMEs nurtured through R&D support by the government or by venture funding, commercialization with a healthy customer base is critical. For smart energy systems, this means that the successful implementation of smart grids and smart demand side management with Time of Use electricity pricing are necessary. The role of the government would be a topic of interest for both countries' participants. Exchange of information and discussion through a working committee are recommended.

6. Summary and Recommendations

As a part of the 2017/18 KSP, researchers of the Czech Republic and Korea examined RDI policies to enhance energy security. As an outgrowth, the KSP team chose smart energy system as the topic for the 2019/20 KSP topic. Smart energy system is an effort to overcome fluctuations in energy supply and ensure steady supply by utilizing the advancements of Industry 4.0. The resilience issue created by variable renewable energy is an area that needs attention. Hence, the KSP team focused on smart energy system related to electricity. A smart energy system includes smart grid, smart home, smart demand management and related technology.

With the advancements of Industry 4.0, smart energy systems are considered as a candidate for disruptive technology at distribution level. It is necessary to carry out in-depth R&D and studies to be prepared for the Industry 4.0 society. Smart energy systems (smart grid, smart city, electric car) are good test beds to examine the effect of Industry 4.0 on energy security. It requires consideration of technical as well as legal and social aspects.

- Use of big data on customers' energy use requires consideration of personal information, knowledge integration, and predictive analysis.
- Use of cloud and energy platform (test bed) approach brings additional challenges to cyberspace security, technology resilience, and networks optimization.
- Use of AI technology involves analysis and definition of digital twins and Cyber Physical Systems (CPS) in energy infrastructure, IoT integration.

Both countries are moving toward the increased use of variable renewable energy as indicated by the EU Green Deal and the Korean government's Green New Deal. The Renewable Energy 2030 policy of Korea aims to have 20% of total electricity generated from renewables by year 2030. This necessitates additional consideration of energy security. Intermittency issue arising from wider use of variable renewable energy poses challenges to the stability of the grid. Smart energy system is one way to solve this issue. R&D on smart energy systems has been active in Korea since 2010, and R&D on smart grids and smart home has received stable funding of around 320 billion Korean won annually in the past decade. Budget on cyber-security R&D has grown from 37 billion Korean won in 2011 to 105 billion Korean won in 2020. Most of the R&D efforts have been focused on technology development. However, field demonstration programs have been initiated recently. Smart grid field demonstration projects were initiated in 2019. Additionally, a smart home field application program is in place. The Fourth R&D Plan places greater emphasis on field application and commercialization. Further development and demonstration are needed in big data analytics and cybersecurity areas. In this regard, a flagship project including integrated demonstration and qualification is essential to reach the goal of practical application and commercialization of smart energy systems. In designing the flagship project, gap analysis and a roadmap are desired as the starting point. It is recommended that technical as well as nontechnical elements such as legal and social issues be included in the gap analysis.

The researchers of the CR continue to examine the topic of nurturing/promoting SMEs working on technologies related to Industry 4.0 and smart energy industry. This is in line with the EU Directive regarding the importance of the support of digital transformation in SMEs. Most elements of smart energy systems require further applied research and demonstration before they reach the commercialization stage (Pasteur quadrant). Three factors are important for the transition to application/commercialization: consortia of government and private companies; strong education programs; and university-industry cooperation. KEPRI and the Korean government have strong SME support programs in smart energy systems. These include: R&D funding including field demonstration, venture incubation programs, technical information services, equipment qualification services for SME products, and annual exhibitions. In the end, commercialization with a healthy customer base is critical for innovative SMEs. For smart energy systems, the successful implementation of smart grids and smart demand side management with Time of Use electricity pricing are necessary. Nurturing of innovative SMEs is a difficult task and there are no clear cut answers regarding the right approach; accordingly, it is one of key challenges for policy makers of both countries. The exchange of the success stories between the two countries will be useful in devising support measures for SMEs' growth in the future.

Energy security and resilience are critical for the economy and residents' well-being. However, it is a fact that R&D efforts in this direction, though pursued vigorously, need time for successful implementation. The practical and wider use of variable renewable energy, storage, and smart demand management require multiple stakeholders' agreement. Two examples are electricity pricing based on the Time of Use, and handling of personal data. For this reason, decision making in electric utility sector would move slowly. Grid transformation to meet the intermittency challenge requires an integrated plan (roadmap), since security and resilience of electricity supply need to be considered in planning for grid transformation. In the meantime, maintaining sufficient base-load electricity is cost effective and necessary. A MIT study (Buongiomo, 2018) reported the role of nuclear energy as a cost–effective way to reduce carbon emission. In planning energy mixes for the future, it is suggested that policymakers examine the benefits of the nuclear option. The Czech Republic has six nuclear plants currently in operation, and the country has announced the plan to build a new nuclear plant. Korea has twenty-four nuclear plants in operation and four are under construction. Hence, nuclear power would be an area where collaboration can be of benefit to both countries.

This year, the KSP Team focused on identifying collaboration topics and researchers to move forward with successful information exchange and collaboration. Considering the interest toward deployment and application of technologies, projects being conducted at KEPRI have been reviewed in detail. Based on the desire for near-term collaboration, the KSP Team examined candidate projects linked to university R&Ds. Smart energy system research at University of Ostrava and smart grid study at Korea University were introduced. Furthermore, Cybersecurity R&D at Sooncheonhyung University and Tomas Bata University were discussed. In the SME area, it is strongly recommended that the interested parties of CR visit the annual Korea Industry Technology R&D Exhibit for information exchange. Certification in EU standardization and compliance are necessary to enter the EU market. Collaboration of industries in the CR and Korea in the process would be beneficial to both parties. Sharing of R&D in the area of energy and security would be beneficial to both countries in preparing for the society of Industry 4.0. Both parties hope that this effort would serve as a ground for establishing a working committee on digital economy and Industry 4.0. It is highly recommended that the TACR and KETEP/KIAT agreement be utilized fully for future collaborative R&D.

References

Biannual NEW TECHNOLOGIES OF KOREA, Spring/Summer 2019, 2019, pp2-5.

Buongiomo J., *et al., The Future of Nuclear Energy in a Carbon-Constrained World: An Interdisciplinary MIT Study,* MIT, 2018.

Deutch and Lester, *Making Technology Work; Applications in Energy and the Environment,* Cambridge University Press, 2004.

European Commission, "SHAPING EUROPE'S DIGITAL FUTURE," ISBN 978-92-76-16383-3, 2020, https://ec.europa.eu/info/sites/info/files/communication-shaping-europes-digital-future-feb2020_en_4.pdf.

Kang Sang-gyun *et al., Investigation of the Influence on the Power Systems at the Time of Suspension of Large Scale Plants due to Natural Disaster,* KPX, 2019.

Kassaian J. G. *et al., The Future of the Electric Grid: An Interdisciplinary MIT Study,* MIT, 2011.

KEPCO Research Institute (KEPRI), "2017 Research Activity Report," 2018, www.kepri.re.kr.

KEPCO Research Institute (KEPRI), "2018 Research Activity Report," in Korean, 2019, www.kepri.re.kr.

KETEP, PD Insights-Smart Demand Management: Strategy for Energy Data Collection and Use, *Energy Technology Policy Brief, Vol.7,* 2020.

Kim Kyounggook, *Mid and Long Term Energy R&D Plan,* presented at 'Energy R&D Information Exchange Workshop,' KETEP, 2019.

Korea Development Institute (KDI), *Sharing Knowledge: Sharing the Future 2018,* KDI Strategic Report 16067-2, edited by Yongsun Koh, 'Chapter 4. Science, Technology, and Innovation Capacity-building for Industrialization,' 2018, pp128-188.

Korea Development Institute (KDI), *2017/18 Knowledge Sharing Program with Visegard Group: Innovation Policy for SMEs in the Era of Industry 4.0,* 2019.

Meffert Jurgen and Swaminathan Anand, *Digital@ Scale: The Playbook You Need to Transform Your Company,* section 'Future of Smart Building' written by Sarazin Hugo, Ahuja Kabir, Patel Mark, 2017.

MIT Energy Initiative, *Utility of the Future*, 2016.

Suh Jaewan *et al.*, *Flexible Frequency Operation Strategy of Power System with High Renewable Penetration*, IEEE Transactions on Sustainable Energy, Vol. 8, No.1, 2017.

World Economic Forum White Paper, *Digital Transformation of Industries: In Collaboration with Accenture, Electricity Industry*, 2016.

Appendix 1

Czech Republic Policy and Regulation on Energy Security

The following text discusses the most important legal regulations for creating an institutional framework that promotes energy security and resilience in a wider context in the CR.

A. Policies and Strategies

- The State Energy Concept approved by the government in May 2015.
- The National Action Plan for Smart Grids (NAP SG).
- The National Research, Development and Innovation Policy of the Czech Republic 2016–2020.
- The National Priorities of Oriented Research, Experimental Development and Innovation.
- The National Research and Innovation Strategy for Smart Specialization—National RIS3 Strategy.
- The Reform of the System of Research, Development and Innovation of the Czech Republic.

B. Law

- Act No. 458/2000 Coll. — on the conditions of business and the role of state administration in the energy sectors, and on the amendment of certain laws (Energy Act).
- Act No. 240/2000 Coll. — on crisis management and on the amendment of certain acts (Crisis Act), as amended by Act No. 320/2002 Coll.
- Act No. 241/2000 Coll. — on economic measures for crisis situations, and on the amendment of some related acts, as amended by Act No. 320/2002 Coll.
- Act No. 222/1999 Coll. — on the defence of the Czech Republic.
- Act No. 239/2000 Coll. — on an integrated rescue system.
- Act No. 238/2000 Coll. — on the Fire Brigade of the Czech Republic.
- Act No. 133/1985 Coll. — on fire protection (the full text was published as No. 67/2001 Coll.).
- Act No. 254/2001 Coll. — on water (Water Act).

- Act No. 258/2000 Coll. — on the protection of public health.

C. Others

- Decree of the State Material Reserves Administration No. 498/2000 Coll. — on the planning and implementation of economic measures for crisis situations, as amended by Decree No. 542/2002 Coll.
- Decree of the Ministry of Industry and Trade No. 219/2001 Coll. — on the procedure to be followed in the event of an imminent or present emergency in the electricity sector.
- Act No. 181/2014 Coll. — Cyber Security Law.
- Type plan for solving the crisis situation involving disruption of a large-scale power supply system.
- Type plan for solving the crisis situation involving disruption of a large-scale gas supply system.
- Type plan for solving the crisis situation involving disruption of a large-scale heat supply system.

Appendix 2

R&D Programs of the Czech Republic

The Establishment of a Doctoral Study Program on Smart Cities and Development of Research-focused Study Program at CTU FTS

The project has two main objectives: the development of Transport Systems and Technology in the Modernized Study Program, taking into account the needs of the practice; and the creation of the Smart Cities study program. Strengthening the doctoral studies at ČVUT FD means increasing the quality of the graduate courses of this study and boosting research, technological development and innovation in the field of transport systems, as an important science. It is necessary not only to innovate the existing doctoral study programs, increase the share of subjects taught in English, and make students' visits abroad compulsory, but also to introduce short-term and long-term internships, especially training at prestigious foreign workplaces, and enhance the quality of study by deepening cooperation with industry partners, especially with entities focused on technical innovation.

National Competence Center - Cybernetics and Artificial Intelligence

The NCK KUI project aims to create a national platform for cybernetics and artificial intelligence. This platform would interlink research and application oriented centers of robotics and cybernetics for Industry 4.0, Smart Cities, intelligent transport systems and cybersecurity. The connection of innovation leaders will raise the effectiveness of applied research in key areas, and reinforce advanced technology for globally competitive industry, ICT and transportation for the 21st century. NCK KUI is closely related to the application sector and enables cross-domain collaboration, innovation development and technology transfer.

SMARTCarPark - Surveillance Monitoring, Analysis and Re-identification of Traffic for Enhanced Car Parking

The aim of the project is to develop new functionality of a parking monitoring system using surveillance camera systems. The system will be implemented by monitoring and analyzing the movement of vehicles in the applicable area. The main goal is placed on the non-invasiveness of the proposed solution and on maximization of anonymous vehicle traffic monitoring only with the use of visual features without unambiguous identification of vehicles, i.e. with protection of personal data. By creating the proposed solution, it will be possible to make transportation and parking in cities more efficient.

Decision Support System of Urban Mobility and Intelligent Settlement Services Including Specific Needs of Individual Persons

The objective is to create software for the testing model of a multimodal planner while using participatory design methods. The software will be available for all types of users, including the handicapped, taking into account their specific needs, and will take into consideration all possible modes of transport and their combinations. At the same time, it will include as many points of interest as possible. The planner will be an open platform that can be used by other developers. The platform may also be used by the city and state administration once it is integrated into the relevant systems. The project thus provides missing products on the market.

Sustainable and Affordable Housing in Strategic Urban Planning

This project is for methodological anchoring of housing issues as the next pillar of strategic plans for settlements and smart city concepts alongside existing technological plans. The plan summarizes and describes the key determinants of sustainable and affordable housing; and describes the relationship between available housing and the competitiveness of settlements and regions, their economic and social sustainability and quality of life. Further, the plan defines the administrative and technological barriers to the availability of housing compared to the availability of housing in other contexts. The project study then designs a methodological framework for implementation in strategic city plans. It also has provisions to assess the potential of new economic instruments for housing support and make recommendations on financial and administrative tools.

Low-cost Sensors Application for Air Quality Measurements Relating to Urban Traffic Measures

The aim of the project is research and development of a system based on low cost sensors, which will be used for monitoring of air quality with adequate quality of produced data, reproducibility of measurement and robustness of the whole system, as a basis for ITS systems with subsequent adoption of transport measures to improve air quality. In this area, the project will produce a functional sample of the air quality measurement system. Another aim of the project is to develop a methodology for air quality measurements utilizing low-cost sensors in order to define their suitability for use, in connection with both location at the relevant sites and practical operation of the system. It will also include a procedure for processing of the data provided by the system.

Smart City Compass: Software Supporting Implementation and Evaluation of Smart Measures in Cities

The project's objective is to contribute to implementation and monitoring of the Smart City (SC) concept in the Czech Republic by developing a dedicated public SW tool known as Smart City Compass. The tool will have three main functions: (1) EDUCATE municipal staff; (2) GUIDE municipalities through the process of setting quantitative SC indicators; (3) help municipalities monitor and EVALUATE the progress of SC concept implementation. The project builds on existing methodology developed by CTU and CZGBC and focuses on the needs identified in consultation with Ministry of Regional Development. The key value added by the tool is the translation of the SC indicators into electronic interactive mode for simplification of the SC evaluation process. The tool will be ready in April 2021.

Logistics City Readiness Study on the Development of Courier Express and Parcel Services in Smart City Projects

The output of the project will take the form of a research study containing a certified, applicable methodology for assessing cities' logistics preparedness considering the growing importance of courier, express and parcel services in relation to the e-commerce economy. The project introduces the mapping of current or already implemented innovation principles in city logistics related to SC projects. Furthermore, it analyses the logistic process, based on implementation of courier, express and parcel services in economic, technical and legal terms and the classification of relevant measures on the basis of best practices from abroad. Within the distribution process, the project will define and analyse problem areas that require further development through implementation projects related to transport and transfer points within courier, express and parcel services.

Flow Analytics for Smart Cities

CityFlow will build wide-scale demographic databases based on how people move within a city. The project will provide operators of physical premises such as shops, shopping malls and even municipalities, with detailed demographic information on their customers without interfering with the customers' privacy. Using anonymous mobile phone location data collected by various sensors deployed citywide, CityFlow will be able to provide demographic analysis and footfall analysis, and provide information on activity patterns at specific locations (such as in shops or near advertisement signs) as well as information related to larger infrastructures such as public transport systems.

System for Implementing the Concept of Mobility as a Service in Practice

The aim of the project is to develop the Intermodal Planner with features to support the concept of Mobility as a Service and thus to support the implementation of this concept into practice in the Czech Republic. Three software will be developed – a Geospatial Model for intermodal planning, the Open Intermodal Route Search service and the Mobility Planner application for passengers. The SW will be available for all types of users including the disabled, taking into account their specific needs and all possible modes of transport and their combinations. The planner will be an open platform that other developers can use. The platform will also be used by municipal and state administrations to integrate the data into their systems. There is no similar solution on the market. Outputs will develop in 3 years.

Identification of Locations Vulnerable to Thermal Stress — Tool for Sustainable Urban Planning

The aim of the project is the development of a standardized, validated and transferable tool for the identification of locations vulnerable to Thermal Stress (TS) and the determination of their typology. The tool will contain a specific set of recommended adaptation measures for each type of vulnerable localities in the wider context of sustainable planning. At least three collaborating municipalities will be contracted and the following outputs will be shared: map of vulnerability to TS; map of classification of localities with high vulnerability to TS; guidebook for the classification of localities with high vulnerability to TS including sets of appropriate adaptation measures with an overview of the tools for their implementation. Furthermore, the products (maps and guidebook) will be offered commercially.

Attitudes of the Population of the Moravian-Silesian Region to the Use of the Internet of Things in Order to Develop the Concept of Smart Cities

The project aims to analyse the issues related to the deployment of technologies that increase competitiveness in handling problems and improve the quality of citizens' life on the site. The research strategy will be based on a combination of qualitative and quantitative sociological research among the region's population. It will link knowledge from multiple disciplines, and visualization of research data will provide representatives of region with information and model cases of technology deployment in the context of building a Smart City. Partial goals are to visualize data from research and publish it in the form of content maps in GIS applications in accordance with the requirements of the application guarantor, and to prepare electronic learning materials.

Livable Cities and Communities: Guidelines for Planning of Public Spaces in the Digital Era

The main goal of the project is to present Czech municipalities with certified methodologies with focus on planning specific and realistic measures for long-term improvements in the quality of public spaces based on analysis of specific conditions in a given municipality. The methodology will combine urban development, sociology, and social psychology, and address how spatial functions influence the satisfaction of citizens‘ needs and identify the elements that are instrumental to this. The methodology shall enable the municipalities to (1) make efficient use of modern technology during the needs analysis and spatial planning; (2) understand the inter-link between technology and public spaces; (3) reflect upon the context of metropolitan area and demographic change. Deliverables will be produced within 3 years.

Common Urban Values of Historic Towns in the Danube Region

The intended research project focuses on exchange of scientific methods and procedures for integration of values, quality of life and smart development potential in historic towns, which will be studied and assessed based on selected cities in the Danube region with similar historical, environmental and cultural background. The objectives include joint verification and adaptation of a complex innovative analysis on landscape, urban, architectural attributes of physical structure and composition of historic cities as well as their complementarity with cultural-civilizational and socio-economic activities and features. The project will naturally encompass research on practices related to management of long term sustainability of protected heritage values, which is seen as critical for active sustainment of a historic town's heritage essence and its authenticity. It will also focus on the design of innovative tools for safeguarding these features through the process of town planning, management and protection of cultural heritage.

Smart Rural Cities: Exchange of Best Practices with Focus on Effective Cooperation between Research and Public Sectors

The research on technologies and concepts applicable to the Smart Cities is still an evolving field in both the Czech Republic and Norway. The greatest weakness is the often undefined or missing link between research organizations and municipalities. This is especially valid for small and rural Smart Cities. Norwegian cities are at the forefront of Smart City implementation, but new models for collaboration are needed to make the Smart City development even more efficient. The prime objective of the proposed activities is to strengthen the collaboration between WNRI and CTU-UCEEB through sharing knowledge and best practices in channelling the research outputs in the field of Smart Rural Cities from the research institutions towards municipal policy-making. Both institutes share common research topics related to rural smart cities, working closely with municipalities with the number of inhabitants below 20,000. The project will enable development of a joint H2020 proposal for the EE-09 call focused on energy efficient policies of the public sector. Furthermore, both institutes will exchange know-how on joint projects in the field of Smart Rural Cities. For this purpose, an exchange of research and management staff from each of the partnering institutions took place in March and April 2017. Topical site-visits took place in Eid (NOR) and Bustehrad (CZE). The activities will contribute to the joint H2020 proposal and a report on applied research at the respective institutes related to Smart Rural City related topics.

Arrowhead

Our society is facing both energy and competitiveness challenges. These challenges are closely linked and require new dynamic interactions between energy producers and energy consumers, between machines, between systems, and between people and systems. Cooperative automation, enabled by the technologies developed around the Internet of Things and Service Oriented Architectures, is the key for these dynamic interactions. The objective of the Arrowhead project is to address the technical and applicative challenges associated with cooperative automation: provide a technical framework adapted in terms of functions and performances; propose solutions for integration with legacy systems; implement and evaluate cooperative automation through real experimentations in applicative domains such as electro-mobility, smart buildings, infrastructures and smart cities, industrial production, energy production and energy virtual market; point out the accessible innovations thanks to new services; and lead the way to further standardization work. The strategy adopted in the project has four major dimensions: an innovation strategy based on business and technology gap analysis paired with a market implementation strategy based on end users' priorities and long term technology strategies; application pilots where technology demonstrations in real working environments will be made; a technology framework enabling collaborative automation and closing critical technology gaps; a coordination methodology for complex innovation "orchestration"

Autonomous System for Detecting Dangerous Traffic Situations based on Image Sequence Analysis

The main goal of the project is the research and development of a modern autonomous system for the detection of dangerous traffic situations. The proposed system takes advantage of a camera module that detects vehicle trajectories, and based on the knowledge, it evaluates dangerous situations in real time. If a dangerous situation occurs, the system forwards the information for further processing. The processing is based on adaptation of the variable traffic signs and may also include procedures for possible driver punishment. The important part of the proposed system will be the statistical evaluation of the traffic load including elements such as the number of intersection crossings in the individual directions, the average speed at intersection in a particular time horizon, the frequency of vehicle categories according to regular expressions and others. The system will also allow monitoring of the local environment by measuring physical quantities (temperature, humidity, air quality, etc.). The partial goal is research and development of advanced software that detects traffic violations and processes statistical data from the traffic section. Modern cryptographic methods will be used to secure data transfers. The aim is to ensure a high level of system security according to the latest recommendations to provide protection against cyber attacks. The system is in line with the objectives of intelligent specialization vehicles for the 21st Century: automotive maintaining of road safety and improving the processes and services for intelligent transport systems. The methods developed for advanced image processing and secure telematics and secure data collection can be further implemented in other technologies such as Smart Cities, Industry 4.0 and Smart Society.

The Tools for Reducing the Personal-transport-related Energy Consumption of Smart Cities

The goal of the project is to develop tools to support decision making in town and country planning with the aim of decreasing the energy consumption of personal transport in relation to the spatial arrangement of settlements. The tools will allow evaluation of alternative spatial development scenarios. The results will enable decreasing energy intensity of personal transportation by means of policy measures implemented in the districts. These tools will supplement other tools for decreasing transport energy consumption, which are focused mostly on increasing energy efficiency of vehicles and support of environment-friendly means of transport (see the SETIS project as an example).

Developing Analytical Framework for Energy Security: Time-Series Econometrics, Game Theory, Meta-Analysis and Theory of Regulation

The aim of this project is to develop and apply economic methods suitable for basic research on energy security, which has been so far analysed mostly as a political issue and not as a problem with complex economic fundamentals. This project therefore represents an original research of the economic factors that determine energy security using methods usually employed in other fields of economics, such as quantitative finance models, the theory of regulation, meta-analysis, or game theory. The research results are expected to pave the way for the creation of a consistent set of economic methods suitable for the evaluation of energy security.

Cyber Security for Cross Domain Reliable Dependable Automated Systems

The high-level goal of SECREDAS is to develop and validate multi-domain architecting methodologies, reference architectures, components and suitable integration and verification approaches for automated systems in different domains, combining high security and privacy protection while maintaining functional-safety and operational performance.

An Analytical Software Module for the Real-time Resilience Evaluation from the Point of View of Converged Security

The project defines converged security management based on the coordination between physical and cyber security managements. The SW application OSM (Online Security Manager) using a resilience parameter will be created to evaluate converged security with the functionality for prediction of events or incidents. Results of the project will be generally useful in estimating the behavior of any monitored systems in the field of physical and cyber security management or business continuity management.

Reduction of Security Threats to Optical Networks

The project is focused on research, design and development of an active network element and a hardware FPGA network card, which enable effective analysis of the transmitted data structures in an optical network in real time, based on xPON standards. It brings innovation in the field of security and introduces the possibility of analysis frameworks GPON G.984, G.987 NG-PON and NG-PON2. This new system will help to improve the security of critical infrastructures and metropolitan networks.

Deep Hardware Detection of Network Traffic in Next Generation Passive Optical Network for Critical Infrastructures

A neglected component of critical infrastructures at present is the rapidly evolving passive optical network of the XG-PON type, which gradually, according to business analyses, replaces GPON networks. The goal of the project is to research, design and develop an active FPGA network device that allows deep detection of transmitted data structures in the XG-PON network for 10G speeds based on the XG-PON transmission protocol and an API interface for automatic reports.

The research objective is to develop large-scale similarity-based technologies suitable for Internet multimedia object analysis based on face recognition.

The specific goals of the project are: 1. a generic multimedia portal with face recognition similarity search capabilities; 2. extension of CY-HUMINT for face recognition similarity search capabilities through newly developed Application Programming Interfaces

Experimental Research on Individual Responses to Threats in Cyberspace

The project will summarize the results of experimental research, which will examine emotional responses of individuals to cyber threats. Special attention will be given to the differences between the perceptions on conventional and cyber threats. The outputs of the project will be three comprehensive research reports dealing with: 1) the differences between individual responses to cybernetic and conventional threats; 2) guidelines for increasing public resilience to cyber threats; and 3) analysis of emotional responses to cyber threats in a population of cyber security experts. Another Jrec result will be prepared, summarizing the methodology. The project is proposed with a three-year timetable for investigation, and will be carried out in close cooperation with the application guarantor, NÚKIB.

Adaptive Control of Data Collection and Analysis in High Speed Networks (FOKUS)

The aim of the project is to create and evaluate a complex system that will allow higher detection rate for security threats and enable acquisition of higher quality data in high-speed computer networks. The goal will be achieved by introducing a feedback loop from detection systems to probes. Detection systems will be able, based on advanced data analysis and threat detection, to command probes to perform more detailed analysis of a selected portion of traffic, such as that of a specific IP address. Probes will, based on request, perform additional processing, e.g. application protocol analysis, signature matching, capture of full packets and their handover to the collector, and storage of traffic for the purpose of lawful interception or forensic analysis. It is infeasible to perform these tasks over the whole traffic due to performance reasons. The project will focus on the fastest current and near-future networks. The aim is to create a system capable of gathering data from the network at 400 GB/s, which is a future standard. The technology will be evaluated by a pilot deployment in the CESNET e-infrastructure.

The Critical Infrastructure Component and Sector Resilience Evaluation System

The aim of this security research project is to conduct research in the area of critical infrastructure components and resilience evaluation of the chosen critical infrastructure sector networks. Presently, the research area is in progress. For adoption of effective, quantifiable and evaluable measures, it is necessary to create a theoretical appliance and knowledge base. In the next stage, it is necessary to conceive an evaluation methodology, method, mathematical appliance and software application, in order to enable responsible entities form effective decisions in the area of Critical Infrastructure.

Threats to Critical Infrastructure

This task specifies and elaborates on ebene menaces, which are threating critical infrastructure in a civil context. It is offering advancements for elimination and practical resolutions of the threats.

Security of DNS Servers in the Czech Republic

The project aims to contribute to a higher level of security and protection of DNS (Domain Name System) as a key part of critical information infrastructure and the internet.

Appendix 3

Specific Projects related to Cyber Security Issues (Czech Republic)

C4e: CyberSecurity, CyberCrime and Critical Information Infrastructures Center of Excellence (www.c4e.cz)

The CyberSecurity, CyberCrime and Critical Information Infrastructures Center of Excellence (C4e) connects research teams at Masaryk University and carries out research on complex issues in the cyberspace. C4e focuses primarily on research into the technical and non-technical aspects of cyber security under the three pillars of cyber security, the security of critical information infrastructures and related legal issues.

The purpose of C4e is to connect expert academic institutions to collaborate in the field of research and development within the research framework of cybersecurity, protection of critical information infrastructures and law, and facilitate the implementation of excellent multi-disciplinary research. The knowledge and experience gained through research activities are used in the form of continuing education. C4e's collaboration with many public and private actors also leads to a much closer link between research activities and practice.

National Cybersecurity Competence Center (www.nc3.cz)

The National Cybersecurity Competence Center has been established in response to growing demands for practically applicable products and solutions for ensuring the cybersecurity of critical and noncritical information infrastructures.

The centre connects excellent research departments and representatives from long-operated industries focused on cybersecurity, to accomplish collaborative research, develop technical solutions in cybersecurity at the levels of hardware and software, and to strengthen certification mechanics for safety attributes of technological products.

In cooperation with industry partners, the centre endeavors to apply the developed solutions to the still nascent cybersecurity market. This will empower Czech industry and research on the European and global level.

Cybersecurity Innovation Hub (www.cybersecuritydih.cz)

Cybersecurity Innovation Hub is a non-profit network organization that creates a multidisciplinary ecosystem of research institutions, governmental bodies, clusters and private companies focused on cooperation, information sharing, research and implementation of cutting-edge technologies in cybersecurity.

The key features of the hub are its multidisciplinarity, its cooperation with a wide range of national and international, and public and private institutions, as well as the possibility of utilizing unique infrastructures. Partners involved in the operation of the hub retain experts dealing with cybersecurity issues not only from a technical perspective but also from procedural, organizational, legal, economic and sociological points of view.

The hub also cooperates with and provides support to a variety of national public authorities (such as the National Cyber and Information Security Authority, Ministry of Justice, Czech Police, and Data Protection Authority), international institutions (ENISA, Europol and United Nations), private clusters, trade organizations, scientific parks, and private corporations. As some of the partners of the hub are research organizations and innovative companies, the hub can utilize their research, development and production infrastructures (i.e., cyber ranges, training facilities, security operations centres, proving grounds or testing infrastructures).

The hub is coordinated by the National Centre of Competence on Cybersecurity, which is governed by its Board that consists of representatives of key private and public stakeholders in cybersecurity in the Czech Republic.

KYPO Cyber Range Platform (www.kypo.cz)

KYPO is a cyber-range designed as a cloud platform, which facilitates maximum flexibility, scalability, and cost-effectiveness.

The KYPO is designed as a modular distributed system. In order to achieve high flexibility, scalability, and cost-effectiveness, the KYPO platform utilizes a cloud environment. Massive virtualization allows KYPO to repeatedly create fully operational virtualized networks with full-fledged operating systems and network devices that closely mimic real world systems. Thanks to its modular architecture, KYPO is able to run on various cloud computing platforms, such as OpenNebula, or OpenStack. Significant amounts of development effort have been dedicated to user interactions within KYPO since it is planned to be offered as Platform as a Service. It is accessed through web browser in every phase of the life cycle of a virtualized network: from the preparation and configuration artefacts to the resulting deployment, instantization and operation. It allows the users to stay focused on the desired task whilst not being distracted with efforts related to the infrastructure, virtualization, networking, measurement and other important parts of cyber research and cyber exercise activities.

CONCORDIA – Cyber Security Competence for Research and Innovation (https://www.concordia-h2020.eu)

CONCORDIA is one of the four projects established as an appeal of the EU's Horizont 2020 that deals with cybersecurity policies in the EU. The four-year project Concordia started in January 2019 to connect cybersecurity competencies throughout Europe and build an ecosystem of cybersecurity. Its outcomes are expected to lead to the strengthening of European cybersecurity and digital sovereignty. The central coordinator of the project is the research facility CODE from Bundeswehr University Munich.

Information and communication technologies are necessary for the development of Europe. Key aspects of development are an approach for re-evaluation of cybersecurity and cooperation.

In the field of cybersecurity of the EU, one may find different areas of research, competencies, and projects, but most of them are saddled with local priorities and standpoints. This has an adverse impact, such as fragmentation and lack of coordination on the potential. CONCORDIA´s target is an integration of these various competitions into the European-wide network with experts' support.

This leads to the creation of a constantly growing consortium consisting of 46+ significant partners from the industrial and academic sector. Integration of competencies between these entities is expected to establish the foundations for a European-wide cybersecurity ecosystem. Project Concordia creates a plan for the next stage of European cybersecurity's progress. This shows the effort for utilizing the European potential in this area, continuing with more project activity from research, education, politics, development, and testing pilot prototypes.

Masaryk University is a member of the consortium for project CONCORDIA, which also has specific experts from Czech centrum excellence for cyber criminality C4e and team cybersecurity CSIRT-MU as associates. These members participate in research in the area of technological cybersecurity questions, education, and law. The project also significantly uses

Platform KYPO. Masaryk University has a leading position in the area of communication, dissemination of knowledge, and facilitates outcomes of impact pursued by all consortia.

CyberSec4Europe (https://cybersec4europe.eu)

CyberSec4Europe's vision is a European Union that possesses all the skills necessary to secure and maintain a democratic society aligned with European constitutional values, particularly regarding the protection of shared data and privacy. The CyberSec4Europe consortium consists of 43 partners from 22 member states of the European Union and associated countries dedicated to research, development, and testing in the field of cybersecurity.

The CyberSec4Europe project connects the expertise and experience of the involved parties, mainly through testing and demonstration of management structures for networks of competence centers. It also plays an essential role in addressing key EU directives and regulations such as GDPR, PSD2, eIDAS, and ePrivacy, implementing the EU Cyber Security and Development Act, and specifying the role of the European Network Cybersecurity Agency (ENISA).

CyberSec4Europe contributes critical knowledge and experience from research and projects to the EU's cybersecurity sphere. The comprehensive knowledge base of the project also offers practical solutions to cybersecurity problems. Europe's role as a pioneer in researching, developing, and addressing cybersecurity issues is realized by the project consortium consisting of non-profit research institutions, university laboratories, multinationals, and small and medium-sized enterprises in the economic sector. The consortium's capabilities and reach allow the participants to establish a broad governance structure and expand research into cybersecurity.

The role of Masaryk University is to develop open-source tools to support cybersecurity education, software testing, and certification of hardware and software products.

SAPPAN – Sharing and Automation for Privacy-Preserving Attack Neutralization (https://sappan-project.eu)

The SAPPAN project was established as an appeal of the European Union's Horizon 2020 (H2020) to solve cybersecurity issues within the European Union. The implementation of the four-year SAPPAN project was launched in May 2019 with the aim of effectively protecting ICT infrastructures from cyberattacks. Pursuing a safer virtual environment, the project relies primarily on threat analysis, advanced data collection techniques, and collaboration across institutions, particularly in terms of sharing security information and experience. It places great emphasis on maintaining the privacy of all stakeholders.

ICT infrastructures are facing an ever-increasing number of security threats, and hence there is a strong need for capabilities to respond adequately. The appropriate response is often based primarily on knowledge of the technical and organizational aspects of the attack itself. To this end, the SAPPAN project will develop a system for collaborative and federated detection of cyberattacks, enabling a swift and effective response to security threats.

SAPPAN will contribute to the protection of ICT infrastructures by proposing a standard, including a procedure for responding to cyberattacks and measures necessary to relaunch the affected system. Based on the standard, it will be possible to develop a fair and comprehensive set of knowledge and responses to security incidents through automated handling of incidents, and through facilitating the sharing of knowledge and experience in cybersecurity threats.

The SAPPAN project consortium is formed by partners from the academic and industrial sectors, maximizing the social impact and effectiveness of the results. Specifically, the research institute Fraunhofer-Gesellschaft, the national research and education network CESNET, the multinationals Hewlett Packard Enterprise, F-Secure Oyj and Dreamlab Technologies AG are partners. Academic representation is made up of Masaryk University, RWTH Aachen University and Universität Stuttgart.

Masaryk University, namely the CSIRT-MU cybersecurity team, contributes to the project with its experience in the field of cybersecurity incidents, processing of large amounts of data and detection of attacks and anomalies at the local level. The CSIRT-MU team also provide its expertise to identify relevant inputs and threat mitigation processes.

National Cybersecurity Workforce Qualification Framework

The aim of the project is research focused on creating a universal and holistic framework of qualifications in the Czechia in the field of cyber security. The framework will classify individual professional roles of cyber security workforce, describe the required knowledge, skills and abilities, and will serve as a single basis for capacity development in this area in the Czechia. The Proposed Action Plan and software will allow the use of the framework in the training and recruitment of workforce.

At present, it is clear that there is a lack of human resources in the area of cyber security, which is not only noticeable in the Czech Republic. This situation affects security not only in individual organizations, but also the overall security situation of the state, which, without the necessary professional capacities, is not able to effectively protect its cyberspace. Building these capacities is dependent on the availability of appropriate training. However, the currently available cyber security education (including areas of cyber defense and cybercrime) is fragmented and only partially covers existing needs.

Therefore, the current trend is the development of cyber security education based on an analytical assessment of the extent of human resources needed in each position, and the identification of the appropriate scope and level of education for these positions. Examples of this approach are the NICE Framework in the US, the ACM CSec curriculum, and the ICT framework in general.

The aim of the project is therefore to carry out research focused on description and categorization of individual qualifications in the field of cyber security, identification of necessary capacities in individual qualifications, proposal of the expected level of their knowledge and abilities, analysis of available education in the Czech Republic in the field of cyber security and designing new content for cyber security education programs. The contribution of the project for security practice will be primarily to develop a holistic view of the human resources needed in cyber security and to provide educational institutions with guidance on the development of the necessary training programs with a view to meeting the identified demand. This will increase the availability of cyber security expertise and, as a consequence, improve the security situation at organizational and national levels.

Legal and Organisational Model of Certification under the EU Cybersecurity Act

The subject of the project is a comprehensive solution to the functioning of the national cyber security certification authority. Within the project, a hypothetical model of the certification authority's functions will be proposed and, on the basis of this, a specific solution of the partial functionalities will be created in the form of an experiment. The project team will focus on the institutional organization of the certification authority, the identification and legal assurance of certification capacities (in particular in the form of unnamed contracts), the internal regulation of certification processes (including the implementation of certification schemes), legal treatment of the original outputs of the certification authority (including autonomous definition of schemes that are outside of the scope of specific legal regulations, such as in the area of autonomous technologies, personal data protection, authentication, etc.) and the basic compliance mechanisms of the certification authority. The project foresees that the rights to the outputs of the project, i.e. the various types of documentation, will be exploited economically in the form of a licensing.

System Architecture for Secured Real-Time Monitoring of Energy Grids

The project deals with the field of energy management and monitoring systems for transmission system operators and their cooperation. These systems are now being developed as individual solutions without a standardized architecture and without accurately determining accessibility, reliability and cybersecurity requirements. Unlike conventional information systems running exclusively on the IP network, industrial real-time protocols such as ICCP-TASE.2 are used, and there is no comprehensive methodology or procedure for verifying the reliability characteristics and cybersecurity, even though they are already deployed on a large scale and in critical infrastructures such as electricity transmission systems. Due to the novelty, uniqueness and individuality of the whole area, and the lack of standard solutions on the market, it is not clear what architectures and individual data processing technologies are suitable for robust balancing, management, billing and trading systems with real-time communication, from the perspective of reliability, scalability and security.

The project has two main parts: architectures and communications in the transmission system monitoring systems. The first part refers to the architecture of systems for the monitoring of transmission grids with the main focus on the real-time communication module for receiving and processing of data and reliability and cybersecurity characteristics of communication used in energy environments including SCADA. The second part will be devoted to the design and implementation of a testbed for verifying the communication among systems used in the energy sector. The testbed will be composed of novel testing methodology, a traffic generator based on energy-sector-specific communication protocols and the functional sample realizing the testbed. The testbed will be usable for proper verification of the software system's functionality to receive and process large real-time data with specific distribution (i.e., by error simulation).

Secure Power Flexibility for Grid Control and Market Purposes (SecureFlex)

The project focuses on the development of analytics, computation and optimization tools and specialized research reports, which will lead to the development of systematic energy solutions for secure utilization of power flexibility, enabled by new technologies and market stakeholders' integration into the Czech Republic's energy domain. The support tools, developed in cooperation with system operators, will have significant potential for real-world deployment. They will also provide a systematic solution for utilization of power flexibility in the market and power networks mechanisms of the Czech Republic. The project's timeline is in line with the expected middle-term schedule of the Fourth Energy Package implementation (winter package), where there is a lack of suitable support tools.

Appendix 4

TACR and TPEP: Two Key Organizations of the Czech Republic in Energy and Energy Security

TACR - Technology Agency of the Czech Republic

The Technology Agency of the Czech Republic is an organizational unit of the state that was founded in 2009 by the Act No. 130/2002 Coll. on the Support of Research, Experimental Development and Innovation. The creation of TA CR is one of the cornerstones of the fundamental reforms in Research and Development (R&D) in the Czech Republic. A key feature of the reform is the redistribution of financial support from the national budget. The Technology Agency of the Czech Republic simplifies the state support for applied research and experimental development, which have been fragmented and implemented by many bodies before the reform.

In accordance with the Act No. 130/2002, activities assigned to TA CR are:

- Preparation and realization of its own programs of applied research, experimental development and innovation; and realization of programs from various governmental departments without public financial support;
- Evaluation and selection of program proposals;
- Administration of functional financial support for applied research from the national budget;
- Control of the fulfilment of project contracts;
- Evaluation of the fulfilment of program objectives control of their results;
- Counseling (legal, financial and IPR) for programs and projects of applied research, experimental development and innovation,
- Communication support between research organizations and the private sector;
- Negotiations with institutions in the Czech Republic and the European Union in terms of permitted public support for applied research and innovation; and
- Cooperation with similar foreign institutions.

TPEB - Energy Security Platform

The Energy Security Platform was formed in October 2011 in attendance of public administration bodies and municipalities within the Economy Committee of the parliament of the Czech Republic. It is a unique PPP project in the Czech Republic.

The TPEB CR founding members are on the one side leading private energy companies; companies administering energy distributing networks and energy lines; mobile phone operators; software and communication companies; and leading research centres. On the other side, the public sector is represented by representatives of the establishment, namely the Ministry of Interior and Ministry of Industry and Trade, universities and top experts as well as companies focusing on security, both cybernetic and physical, including companies providing security guard services for both building and physical persons.

At present membership is growing and the platform is facilitating intensive cooperation with all entities for which the membership or services of technological platform may be an asset.

The Mission:

- The mission of TPEB CR is to establish a scientific-research and industrial platform, the aim of which is to support activities relating to research, development and introduction of new technologies ensuring protection of critical infrastructure in the areas of energy industry and cybernetic.
- TPEB CR defines, represents, and speaks in support and advocates legitimate and joint interest of its members in the area of research, development and application of modern technologies that raise the level of energy and cybernetics security.
- TPEB CR contributes to mutual coordination of activities and strengthens the awareness of public administration bodies, research and development entities and security technology suppliers. These activities are carried out in connection with both EU and CR programs, related to the financial and as well legal regulation of CR and EU.
- Allows direct participation and options for joint enforcement of particular technological, standard-setting, and legislative matters in the EC advisory bodies.
- A Cyber Act was already accepted in the Czech Republic. This is associated with a number of implementing rules and regulations impacting the operation of institutions and companies.
- In cooperation with the Ministry of Industry and Trade (Czech Office for Standards, Metrology and Testing), the TP may, upon request, initiate the establishment of a Special Working Group on certain issues within the scope of the EC organizations. A company or its experts may serve as the process leaders.
- Utilizing direct communication (formal as well as operational) between the TP and

the Ministry of Industry and Trade of the Czech Republic, the “Task Force” serves as a mechanism for making comments and suggestions in the areas that the TP covers. The same applies to its relationship with the Ministry of Interior where the same mode has been established.

Based on the requirements and needs, the TP will mediate communication with EC bodies and institutions or with particular prominent representatives of these institutions.

Appendix 5

CNS Key Products

Safety4Transfer

The value of a trusted relationship, whether in a private conversation, a critical moment of need, or protecting assets, cannot be underestimated. We develop relationships and communicate in a unique way; secure data is very much akin to this. When we transfer data, it must be as safe as a precious cargo. If we establish a peer to peer relationship, with a toolset that guarantees secure file transfer, we can substantially protect files and data. Imagine a cyber-approach where the user can increase protection in five minutes - one where the user establishes a trusted peer relationship and extracts files from a trusted place for both parties. It functions like an armored truck.

Safety4Transfer is a data encryption and transfer application that relies upon a secured, peer-to-peer virtual network that allows users to confidently exchange data with anyone in their network. The client software manages four layers of security. From 1) Initial Encryption to 2) HTTPS Transport to 3) Public Key Infrastructure to 4) Peer Authorization, every file is secure from the moment of release to the moment of acceptance. A simple client install provides the first best step to prevent cyber threats.

In addition, the company just finished a development of two new products in cooperation with the Technical University of Brno. Both of these projects were partially supported by the EU funds and by the Ministry of Interior of the Czech Republic. Currently, the company is in the commercialization phase with:

S4T-Pro — S4T-Pro adds a new layer of security with encryption method NOTEZA based on the Vernam cypher into the current Safety4Transfer infrastructure. With this new method, senders can choose multiple transfer grants for encryption purposes. The method guarantees an unbreakable transfer.

NOTEBAR is a technology solution for archiving of electronic documents, enabling secure and long-term archiving of these documents. The application offers 100% security of archived documents against unauthorized access by entities including storage operators and providers. Furthermore, the application will ensure reduction of individual failure risk through the cooperation of more than one person. This in turn redefines the minimum number of people necessary to access the archived document, and in particular enhances the possibility of obtaining a duplicate for a damaged (destroyed) electronic document. The technology for archiving is, again, based on the unbreakable Vernam Cypher and the company's encryption method NOTEZA.

NOTEBAR solution protects the most sensitive documents that contain companies' know-how. The potential loss or misuse of these documents could negatively affect a company's profitability, reputation, and market position, and in case of government organizations even the security of states and citizens.

03

CHAPTER

Policy Instruments Supporting Innovation in Services: Policy Implications for Korea and V4 Countries

Siwook Lee (KDI School of Public Policy and Management)
Marzenna Anna Weresa (SGH Warsaw School of Economics)
Arkadiusz Michal Kowalski (SGH Warsaw School of Economics)
Marta Mackiewicz (SGH Warsaw School of Economics)

Keywords
Tertiarization, Innovation in Services, Knowledge Intensive Services, Servicification of Manufacturing, Fintech, Regulatory Sandbox.

Policy Instruments Supporting Innovation in Services: Policy Implications for Korea and V4 Countries

Siwook Lee (KDI School of Public Policy and Management)
Marzenna Anna Weresa (SGH Warsaw School of Economics)
Arkadiusz Kowalski (SGH Warsaw School of Economics)
Marta Mackiewicz (SGH Warsaw School of Economics)

Summary

Tertiarization–the structural shift of an economy toward the service sector–is arguably one of the most salient features for the global economy over the last several decades. There has been an overall increase in the share of services in GDP at all levels of income after 1970s., Taking various socio-economic factors into consideration, including higher income elasticity of services compared to manufacturing goods, the ongoing rapid aging of the population, more participation of women into labor market, and the advent of the 4th Industrial Revolution, and so on, such a trend is expected to continue in the future.

The 4th Industrial Revolution, in particular, would invite a tremendous transformation of the production and consumption processes within the global economy. These processes become more intelligent and closely interacted, vis-à-vis up-surging information technologies, such as the Internet of Things, big data, and artificial intelligence, and result in an increased complementarity between the manufacturing of goods and the provision of services. These all imply that innovative capacity in services will play a critical role in shaping industrial competitiveness of an economy in the future.

As Poland is entering into the mature stages of economic development, strengthening innovative capacity emerges as one of the most important tasks for the Polish economy to maintain its growth momentum over the medium to long term. Recognizing that higher innovation is closely connected with a stronger role for service sectors in an economy, Poland's Strategy for Responsible Development (2017) highlights the importance of knowledge-based service sectors in enhancing overall competitiveness.

Korea has often been recognized as a dynamic country in which innovation capacities develop quickly. As of 2017, the proportion of R&D expenditure to GDP in Korea reached

4.55%, which is the highest level in the world. However, most of Korea's innovation activities have been centered on manufacturing, and innovation in the service industry is being hindered.

In this context, as a part of the 2019-20 KSP with the Visegrad Group, this study examines at the current status of the service sector both in Poland and Korea, with a special attention to the knowledge intensive business services (KIBS hereafter). The most binding obstacles that hinder the development of these sectors are also identified for each case. Based on these analyses, effective policy options that can boost service innovation are discussed from two countries' experience.

We find that the service sector, both in Poland and Korea, particularly the knowledge intensive services, is still less developed and less innovative in comparison with average EU countries. The most important barriers to innovation in services seem to be a lack of appropriate financing, regulatory burden, policy bias in favor of the manufacturing sector and a lack of qualified personnel. In this respect, this study emphasizes the importance of policy measures to reduce policy discriminations towards the service sector, improve access to finance for the service firms, eliminate excessive regulatory burden, and promote ICT utilization.

1. Introduction

In the past, the service sector was perceived as less innovative than industrial production and was regarded as a sector that played a rather supportive role in the innovation system (OECD, 2005, p. 10; Howells, Tether, Uyarra, 2007, p. 144). However, in recent years important changes in the nature of services have been observed. Nowadays services are regarded as major users of information and communication technologies (ICTs), their research intensity has been growing, and they have also become more tradable than in the past. These changes also have an impact on innovation processes in the service sector.

There have been many attempts in the economic literature to describe innovation within the services sector, however there has been a common understanding among scholars that innovation in the service sector differs from that in manufacturing. Alarcóna, Aguilarb and Galánca (2019) offer an overview of the theoretical framework explaining innovation in the service sector. The evolution of different concepts starts from an assimilation approach, which assumes that innovation in services is related to the adoption and use of new technologies, in particular ICTs. Barras (1986; 1990) developed the reverse product cycle model, which focuses on non-technological innovation and proves the interactive nature of innovation processes. The starting point of this reverse cycle is an improvement in the delivery of existing services, which brings efficiency gains and leads to innovations that improve service quality. As a result, new types of services (i.e. product innovations) are introduced (Barras, 1990). However, as Gallouj and Savona pointed out (2010, p. 34) the reverse product cycle model can be considered as an extension of the assimilation approach as it identifies the adoption of ICTs as one of the main drivers of innovation in services. Therefore, innovations in ICT services seem to be important for innovating in other service industries and should be studied in depth.

It also should be observed that as a result of the digital revolution the nature of innovation has been changing, and the focus of the innovation processes moving towards services, which are increasingly integrated with manufacturing. Furthermore, innovation becomes more and more data-based and innovation cycles are shorter and faster with the growing role of new forms of collaboration (OECD 2019, pp. 26-35).

Although the companies in the service sector are, in general, less likely to innovate in comparison with manufacturing firms, the sector is becoming more innovative and knowledge-intensive, and it is of growing importance for international competitiveness of the national economies. However, innovation policy measures in many countries have been less attuned to the service sector in comparison with manufacturing.

Considering the changing global environment, which impacts on the nature of innovation in both manufacturing and services, the main objective of the project is to evaluate the level of innovativeness of Polish service sector, and to formulate recommendations for designing policy instruments in this area.

Recently Poland has experienced strong economic growth with sound macroeconomic conditions. Catch-up with average living standards in other OECD countries has been continuing. As Poland is entering into a mature stage of economic development, strengthening innovative capacity emerges as the most important task for the Polish economy to maintain its growth momentum over the medium to long term. Recognizing that higher innovation is often connected with a stronger role of the service sectors in an economy, Poland's Strategy for Responsible Development (2017) highlights the importance of knowledge-based service sectors in enhancing overall competitiveness.

On the other hand, Korea has been recognized as a dynamic country in which innovation capacities develop quickly. As of 2017, the proportion of R&D expenditure to GDP in Korea reached 4.55%, which is the highest level in the world. The European Commission recently evaluated Korea as an innovative leader in the world and has an increasing performance lead over the EU (European Innovation Scoreboard, 2019). At the same time, however, most of Korea's innovation activities have been centered on manufacturing, and innovation in the service industry is being hindered.

In this context, as a part of the 2019-20 KSP with the Visegrad Group, Poland proposed a joint study with Korea on policy measures to enhance innovation in services. The Government of Poland is particularly interested in promoting the knowledge-based business services (KIBS hereafter) sector in preparation for the 4th Industrial Revolution era. In this study, we will look at the current status of KIBS in both countries and identify obstacles that hinder the development of these sectors. Based on this analysis, we will then propose government support policies that can boost service innovation in the future.

Specifically, this paper addresses following research questions in the cases of Poland and Korea:

- What is the level of knowledge-intensity of the service sector?
- What is the role of knowledge intensive services, and in particular knowledge intensive business services in the economy?
- How has innovation performance of ICT services evolved?
- What are the most important barriers to innovation in the service sector that should be addressed by supporting innovation in services?
- What are innovation policy measures that should be implemented to foster innovation in services?

2. Innovation in Services: the Polish Case

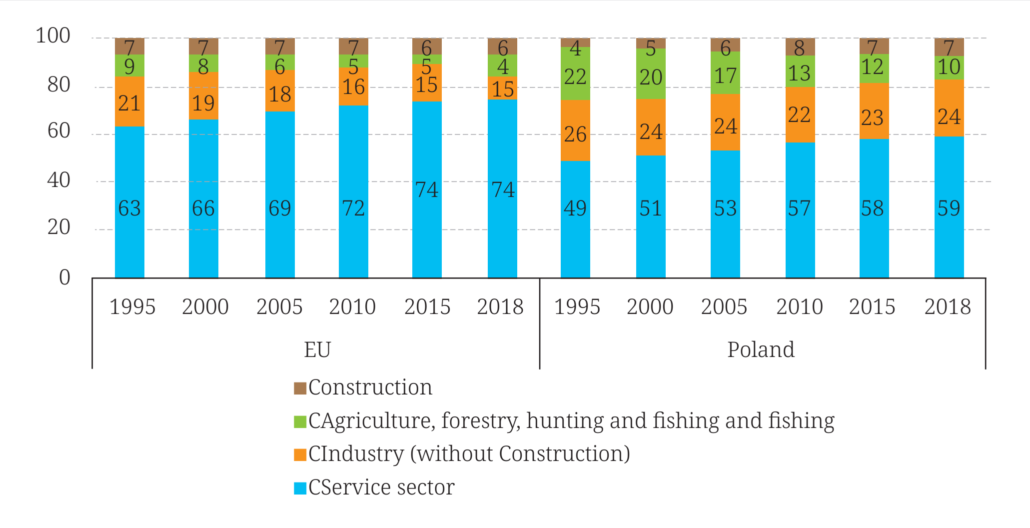
2.1. Overview of the Service Sector in Poland

Together with socio-economic development, the importance of the service sector in an economy has been increasing, reflecting the long-term evolution of the employment or GDP structure. However, the legacy of the centrally planned economy in Poland has caused not only a developmental distance from Western European countries measured in terms of GDP per capita, but also a marginalization of service activities. The evolution of the role of services in an economy can be seen in the share of the service sector in GDP and in employment, as presented in [Figure 3-1].

Since 1995 the share of the service sector in employment in Polish economy increased from 49% in 1995 to 59% in 2018, but it was still below the EU averages (64% in 1995 and 74% in 2018, respectively). The comparison of the long-term changes in the share of service sector in employment in the economy, as shown in [Figure 3-1] also confirms that services are relatively less important for Poland than for the whole EU economy. Since 1995 the share of the service sector in total employment in Poland grew by 10 percentage points. In 2018 it reached 59% in Poland while in the EU it was 74%.

[Figure 3-1] Share of Employment in Poland and EU

(Unit: %)

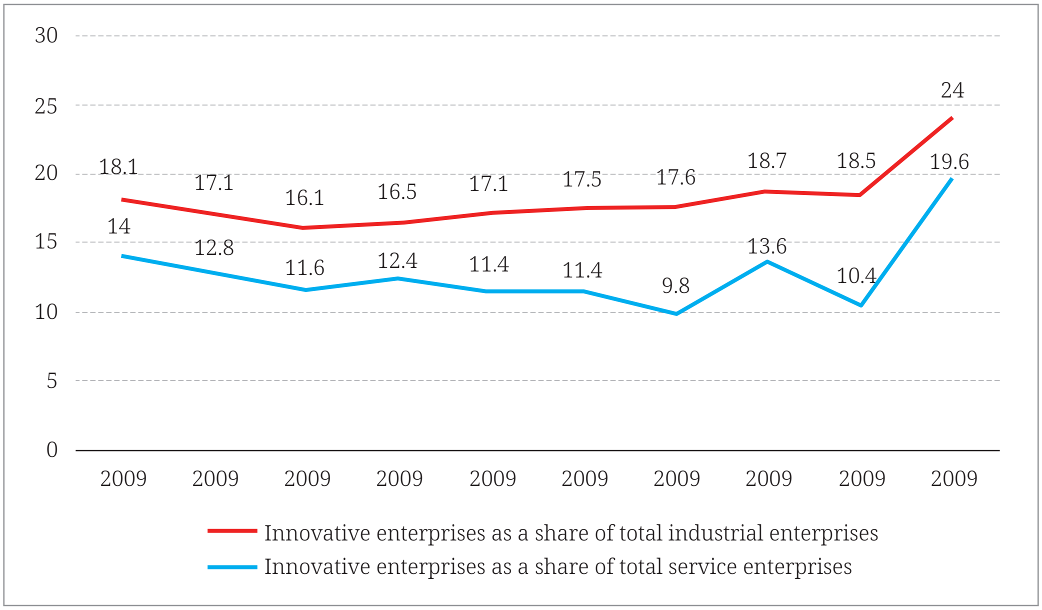


Source: Author's own calculations based on Eurostat data.

According to the Flejterski, Panasiuk, Perenc and Rosa (2005), the development of service sector is accompanied by changes in the structure of that service by type of activity, with a shift from simple services to services requiring higher qualifications and based on higher technologies. On the other hand, the empirical literature shows (e.g. OECD 2005; Gallouj, Djellal 2011; Metcalfe, Miles 2012) that service-sector firms in general are less likely to innovate than manufacturing firms, but they are becoming progressively more innovative and knowledge-intensive. A comparison of innovation-intensity in industrial and service sectors in Poland in a dynamic perspective 2009-2018 is depicted on [Figure 3-2].

[Figure 3-2] Comparison of Innovative Enterprises as the Shares of Total Enterprises

(Unit: %)



Note: An innovative enterprise is defined as an enterprise which in the analyzed period introduced at least one product or process innovation (new or significantly improved product or new or significantly improved process) to the market. Data for enterprises employing 10 persons and more.

Source: Author's own elaboration based on Statistics Poland 2020, p. 24.

The data presented in [Figure 3-2] confirms that Polish firms in the service sector are in general less innovative than manufacturing companies, however, after many years of stagnation, the share of innovative service enterprises started to increase in 2018. The increase was from 14.0% in 2009 to 19.6% in 2018. At the conceptual level, there are four main specific characteristics of service sector determining the nature of innovation activity in that sector (Evangelista & Sirilli, 1995):

- the close interaction between production and consumption (co-terminality),
- the increasing information content of services,
- the large and growing role played by human resources in service production,
- the great importance of organizational change as a means of producing and delivering (new) services.

These features imply that non-technological innovations are an important element of the service sector (Djellal and Gallouj, 1999). However, because of the tendency towards industrialization in services and customization in manufacturing, the distinctions between the two sectors have been blurred (Coombs & Miles, 2000). The decomposition of data concerning the share of employment in particular branches of the service sector in Poland is presented in <Table 3-1>.

<Table 3-1> Share of Employment in Service Subsectors in the Economy in Poland 2018

(Unit: %)

Year	1995	2000	2005	2010	2015	2018	Change in pp(1995-2018)
Wholesale and retail trade, transport, accommodation and food service activities	17.2	19	21.3	22.6	22.6	22.8	5.6
Information and communication	1.1	1.3	1.5	1.9	2.3	2.6	1.5
Financial and insurance activities	1.1	1.7	2.1	2.3	2.5	2.5	1.4
Real estate activities	1.1	1.3	1	1.1	1.1	0.9	-0.2
Professional, scientific and technical activities; administrative and support service activities	2.8	3.8	4.6	5.7	6.3	6.5	3.7
Public administration, defense, education, human health and social work activities	22.8	21.2	20	20.3	20.4	20.4	-2.4
Arts, entertainment and recreation; other service activities; activities of household and extra-territorial organizations and bodies	2.4	2.6	2.7	3	3	3.2	0.8
Service sector (all)	48.5	50.9	53.2	56.9	58.2	58.9	10.4

Source: Author's own calculations based on Eurostat data.

As can be seen from <Table 3-1>, the largest share of employment in the service sectors (as in 2018) is within the following sections: wholesale and retail trade, transport, accommodation and food service activities (22.8% of employment in Polish economy) and public administration and national defense; education; health care and social assistance (20.4%). In the dynamic perspective, however, the development of the service sector in Poland is accompanied by simultaneous changes related to the sectorial structure of this sector. In the period under analysis, the greatest increases were observed, apart from the biggest section of wholesale and retail trade, transport, accommodation and food service activities, in: the professional, scientific and technical activities; administrative and support service activities (from 2.8% in 1995 to 6.5% in 2018) and in information and communication activities (from 1.1% in 1995 to 2.6% in 2018). The fastest-growing types of services are to a large extent classified as knowledge-intensive services, which are analyzed in the next subchapter.

A special role in innovation is played by geographical, institutional and cultural proximity, which makes regional level an important dimension of innovation activity. This approach stems from the interactive model of innovation, in which innovations are seen as a product of interactions between people, organizations and their surroundings. Cooperating firms may search technology broadly and may access the different types of resources and capabilities possessed by their partners either by having many partners that possess unique resources, or a few partners with diverse resource profiles (Gnyawali and Srivastava, 2013). Regional data on innovative, innovation active and co-operating service enterprises in Polish voivodships are provided in <Table 3-2>.

<Table 3-2> Innovative, Innovation Active and Co-operating Service Enterprises in 2016/2018 by Region

Region	Share of enterprises			
	Innovation active	Innovative (product or business process)	Which co-operated with other enterprises or organizations	That collaborated in a cluster initiative
Poland-total	21.0	19.6	8.4	2.5
Mazowieckie	29.8	27.5	12.6	2.1
Podlaskie	26.6	26.2	5.0	1.5
Dolnośląskie	26.3	24.8	6.8	3.0
Pomorskie	25.3	24.4	9.6	3.6
Małopolskie	21.2	19.4	7.6	2.7
Opolskie	20.3	18.7	6.9	-
Lubelskie	19.7	19.1	10.2	4.1
Kujawsko-pomorskie	19.0	18.8	6.2	4.0
Wielkopolskie	18.0	16.6	8.3	2.2
Zachodniopomorskie	16.6	16.5	3.1	1.7
Śląskie	16.3	15.6	7.3	2.3
Podkarpackie	15.5	10.3	13.3	3.1
Lubuskie	13.3	13.3	4.9	1.0
Łódzkie	11.4	11.1	4.0	1.2
Świętokrzyskie	10.7	9.3	7.9	6.6
Warmińsko-mazurskie	9.3	9.3	4.0	3.3

Source: Statistics Poland (2020), accompanying tables – Innovation activity of service enterprises by voivodships, Table 24.

Table above shows that regional innovation potential in service sector is not homogeneous, as there is a strong polarization of innovation activity across Polish regions. This uneven development of regional innovation performance creates challenges for innovation policy as it may diminish innovation performance at the national level. The highest share of innovation active and innovative (in terms of introducing product or business process innovation) service companies takes place in Mazowieckie voivodeship. However, it should be noted that there are also very high intra-regional disparities in this region, with the leading position taken by the Warsaw Metropolitan Area (WMA), which serves as an important Shared Services Centre (SSC). This is connected to the observation that typically metropolitan regions have strong and competitive businesses, good infrastructure and policy environments, appropriate research and education facilities, and supportive labor markets. This often leads to the emergence of dynamic territorial clusters in metropolitan regions, mainly in knowledge-intensive sectors, as clustering creates a competitive and demanding environment which forces companies to innovate and acquire the needed resources (Wolfe, 2009). Whereas clusters were most commonly analyzed in case of industrial sectors, emergence of clusters in services has strong impact on innovativeness of the economy as it is generally accepted that innovation exhibits strong geographical clustering in areas where specialized inputs, services and resources necessary for the innovation process are concentrated (Asheim and Gertler, 2005). Although geographical proximity is neither a necessary nor a sufficient condition for effective innovation processes, it may play a complementary role in building and strengthening other dimensions of proximity that are important in interactive learning (Boschma 2005).

As presented in <Table 3-2>, in 2016–2018 cooperation in innovation activities was undertaken by 8.4% of service enterprises. Taking into account the territorial division, the highest percentage of service businesses participating in innovation activity cooperation was found in Podkarpackie Voivodeship (13.3%). Cooperation within a cluster was reported by 2.5% of service enterprises. Regionally, the highest percentage of service companies, which participated in cluster cooperation, was found in Świętokrzyskie (6.6%), Lubelskie (4.1%) and Kujawsko-pomorskie (4.0%). It is worth underlining that the highest levels of cooperation and clustering took place in the regions located in Eastern Poland, which is a relatively less developed part of Poland. These voivodeships are characterized by low living standards, a low level of economic development, poorly developed and inadequate transport infrastructure, and insufficient growth factors. As a result of this, they received additional support in EU structural funds in recent years, mainly in the framework of the Operational Program Development of Eastern Poland for the period 2007–13, and the Operational Program of Eastern Poland 2014–2020. Fostering networking and cooperation, also within cluster initiatives, were among the priorities of these programs. In such a way, the availability of the EU public support contributed to high levels of cooperation and clustering of innovative enterprises in Eastern Poland, despite the generally low level of development and innovativeness in this macroregion.

2.2. Development of the knowledge-intensive service sector in Poland

2.2.1. Knowledge Intensive Services (KIS)

KIS may be defined as “the accumulation, creation, or dissemination of knowledge for the purpose of developing a customized service or product solution to satisfy the client's needs” (Bettencourt, Ostrom, Brown & Roundtree. 2002). According to OECD (2006), KIS refers to the production and integration of service activities undertaken by firms or public sector actors in the context of manufacturing or services, in combination with manufactured outputs or as stand-alone services. Typical examples of KIS activities include research and development (R&D), management consulting, information and communications services, human resource management and employment services, legal services (including those related to intellectual property rights) accounting, financing, and marketing-related service activities. Knowledge, as a crucial component in KIS, has become a key asset within the service economy (Giddens 2007). <Table 3-3> presents employment in the sectors, which are classified as knowledge-intensive services.

<Table 3-3> Employment in Knowledge-Intensive Services in Poland in 2005-2017

Knowledge based Services	NACE Code	NACE Rev. 2 (2-digit level)	2005	2010	2015	2017	%Δ (2005–2017)
Knowledge Intensive Market services (excluding high-tech and financial services)	50	Water transport	-	-	2,597	2,406	-
	51	Air transport	4,746	5,539	3,902	4,197	-12%
	69	Legal and accounting activities	38,506	86,343	109,821	122,372	218%
	70	Activities of head offices; management consultancy activities	32,450	49,247	71,225	72,302	123%
	71	Architectural and engineering activities; technical testing and analysis	60,642	72,044	77,168	75,883	25%
	73	Advertising and market research	39,543	40,892	44,487	45,599	15%
	74	Other professional, scientific and technical activities	38,737	14,573	19,848	24,135	-38%
	78	Employment activities	32,932	79,017	163,953	183,158	456%
	80	Security and investigation activities	127,309	141,626	109,205	127,362	0%

<Table 3-3> Continued

Knowledge based Services	NACE Code	NACE Rev. 2 (2-digit level)	2005	2010	2015	2017	%Δ (2005–2017)
High-tech Knowledge Intensive Services	59	Motion picture, video and television programme production, sound recording and music publishing activities	7,584	6,528	7,828	6,310	-17%
	60	Programming and broadcasting activities	9,566	15,549	14,941	16,165	69%
	61	Telecommunications	54,650	56,110	46,576	49,621	-9%
	62	Computer programming, consultancy and related activities	33,896	60,023	107,223	133,350	293%
	63	Information service activities	7,927	16,674	30,529	32,529	310%
	72	Scientific research and development	2,948	6,056	8,816	11,808	301%
Knowledge Intensive Financial Services	64-66	Other monetary intermediation	-	-	170,292	164,788	
Other Knowledge Intensive Services	58	Publishing activities	37,217	43,519	32,412	33,312	-10%
	75	Veterinary activities	2,852	3,845	5,763	5,336	87%

Source: Author's own calculations based on Eurostat data [sbs_na_1a_se_r2].

In 2017, the highest level of employment among KIS subsectors was in Employment activities (NACE 78), which also experienced the fastest growth since 2005 (by 456%). Rapid increase was also observed in the case of information service activities (310%), scientific research and development (301%) and computer programming, consultancy and related activities (293%). These branches are highly innovative pillars contributing to the development of a knowledge-intensive economy. It is determined, among other factors, developing ICT sector in Poland manifests in: expanding the offer of high-margin products and services, increasing ability to expand abroad, and attracting well-educated employees (development of ICT sector in Poland and its innovativeness are presented in section 2.3.1). In addition, it is worth noting that legal and accounting activities have also been continually increasing, reflecting the effect of a large-scale deregulation in legal professions, whereas the second part of the deregulation process focused on around 90 professions, including accountants and tax advisors and insurance brokers (Dzienis, Kowalski, Lachowicz, Mackiewicz, Napiórkowski, Weresa 2019). It is worthwhile to underscore that knowledge-intensive service activities play several important roles in innovation processes, as they serve as:

- Sources of innovation when they play a role in initiating and developing innovation activities in client organizations,
- Facilitators of innovation when they support an organization in the innovation process,
- Carriers of innovation when they aid in transferring existing knowledge among or within organizations, industries or networks so that it can be applied in a new context (OECD 2006).

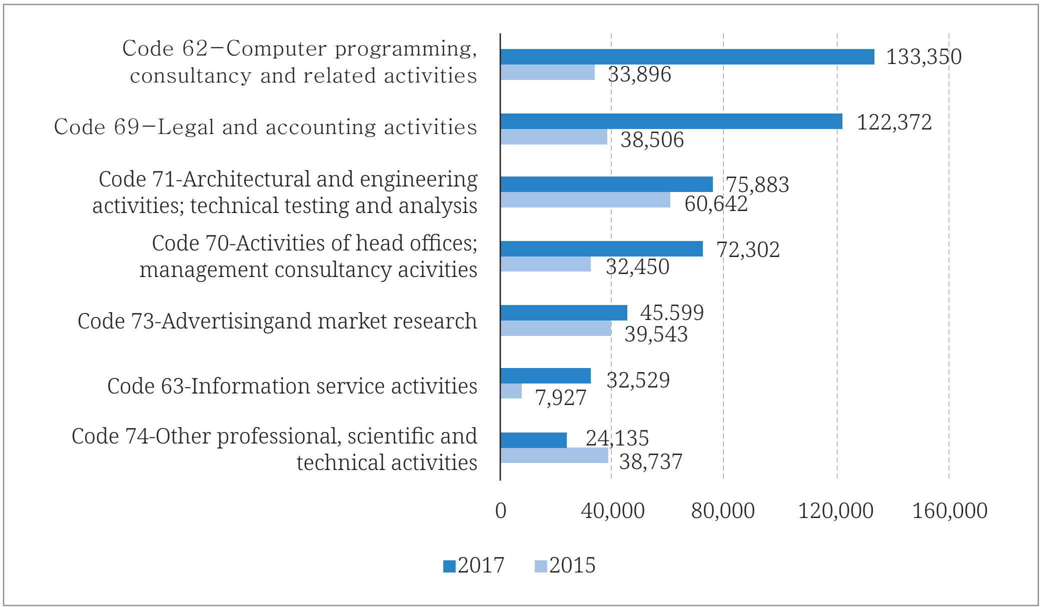
2.2.2. Knowledge Intensive Business Services (KIBS)

While the expansion of the service sector is observed along with economic development, it is not the development of the whole sector, but of certain types of services that plays a key role in economic development. The observation of the modern world economy shows the growing importance of knowledge-intensive business services, which engage high quality labor resources supporting the development of other industries from the manufacturing and service sectors. Fundamentally, KIBS are mainly concerned with providing knowledge-intensive inputs to the business processes of other organizations, both in private and public sector clients (Muller & Doloreux, 2009). More precisely, Miles, Kastrinos, Flanagan, Bilderbeek and Den Hertog (1995) defined KIBS as ‘‘services that involved economic activities which are intended to result in the creation, accumulation or dissemination of knowledge'', and identified their three principal characteristics:

1) they rely heavily on professional knowledge;
2) they either are themselves primary sources of information and knowledge or they use knowledge to produce intermediate services for their clients' production processes;
3) they are of competitive importance and supplied primarily to business.

It should be pointed out that there is no standard approach and generally accepted definition of KIBS. While Eurostat gives a precise classification of knowledge-intensive services (as shown in previous subchapter), there is no formal classification related to which industries should be classified as KIBS. Nevertheless, the industries that are most often classified as knowledge-intensive business services are identified on the basis of the literature review, as shown in the graph below, presenting employment in 2005 and 2007.

[Figure 3-3] Employment Structure in the KIBS Sector in Poland



Source: Author's own calculations based on Eurostat data.

According to Eurostat data, as shown in [Figure 3-3], the largest and fastest growing industry classified as one of the knowledge-intensive business services in Poland is the activity related to computer programming and information service, for which the highest increase in employment was recorded in the analyzed period. This observation confirms the rapid development of the information and communication technologies (ICT) sector, which is a subject to more detailed analysis conducted in the next section of this paper.

The trend towards a knowledge-intensive economy supports the development of structures in which knowledge intensive business service companies play an important role as knowledge brokers and intermediaries (Hipp & Grupp 2005). KIBS are said to play a strategic role in stimulating innovation processes (Miles, 2005), and they are seen to have an increased importance for learning and innovation activity in a knowledge-based economy (Aslesen & Isaksen, 2007). In many cases, KIBS providers cluster in specialized lead markets or regions characterized by accumulated domain knowledge. Hence, they reinforce sectorial dynamics within local innovation systems (Haakonsson, Kirkegaard & Lema, 2020). KIBS generally depend on knowledge exchanges and, therefore, geographical proximity to markets, customers and suppliers would be expected to be a critical factor in their performance (Brunow, Hammer & McCann, 2019). This is why cooperation, including cooperation in clusters, is also taken into account in an overview on innovation process in Polish service sub-sectors, including KIS and KIBS, which is provided in <Table 3-4>.

<Table 3-4> Innovation Activity of Service Enterprises in Selected Subsectors in 2016-2018

Specification	Share of service enterprises (in % of all enterprises in given (sub)sector)			
	Innovation active	Innovative (product or business process)	Which co-operated with other	That collaborated in a cluster initiative
Total	21.0	19.6	8.4	2.5
Scientific research and development *	80.2	58.5	47.0	17.1
Insurance, reinsurance and pension funding, except compulsory social security *	79.1	77.6	28.4	4.5
Computer programming, consultancy and related activities **	48.9	43.5	22.7	7.2
Information service activities **	40.4	33.3	16.7	2.5
Publishing activities *	37.5	36.0	13.5	3.3
Telecommunications *	32.3	30.7	12.1	5.4
Motion picture, video and television programme production, sound recording and music publishing activities *	25.8	25.8	5.6	-
Programming and broadcasting activities *	30.3	25.3	12.1	2.0
Professional, scientific and technical activity **	28,2	24,9	15,2	6,3
Advertising and market research **	24.8	23.4	7.2	3.8
Financial service activities, except insurance and pension funding *	28.4	27.6	16.1	9.7
Warehousing and support activities for transportation	25.6	24.0	6.1	1.6
Activities auxiliary to financial services and insurance activities *	25.5	24.8	13.2	3.2
Architectural and engineering activities; technical testing and analysis **	22.6	20.9	15.0	6.1
Water transport *	16.7	16.7	5.6	2.8
Wholesale trade, except of motor vehicles and motorcycles	17.5	16.7	6.6	1.5
Air transport *	18.2	18.2	9.1	13.6
Postal and courier activities	17.1	17.1	4.9	-
Land transport and transport via pipelines	13.4	12.7	4.0	0.9

Note: *-Knowledge Intensive Services (KIS); **-Knowledge Intensive Business Services (KIBS).
Source: Statistics Poland (2020), accompanying tables – Innovation activity of service enterprises by PKD NACE and size classes, Table 22.

As it can be seen from the above table, all KIBS are above the average in terms of the share of service enterprises: those that are innovation active, those that are innovative (classified as introduction of product or business process innovation), those that co-operated with other enterprises or organizations, and those that collaborated in a cluster initiative. It is worth to underscore that KIBS are part of a service activity category that is highly innovative and facilitates innovation in other organizations. They play an important role in innovation systems, especially in developed regions where production competitiveness depends on knowledge provided by highly specialized suppliers (Windrum & Tomlinson 1999; Braga, Marques, & Serrasqueiro, 2018). KIBS facilitate innovation processes as they combine general knowledge available in the economy with tacit knowledge available in enterprises. Although they represent only a small part of all services, they are an important source of new technologies that affect the whole economy. Instead of providing standard services, these branches adapt expertise and provide customized solutions tailored to the requirements of customers (Tether & Hipp 2002). KIBS' more pragmatic nature offers better responsiveness to other companies, especially useful in incremental innovation activities (Milbratz, Gomes & Carmona, 2020).

An important role in enhancing innovative capacity of the service sector is played by investment in R&D, both internal and external, and all other innovation expenditures, e.g. on fixed or intangible assets or services and materials for innovation, as exemplified in <Table 3-5>.

<Table 3-5> Expenditures on Innovation Activity in 2018

(Unit: %)

Specification	Share of enterprises which incurred expenditures					
	Expenditures on R&D			All other expenditures for innovation, of which:		
	Total	Realized R&D activities in the unit (internal)	R&D activities contracted out	Own personnel working	Services, materials, supplies purchased from others	On fixed or intangible assets
Total	4.4	4.0	1.3	3.2	2.9	3.5
Wholesale trade, except of motor vehicles and motorcycles	2.9	2.5	1.1	2.2	2.3	2.9
Land transport and transport via pipelines	0.2	0.2	0.2	1.1	1.5	2.1
Water transport *	0.0	0.0	0.0	0.0	2.8	2.8
Air transport *	4.5	4.5	0.0	4.5	0.0	4.5

<Table 3-5> Continued

Specification	Share of enterprises which incurred expenditures					
	Expenditures on R&D			All other expenditures for innovation, of which:		
	Total	Realized R&D activities in the unit (internal)	R&D activities contracted out	Own personnel working	Services, materials, supplies purchased from others	On fixed or intangible assets
Warehousing and support activities for transportation	1.3	1.2	0.6	2.0	1.9	3.6
Postal and courier activities	1.2	0.0	1.2	1.2	4.9	1.2
Publishing activities *	11.3	10.6	2.9	9.7	10.4	7.5
Motion picture, video and television programme production, sound recording and music publishing activities *	3.4	3.4	3.4	0.0	0.0	10.1
Programming and broadcasting activities *	7.1	7.1	1.0	5.1	4.0	8.1
Telecommunications *	7.0	7.0	0.8	8.1	3.2	5.4
Computer programming, consultancy and related activities **	23.3	21.7	4.8	13.5	8.6	6.2
Information service activities **	19.4	19.1	2.8	5.2	4.9	3.1
Financial service activities, except insurance and pension funding *	2.4	2.2	0.5	5.5	3.9	9.9
Insurance, reinsurance and pension funding, except compulsory social security *	19.4	14.9	4.5	28.4	20.9	25.4
Activities auxiliary to financial services and insurance activities *	3.3	2.9	0.6	7.5	5.7	6.5
Architectural and engineering activities; technical testing and analysis **	8.0	7.5	1.9	2.8	3.2	4.6
Scientific research and development *	62.7	61.8	21.2	10.6	8.8	8.8
Advertising and market research **	4.7	3.8	2.0	2.5	1.8	1.3

Source: Statistics Poland (2020), accompanying tables –Table 18.

In most of the KIS and KIBS subsectors, the shares of enterprises which incurred R&D and non-R&D innovation expenditures were higher than average for all Polish service enterprises. In particular, with respect to R&D expenditures, top places are taken by scientific research and development (62.7% enterprises reported R&D expenditures), followed by computer programming, consultancy and related activities (23.3%) and information service activities and insurance (both 19.4%). The effects of innovative activity of Polish service subsectors, measured in revenues from sales of new or significantly improved products in % of total turnover, are presented below.

<Table 3-6> Revenues from Sales of New or Significantly Improved Products in the Service Sector Enterprises in Poland (in % of total turnover)

(Unit: %)

Specification	2010 to 2012	2016 to 2018	pp change	2010 to 2012	2016 to 2018	2010 to 2012	2016 to 2018
	Total			New to the market		Only new to the firm	
Total	3.1	3.2	0.1	1.4	1.1	1.8	2.1
Wholesale trade, except of motor vehicles and motorcycles	1.0	1.0	0.0	0.6	0.3	0.4	0.6
Land transport and transport via pipelines	1.6	1.8	0.2	0.4	0.6	1.2	1.2
Water transport *	0.0	#	-	0.0	#	0.0	#
Air transport *	7.4	#	-	0.0	#	7.4	#
Warehousing and support activities for transportation	15.8	0.7	-15.1	13.2	0.3	2.6	0.4
Postal and courier activities	7.0	2.0	-5.0	4.9	#	2.1	#
Publishing activities *	4.5	9.8	5.3	2.0	4.1	2.4	5.7
Motion picture, video and television program production, sound recording and music publishing activities *	1.9	#	-	1.8	0.4	0.1	#
Programming and broadcasting activities *	1.8	#	-	0.7	2.4	1.0	#
Telecommunications *	18.1	20.5	2.4	3.8	4.3	14.3	16.1
Computer programming, consultancy and related activities **	10.3	12.1	1.8	8.1	6.2	2.2	5.8
Information service activities **	4.7	9.7	5.0	1.9	1.6	2.8	8.1
Financial service activities, except insurance and pension funding *	2.6	5.1	2.5	0.7	2.2	1.9	2.9

<Table 3-6> Continued

Specification	2010 to 2012	2016 to 2018	pp change	2010 to 2012	2016 to 2018	2010 to 2012	2016 to 2018
	Total			New to the market		Only new to the firm	
Insurance, reinsurance and pension funding, except compulsory social security *	10.4	6.7	-3.7	1.5	1.5	8.8	5.1
Activities auxiliary to financial services and insurance activities *	0.7	3.8	3.1	0.4	0.7	0.3	3.1
Architectural and engineering activities; technical testing and analysis **	2.0	5.9	3.9	1.2	4.5	0.8	1.4
Scientific research and development *	15.5	28.3	12.8	13.6	10.0	1.9	18.3
Advertising and market research **	1.3	5.1	3.8	0.7	1.1	0.6	4.0

Note: * – Knowledge Intensive Services (KIS); ** – Knowledge Intensive Business Services (KIBS)
means that data cannot be published due to the necessity of maintaining statistical confidentiality in accordance with the Law on Public Statistics.

Source: for 2010 – 2012: Statistics Poland (2013), accompanying tables – Table. 4.(25); for 2016 – 2018: Statistics Poland (2020), accompanying tables – Table 11.

Revenues from sales of new or significantly improved products in the service sector enterprises in Poland increased only by 0.1 p.p. of total turnover, from 3.1% in 2010–2012 to 3.2% in 2016–2018. The highest result in 2016–2018 was reported for scientific research and development (28.3%), for which we also observe the most intensive increase of analyzed indicator (by 12.8 p.p., from 15.5% in 2010-12. Next, the highest share of revenues from innovation in total turnover took place in other KIS sectors: telecommunications (20.5%), and computer programming, consultancy and related activities (12.1%). The conclusion from the above analysis is that the most dynamically growing service subsectors in Poland, also characterized by the most intense increase in both innovation capacity and position, are related to KIS and KIBS. In particular, it concerns computer programming, consultancy and related activities, which points out the directions for innovation policy, which should be focused on supporting ICT-related services.

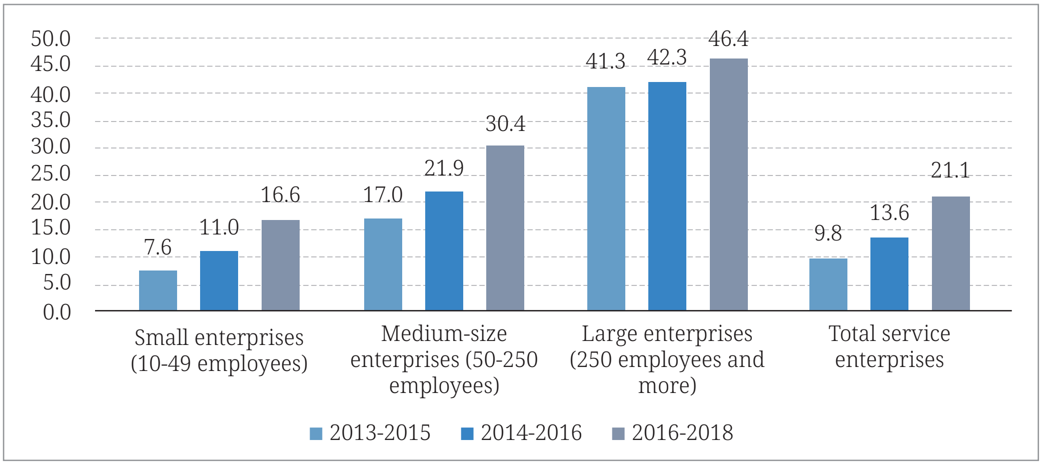
2.3. Innovativeness of service sector in Poland

The service sector in Poland used to be, and still is, less innovative than industry, as illustrated in [Figure 3-2]. The results from all waves of surveys conducted by Statistics Poland since 2008 show that the share of innovative enterprises within the total number of enterprises in the service sector in Poland has been fluctuating in the range of 10-16%, but with a decreasing trend. However, in 2018 a huge increase was observed. [Figure 3-4] shows the share of innovative enterprises grew by 9 percentage points compared to the preceding year, reaching 19.6%. The most important determinant of innovation activities for service companies in the years 2016-2018 was efficiency increase through providing high quality services, in order to satisfy established customer groups as well as gain new customers.

The most innovative service companies in Poland are larger ones, i.e. those employing more than 250 employees. The share of innovative large service enterprises in 2016-2018, in the total number of these enterprises, amounted to 46.4%, and compared to 2013-2015, it increased by 5.1 percentage points). Small firms, employing less than 50 persons, were the least innovative within the service sector. The share of innovative service enterprises in the total number of small enterprises in the service sector stood at 16.6% in the years 2016-2018. [Figure 3-4], however, points out that this share has grown dynamically as in the years 2013-2015 it was only 7.6%.

[Figure 3-4] Innovative Enterprises in the Service Sector in Poland

(Unit: %)

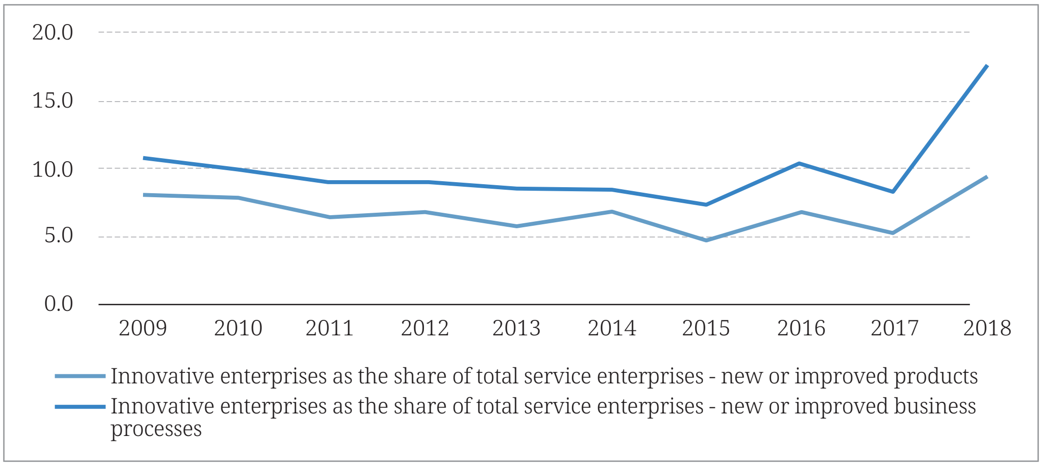


Source: Author's own elaboration based on: Statistics Poland 2016, p. 46 and 50; Statistics Poland 2017, p. 28-29; Statistics Poland 2020, p. 33-34.

[Figure 3-5] shows business process innovation (i.e. new or improved business processes) was a predominate type of innovations introduced by service enterprises in Poland.

[Figure 3-5] Types of Innovations Introduced by Service Enterprises in 2009-2018

(Unit: %)



Source: Author's own elaboration based on Statistics Poland 2020, p. 24.

The share of service enterprises that introduced business process innovations in 2016-2018 was 17.5%, while product innovation (new or improved products) was introduced by 9.6% of innovative service enterprises.

<Table 3-7> Innovative Service Enterprises in the Years 2016–2018 by Innovation types

Innovation types	Innovative service enterprises as a share of total
Enterprises which introduced innovations	19.6
New or improved products	9.6
New or improved business processes	17.5
of which:	
Methods for producing goods or providing services (including methods for developing goods or services	6.9
Logistics, delivery or distribution methods	7.0
Methods for information processing or communication	9.7
Methods for accounting or other administrative operations	9.4
Business practices for organizing procedures or external relations	9.0
Methods of organizing work responsibility, decision making or human resource management	10.4
Marketing methods for promotion, packaging, pricing, product placement or after sales services	7.9

Source: Author's own elaboration based on Statistics Poland, 2020, pp. 40-41.

<Table 3-7> illustrates that among business process innovations, the top three were:

(1) methods of organizing work responsibility, decision making or human resource management; (2) methods for information processing or communication, (3) methods for accounting or other administrative operations. The important role of information processing and communication confirms empirical the findings about the ICT as one of key drivers of innovation in services (see for instance: Gallouj & Djellal, 2010).

2.3.1. Innovation in ICT sector

The vast amount of economic literature on innovation in services discusses the consequences of introducing ICT for innovation activity of service enterprises (see: Quinn & Paquette, 1990; Gallouj & Djellal, 2010; Alarcóna *et al.,* 2019). In the digital age technologies offer more opportunities and new ways for innovative services. The boundaries between services have been blurring as services complement manufacturing. Servitization has become a new characteristic of innovation in the digital era (OECD, 2019, p. 27). On the basis of the literature explaining innovation in the service sector, it should be observed that ICTs' development creates a new techno-economic paradigm that influences innovation activity in the service sector. Therefore, the analysis of innovativeness of ICT allows to get a border picture of service innovation in Poland. The ICT sector[1] consists of ICT production and ICT services. Taking into account the objectives and scope of this paper, this analysis focuses on innovation in ICT services[2]. In order to asses innovativeness of ICT services the following input and output indicators have been analyzed:

- expenditures on innovation activities in ICT services;
- cooperation in innovation activities in ICT services;
- number of innovation enterprises in ICT services;
- revenues from sale of new or improved products.

1 A definition of the ICT sector is based on the Statistical Classification of Economic Activities in the European Community (NACE Rev. 2).

2 ICT services sector covers the following NACE sections (NACE Rev.2), the sections 9511 and 9512 have not been included in the Statistics Poland data (for details see: GUS, 2019, p. 115):
4651 Wholesale of computers, computer peripheral equipment and software
4652 Wholesale of electronic and telecommunications equipment and parts
5821 Publishing of computer games
5829 Other software publishing
6110 Wired telecommunications activities
6120 Wireless telecommunications activities
6130 Satellite telecommunications activities
6190 Other telecommunications activities
6201 Computer programming activities
6202 Computer consultancy activities
6203 Computer facilities management activities
6209 Other information technology and computer service activities
6311 Data processing, hosting and related activities
6312 Web portals
9511 Repair of computers and peripheral equipment
9512 Repair of communication equipment

Additionally, as the literature points out, ICT is one of key drivers of innovation in services, thus the Revealed Technological Advantage (RTA) index in ICT, which measures technological advantages for a country relative to other countries, will be analyzed for Poland compared to selected countries from Visegrad group. It may indicate the potential for innovation in ICT services in the future.

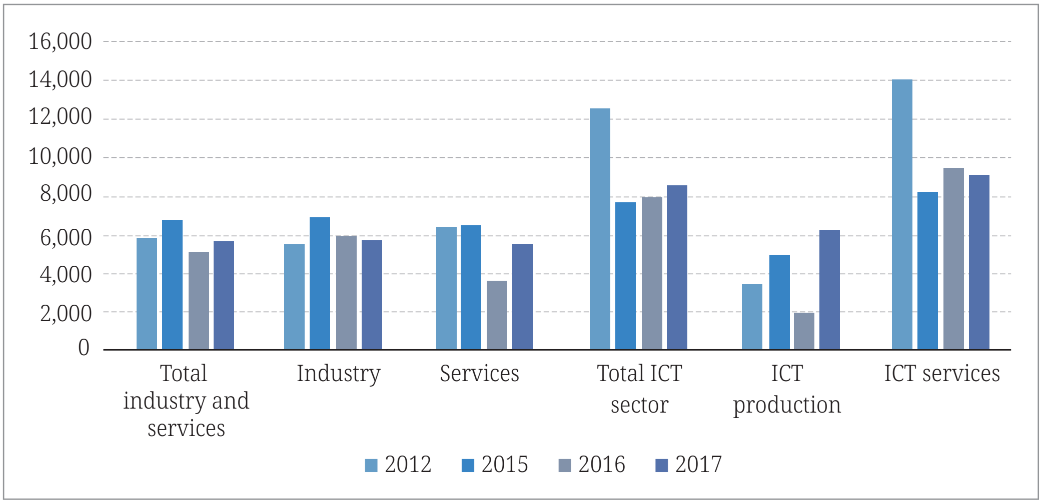
Expenditures on innovation activities are regarded as an important input for innovation, and as the current literature indicates R&D intensity has been growing in both industry and service sector. An OECD study by F. Galindo-Rueda and F. Verger (2016) provides a taxonomy of research intensity measured as a ratio of the industry's R&D expenditure to its gross value added[3]. A classification of economic activity into five major groups has been proposed and results show that some of ICT-based services are regarded as high R&D intensity sections. To this group belong publishing of computer games (section 5821) and other software publishing (section 5829). Medium-high R&D intensity sections include all IT and other information services (sections 6201-6209 and 6311-6312), while telecommunications (sections 6110, 6120, 6130, 6190) are regarded as medium-low R&D intensity services. Only four sections of ICT services belong to the low R&D intensity group. These are: wholesale of computers, electronic and telecom equipment (sections 4651 & 4652) as well as repair of computers and communication (sections 9511 & 9512). As the majority of ICT services are medium-high or medium-low R&D intensive, expenditures on R&D can be an important input for innovation.

Expenditures on innovation activities per single enterprise in ICT services have been decreasing in Poland since 2012. In 2017 they constituted around 65% of the level observed in 2012. A similar decreasing trend was observed also in the whole service sector, with the dip in 2015. However, as in [Figure 3-6], when ICT services were compared with other sectors, these expenditures were the highest. They were over 60 percent higher than R&D expenditures per enterprise in the whole service sector, which confirms that ICT services are much more R&D intensive than the whole service sector. Therefore, public support to this kind of services could focus on strengthening R&D base.

3 For detailed methodology, in particular formula used for calculations see: Galindo-Rueda & Verger, 2016, p. 10.

[Figure 3-6] Expenditures on Innovation Activities per Single Enterprise which Incurred Such Expenditures in Poland: ICT Services, Service Sector and Industry Compared in 2012-2017 (thousand PLN, current prices)

(Unit: Thousand PLN)

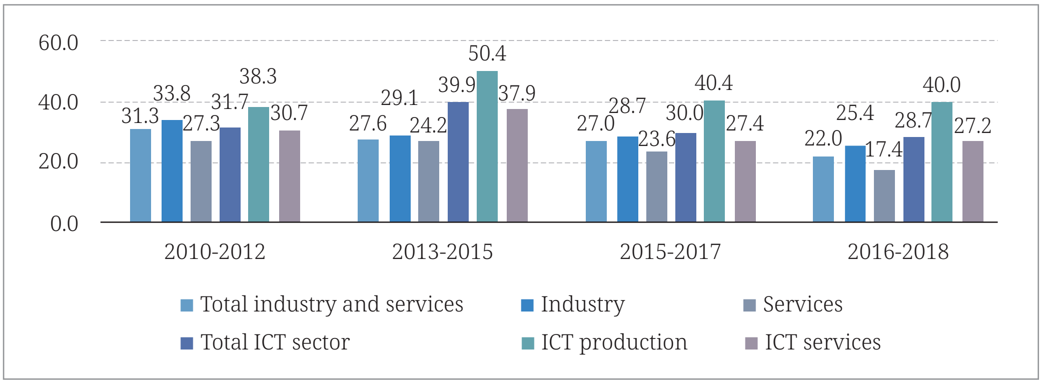


Source: Author's own elaboration based on: Statistics Poland, 2013, p. 78; Statistics Poland, 2016, p. 91; Statistics Poland, 2017, p. 91; Statistics Poland 2018, p. 72.

Cooperation in innovation activities is another important factor that determines innovation in the service sector. Currently, in the digital age, cooperation becomes particularly important with the growing role of new forms of collaboration, such as data sharing, business incubation, partnerships between start-ups and universities, crowdsourcing etc. (OECD, 2019, pp. 32). In this context it is worth analyzing the scope of cooperation in innovation activities in ICT services in Poland.

[Figure 3-7] Enterprises which Cooperate in Innovation Activities as a Percentage of Innovation Active Enterprises in Selected Sectors Poland: ICT Services, Service Sector and Industry Compared in 2010-2018

(Unit: %)



Source: Author's own elaboration based on Statistics Poland 2013, p. 91; Statistics Poland 2016, p. 105; Statistics Poland 2018, p. 86; Statistics Poland 2020, p. 82.

A comparison of enterprises from different sectors and their the cooperation in innovation activities in the years of 2010-2018 in [Figure 3-7] shows that since 2015 nearly one third of innovation active enterprises in ICT services has been engaged in any form of cooperation in creating innovations. This percentage was quite stable in the second half of the last decade, but much lower than in the years 2010-2015. This result implies that public support for collaboration in innovation activity of ICT service enterprises is needed to increase their propensity to innovate.

Having analyzed key input measures of innovation activity, we focus on the output indicators. The statistical data on innovativeness of ICT companies in Poland in the years 2016–2018 show that innovative enterprises in ICT service constituted 38.8% of the total number of such kind of entities. <Table 3-8> indicates the share of innovative enterprises in ICT services was higher than that of service enterprises (38.8% against 19.6%). However, in ICT production the percentage of the innovative enterprises was even higher than in ICT services as it amounted to 46.4% (Statistics Poland, 2020, p. 38). Nevertheless, it should be pointed out that since 2010-2012 the share of innovative enterprises in ICT services has doubled from the level of 19.2%, while in the whole service sector this increase was only 8 percentage points. A tentative conclusion that can be drawn on the basis of data showing that more and more ICT service enterprises are engaged in innovation activities, is that public support should be directed at first to promote further expansion of innovation activities of the leaders. Fostering an increase of the number of innovative companies in ICT sector comes only as a second priority.

<Table 3-8> Innovation in ICT Services in Poland in the Years 2010–2018

(Unit: %)

Sector	Innovative enterprises as a share of total entities (in %)			
	2010-2012	2013-2015	2015-2017	2016-2018
Services	12.4%	9.8%	10.4%	19.6%
ICT services	19.2%	22.5%	20.0%	38.8%

Source: Author's own elaboration based on: Statistics Poland 2013, p. 40; Statistics Poland 2016, p. 105; Statistics Poland 2018, p. 30; Statistics Poland 2020, p. 33.

The ICT service subsector has been more active in introducing new or improved business processes than product innovations or both product and process innovations. In the years 2016-2018 34.8% of innovative enterprises in ICT services introduced business process innovations, while 27.2% of such firms implemented product innovations. In the same period 23% of the innovative ICT service enterprises introduced both product and business process innovations. In the past, the trend was slightly different as three previous waves of innovation surveys (2010-2012, 2013-2015 and 2015-2017) product innovations were the predominant type of innovation introduced in the ICT service subsector, followed by process innovation, with the least percentage of enterprises introducing both product and process innovations according to <Table 3-9>. The change in methodology in 2018, which differently defined types of innovations (OECD/Eurostat, 2018) does not allow direct comparison of results with the previous years' trends. However, a rough comparison is possible and presented in <Table 3-9>. It should be pointed out that in the whole service sector process innovation was the most popular type of innovation over the whole analyzed period of 2010-2018, while in ICT service subsector it dominated only in the years 2016-2018. There are two possible ways of explaining this. First, it is possible that this shift in the predominant innovation type from product to business process innovation is driven by changes in methodology mentioned above. Another explanation could be that this change occurred due to growing digitalization, which according to vast number of studies caused huge changes in business processes and models (OECD, 2019; Planes-Satorra & Paunov, 2019; Weresa, 2019).

<Table 3-9> Innovative Enterprises in the Whole Service Sector and ICT Services in Poland by Type of Innovation, 2010-2018

(Unit: %)

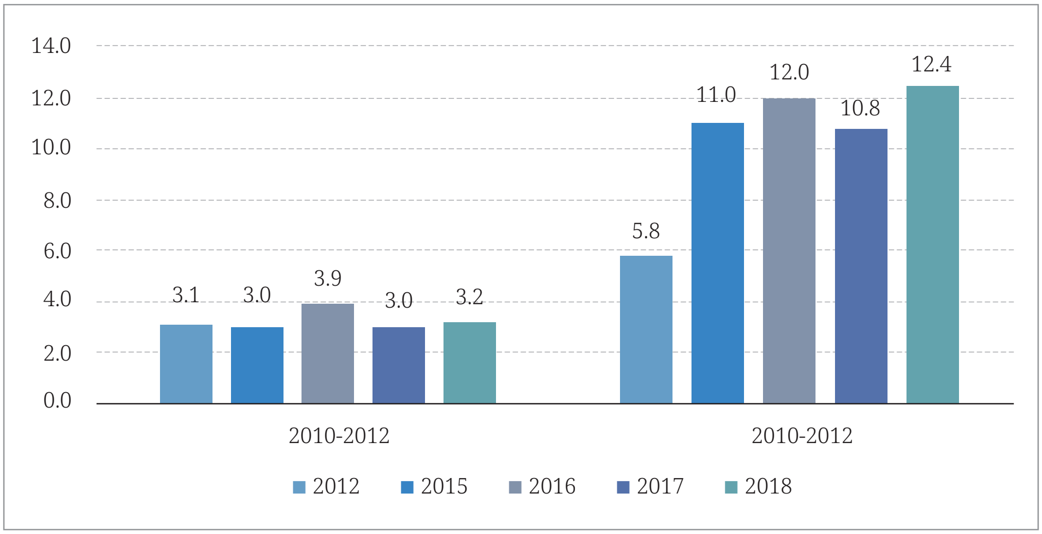
Type of Innovation	Enterprises which introduced new or significantly improved as the share of total enterprises of a given economic activity (in %)				
	Years	2010-2012	2013-2015	2015-2017	2016-2018
Total services					
Type of Innovation	product	7.0	4.8	5.4	9.6
	processes*	9.1	7.4	8.3	17.5
	products and processes**	3.8	2.4	3.3	7.6
ICT services					
Type of Innovation	product	15.6	16.6	16.8	27.2
	processes*	12.6	13.4	14.1	34.8
	products and processes**	9.0	7.4	10.9	23.2

Note: * in 2016-2018 business processes; ** in 2016-2018 products and business processes.
Source: Author's own elaboration based on: Statistics Poland, 2013, p. 47; Statistics Poland, 2016, p. 57; Statistics Poland 2018, p. 37; Statistics Poland 2020, p. 46.

One of key measures of innovation output commonly used by scholars is related to indicators based on revenues from sale of new or improved products. Economic effects of innovations are captured by revenues from sale of new or improved products measured as a share of total revenues from sale. As shown on [Figure 3-8] this indicator for the whole service sector was low and stable, fluctuating around 3% over the 2012-2018 period. In ICT services a dynamic growth of the share of revenues from new or improved products in total sale has been observed. In 2012 these revenues constituted only 5.8% of the total sales in ICT services, while in 2018 they were more than two times higher and amounted to 12.4%. However, this dynamic growth was noted in the period of 2012-2015, and since 2015 the indicator has grown only slightly. The stability of this indicator for ICT services in 2015-2018 confirms the need for policy intervention in this area.

[Figure 3-8] Revenues from Sale of New or Significantly Improved Products as a Share of Total Revenues from Sale in Services and ICT Services in Poland in 2012-2018

(Unit: %)

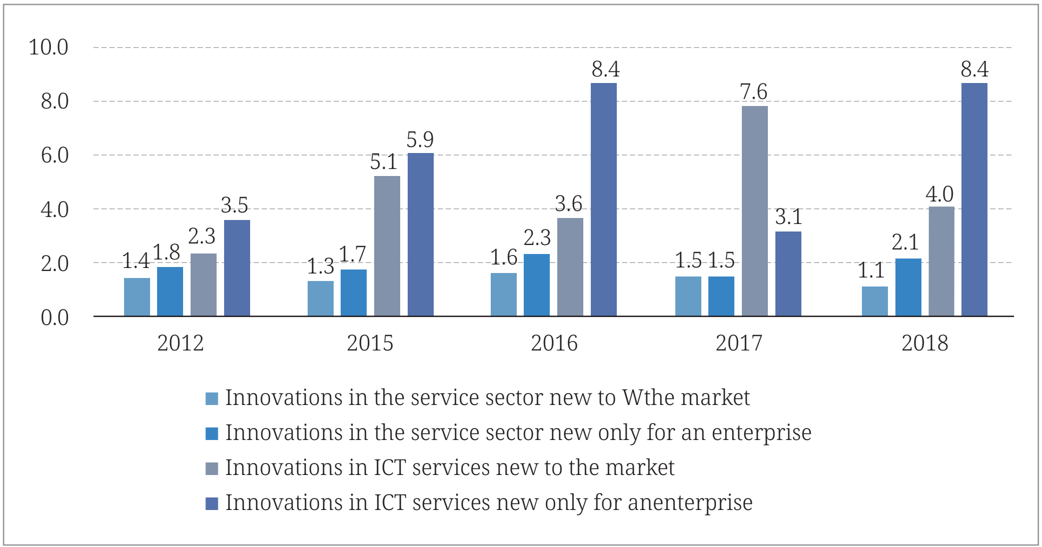


Source: Author's own elaboration based on: Statistics Poland, 2013, p. 68; Statistics Poland, 2016, p. 78; Statistics Poland 2017, p. 58; Statistics Poland 2018, p. 58; Statistics Poland 2020, p. 57-58.

A more detailed picture of the economic effects of innovations in ICT services is shown on [Figure 3-9].

[Figure 3-9] Revenues from Sale of New or Significantly Improved Products as a Share of Total Revenues from Sale in the Service Sector and ICT Services in Poland by Novelty of Innovations, 2012-2018

(Unit: %)



Source: Author's own elaboration based on: Statistics Poland, 2013, p. 68; Statistics Poland, 2016, p. 78; Statistics Poland 2017, p. 58; Statistics Poland 2018, p. 58; Statistics Poland 2020, p. 57-58.

[Figure 3-9] includes a comparative analysis of the novelty of innovations in the service sectors and ICT services and shows that trends in Poland over the period 2012-2018 have been similar in the whole service sector and in ICT services. The share of revenues from innovations new only for an enterprise in the total revenues was the highest in both the service sector and ICT services. This share has been much higher for ICT services than for total services, however still quite low in both cases, however even lower shares were on the whole analyzed period for revenues from innovations new to the market. It may indicate that the public intervention should strengthen support innovations that are new to the market.

To sum up the analysis of innovativeness of ICT services, it is worth looking at the Revealed Technological Advantage (RTA) index[4] in ICT, which measures technological advantages for a country relative to other countries (OECD, 2017; Montresor & Quatraro, 2017, Weresa, 2019). An RTA<1 means that a country does not have technological advantages in the information and communication technologies while an RTA>1 confirms advantages in the ICT. Before analyzing the RTA indices for Poland one remark should be made. The index

4 The RTA index is defined by the OECD (2017): "The revealed technological advantage index is calculated as the share of patents of an economy in a particular technology area relative to the share of total patents belonging to the economy. Data refer to IP5 families, by filing date, according to the inventors' residence using fractional counts. 2014 and 2015 figures are estimated based on available data for those years."

does not measure innovativeness of ICT services. It is broader as the index is based on ICT-related patent families. It shows advantages in ICT technologies, which are important for the development and also innovations of ICT services. <Table 3-10> presents the data for Poland and for comparison some other countries from Visegrad group and the whole EU, as well as for Korea.

<Table 3-10> Revealed Technology Advantage in ICT in Selected Countries the Years 2012-2015

Country	2012-15	ICT-related patent families(IP5) 2012-15
Poland	0.58	394
Czech Republic	0.44	191
Hungary	0.78	193
EU28	0.57	46,591
Korea	1.56	57,643

Source: Elaborated from: OECD, STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats, June 2017.

According to the OECD data Poland, similar to other Visegrad countries and to the whole EU28, did not enjoy advantages in ICT as the RTA index was below zero. Korea enjoyed such advantages in 2012-2015 as its RTA index equaled to 1.56. It is also worth noting that the number of ICT-related patent families in Korea was higher than in the whole EU28.

The lack of revealed technology advantages in ICT in Poland and its relatively low RTA index may indicate that the potential for new-to-the-market innovation in ICT services is relatively low and public support should not be limited to ICT services, but rather integrated with ICT development.

Together with the examination of the trends related to the development of ICT industry at the national level, it is also important to observe that economic activity in high-technology sectors, like ICT, tends to be more and more geographically concentrated. In Poland, significant parts of the ICT industry concentrated in the 7 biggest agglomerations, Warsaw, Cracow, Łódź, Wrocław, Tricity (Gdańsk), Poznań, and Katowice, function as Shared Services Centers (SSC), offering different types of ICT services to foreign clients, mostly from Western Europe, North America, and Central and Eastern Europe. Poland’s geographical location, allowing it to work with both Asia and America within the same business day, together with the favorable balance between costs and quality of products and services, are excellent factors increasing competitive advantages of Polish ICT sector. Successful development of the ICT industry in Poland is strengthened by widely available human resources, with thousands of computer science graduates entering the market every year. At the same time this is a very prospective sector, as the demand for qualified IT specialists continues to grow, reflecting continuous expansion of Polish enterprises, and dynamic development of outsourcing and shared services centers. Nevertheless, the job market within the sector remains highly competitive, ensuring good quality of workforce, as the average salary is much higher than the national average. To conclude, ICT industry is one of the most dynamically growing sectors within the Polish economy, with decent fundamentals for further development (Kowalski, 2016).

2.3.2. Innovation in financial sector (FinTech)

This section provides an overview of FinTech in Poland. Currently, a technological revolution has been transforming the world and firms are challenged by digital innovation. In particularly this is true in the financial services sector. Innovation in financial services sector, know under the name of FinTech, brings changes in the way that financial institutions do business, invest, provide insurance and arrange payments. The growth of FinTech business is driven by a strong domestic demand for FinTech products, and can be facilitated by a positive regulatory environment, as well as innovation policy support. The need for designing FinTech sector strategy, which respond to challenges for policy makers to maximize the benefits of FinTech for the economy, while minimizing risks for the financial system has been recognized in many countries, including Poland (HM Treasury, 2018; KNF, 2019; Ehrentraud, Ocampo, Garzoni & Piccolo, 2020).

The FinTech sector includes very diverse entities, such as (Milic-Czerniak, 2019, pp. 41-43):

- big multinational companies that develop and provide technological applications for mobile payments, such as Google, Apple, Facebook and Amazon, which cooperate with traditional banks;
- modern virtual banks, i.e. neobanks (e.g. Revolut, Atom Bank);
- companies offering several financial services (multifintechs), i.e. virtual and mobile payments platforms (e.g. Ant Financial Services Group, Grab);
- start-ups specialized in providing a narrow range of services, such as applications for trading of shares of listed companies (e.g. Robinhood) (Milic-Czerniak, 2019, pp. 41-43).

According to the study by KPMG and H2 Ventures in 2018 over 60% of the 100 largest FinTech companies were created in six countries, namely the USA, Great Britain, China, Australia, Singapore and Germany (KPMG, 2018).

FinTech in Poland is still at an early stage of development and there are barriers to it (KNF, 2017; 2019; Mazurek *et al.,* 2018). As of 2019 there were already nearly 200 entities in the FinTech sector in Poland. The biggest group are companies specializing in payments and financing (Milic-Czerniak, 2019, p. 57). FinTech companies in Poland are mainly small, specialized companies or multifintechs, which focus on the development of innovation in a few products. The map of FinTech companies in Poland, developed in 2018, recognized 106 FinTech companies, 26 FinTech projects carried out by traditional financial institutions, 12 on-line money exchange offices, 13 crowdfunding Internet platforms and 10 FinTech loan companies (Mazurek *et al.,* 2018, pp. 28-60). Blue Media and PayU are regarded as precursors of Polish FinTechs. Other important FinTechs operating in Poland are Polish Payment Standard companies - Polish Payment Standard (Blik), CurrencyOne, Finanteq, VoicePIN and ZenCard (Milic-Czerniak, 2019, p. 44).

According to the results of a survey conducted by Accenture, Cashless.pl and the foundation FinTech Poland, 60% of Polish FinTechs have been operating on the market for a few years (established in 2013 or later), and only 3% have been on the market for more than 20 years. A majority of such companies in Poland are start-ups that generate low income and still in the phase of building their product offer (Mazurek *et al.*, 2018, p. 16).

Apart from these small FinTech companies, large, mature financial institutions, such as banks, interbank entities and other financial institutions play an important role in the development of the Polish FinTech market. They develop innovative financial products and implement financial innovations.

Another type of activity of the Polish banks in the FinTech sector is acquisition of small FinTech firms. An example of such transaction is the acquisition of Zencard by the bank PKO BP. This acquisition was aimed at expanding services related to handling loyalty processes based on payment card transactions (Mazurek *et al.,* 2018, p. 6). Another field of FinTech activity of Polish banks is acceleration of small Fintech start-ups. So far 12 Polish financial institutions carried out such projects, as presented in <Table 3-11>.

<Table 3-11> Examples of Acceleration FinTech Projects Carried by Polish Banks

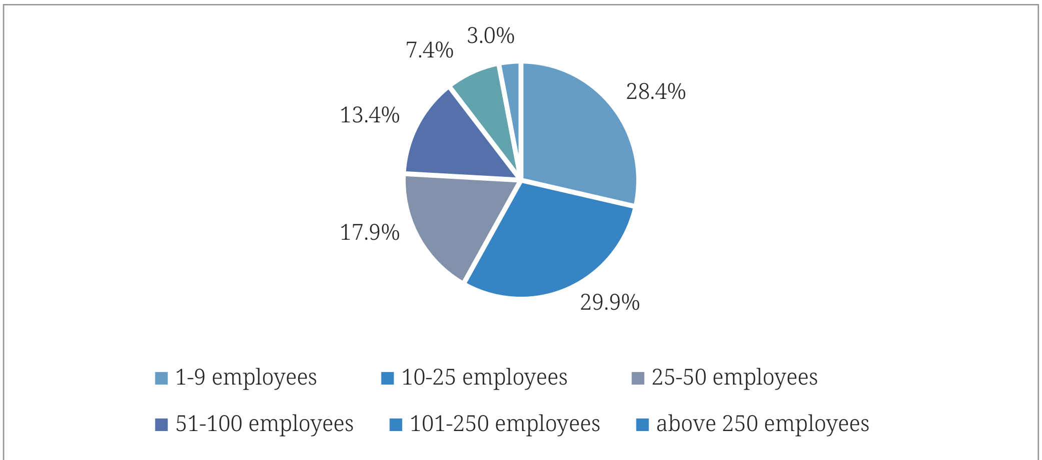
Name of the bank	Acceleration project
Alior Bank	Huge Thing
BGŻ BNP Paribas Bank Polska	Office Hours
Citi (Bank Handlowy w Warszawie)	Citi Mobile Challenge
Millennium	317G Coworking
Bank Pocztowy	GammaRebels powered by Poczta Polska
Bank Pekao SA	Społeczny StartUp
Bank Zachodni WBK	startMEup
ING Bank Śląski	Akcelerator ING
mBank	mAkcelerator
PKO Bank Polski	Let's Fintech
Raiffeisen	Elevator Lab
Santander Consumer Bank	Akcelerator Przedsiębiorczości Akademickiej Santander Universidades

Source: Author's own elaboration based on: Mazurek *et al.,* 2018, p. 6.

Interbank entities are another element of the FinTech market in Poland. Krajowa Izba Rozliczeniowa S.A is one of the oldest and well known such institutions. It is involved in constructing of a communication hub between banks and third parties for services related to implementation of Payment Services Directive.

[Figure 3-10] Fintech Companies in Poland by Employment in 2017

(Unit: %)



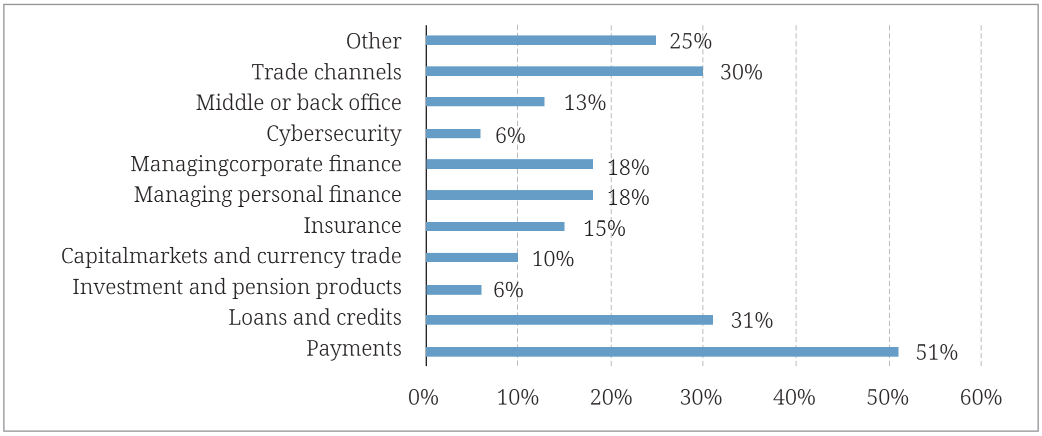
Source: Based on Accenture, Cashless.pl, FinTech Poland survey carried out in April 2018 (Mazurek *et al.,* 2018, p. 17).

Nevertheless, small companies dominate Poland's FinTech map. Almost 60% of surveyed companies declared that they employ less than 50 people, and only 3% of them are large enterprises with over 250 employees, as illustrated in [Figure 3-10].

The survey, summarized in [Figure 3-11], conducted among FinTech companies in Poland, revealed that payments are the predominant type of services offered by FinTech, followed by loans and credits and services related to digitization and automation supporting clients in product acquisitions on financial markets. Products and services related to investment banking and financial markets are less important in FinTech activity. Furthermore, only 6% of respondents are active in the sphere of cybersecurity.

[Figure 3-11] Products and Services Offered by Fintech in Poland

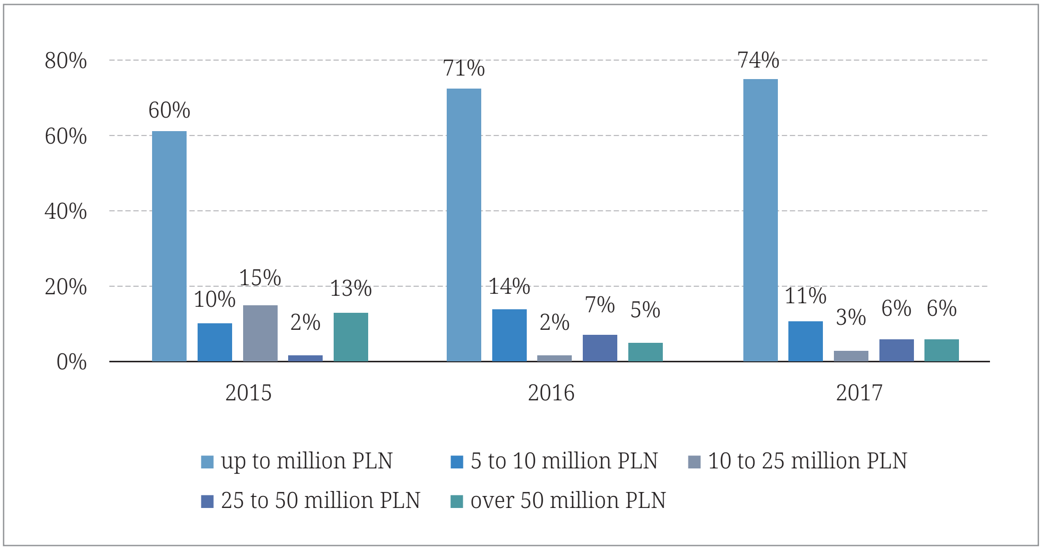
(Unit: %)



Source: Based on Accenture, Cashless.pl, FinTech Poland survey carried out in April 2018 (Mazurek *et al.,* 2018, p. 19).

The majority of FinTech companies achieved rather low level of revenues from the sale of products and services in the years 2015-2017, and the percentage of FinTech companies with the lowest level of revenues has been growing. In 2015, as shown in [Figure 3-12], 60.4% of surveyed companies reported the level of revenues below 5 million PLN, while in 2017 this percentage was 74.3%.

[Figure 3-12] Percentage of Companies According to Their Level of Revenues from the Sale of Products and Services in the Years 2015-2017



Source: Based on Accenture, Cashless.pl, FinTech Poland survey carried out in April 2018 (Mazurek *et al.*, 2018, p. 22).

Almost 60%of Polish FinTechs are located in Warsaw. The remaining 40% are widely dispersed throughout the whole country. Poznań is the second largest FinTech center in Poland (12%) and Wrocław (8%) the third. Other large urban areas, such as Krakow, the Tri-City, play a much smaller role (Mazurek, 2018, p. 15).

According to Accenture data, FinTech investment in Poland was very low, in 2016 it amounted to over EUR 860 million. On the other hand, it achieved the highest value among the countries of Central and Eastern Europe, and constituted about 40% of the value of investments in this region. Just for comparison, it is worth noting that the total value of investments in the three leading European countries in Fintech industry (i.e. the UK, Germany and Sweden) amounted to USD 1.72 billion in 2016 (Mazurek *et al.*, 2017, p. 48-49).

Studies of the Obserwatorium.biz carried out in 2017 show that there is no single key factor affecting the development of the FinTech ecosystem. Its quality is determined by many elements that must coexist. Since 2017 a Taskforce for the development of Fintech sector has been identifying legal, regulatory and supervisory barriers to the development of the FinTech sector and preparing proposals on how to eliminate them. As of December, 2019 the list of barriers included in the Report on the work of the Taskforce for the Development of Financial Innovation (FinTech) consisted of 85 barriers, but the majority of them were already addressed (KNF, 2019).

2.4. Barriers to innovative activity in the service sector in Poland

Why are service enterprises in Poland less innovative that those in industry? This question can be answered through analysis of the barriers to innovation. The analysis is based on: a) Statistics Poland data published in a series “Innovation activity of enterprises”, b) the data provided by the Polish Agency for Enterprise Development (PARP from the survey “Monitoring the innovativeness of Polish enterprises”. The survey was conducted using the CAPI method (Computer Assisted Personal Interviews) on a nationwide representative sample of the enterprise population of 1327 companies. The analysis was supplemented by data from the third Community Innovation Survey (Eurostat) and the database of projects co-financed by the EU structural funds (SL2014). The third Community Innovation Survey represented the most comprehensive investigation on the barriers to innovation in services. High innovation costs, a lack of appropriate finance, a perception of excessive risk and the lack of qualified personnel were ranked as the most important barriers to innovation (Eurostat, 2004). A comparison between EU15 and new EU member states (NMS) reveals that economic risk is perceived as a barrier by more companies in the UE15 than in the NMS. The lack of qualified personnel is seen as a highly significant barrier to innovation in services, mostly in the UE15. Innovation costs are assessed as a very significant factor, hindering innovation in services both in the UE15 and the NMS. Companies from the NMS face more difficulties in access to finance.

The „Innobarometer”[5] asked the firms about the barriers or impediments they faced in undertaking innovation activities. In particular the firms were asked to identify the two most important of the following impediments to innovation activities: 1) “finding or mobilizing human resources”; 2) “accessing innovative customers and/or markets”; 3) “finding or using new technologies”; 4) “finding or mobilizing financial resources”; 5) “knowledge sharing or networking”; or 6) “protecting the companies knowledge”.

Of these, “accessing innovative customers or markets”, and “accessing or mobilizing human resources” were the two most widely indicated factors, both being identified by around one third of service firms. “Access to financial resources” was identified as a barrier to innovation by about a quarter of service firms, whilst “access to new technologies” was identified by around a fifth of the service firms.

“Apprenticeships and training of technical and/or commercial staff" was also widely regarded as a problem. Moreover, about 15% of both manufacturers and service firms were dissatisfied with the quality of university graduates. More than two thirds of the service

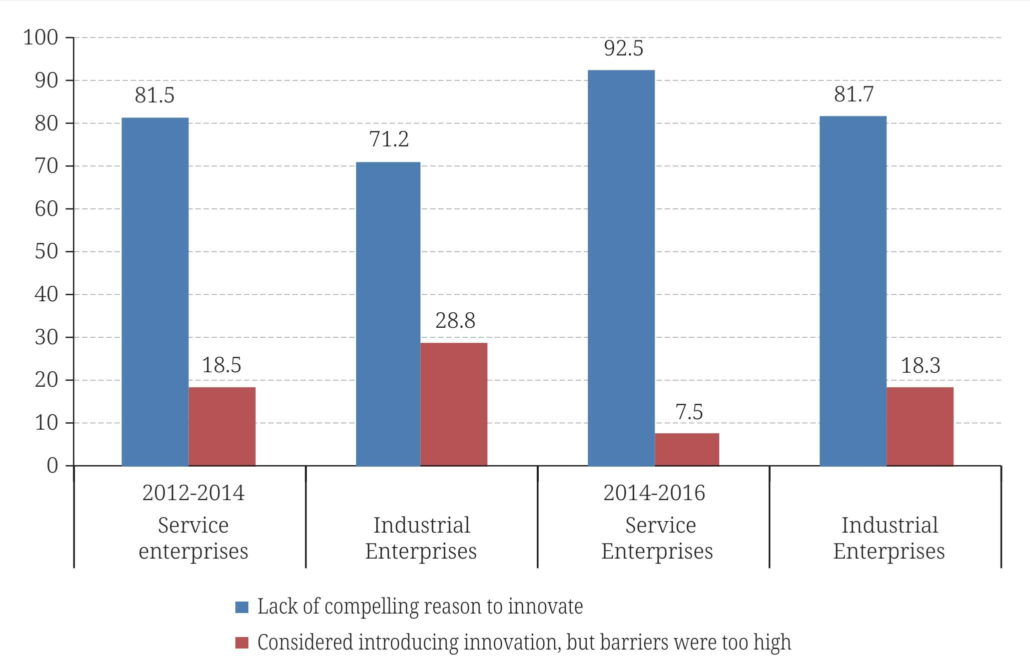
5 The Innobarometer is a survey on activities and attitudes related to innovation. It is carried out every year by EUROSTAT.

firms reported difficulties with the motivation of their staff (with respect to innovation).

Similarly, a survey of Polish companies carried out by Statistics Poland shows that for about three-quarters of industrial and service enterprises that did not implement innovation in 2012-2016, they gave the reason as a "lack of a convincing reason" for their introduction. Other entities considered implementing innovations, but the barriers proved to be too high.

[Figure 3-13] Enterprises Which Didn't Introduce Innovations by Main Reasons as the Share of Total Innovation Inactive Enterprises in the Years 2012-2016

(Unit: Number of company)



Source: Author's own elaboration based on GUS, Innovative activity of enterprises in the years 2012–2014 and Innovative activity of enterprises in the years 2012–2014, Statistics Poland, Statistical Office in Szczecin.

The significance of the individual reasons for not introducing innovation and the barriers encountered were determined by enterprises on a four-point scale: "high", "medium", "low", "meaningless."

Most often, enterprises indicated the high significance of the reason for which the enterprise did not introduce innovation in 2012-2016: "no good ideas for innovation" (9.1% of non-innovative service entities in the years 2012-2014 and 10.2 in the years 2014-2016).

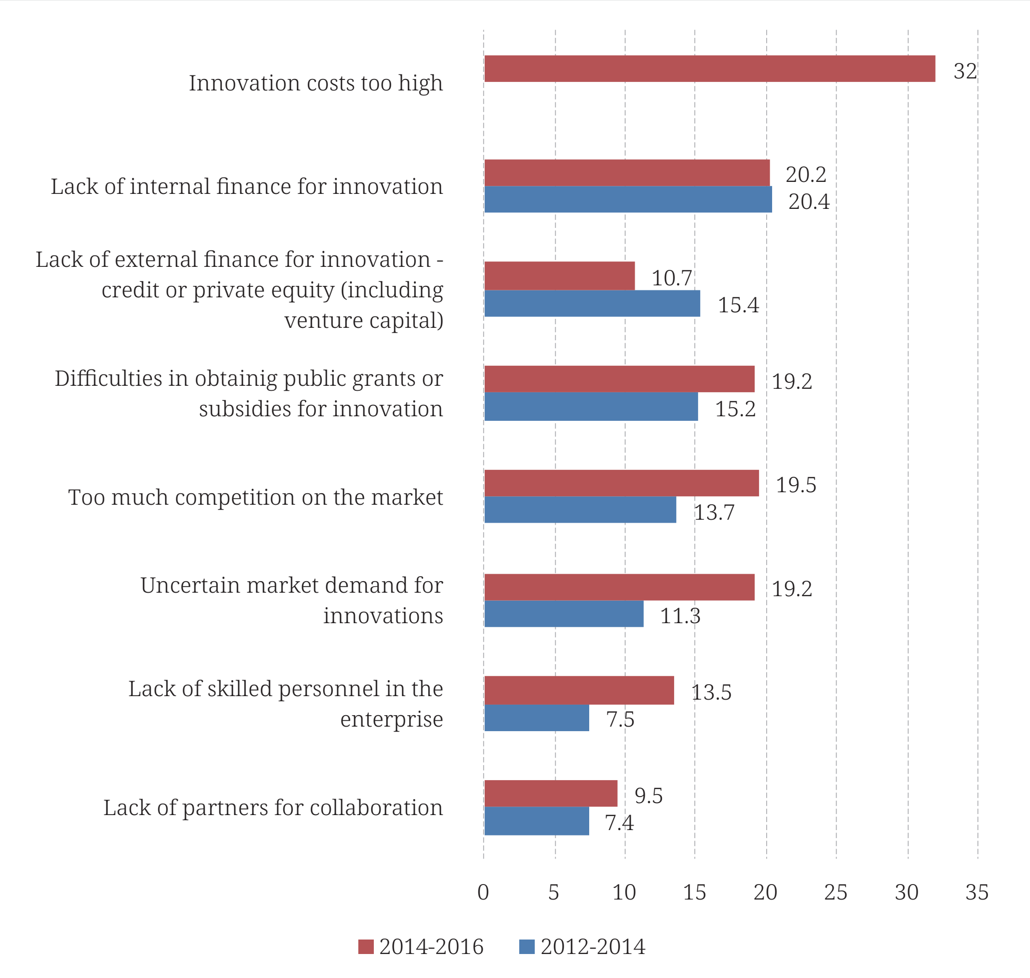
A lack of demand is often highlighted as a key factor explaining the low levels of service innovation, to which we must add a lack of awareness on the supply side concerning its innovative activities and potential.

Among the barriers to innovation, more often than one in every fourth industrial enterprise and one in every fifth service enterprise, as the most significant barrier they indicated the lack of financing of innovations from internal sources of the enterprise. In the case of this factor, the largest difference was also noted between service sector companies and industrial companies (8 percentage points). Many types of knowledge-intensive services require a direct relationship with the client. This creates a need to involve people who provide a specific service to the client at a given time. It is more difficult to decouple financial revenues from the time of service provision (than in the case of industrial companies). Therefore, revenues are often a function of the time spent on providing the service. So, it is easy to reach the ceiling determined by the number of hours that can be worked per day or month, because the rates per hour / day of work cannot be raised significantly above the market level set by the competition. For this reason, it is difficult to find a financial surplus that can be allocated to investments that lead to increasing the scale of services and improving their quality. This is a significant limitation to the development of companies operating in the service sector.

As indicated in [Figure 3-14], the barrier least often indicated as high significance of the innovation was lack of cooperation partners (7.4% of entities in the years 2012-2014 and 1.3% in the years 2014-2016).

[Figure 3-14] Enterprises which Rated Importance of a Given Barrier as "High" as the Share of Innovation Inactive Enterprises in the Years 2012-2016

(Unit: %)



Source: Author's own elaboration based on GUS (2015), Innovative activity of enterprises in the years 2012–2014, Statistics Poland, Statistical Office in Szczecin, p. 120.

Every third service enterprise active in innovation indicated "too high costs of innovation" as the man factor hindering innovation activity. The innovation costs include: research and development, own personnel working on innovations, materials and third party services purchased in order to implement innovations, investments for fixed assets and intangible assets in the form of patents, unpatented inventions and other intellectual property rights for the purpose of carrying out the innovation activity, and other costs incurred e.g. for defining the method of providing services, staff training, marketing(including market research) and costs incurred for reporting or registering and monitoring the intellectual property developed by the enterprise, related directly to the introduction of innovation. Another factor hindering innovation activity was the inability to finance innovations from the company's internal sources; one in five service enterprises indicated this.

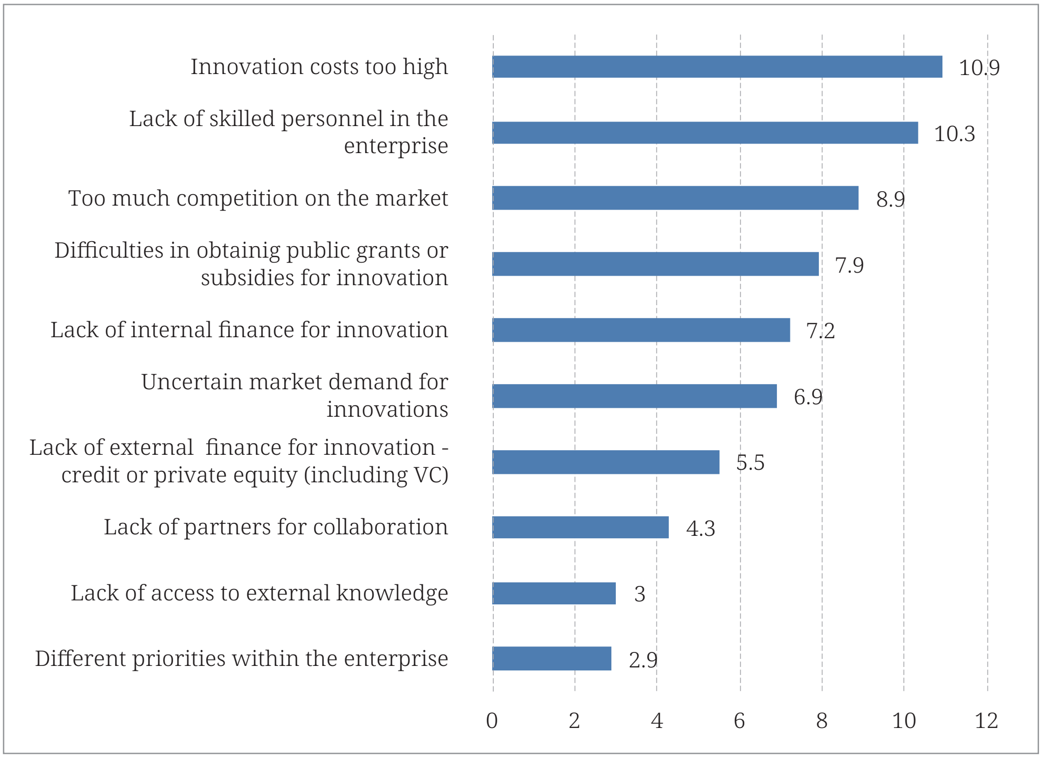
External condition factors are seen as more significant barriers to firm innovation than internal barriers, and are associated with, for example, the lack of qualified personnel and organizational rigidities. In particular, the lack of demanding and novelty seeking customers who are willing and able to pay for upgraded, improved or novel services may be an important barrier in service innovation which enterprises find difficult to overcome.

The Report on Innovative activity of enterprises in the years 2016–2018 published by Statistics Poland presents the results of a survey among innovation active enterprises.

The survey covered enterprises regardless of their innovative activity. Therefore, the results are not comparable between periods. Most respondents indicated that the "very important" factor was “too high costs of implementing innovations” (10.9% of service enterprises). “Lack of skilled employees within the enterprise” was another factor that was important for making a decision about starting an innovative activity or hindering its conduct. It can therefore be concluded that reducing these two barriers will increase the entrepreneurs' propensity to invest in innovation.

[Figure 3-15] Enterprises in the Service Sector which Rated Importance of a Given Factors in Hampering Enterprises' Decision to Start Innovation Activities, or its Execution of Innovation Activities as "Very Important" in the Years 2016-2018 2016

(Unit: %)



Source: Own elaboration based on GUS (2019), Innovative activity of enterprises in the years 2016–2018, Statistics Poland, Statistical Office in Szczecin, p. 99.

<Table 3-12> presents the share of enterprises in the service sector which rated importance of a given reason or barrier as "high" or "very high" in the years 2016-2018 by PKD NACE. It can be seen that the sections that face the majority of barriers (or all of them) include first of all "Scientific research and development" and "Telecommunications".

<Table 3-12> Factors Hampering the Decision to Start or Execution Innovation Activities in the Years 2016-2018 (% of enterprises that assessed a given factor as high or very -high) by PKD NACE

(Unit: %)

Specification	Too high costs innovative activity	Too much competition in the market	Lack of skilled employees	Uncertain market demand for new ideas	Difficulties in obtaining public grants or subsidies	Lack of internal finance for innovation	Lack of collaboration partners	Lack of external finance for innovation	Lack of access to external knowledge	Different priorities within the enterprise
Wholesale trade, except of motor vehicles and motorcycles	21.1	18.2	22.7	28.5	28.7	17.9	16.2	24.3	29.2	12.9
Land transport and transport via pipelines	19.5	17.8	19.8	27.4	27.4	19.3	11.8	20.8	30.4	12.5
Water transport	13.9	11.1	13.9	13.9	13.9	2.8	0	13.9	5.6	0
Air transport	13.6	9.1	13.6	27.3	22.7	13.6	4.5	31.8	27.3	13.6
Warehousing and support activities for transportation	17.3	14.1	22.3	26.8	24.6	15.9	12.3	16.2	23.1	14.1
Postal and courier activities	20.8	20.8	19.5	35.4	21.9	21.9	9.8	21.9	32.9	15.8
Publishing activities	30.5	25.3	32	41.2	39.9	25.8	20.8	39.3	40.6	20.5
Motion picture, video and television program production, sound recording and music publishing activities	31.5	24.8	21.3	39.3	40.5	29.2	20.3	30.3	30.3	22.5
Programming and broadcasting activities	16.1	16.1	20.2	25.2	31.3	17.2	9.1	31.3	37.4	17.2
Telecommunications	35.3	28	33.2	45.1	44	24	21.5	28.6	39.4	16.7
Computer programming, consultancy and related activities	30	23.1	27.2	43.8	44.3	22.8	17.7	35.6	32.7	18.4
Information service activities	25.9	21.3	21.3	35.5	36.1	20.1	15.5	27.4	31.2	18.2
Financial service activities, except insurance and pension funding	19.7	13.4	14.5	30.2	25	14.1	12.4	23.5	33.7	11.7
Insurance, reinsurance and pension funding, except compulsory social security	31.4	17.9	3	49.3	34.4	26.9	10.5	40.3	40.3	22.4

<Table 3-12> Continued

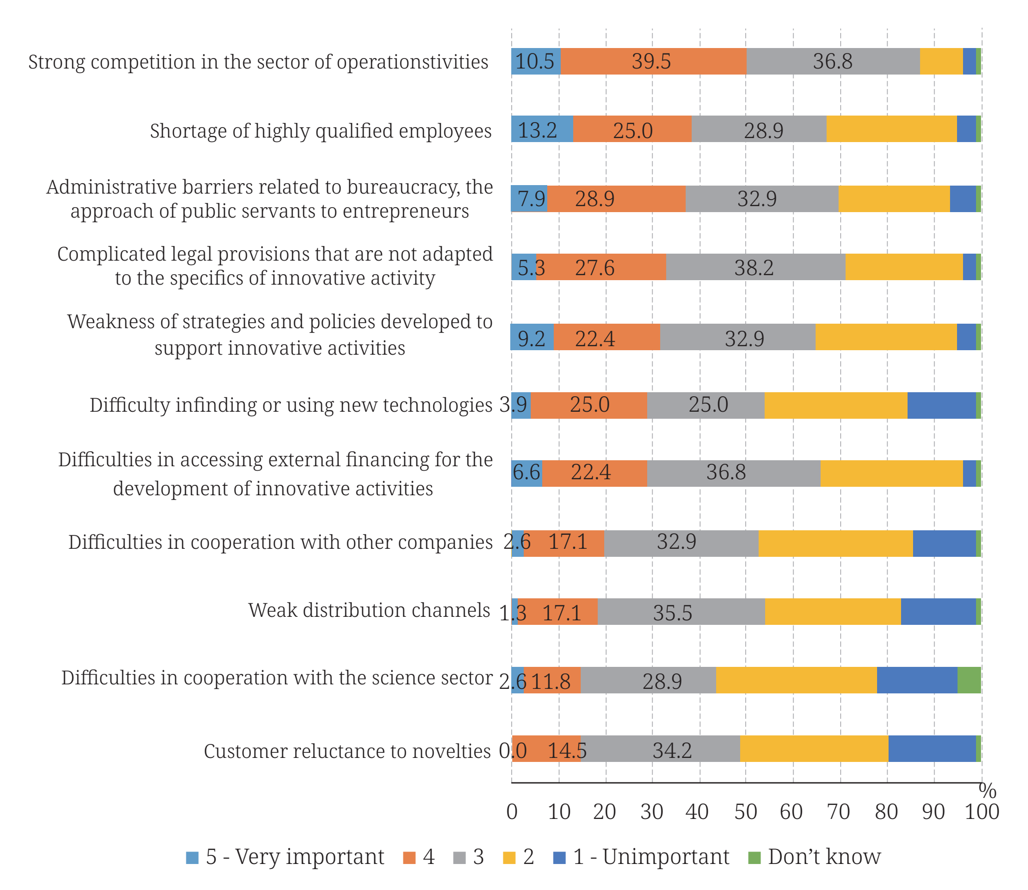
Specification	Too high costs innovative activity	Too much competition in the market	Lack of skilled employees	Uncertain market demand for new ideas	Difficulties in obtaining public grants or subsidies	Lack of internal finance for innovation	Lack of collaboration partners	Lack of external finance for innovation	Lack of access to external knowledge	Different priorities within the enterprise
Activities auxiliary to financial services and insurance activities	13.6	11	10.3	19.6	22.1	13.2	10.4	21.3	25.4	10.4
Architectural and engineering activities; technical testing and analysis	26.4	24	28.2	31.9	32.2	21.5	17.7	27.1	24.5	15.5
Scientific research and development	46	36.4	48.9	59.4	53.5	34.5	21.6	42.8	38.7	20.3
Advertising and market research	22.5	15.6	17.4	32.7	25.6	16.2	11.7	23.4	23.4	12

Source: Author's own elaboration based on GUS (2020), Innovative activity of enterprises in the years 2016–2018, Statistics Poland, Statistical Office in Szczecin, Tab. 26.

The factors influencing innovative activity in the service sector change over time. In a survey conducted in 2019 by the Polish Agency for Enterprise Development the significance of the individual reasons for not introducing innovation and the barriers encountered were determined by enterprises on a five-point scale, where 1 means "unimportant" and 5 – "very important". The results show that in the Knowledge Intensive Business Services sector, access to highly qualified employees is a barrier.

[Figure 3-16] Barriers in Developing Innovative Activity by Companies Operating in the Sector of Knowledge Intensive Business Services

(Unit: %)



Source: Author’s own elaboration of data collected in the project „Monitoring of innovation of the Polish enterprises", Polish Agency of Enterprise Development.

Staff qualifications and professionalism are amongst the most widely regarded strengths of companies with respect to innovation in service activities. Accessing and mobilizing human resources as one of the most widely identified barriers to innovation highlights the significance of “human capital” in service activities and innovation in services. In the sale of services, especially in services that require direct contact with the customer, trust plays a role. Highly qualified specialists not only must receive a high salary, but they also need working conditions that provide the opportunity to acquire new qualifications and expand knowledge.

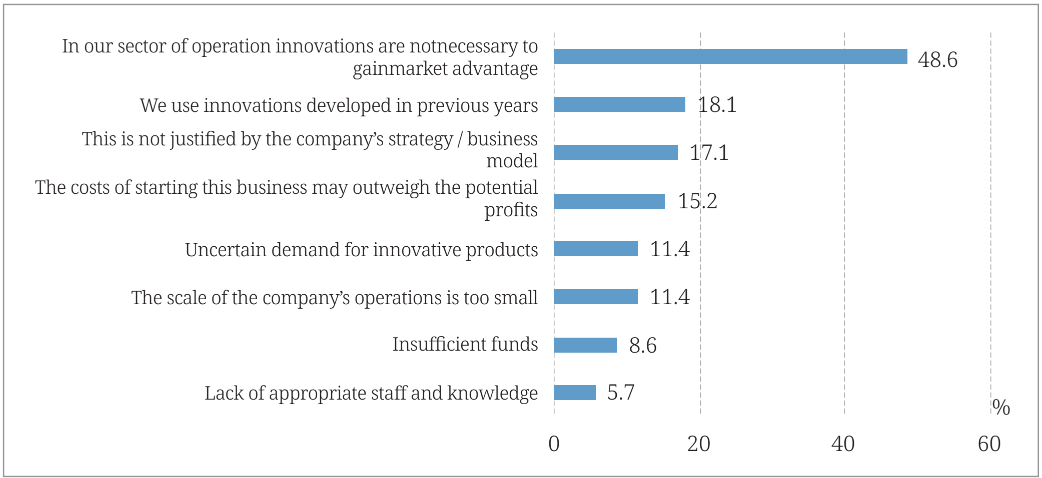
Another barrier, mainly concerning micro and small companies, is the difficulty in combining specialist knowledge and management. Small companies focus on operational activities related to ongoing order processing. This limits the possibility of spending time on strategic activities. There is a lack of knowledge on how to carry out the transition from a micro business to a larger company.

Another issue limiting the development of knowledge-intensive services is insufficient knowledge of marketing tools. Obviously, there is the possibility of using the services of specialized marketing companies, but this is associated with high costs, which increase the problem of accumulation of capital needed for development.

The reasons not to introduce innovations for enterprises in Knowledge Intensive Business Services are presented in [Figure 3-17]. Almost half of companies operating in the KIBS sector indicated that in their sector of operation innovations are not necessary to gain a market advantage. This may result from insufficient market competition, which may be related to the sluggish deregulatory process, and the fact that services tend to be locally produced and consumed.

[Figure 3-17] Why Did the Company Not Take Actions to Introduce Innovation in 2016-2018? - Knowledge Intensive Business Services

(Unit: %)



Source: Author's own elaboration of data collected in the project „Monitoring of innovation of the Polish enterprises", Polish Agency of Enterprise Development.

Due to certain characteristics of the services sector, including less tradability, intangibility (making it difficult to consumers to evaluate services quality before purchase and consumption), and due to the fact that SMEs are particular predominant in the service sector, firms operating in the sector, along with their customers, are less informed about alternatives and choices. This has a negative impact on innovation activity as less-informed parties tend to avoid risk by reducing exposure, which would negatively impact innovation activity.

Public support can therefore, on the one hand, enable breaking the vicious circle by providing financial leverage, on the other hand - facilitate development by providing advice on scaling up. It seems to be a good solution to allow for service companies to accumulate capital for development, for example, by deferring the payment of certain public contributions for a certain period of time (income tax).

3. Innovation in Services: the Korean Case

3.1. Overview of the Service Sector in Korea

The service sector is the segment of the economy that provides services to its consumers, covering a diverse set of economic and organizational activities. The diversity of service activities often makes it difficult to define the service industry as a unit. The definition of its coverage often differs from one case to another, and the policy direction and measures for supporting the service sector would critically depend on how to define it. In this section, we define the service sector as the collection of all the industries that are related to all economic activities except those that produce tangible goods, such as agriculture, fisheries and manufacturing.[6]

As shown in [Figure 3-18], as of 2018 the service sector in Korea accounts for 60.9% of its GDP and 69.8% of the total employment. During the 1991-2018 period, the proportion of Korea's service sector in its total GDP increased by about 7.2 percentage points while its employment share expanded by 21.1 percentage points. Within the service sector, the GDP shares of Professional, Scientific and Technical activities (Section M) and Human Health and Social Work activities (Q) have increased the most, by 2.8 and 2.7 percent points respectively, over the 1991-2018 period. In the meantime, the GDP share of traditional sectors, including Wholesale and Retail Trade (Section G), Transportation and Storage (H) and Accommodation and Food Service activities (I), has declined from 18.0%in 1991 to 13.7% in 2018. At the same time, however, these traditional service sectors represent around 27.5% of the total employment and more than one-third of the service sector employment in 2018.

6 Hence its scope comprises a variety of the sectors, including Wholesale and Retail Trade (Section G of NACE Rev.2 classification), Transportation and Storage (H), Accommodation and Food Service activities (I), Information and Communication (J), Financial and Insurance activities (K), Real Estate activities (L), Professional, Scientific and Technical activities (M), Administrative and Support Service activities (N), Public Administration and Defense; Social Security (O), Education (P), Human Health and Social Work activities (Q), Arts, Entertainment and Recreation (R), Other services activities (S), Activities of Households as employers(T), and Activities of extra-territorial organization/bodies (U).

[Figure 3-18] Importance of the Service Sector in Korea

Source: Statistics Korea Database.

As reported in <Table 3-13>, the service sectors in EU 28 countries and the United States account for 73.6% as of 2016, and 80.4% of their GDPs as of 2017, respectively, suggesting that Korea's share is substantially lower than these countries. The employment share of the Korean service sector is around 4.0 percent point lower than the EU 28 countries, while its GDP share is 13.6% lower than in the EU 28 countries. As mentioned, traditional sectors (Sections G, H & I) account for about 40% of the overall employment in the service sector, but only for 13.9 % in the total GDP in 2017.

<Table 3-13> Importance of the Service Sector: International Comparison (2017)

(Unit: %)

Panel A: Share in the Overall GDP								
Section	EU28	France	Germany	U.K.	Poland	U.S.	Japan	Korea
G, H & I	18.9%	17.8%	16.2%	17.7%	25.2%	18.3%	22.0%	13.9%
J	5.0%	5.2%	4.6%	6.3%	4.2%	7.1%	5.0%	4.6%
K	5.2%	3.5%	10.8%	7.3%	4.4%	7.6%	4.5%	5.8%
L	11.3%	12.9%	10.7%	13.8%	5.05	12.3%	11.5%	7.9%
M & N	11.0%	13.8%	10.8%	12.3%	8.3%	10.4%	7.9%	9.4%
O, P & Q	18.7%	22.5%	18.0%	18.1%	14.5%	21.3%	15.6%	16.1%
R, S, T & U	3.5%	3.0%	3.9%	4.0%	2.3%	3.3%	3.9%	2.4%
Total	73.6%	78.8%	75.1%	79.6%	63.9%	80.4%	70.3%	60.0%

<Table 3-13> Continued

Panel B: Share in the Number of Persons Employed								
Section	EU28	France	Germany	U.K.	Poland	U.S.	Japan	Korea
G, H & I	24.7%	22.9%	22.8%	26.4%	22.8%	26.5%	29.1%	28.0%
J	2.9%	3.1%	2.9%	4.2%	2.3%	1.9%	2.8%	2.9%
K	2.6%	2.8%	2.6%	3.3%	2.4%	4.1%	2.3%	3.0%
L	1.1%	1.3%	1.1%	1.6%	0.9%	1.3%	1.7%	2.0%
M & N	12.7%	15.3%	13.7%	16.7%	6.6%	14.3%	9.9%	9.2%
O, P & Q	23.6%	30.0%	24.7%	24.9%	20.2%	29.3%	19.7%	18.3%
R, S, T & U	6.2%	5.5%	6.8%	5.6%	3.5%	6.1%	6.2%	6.5%
Total	73.9%	80.8%	74.5%	82.7%	58.7%	83.6%	71.7%	69.9%

Note: All the figures are as of 2017, except EU28 (2016), U.K. (2016) and Japan (2015).
Source: EU KLEMS and Statistics Korea databases.

One of the apparent reasons for a low GDP share of the service sector in Korea stems from its manufacturing–centered economic structure. The Korean government has maintained an export-oriented growth strategy since its economic take-off in 1960s, and until recently, the most productive resources have been diverted mainly toward manufacturing. As a result, the importance of the manufacturing sector in the overall economy is greater than in other advanced countries. In 2017, Korea's manufacturing accounted for 26.9% of its nominal GDP, while manufacturing represented around 10 to 12% of the overall GDPs in the U.S., the U.K. and France. Korea's manufacturing share is even higher than Germany (23.4% in 2017) and Japan (20.2% in 2016). As depicted in <Table 3-13>, countries with a relatively higher share of manufacturing, such as Korea, Germany and Japan, tend to have a relatively low proportion of the service sector in GDP.

It is well-known that Korea, along with Israel, is one of the countries with the highest R&D intensity in the world. As of 2017, Korea invested 4.55% of its GDP in R&D activities. According to <Table 3-14>, the lion's share (89.5%) of Korea's R&D investment goes to the manufacturing sector, while R&D investments in the service sector are relatively smaller (8.3% in the total R&D expenditure) in comparison to other countries. Once again, similar to the Korean case, we find that, for Germany and Japan, most of their R&D investments are concentrated on manufacturing, however Korea's R&D share of the service sector is seemingly much lower than these countries, as shown in <Table 3-14>.

<Table 3-14> Industrial Composition of R&D Expenditure (2017)

(Unit: %)

Sector	France	Germany	U.K.	U.S.	Japan	Poland	Korea
Manufacturing	48.7%	85.2%	41.4%[1)]	64.3%	86.8%	39.8%	89.5%
Services	48.5%	13.7%	56.6%[1)]	34.7%	11.8%	58.1%	8.3%
Others	2.8%	1.1%	2.0%[1)]	1.0%	1.4%	2.1%	2.2%
R&D/GDP	2.19%	3.04%	1.66%	2.79%	3.21%	1.03%	4.55%

Note: Figures as of 2016.

Source: OECD Main S&T Indicators, OECD ANBERD, and Survey of R&D in Korea .

One notable problem with the aforementioned statistics regarding production and R&D activities is that they are unable to appropriately reflect the fact that there are great deal of service activities going on within manufacturing businesses. As Miroudot (2019) argues, servicification in manufacturing is carried out through several channels: first of all, manufacturing firms could outsource services and use them as intermediate inputs in production process. If it is the case, these market transactions are well reflected in official statistics on national accounts and input/output tables, and thus no measurement issues might occur. On the other hand, a problem arises when services are produced in house by manufacturing companies. Under the current statistical system, these services are attributed to the production and added value of the manufacturing industry, not to the service sector. Moreover, currently manufacturing companies increasingly produce services and provide them to consumers as a bundle with the goods. These all imply that the current statistical system could potentially underestimate the genuine magnitude of service activities for an economy. Whether services are produced in-house or outsourced, critically affects the measured size of the manufacturing sector.

Unfortunately, there are currently no statistics that accurately describe the overall scale of in-house servicification in manufacturing, especially in terms of production and value-added. Meantime, much as in the recent study by Miroudot and Cadestin (2017), we could indirectly observe the activities by examining labor force surveys that contain information on occupational composition for manufacturing firms. As depicted in <Table 3-3>, service-related tasks–managers, professionals, and clerical workers - have been expanding within the manufacturing sector in Korea.

As shown in the table, service-related tasks account for 42.3% of the total manufacturing employment in 2018. Their share increased by 4.3% during the period of 2012-18, at the expense of low-skill production jobs, such as parts/product assemblers and craft workers. The shift towards service-related tasks is more conspicuous in the case of large companies.

It is a well-known fact that large conglomerates–notably Samsung, LG, SK and Hyundai–take a significant share of industrial production, value-added and innovation activities in Korea. As shown in the right-hand columns in <Table 3-15>, in-house servicification has been progressing more substantially in large firms than others. The proportion of Mangers & Professionals has increased from 22.0% in 2012 to 24.2% in 2018. The increase has been more conspicuous for the case of clerical workers, from 19.5 to 23.3% over the same period. Meanwhile, the share of typical manufacturing tasks, such as craft workers, machine operators and parts/product assemblers, has declined substantially.

<Table 3-15> Occupational Composition of Manufacturing Workers

(Unit: %)

Occupation	Total			Large firms		
	2012(A)	2018(B)	B-A	2012(C)	2018(D)	D-C
Managers & Professionals	16.5%	18.4%	1.8%p	22.0%	24.4%	2.3%p
Clerical Workers	21.4%	23.9%	2.5%p	19.5%	23.3%	3.8%p
Sales & Service Workers	2.7%	2.4%	-0.3%p	1.1%	1.3%	0.2%p
Craft & Related Trade Workers	9.5%	8.1%	-1.4%p	8.3%	6.6%	-1.7%p
Machine Operators & Assemblers	44.2%	40.5%	-3.8%p	45.1%	40.0%	-5.1%p
Elementary Workers	5.6%	6.7%	1.2%p	3.9%	4.4%	0.5%p

Note: Large firms refer to those employing more than 700 regular workers.
Source: Labor Status Survey database.

In the Appendix of this paper, we discuss in-house servicification in the case of Samsung Electronics, South Korea's largest conglomerate. In 2006, Samsung Electronics employed more than 84 thousand regular employees, and only 24.2% of them engaged in service tasks. On the other hand, while this company has more than 100 thousand regular employees in 2018, more than a half of them are those performing service tasks, most notably R&D. At the same time, service outsourcing is not active and most services are carried out within the enterprise. These all suggest that servicification in the Korean manufacturing sector has been proceeding rapidly.

In sum, the Korean service sector is relatively sluggish compared to other countries, but this does not necessarily mean that service activities for the overall the economy are not active. Considering the rapid servicification of manufacturing, especially by large conglomerates, the magnitude of service activities are more substantial than those represented in production and R&D statistics. Therefore, we need to pay attention not only to the service sector itself, but also to the servicification of manufacturing, in order to get the genuine picture of the overall service activities in the Korean economy. In this context, while our research focus lies primarily on activities in Korea's service sector, we also briefly discuss the current trend of servicification basing on a case study of Samsung Electronics in the Appendix 2.

3.2. Development of the Service Sector in Korea-Knowledge Intensive Services (KIS)

Since the 1990s, knowledge intensive services have received a great policy attention, due to their close association with innovative activities and their impacts on productivity, international competitiveness, employment creation potential and overall economic growth. Knowledge intensive services are a group of sectors that generate high value by intensively utilizing knowledge and ideas, related to the production, processing, utilization, and distribution of goods and services, which are a key element in the transition to a knowledge-based economy.

In 1999, OECD defined knowledge intensive services - or knowledge-based services - as "a relatively large industry with new technology and human capital input compared to other industries." In addition, information and communication services, financial and insurance industries and business services, education, health care, publishing, culture and entertainment are often included in the coverage of knowledge intensive services. We employ the definition proposed by the Polish experts here, of which the detailed classification is presented in Appendix 3. Knowledge intensive services are divided into four categories: High-tech Knowledge Intensive services (High-tech KIS hereafter), Knowledge-Intensive Market services (Market KIS), Knowledge-Intensive Financial services (Financial KIS) and Other Knowledge-Intensive services (Other KIS).

As depicted in <Table 3-16>, the proportions of Korea’s knowledge intensive services in the overall GDP and employment are 18.1% and 15.5% in 2017, respectively.

<Table 3-16> Importance of Knowledge Intensive Services in Korea

(Unit: %)

Category	GDP Share (Nominal)		Employment Share	
	2007	2017	2007	2017
High-tech KIS	1.7%	7.0%	2.8%	3.6%
Market KIS	5.0%	5.3%	5.3%	7.6%
Financial KIS	4.7%	5.6%	3.2%	3.0%
Other KIS	0.3%	0.2%	0.3%	1.4%
KIS (Total)	11.7%	18.1%	11.6%	15.5%

Source: Statistics Korea database.

The GDP share of KIS has increased by 6.4% over the period of 2007-17. The lion's share of this increase stems from High-tech KIS, expanding from 1.7% of the total GDP in 2007 to 7.5 1in 2017. Among the subsectors of High-tech KIS, the GDP share of in Scientific Research and Development (72) significantly rose from 1.1% in 2007 to 2.7% in 2017, as well as that of Computer Programming, Consultancy and Related activities (62) from 1.2% to 2.4% over the same period.

As mentioned, most of R&D activities in Korea are centered around the manufacturing industry, and consequently R&D activities of the KIS sector represent a relatively small proportion. Furthermore, as shown in <Table 3-17>, the share of the KIS sector in total R&D spending has remained little changed for the period of 2008-18. At the same time, however, it does not imply that R&D in the KIS sector has been stagnant.

In fact, R&D investment in the KIS sector had increased 11.6% every year for the period of 2008-18. R&D investment in the Financial KIS increased the most conspicuously, with an annual increase of more than 100%. In addition, some of the high KIS sectors, such as Scientific Research and Development (72), Computer Programming, Consultancy and Related activities (62) and Motion Picture, Video and Television Programme Production, Sound Recording and Music Publishing activities (59), have maintained an annual increase of more than 20%.

<Table 3-17> Importance of Knowledge Intensive Services in Korea

(Unit: %)

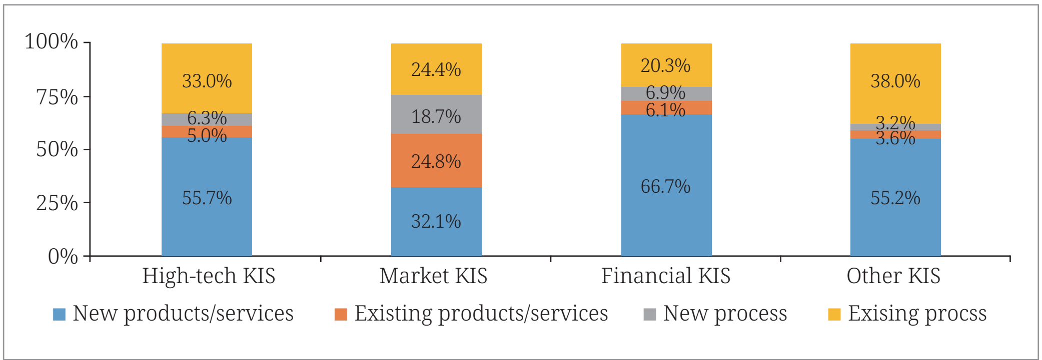
Category		Share in Total R&D (2008)	Share in Total R&D (2018)	Annual Growth (2008-18)	Annual Growth (2012-18)
High-tech KIS		2.56%	2.51%	11.2%	10.3%
	Motion picture, TV, Music, etc. (59)	0.02%	0.04%	21.9%	18.1%
	Broadcasting activities (60)	0.06%	0.02%	0.8%	0.8%
	Telecommunications (61)	1.46%	0.51%	-0.9%	-1.6%
	Computer programming, etc. (62)	0.29%	0.60%	20.6%	11.8%
	Information service activities (63)	0.28%	0.34%	13.7%	14.5%
	Scientific R&D (72)	0.45%	1.00%	21.9%	19.7%
Market KIS		1.56%	1.39%	10.0%	6.5%
Financial KIS		0.00%	0.24%	124.3%	111.9%
Other KIS		2.86%	2.95%	11.8%	7.7%
KIS (Total)		6.98%	7.09%	11.6%	8.9%

Note: The data for Section 50, 51, 75, 78 and 80 are missing and thus not included in the table.
Source: Korea R&D Survey Database.

[Figure3-19] depicts the usage of R&D expenditure by the KIS sector. R&D investments in the sector are used mostly either to develop new products/services or to improve existing production processes. For example, in the case of the High-tech KIS, around 55.7% and 33.0%, respectively, of its R&D investments are spent for such purposes. In the case of the Market KIS sector, there is a higher proportion of the investment in improving existing products or services or introducing new processes in the market KIS than in other KIS types.

[Figure3-19] R&D Expenditure of KIS by Type of Usage (2018)

(Unit: %)



Note: The data for Section 50, 51, 75, 78 and 80 are missing and thus not included in the table.
Source: Korea R&D Survey Database.

In <Table 3-18>, we report innovation densities of Korea's knowledge intensive services, basing on two different waves of the Korea Innovation Surveys, one for 2012 and the other for 2018. These surveys, which are equivalent to the Community Innovation Survey (CIS) of the European Union, contain information on firm-level innovation activities for 2009-11 and 2015-17, respectively. Here innovation density is defined as the proportion of companies actually engaging in each of the innovation activities. We find that innovation density in the KIS sector has seen a significant increase over the past six years or so. During the period, the proportion of companies carrying out product/service innovation increased from 8.6% to 20.9%, and that for innovation increased from 4.5 2to 14.4%. Similar or even greater improvement is observed in organizational and marketing innovation activities. According to the 2018 survey, 36.9% and 29.0% of the KIS companies are carrying out organizational and marketing innovation, respectively.

<Table 3-18> Innovation Density in the KIS Sector

(Unit: %)

Category	Service/Product Innovation		Process Innovation		Organizational Innovation		Marketing Innovation	
	KIS_12	KSI_18	KIS_12	KSI_18	KIS_12	KSI_18	KIS_12	KSI_18
High-tech KIS	18.3%	29.1%	4.1%	10.5%	27.6%	26.4%	13.0%	20.0%
Market KIS	2.5%	21.0%	3.0%	18.2%	14.3%	41.2%	5.4%	32.3%
Financial KIS	11.1%	10.1%	8.0%	4.0%	38.2%	13.1%	20.6%	28.3%
Other KIS	17.6%	17.0%	4.9%	6.1%	15.1%	39.2%	11.4%	24.1%
KIS (Total)	8.6%	20.9%	4.2%	14.4%	19.7%	36.9%	9.6%	29.0%

Source: Korea Innovation Survey (2012, 2018).

In the case of the High-tech KIS, the proportion of companies that engage in product/service innovation increased by more than 10% point from 18.3% to 29.1%, and the innovation densities for process innovation and marketing innovation also grew by about 7% point. Meanwhile, Market KIS is the sector with the most significant increase in innovation density. During the 2009–11 period, only less than 3% of the companies in this sector performed product/service innovation or process innovation. In contrast, during the 2015-17 period, the proportion of companies that are involved in these innovative activities becomes more than 18%. In addition, the innovation density for organizational innovation reached 41.2% during the 2015-17 period.

3.3. Knowledge Intensive Business Services (KIBS)

Amongst knowledge intensive services, Knowledge-Based Business services (KIBS hereafter) are widely regarded as a critical growth engine in the digital age. Since the initial discussion by Miles *et al.* (1995), many scholars and policymakers have paid special attention to them. KIBS refers to services and business operations which are reliant largely on professional, scientific and technological knowledge. Their key role is to supply knowledge intensive inputs and solutions to other companies and thus their employment structures are heavily weighted towards professionals with specific knowledge, such as scientists, researchers, engineers, consultants and lawyers. Again, while there are various ways to classify KIBS, we adopt the European Union's definition, as shown in <Table3-19>. The EU identifies KIBS as the sector that comprises activities of information and communication, research and development, and professional business services.

<Table 3-19> Classification of the KIBS sector (NACE Rev.2)

Section	Division Code	Division Activities
J: Information and Communication	62	Computer programming, consultancy and related activities
	63	Information service activities
M: Professional, scientific and technical activities	69	Legal and accounting activities
	70	Activities of head offices; management consultancy activities
	71	Architectural and engineering activities; technical testing/analysis
	72	Scientific research and development
	73	Advertising and market research
	74	Other professional, scientific and technical activities

Source: Eurostat.

<Table 3-20> describes the current status of the KIBS sector in 4 European countries and Korea. As of 2017, the KIBS sectors in these countries comprise around 8~11% of the total GDP. France has the largest share of KIBS in GDP, followed by U.K. and Germany. Poland and Korea have a similar size of KIBS relative to their GDPs, with 8.0% and 8.4%, respectively. In the case of Korea, professional services like legal, accounting, advertising and consultancy activities (69, 70 and 73) are relatively weak, compared to other countries. The GDP share of these services in Korea is merely about 1.3%, while those for U.K. and France exceeds 4% of their GDPs. A similar pattern, but to a slightly lesser degree, can be also observed in the employment composition. In contrast, the sector of scientific research and development (72) takes a larger share, both in GDP and share, in Korea than the countries in comparison.

<Table 3-20> Importance of the KIBS sector (2017)

(Unit: %)

Division code	France		Germany		UK		Poland		Korea	
	VA	EMP	VA	EMP	VA	EMP	VA	EMP	VA	EMP
62/63	2.8%	2.0%	2.7%	1.9%	3.0%	2.4%	2.1%	1.3%	2.7%	0.6%
69/70	3.9%	3.1%	3.1%	3.2%	3.8%	4.2%	2.9%	8.6%	1.2%	1.9%
71	1.5%	1.5%	1.5%	1.7%	1.4%	1.8%	1.1%	1.0%	0.7%	0.7%
72	1.8%	1.5%	0.8%	0.5%	0.7%	0.4%	0.5%	0.2%	2.7%	2.2%
73	0.4%	0.6%	0.4%	0.6%	1.0%	0.6%	0.9%	0.6%	0.1%	0.4%
74	0.3%	0.4%	0.5%	0.5%	0.7%	1.3%	0.5%	0.4%	0.9%	0.9%
KIBS	10.8%	9.2%	9.1%	8.4%	10.5%	10.6%	8.0%	12.1%	8.4%	6.8%

Note: VA – the share in the total value-added (GDP); EMP – the share in the total employment.
Source: Author's own on Eurostat and the Bank of Korea databases.

In <Table 3-21>, we compare labor productivity of the KIBS sectors across countries. Here the level of labor productivity for each sector in real terms is measured relative to that of manufacturing, and the reference year is 2015. Compared to manufacturing, the productivity level of KIBS is substantially higher - around 22 percentage points – in Poland, especially for Professional, Scientific and Technical activities (Section M). On the other hand, the productivity of the KIBS sector is lower than that of manufacturing in the cases of Korea and Germany. In both countries, the ICT service sector is more productive than manufacturing, but it is not the case for professional, scientific and technical activities. Therefore, taken into account the observations contained in <Tables 3-20> and <Table 3-21>, it seems to be clear that an in-depth study is needed to investigate why professional services are under-represented and less productive in Korea.

<Table 3-21> Labor Productivity (Manufacturing =100, 2015)

Section	France	Germany	U.K.	Poland	Korea
Section J (62-63)	127	135	108	202	126
Section M (69-75)	102	84	101	230	71
KIBS (Total)	107	96	103	222	81

Note: Due to the difference in industrial classification, we include veterinary activities (75) in Section M.
Source: Author's own using OECD STAN database.

As of 2018, Korean companies in the KIBS sector spend a total of 2.3 trillion won (i.e. 2.1 billion U.S. dollars) on R&D activities, which is around 3.3% of the overall corporate R&D expenditure in Korea. From <Table 3-22>, architectural and Engineering activities (71) and Scientific Research and Development (72) account for more than 60% of the total R&D spending in the KIBS sector. Additionally, there are 10.6 thousand R&D researchers engaging in Architectural and Engineering Activities (71), which are 38.3% of R&D researchers in the KIBS sector. The average R&D spending per researcher in this sector is 83.1 million won, with the highest in scientific research and development (72) at 127.6 million won. Further, the number of researchers per 1,000 employees is also the highest in scientific research and development (72) at 386.8, followed by other professional, scientific and technical activities (74). As presented in <Table 3-22>, the average R&D spending per researcher in manufacturing amounts to 186.9 million won, and therefore the average R&D spending in KIBS is about 44.4% of the manufacturing's

<Table 3-22> Summary Statistics for BERD R&D Activities in the KIBS Sector (2018)

Division code	R&D performing institutions (Number)	Total R&D spending (Billion Won)	Researchers (Person)	R&D Spending per researcher (Million won)	Researcher per 1,000 employees (Person)	R&D per Sales (%)
62	870	412.1	4,962	83.0	79.9	3.18
63	393	233.0	3,018	77.2	117.8	2.38
69/70/73	558	107.9	1,990	54.2	127.1	3.64
71	2,004	752.2	10,587	71.0	76.0	2.58
72	619	689.4	5,402	127.6	386.8	35.39
74	403	99.2	1,659	59.8	244.8	7.69
KIBS (Total)	4,847	2,293.8	27,618	83.1	104.8	4.22
All Industries	48,536	68,834.4	368,237	186.9	114.0	3.26

Source: Korea R&D Survey (2018).

As mentioned, the key role of KIBS is the provision of professional, scientific and technological knowledge inputs/solutions to other companies. Since knowledge is arguably one of the most decisive factors for a firm's productivity, profitability and survival, KIBS can generate substantial forward linkage effect to other industrial sectors. In this respect, it would be interesting to see which sectors utilize KIBS. In <Table 3-23>, we report the composition of final demands for the case of Professional, scientific and technical activities (Section M). As of 2018, about 41.9% of these activities are used in the service sector, 30.1% for individuals or unincorporated businesses, 15.3% for manufacturing, and 11.2% for the public sector, respectively. The composition of final consumption varies across different KIBS activities. Not surprisingly, legal services have a higher proportion of services to individuals (45.5%), while Architectural/engineering services have a higher share to other industries, notably construction, than other types of KIBS activities. Likewise, consulting, accounting and advertising activities are more service-centered in terms of forward linkage. In contrast, the scientific R&D sector maintains a more balanced portfolio; manufacturing account for 29.5%, services for 25.6%, and individuals/unincorporated businesses for 23.7%. As presented in <Table 3-23>, other than scientific R&D, the forward linkage between KIBS and manufacturing is apparently weak, which results in the relatively low contribution of professional, scientific and technical activities to the overall GDP.

<Table 3-23> Sales Composition of the KIBS Sector by Final Demander (2018)

(Unit: %)

Code	Sector	Manufacturing	Services	Other industries	Public sector	Overseas	Others[1]
69	Legal Activities	10.0%	37.9%	8.8%	3.1%	3.5%	45.5%
70	Accounting Activities Head offices/consulting	17.4% 12.4%	56.0% 62.6%	8.5% 6.7%	0.5% 11.5%	0.7% 1.5%	25.4% 12.0%
71	Architectural/ engineering	14.7%	26.0%	33.0%	17.4%	1.8%	7.0%
72	Scientific R&D	29.5%	25.6%	17.1%	20.1%	1.1%	23.7%
73	Advertising	15.8%	67.6%	3.6%	3.6%	0.1%	12.8%
74	Marketing research Other activities	12.9% 9.4%	43.5% 42.2%	2.3% 13.0%	24.5% 3.7%	1.4% 3.0%	17.7% 41.6%
Section M (Total)		15.3%	41.9%	8.8%	11.2%	1.6%	30.1%

Note: 1) Others include service provisions to individuals and unincorporated businesses.
Source: Service Industry Survey database.

In recent years, digital technologies related to the 4th Industrial Revolution are widely considered as game changers that determine success or failure of innovation and economic growth. <Table 3-24> provides the current status of development and utilization of digital technology in the KIBS sector, based on the survey of business activities conducted by the Korea Statistics Office. In 2018, around 11.4% of Korean companies in the sample are currently developing or utilizing technologies related to the 4th Industrial Revolution, including the Internet of Things, crowd, big data, artificial intelligence, block chain, 3D print, robot engineering and virtual reality/augmented reality.

Big data (12.6%) is the most frequently developed/utilized technological area in Korea's KIBS sector, followed by crowd (12.2%), Internet of Things (7.3%) and artificial intelligence. Among sub-sectors, Computer Programming, Consultancy and Related activities (62) are mostly heavily engaging in innovations related to the 4th industrial revolution. Around 31.7% and 25.5% of the firms in this sector are engaging in the development and/ or utilization of crowd technology and/or big data, respectively. AI, IoT and block chain are other areas that ICT service firms pay special attention to. Korean firms providing information service activities (63) are also active in utilizing big data as well as developing crowd and AI technologies/applications.

<Table 3-24> Development/Utilization of Digital Technology in KIBS (2018)

(Unit: %)

Division Code	IoT	Crowd	Big Data	5G	AI	Block Chain	3D Printing	Robotics	VR/AR
62	18.8%	31.7%	25.5%	10.1%	16.8%	13.9%	1.0%	2.4%	3.8%
63	5.0%	16.8%	25.7%	9.9%	12. 9%	7.9%	1.0%	0.0%	5.9%
72	5.3%	7.9%	10.5%	6.6%	9. 2%	2.6%	2.6%	3.9%	3.9%
69/70/73	4.2%	5.6%	9.9%	5.6%	3. 5%	0.7%	0.7%	0.7%	0.0%
71	3.0%	3.0%	3.3%	1.2%	0.9%	1.2%	1.2%	1.2%	1.2%
74	4.3%	4.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
KIBS(Total)	7.3%	12.2%	12.6%	5.4%	7.1%	1.4%	1.4%	1.5%	2.4%

Note: The proportion of companies that develop/utilize each category of digital technology.
Source: Survey of Business Activities (2019).

The survey of Business Activities also asks the key motivations for the usage of digital technologies. As reported in <Table 3-25>, more than one-third of the KIBS companies that are developing or utilizing digital technology responded that product/service development and technology sales are the key drivers. Regarding Computer Programming, Consultancy and Related activities (62), over 85% of the firms in these activities are shown to implement preemptive R&D investment and utilization in digital technology to promote product/service development and technology sales.

<Table 3-25> Usage of Digital Technology in KIBS (2018)

(Unit: %)

Division Code	Product(Service) Development	Marketing Strategy	Production Process	Organization Management	Technology Sales
62	88.0%	8.2%	2.4%	4.8%	85.6%
63	59.4%	12.9%	1.0%	1.0%	69.3%
72	30.3%	13.2%	3.9%	3.9%	15.8%
69/70/73	26.1%	4.9%	0.0%	2.1%	22.5%
71	8.3%	0.9%	2.1%	2.7%	11.3%
74	4.3%	4.3%	0.0%	0.0%	8.7%
KIBS(Total)	37.4%	5.7%	1.8%	2.9%	37.4%

Source: Survey of Business Activities (2019).

3.4. Innovativeness of the Service Sector in Korea

3.4.1. Innovativeness in ICT Sector

Nowadays, it is widely accepted that information and communications technology (ICT hereafter), as a key driver of sustainable development, contributes to enhance industrial productivity, promote economic growth and create new employment opportunities for an economy. According to the World Economic Forum (2013), every 10% increase in the digitization of a country leads to a 0.8% increase in per capita GDP, and a 1.0% decrease in the unemployment rate. ICT is gaining even more importance in the 4th industrial revolution era. Under such circumstances, most countries in the world are investing in ICT to gain a national competitive edge.

With high Internet/mobile phone penetration and sophisticated ICT manufacturing technology, Korea's ICT sector has played a critical role in its sustained economic growth over the last two decades. The ICT sector in Korea accounts for more than 10% of its GDP growth since 2000s and over 30% of the total exports. Korea has steadily been posited as one of the top performing countries in the ICT Development Index announced by the International Telecommunication Union (ITU) over the decade. In 2019, Korea became the first country in the world to launch the commercial 5G network.

At the same time, however, Korea's ICT competitiveness is connected mostly to ICT manufacturing, not the ICT service sector. As depicted in< Table 3-26>, ICT manufacturing takes the lions' share in value-added (78.6% of the overall ICT sector), total sales (72.3%) and exports (94.2%).

<Table 3-26> Key Indicators of the ICT Sector in Korea

(Unit: %)

Sector	Value-added	Employment	No. of Firms	Sales	Domestic Sales	Exports
Share (2017)						
ICT Manufacturing	78.6%	57.8%	24.7%	72.3%	64.1%	94.2%
ICT Services	14.6%	11.5%	13.5%	15.8%	20.4%	0.1%
Digital Contents	6.8%	30.7%	61.8%	12.0%	15.5%	5.7%
ICT total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

<Table 3-26> Continued

Sector	Value-added	Employment	No. of Firms	Sales	Domestic Sales	Exports
Annual Growth Rate (Average: 2000-17)						
ICT Manufacturing	6.7%	0.4%	1.4%	7.1%	6.5%	5.3%
ICT Services	3.9%.	1.6%	2.6%	5.2%	5.2%	7.4%
Digital Contents	6.6%.	7.0%	7.7%	12.0%	10.6%	28.4%
ICT total	6.2%	2.1%	4.7%	7.1%	6.6%	5.8%

Note: The growth rates for employment and exports are for the period of 2005-17.
Source: Statistics Korea Database.

Likewise, the proportion of ICT manufacturers in R&D spending is also very high. As of 2017, Korea's total R&D investment in the ICT sector stands at $33.3 billion, of which investment by the ICT manufacturers amounts to $30.5 billion, which is more than 90% of the total R&D spending. In particular, the proportion of investments made by large manufacturing conglomerates reached 83.9% of the total. On the other hand, R&D investment in the ICT service sector is $2.7 billion, more than a half of which is carried out by small and medium-sized enterprises.

<Table 3-27> R&D Spending and Personnel of the ICT Sector in Korea (2017)

(Unit: %)

Type		R&D Spending (billion US $)	R&D Personnel (thousand)
ICT Manufacturing	Large firms	27.9 (83.9%)	76.7 (47.6%)
	Other firms	2.7 (8.0%)	31.8 (19.7%)
	Subtotal	30.5 (91.8%)	108.5 (67.3%)
ICT Services	Large firms	0.8 (2.3%)	6.7 (4.1%)
	Other firms	2.0 (5.9%)	46.0 (28.6%)
	Subtotal	2.7 (8.2%)	52.7 (32.7%)
ICT (Total)		33.3 (100.0%)	161.2 (100.0%)

Note: Large firms refer to those employing more than 1,000 regular workers.
Source: Korea R&D Survey (2018).

Among the Top 10 ICT companies in Korea, listed in <Table 3-28>, seven firms are all ICT manufacturers, including Samsung Electronics, LG Electronics and SK Hynix. SK Telecom and KT Corporation, the top two ICT service providers, contain relatively low R&D strengths compared to the other ICT conglomerates.

<Table 3-28> Top 10 ICT Companies in Korea (2018)

(Unit: Billion won)

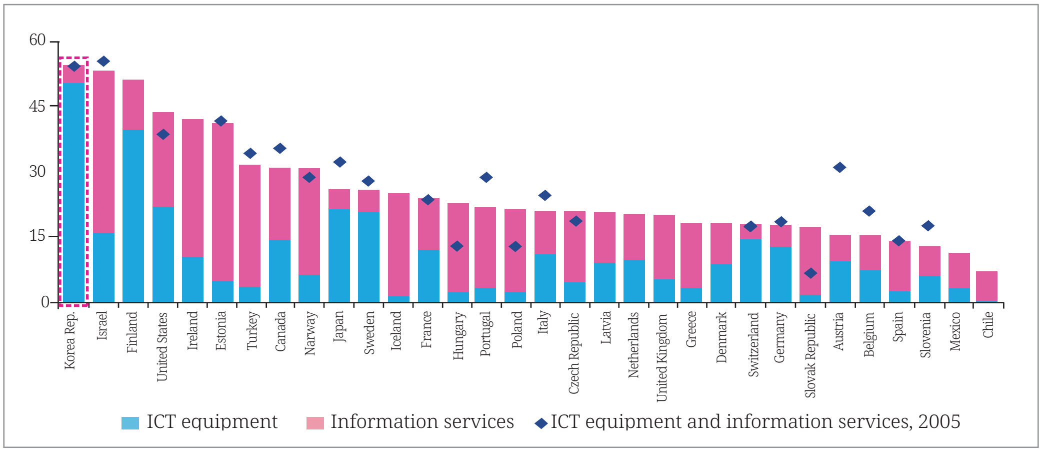
Rank	Company Name	Industry	Sales (A)	R&D (B)	B/A
2	Samsung Electronics	ICT Equipment	219.0	16.9	7.7%
20	LG Electronics	Consumer Electronics	55.1	3.3	5.9%
26	SK Hynix	Semiconductors	36.3	2.4	6.5%
31	Samsung Display	Display Components	29.0	1.9	6.7%
66	LG Display	Display Components	21.9	1.1	5.0%
122	Samsung SDI	Display Components	8.2	0.5	6.6%
159	Samsung Electro-Mechanics	Electronic Components	7.4	0.4	5.6%
187	SK Telecom	Telecommunication Services	15.2	0.4	2.3%
247	NC Soft	Software/Digital Contents	1.5	0.3	16.0%
369	KT Corporation	ICT	21.1	0.2	0.8%

Source: 2019 EU Industrial R&D Investment Scoreboard.

According to OECD (2017), Korea's R&D expenditures in the ICT sector turn out to be the second highest among a total of 32 OECD countries. A look at the breakdown of R&D expenditure in ICT industries indicates that the share of R&D expenditure on ICT equipment - 50.1% in 2015 - is the highest among the countries by comparison. On the other hand, the share of information services is only 4.1%, which is so low as to be ranked 31st among the 32 countries in the sample.

[Figure 3-20] R&D Spending by ICT Equipment and Information Services (2015)

(Unit: In %)

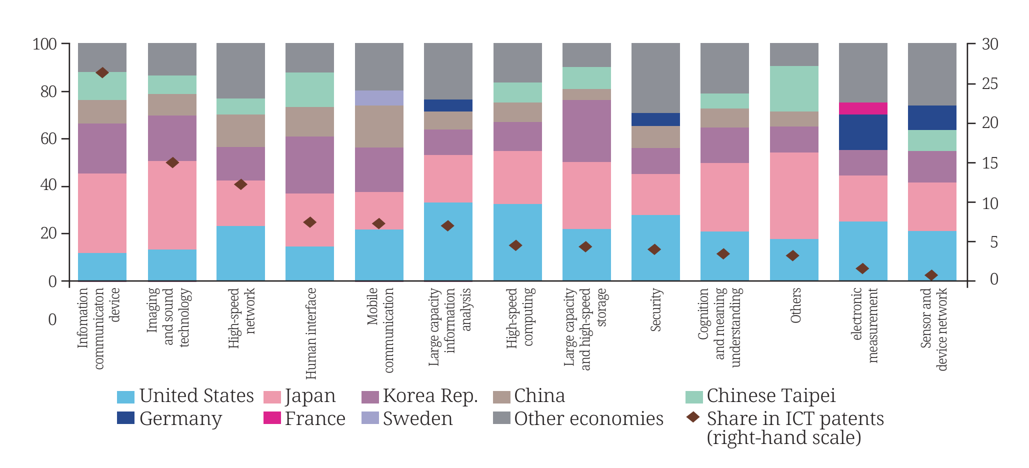


Note: As a percentage of business enterprise expenditure on R&D.
Source: OECD (2017).

[Figure 3-21] depicts the composition of ICT-Related Technologies by major countries in the ICT field. According to OECD (2017), the total number of Korea's ICT-related patents for the period of 2012-2015 is 60,630, which corresponds to 17.6% of the world's ICT-related patents. Korea has the third largest number of ICT-related patents, after Japan and the US, among the OECD countries.

[Figure 3-21] Patents in ICT-Related Technologies by Major Countries (2012-2015)

(Unit: In %)



Note: Share of the top five players in the field.
Source: OECD (2017).

Korea is actively engaged in ICT patent activities in various fields. Korea takes the top place in human interface (23.8%), and second to Japan in the field of large capacity and high-speed storage (25.8%). Despite such active ICT-related R&D activities, Korea's digital technology level is still behind major countries in the world, as indicated in <Table 3-29>. For instance, the level of AI technology is equivalent to 81.6% compared to that of the U.S., which is also lower than five European countries, Japan and China. R&D investment on AI technology is rapidly growing in Korea, but the relative gap is not narrowing due to the rapid pace of technology development in other countries in comparison. Furthermore, according to a survey pursued by a Korean research institute, only 0.6% of 3.95 million domestic businesses are utilizing AI technology and services on as of the end of 2017. Among the companies that are knowledgeable in artificial intelligence but do not currently use it, only 3.4% of them are willing to use AI technology in the near future. The survey results also indicate that the main reason for a low level of AI utilization is the lack of perceived necessity for it.

<Table 3-29> Relative Level of Digital Technology: An International Comparison

Technology	Korea	Japan	China	Europe
Artificial Intelligence (AI)	81.6 (2.0)	86.4 (1.8)	88.1 (1.5)	90.1 (1.4)
Big data	83.4 (1.9)	84.8 (1.4)	87.7 (1.1)	92.7 (0.8)
Crowd Computing	84.0 (1.8)	84.2 (1.7)	85 (1.6)	89.3 (0.9)
IoT	82.8 (1.2)	87.1 (0.9)	84.4 (1.0)	93.8 (0.5)
3D printing	79.9 (2.0)	91.0 (0.9)	84.7 (1.3)	95.3 (0.4)
Block Chain	80.8 (2.3)	87.5 (1.2)	85.8 (1.3)	90.5 (1.0)
Intelligence semiconductor	84.0 (1.4)	88.0 (1.3)	88.8 (0.9)	89.3 (0.8)
Smart Car	82.4 (1.4)	92.7 (0.5)	88.0 (0.8)	100.0 (0.0)
ICT Fusion	85.6 (1.3)	91.8 (0.6)	82.3 (1.5)	96.1 (0.4)
ICT Overall	84.5 (1.4)	88.9 (1.1)	86.1 (1.2)	92.9 (0.7)

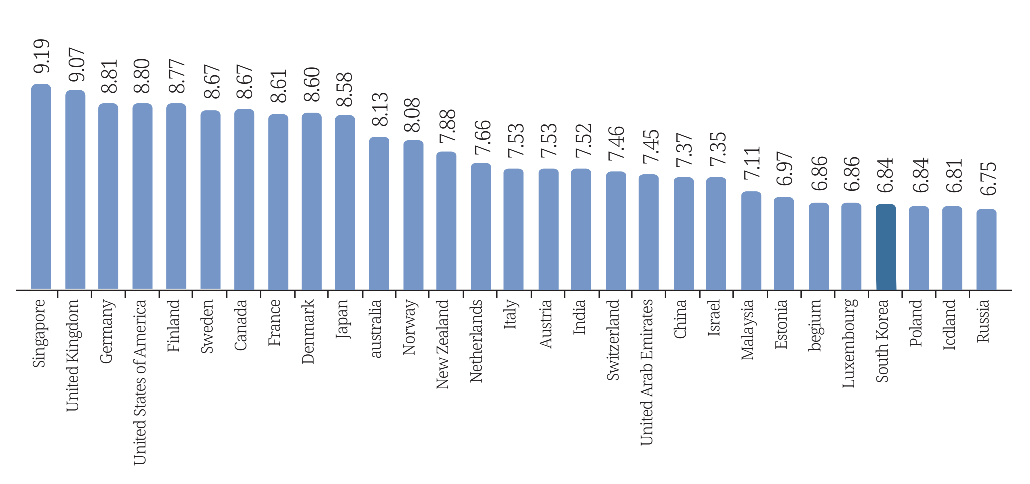
Note: The main figures are relative to the level of the U.S. (U.S.=100). The numbers in parentheses represent the technological gap (years). The European sample consists of U.K. France, Germany, Finland and Sweden.

Source: IITP (2018).

Oxford Insights, with the support of the International Development Research Centre (IDRC), recently published "Government Artificial Intelligence Readiness Index" measuring the current capacity of governments to exploit the innovative potential of AI in public services. According to the 2019 index, shown in [Figure 3-22] Korea turns out to rank 26th in the world, indicating that Korea's public environment for introducing artificial intelligence is worse than those of major countries in the world.

Among other digital technologies, the technology gap is particularly large in the areas of 3D printing and block chain, as can be seen in <Table 3-29>. Although the technology level for 3D printing is low and the domestic market size is still small, Korea's 3D printing technology is expected to catch up with major countries soon, thanks to its accumulated experience on manufacturing machine tools, precision parts, and semiconductor equipment as well as excellent post-processing manufacturing technology. On the other hand, recognizing the importance of the block chain sector, private companies and the government have been strengthening investment efforts for the development of related technologies, but the speed of technology improvement is somewhat slow.

[Figure 3-22] Government Artificial Intelligence Readiness Index (2019)

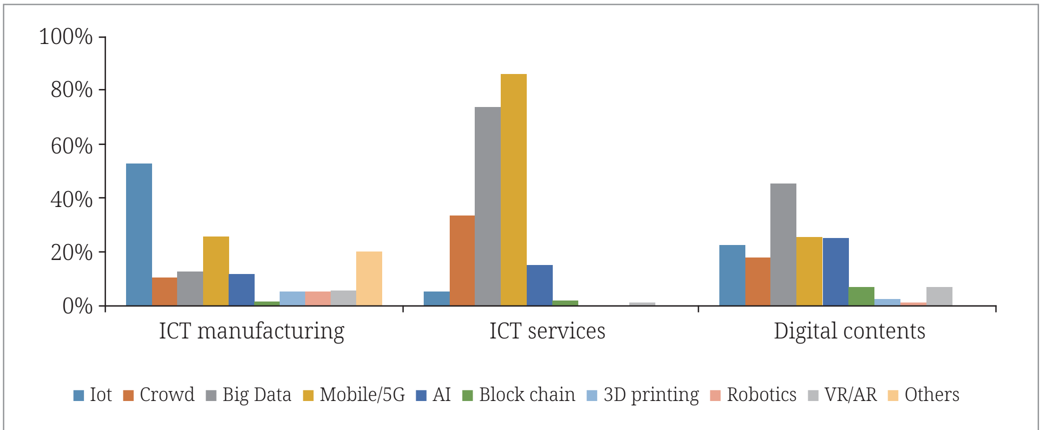


Source: Oxford Insights and IDRC (2019).

Finally, [Figure 3-23] reports the current status of digital technology development implemented by SMEs in Korea's ICT sector, based on a national survey. The sample consists of 60,502 companies, and around 10.9% of them are currently investing in cutting-edge technologies related to the 4th Industrial revolution. The share of firms engaging in developing these technologies is the highest for the Digital Contents-related sector (21.9%), followed by ICT services (8.7%) and ICT manufacturing (5.0%). As shown in the table, the development patterns vary across different sectors. In the case of ICT services, the focus is on the development of mobile/5G and big data technologies, while SMEs in ICT manufacturing is on IoT. Meanwhile, SMEs producing digital contents show more diversified interest in technological types.

[Figure 3-23] Development of Digital Technology by ICT SMEs (2018)

(Unit: %)



Source: Statistics Korea Database.

3.4.2. Innovativeness in Financial Sector

Over the past several decades, Korea's financial sector has experienced various changes, starting with strong governmental control and going through liberalization, crises and restructuring. At the early stages of Korea's economic development, the financial sector played a significant role in implementing its manufacturing-based growth strategy. Like many developing countries, Korea lacked domestic financial resources for development at the early stages, and it prompted the government to intervene heavily in the mobilization and allocation of financial resources toward the manufacturing sector. Consequently, the financial sector was under strong government control.

Later, as the Korean economy entered into its mature stages, the legacy of the government's control over the financial sector, and of its intervention in credit allocation, began to hinder the sound development of the financial sector. Consequently, Korea's financial sector experienced recurrent large-scale restructuring, especially after capital market liberalization in 1980-90s and the two economic crises – the Asian financial crisis in 1997 and the global financial crisis in 2008. Due to bankruptcy and liquidity problems during these periods, the number of banks decreased from more than fifty in 1990s to 17 in 2019. Medium-to small scale banks were largely consolidated to create large financial groups.

Nowadays, 6 financial-holding companies are leading the financial market in Korea, but they are still heavily regulated by the government. In the wake of the global financial crisis, the government has maintained a conservative lending stance as the economic recession persists. As a result, it has become very difficult for low-income consumers and/or SMEs without sufficient collateral capacity to take advantage of financial services. Under such circumstances, the Korean government began to recognize the FinTech industry as a key driver for the improved access to financial services as well as for an open and competitive financial ecosystem. FSB (2017) shows the various potential channels through which FinTech services contributes to economic growth and financial stability, as summarized in <Table 3-30 >.

<Table 3-30> Potential Benefits of FinTech Services

Channel	Potential Impact
Decentralization/diversification	-Dampening the impacts of financial shocks -Easing market entry -Diversifying financial services
Improving efficiency	-Reducing costs/fees and time -Supporting stable business models of financial institutions -Generating information asymmetries

<Table 3-30> Continued

Channel	Potential Impact
Enhancing transparency	-Improving risk management and pricing mechanism -Fostering new financial instruments with exposure to specific risks
Improved access to/convenience of financial services	-Enhancing financial inclusion for underprivileged households/SMEs -Supporting sustainable economic growth

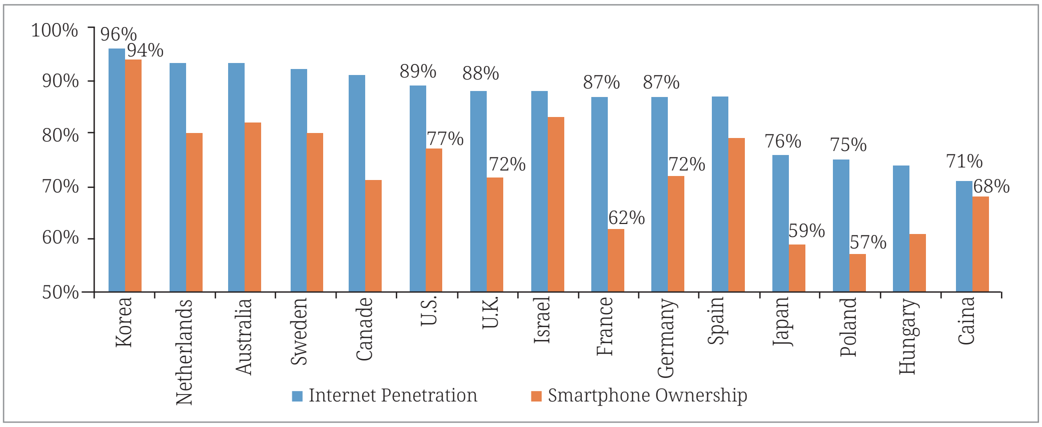
Source: FSB (2017).

In fact, Korea as a tech-savvy nation, with the world's top-level internet network infrastructure, cutting-edge technologies and smartphone penetration rate, has a very favorable condition for nurturing the FinTech industry. Korea has maintained the world's No. 1 level in terms of internet usage (96%) and smartphone penetration (94%) over the last several years. Especially, Korea has a huge edge in smartphone penetration over other countries.

Despites such sound market fundamentals, rigid financial regulations have been substantially impeding the proper development of the FinTech industry in Korea.[7] According to KPMG (2019), only two Korean FinTech firms - Viva Republica, which operates Toss and Moin, a blockchain technology company - are on the list of the world's top 100 FinTech Leading Companies. Among the world's top 100 FinTech leaders, the United States has the largest number of companies with 15, followed by UK (11), China (10), and Australia (7). Similarly, there is currently only one Korean unicorn company, Viva Republica, among the 60 FinTech unicorns worldwide listed by CB Insight.

[Figure 3-24] Internet Penetration and Smartphone Ownership

(Unit: %)



Note: The proportion of adults who use the internet at least occasionally/report owning a smartphone

Source: Pew Research Center (2018).

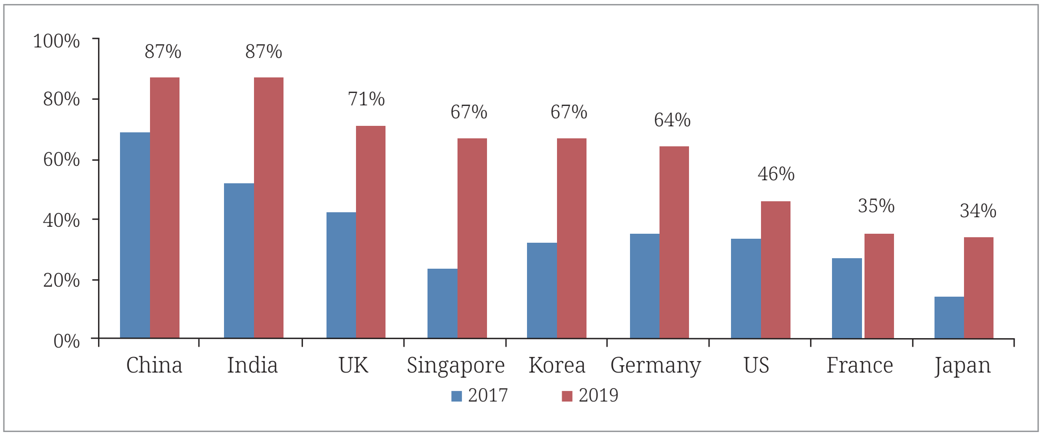
7 Korea ranks 13th in the overall ranking for the 2019 WEF global competitiveness index among 141 countries in comparison. While Korea tops in areas of macro-economic stability and ICT adoption rate, it ranks 87th in terms of government regulatory burden.

As depicted in [Figure 3-25], the proportion of FinTech adopters among the digitally active population in Korea drastically increased from 32% to 67% over the last two years. However, this is just above the global average (64%) and Korea still lags behind markets at the top of the list—China and India, both with 87%. The figure suggests that, in developed economies such as the United States and France, advanced financial infrastructure and financial regulations restrict the FinTech introduction, while emerging countries are more actively utilizing FinTech services as an alternative to their weak financial infrastructure.

Since 2015, the Korean government has taken a series of ambitious steps toward helping the FinTech industry grow into a new growth engine for the Korean economy. The government introduced a FinTech policy roadmap to revamp the offline-oriented financial system and to foster growth of the FinTech industry in 2015. It also launched the "FinTech Center Korea" to foster and support FinTech innovation startups. The center provides customized business counseling and mentoring to FinTech companies. In addition, the government lowered entry barriers to electronic finance business and introduced a crowd-funding scheme. In 2016, "FinTech Open Platform" was launched in Korea for the first time in the world, which is a combination of a website where FinTech firms can download program commands for FinTech services, and a physical space where these firms are able to pursue actual tests of the programs they develop.

[Figure 3-25] FinTech Adoption Rate: An International Comparison

(Unit: %)



Note: FinTech adopters as a percentage of the digitally active population in each market.
Source: EY (2017, 2019).

The Korean government has recently been focusing its efforts on creating a vibrant ecosystem to boost the FinTech market while laying the foundation for a more systematic organization and budget system to support FinTech companies. Deregulation is arguably the most critical factor for nurturing the FinTech sector. Under the newly enacted “Special Act on Financial Innovation Support,” FinTech firms/institutions may apply for participation in the regulatory sandbox with new financial services. Those seeking the regulatory waiver should file an application for a special designation. They need to submit their plans for consumer protection and risk management. If approved, then the designated service providers are allowed to test their new services for a maximum two years in an environment where the existing regulations are to be exempted, with the possibility of a one-time extension. So far, a total of 102 FinTech firms are designated as ‘innovative financial services’ since the launching of the regulatory sandbox program last year.

Another important policy change is the facilitation of the “Open banking system.” Under this system, FinTech firms access to banks' payment network is granted, which could lead to encourage the development of new payment services and greater competition in the financial sector. Until recently, the network access was restricted to banks, and even established lenders are only allowed to process their own bank account-based transactions. Although banks jointly launched a technology protocol in 2016 for an open banking system, few FinTech firms could access to the system by bearing relatively high fees. With open banking system, customers are able to use a single application to access their accounts at different banks and make payments. Furthermore, it induces banks to lower the fees charged to FinTech firms up to one tenth of the current level to ensure fair competition. On the top of that, incumbent banks in Korea started to actively collaborate with finTech companies and invest in them as strategic investors. Collaboration between FinTech companies and banks will definitely help drive innovation for better services and products.

<Table 3-31> Major Policy Moves for the FinTech Industry in Korea

Date		Policy moves
2015	January	Releasing “Plan to support convergence of Finance and Technology”
	March	Abolishing mandatory obligation to use public security certificates Launching “FinTech Center Korea”
	June	Releasing “Plan to introduce internet-only banks in Korea”
	July	Introducing “Crowd-funding scheme”
2016	June	Easing capital requirements for small-scaled electronic finance services
	August	Launching “FinTech Open Platform”
2017	March	Introducing financial regulation test-bed system
2018	February	Easing investment requirement for P2P lending
2019	April	Enacting the “Special Act on Financial Innovation Support” Launching financial regulatory sandbox
	September	Releasing “Guidelines on Financial Companies’ Investment in FinTech Business”

<Table 3-31> Continued

Date		Policy moves
	October	Launching “Open banking system” Approving “Act on Online Investment-Linked Financing (P2P Lending)”
	November	Releasing “Revision Bill on Credit Information Act”

Source: Author.

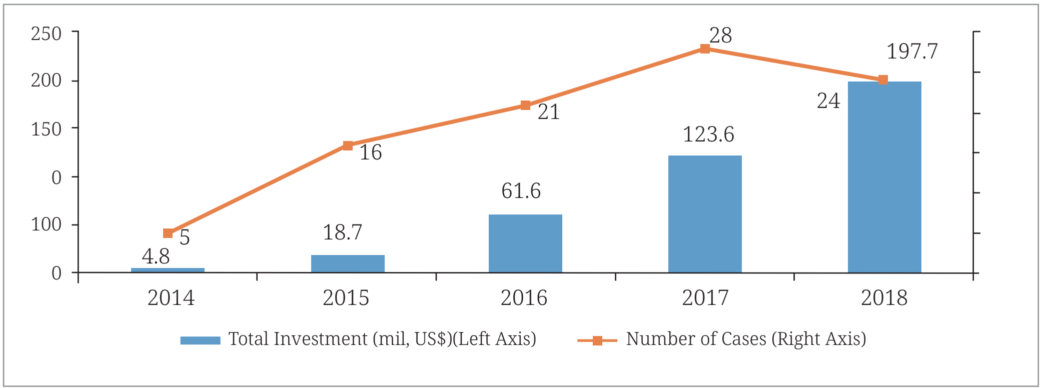
In addition, in order to remove the legal uncertainties on P2P lending and promote the related industry, the Korean government prepared a new legislation on online investment-linked financing, which was passed by the National Assembly on October 2019. The new legislation established a legal basis for the operation of P2P lending businesses and the regulatory oversight role of the Financial Services Commission. It will help build credibility to the P2P lending sector and speed growth. The total investment in P2P increased 37.3 billion won at the end of 2015 to 6.2 trillion won in June 2019.

In December 2019, the government announced measures to promote FinTech scale-ups, which contains the following 8 different policy areas:

- Improving the current regulatory sandbox system;
- Performing regulatory reforms to FinTech development;
- Lowering entry barriers to financial industry;
- Establishing regulatory foundations for digital era;
- Developing new engines for financial innovation;
- Promoting investment in FinTech and fostering a private sector-driven venture capital ecosystem;
- Assisting FinTech firms with overseas business opportunities;
- Expanding public sector support for FinTech firms.

The government will continue to eliminate regulatory obstacles and administrative red tape to FinTech innovation and make a regulatory shift towards a negative list system in the near future, under which everything not forbidden is allowed. With the aforementioned government’s efforts, Korea’s first two internet-only banks – K-bank and KakaoBank - began to operate in 2017. Furthermore, FinTech startups have begun to emerge in various fields, including crowdfunding, P2P and RoboAdvisor. And Viva Republica became Korea’s first FinTech unicorn in 2018, after receiving 80 million US dollars in investment from investors including Silicon Valley-based venture capital firms and U.S. global payment system company PayPal. The investment into domestic FinTech companies has steadily increased over the past five years, from 4.8 million US dollars in 2014 to 197.7 million in 2018. Additionally, the average amount per investment also rose from 1 million US dollars to 11.6 million during the same period.

[Figure 3-26] Investment into FinTech Companies in Korea

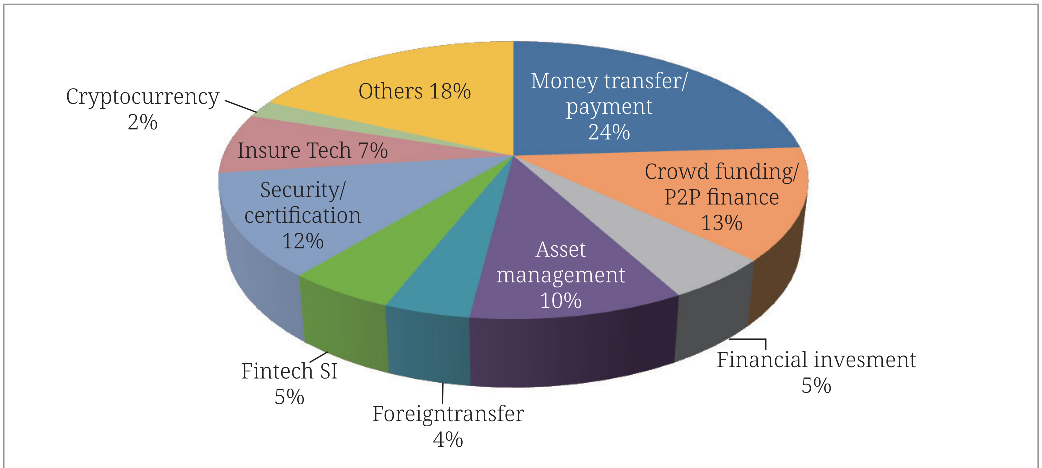


Source: CB Insight (2019).

As of October 2019, there are 328 FinTech companies in Korea.[8] A majority of them are start-ups established in the last three to four years. Within the service sector, companies engaging in simple payment/money transfer and P2P financing account for about 37% of all FinTech firms, as can be seen in [Figure 3-27].

[Figure 3-27] Composition of Korea's FinTech Firms by Services (2019)

(Unit: %)

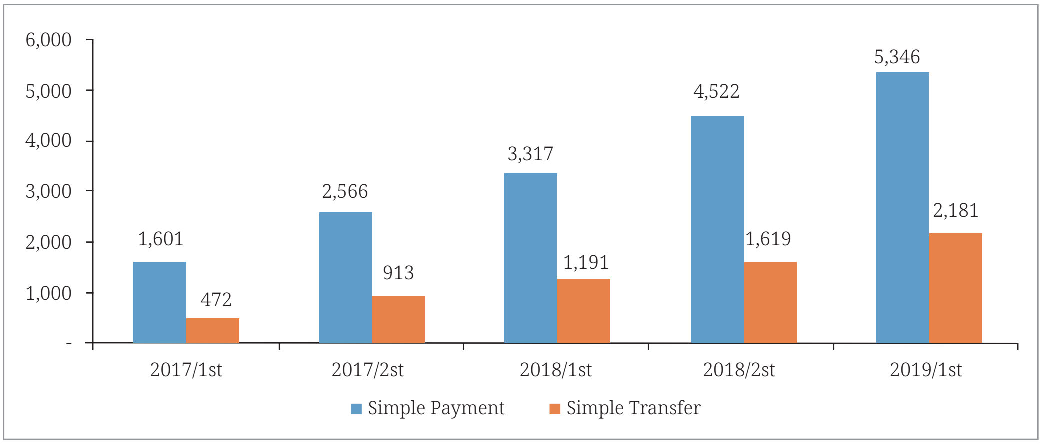


Source: KISA *et al.* (2019).

8 The figure is based on the membership of the Korea Fintech Industry Association. Including non-member companies, it is estimated that there are more than 550 companies.

Simple payment/money transfer is an area that has already seen rapid growth and become popularized. Here "simple payment" means a service that registers account information or credit cards on a smartphone and pays with simple self-certification, and "simple money transfer" refers to money transfers using mobile devices. Both services are very convenient; for instance, you can transfer money not just by using a bank account number but also mobile phone numbers, email addresses and SNS accounts, and so on.

[Figure 3-28] Utilization of Simple Payment/Money Transfer (1,000 cases per day)



Source: The Bank of Korea.

Although Korea has the highest level of smartphone penetration, until recently money transfers required a great deal of cumbersome and time-consuming procedures. Consumers needed to enter several passwords, use a physical password key card and complete multiple clicks to transfer money, even for a small sum of 1~2 dollars. Now thanks to new FinTech firms offering mobile payments, the whole procedure became simplified with a single password and one click. As of the first quarter of 2019, the number of domestic use of simple payment services (per day) totaled 5.3 million, up 3.3 times from two years earlier. Similarly, the cases for simple money transfer also increased from 0.5 million per day in the first quarter of 2014 to 2.2 million just two years later.

3.5. Barriers to innovative activity in Services in Korea

3.5.1. Business Environment for Services

In this section, we briefly discuss the existing barriers to innovation activities in Korea's service sector. As OECD (2005) suggests, there are several distinctive characteristics to innovation in services. First of all, service-related innovation often heavily depends on acquisition of knowledge from outside sources, via capital goods purchase, collaboration with partners and/or third parties, training and education, and so on. Therefore, in order to vitalize innovation in services, it is important to have a favorable business environment in which external knowledge can be acquired and utilized more easily. Second, the service sector is more human-capital intensive compared to other industrial sectors, and human resource development is very critical to service firms. Lack of highly skilled personnel is a major obstacle to innovation in the service sector. Third, the service sector generally has a low physical capital requirement, which makes it more common for companies to enter and exit out of the market. Consequently, the role of newly established firms, both in production and innovative activity, is greater in services than in other industries. Thus, creating a market environment that fosters entrepreneurship and innovation capabilities of start-ups is arguably an essential element of innovation in services.

Korea has experienced gradual improvements in market environments during the course of its economic development over the last several decades. According to the recent report by WEF (2019), Korea ranks 13th in terms of the overall global competitiveness among 141 countries in the world. Korea maintains the world's top rankings in several areas, notably ICT adoption rate, innovation capabilities and macro-economic stability. On the other hand, Korea has been stuck in the middle and lower ranks of the world in terms of burden of government regulations, market concentration and labor market rigidity. In WEF (2019), Korea ranks 87th in terms of government regulatory burden, 93rd for market concentration and 97th for labor market rigidity, respectively. As the service industry is an area where many government regulations exist due to its non-tradable goods nature, the heavy burden of government regulations, in particular, is likely to act as a major obstacle to innovation in services.

<Table 3-32> Global Competitiveness: An International Comparison

Pillar	France	Germany	U.K.	Poland	Korea
Overall	15th	7th	9th	37th	13th
Innovation Capacity	9th	1st	8th	39th	6th
ICT Adoption	29th	36th	31th	51th	1st
Skills	35th	5th	11th	34th	27th
Macroeconomic Stability	36th	1st	1st	1st	1st
Growth of Innovative Companies	31th	8th	19th	84th	37th
Burden of government regulation	65th	15th	21th	113th	87th
Extent of market dominance	25th	5th	23th	20th	93th
Labor market Flexibility	35th	18th	14th	95th	97th

Source: WEF, the Global Competitiveness Report (2019).

The Korea Innovation Survey includes questions about how government regulations have affected innovation activities for individual companies. <Table 3-32> shows the results of the 2018 Korea Innovation Survey on these questions. The figures in the table represent the percentage of service companies that respond that government regulation has hindered their innovation activities for each of different regulation categories.

<Table 3-33> Binding Regulatory Constraints against Innovation in Services

(Unit: %)

Type of Regulation		Overall Service Sector	KIS	KIBS
Economic regulation	Regulation on competition structure	18.6%	18.6%	21.3%
	Price regulation	19.3%	17.5%	14.8%
	Entry restriction on public service provisions	14.2%	14.0%	14.3%
	Sectorial restriction in favor of SMEs	14.5%	13.8%	14.7%
Social regulation	Financial market regulation	16.2%	16.3%	15.3%
	Environmental regulation	17.5%	14.1%	16.9%
	Industrial safety and health regulations	19.4%	15.7%	13.7%
	Consumer safety and sanitary regulations	19.2%	15.0%	13.4%
	Labor market regulation	24.5%	20.0%	15.5%
Administrative regulation	Regulations on start-up conditions	7.8%	7.3%	3.9%
	IPR regulation	8.1%	6.6%	2.8%

Note: Percentage of companies that respond that the regulation has hindered their innovation activities.
Source: Korea Innovation Survey (2018).

In <Table 3-33>, we summarize regulatory constraints in the case of the FinTech industry in Korea as an example. As a new service area, FinTech can only demonstrate rapid growth by revising existing related-laws or improving practices. As described in the table, there still exist a variety of cumbersome and inefficient regulations and practices that hinder the growth of the FinTech industry. Hence, the government needs to draw special attention to eliminate regulatory conflicts with existing laws/practices, relax competition-restricting regulations and/or implement temporary suspension for current regulations.

<Table 3-34> Regulatory Obstacles: The Case of FinTech Services in Korea

Difficulty	Binding Obstacles
Difficulty of entering the financial industry	- Strict licensing conditions and high capital requirements - Many financial services that are difficult or impossible to sign up for without any face-to-face contact - Various cumbersome procedures imposed by incumbent financial firms to customers to avoid liability
Difficulty in Fusion and convergence	- High barriers and prior permission required for partnership between companies. - Restrict manageability or incidental work to a positive list.
Difficulty in access to payment network	- High subscription costs to use the payment settlement network of non-banking financial companies - Separate business partnership with the banks required for Customer account withdrawals

Source: Author.

3.5.2. Internal Barriers to innovative Activities

The internal barriers to innovative activities within enterprises vary widely. From a financial perspective, firms may face a shortage of internal financial resources for innovation, limited access to external credit/private equity or difficulties in obtaining public grants/subsidies. Conversely, their innovation activities may be insufficient due to lack of internal capacity to analyze or obtain relevant information on technology, skill requirements and market situation, potential cooperative partners, and so on. The existing policy studies generally suggest that internal barriers are more significant factors hampering innovation than external factors.

<Table 3-35> presents the results from the 2018 Korea Innovation Survey on the importance of internal barriers to innovation in the service sector. The survey asks what factors have prevented individual firms from performing innovative activities over the past three years or, even if they have, from successfully commercializing them. For the service sector as a whole, financial constraints appear to be the biggest downside, especially due to a lack of internal funds. Approximately 17.8% of the surveyed companies said “lack of internal funds” is an important factor in delaying innovation. According the survey results, the “lack of internal financial resources for innovation” is a more critical factor in knowledge intensive services than other sectors. As for KIBS, financial factors are relatively less important, while the shortage of technological information, innovative capacities, market information and skilled workers seems to be a more binding constraint to innovation than other sectors.

<Table 3-35> Internal Barriers to Innovation in Services

(Unit: %)

Constraints		Overall Service Sector	KIS	KIBS
Financial factor	Lack of internal finance for innovation	17.8%	19.2%	16.9%
	Lack of credit or private equity	12.3%	13.6%	13.1%
	Difficulties in obtaining public grants/ subsidies	13.8%	14.4%	13.1%
	Innovation costs too high	14.8%	15.6%	12.5%
International capacity factor	Lack of skilled employees within your enterprise	12.3%	13.1%	13.7%
	Lack of information on technology	11.1%	12.2%	14.0%
	Lack of information on market	13.5%	14.7%	14.7%
	Lack of collaboration partners	9.8%	10.6%	11.5%
	Lack of internal ideas on innovation	12.9%	13.6%	16.2%
Market factor	Too much competition in your market	8.0%	8.4%	6.6%
	Uncertain market demand for innovation ideas	8.2%	8.6%	7.9%
Other factor	No need due to prior innovations	3.6%	3.8%	2.6%
	No need because of little demand for innovation	3.2%	3.4%	2.3%
	No need because of little market pressure	3.3%	3.6%	2.3%

Source: Korea Innovation Survey (2018).

4. Policy Options to Promote Innovation in Services

4.1. The Polish Case

As seen in [Figure 3-2], services in Poland are considered less innovative than manufacturing. There is also a significant difference in the degree of support to the manufacturing and services sectors. Evidently, higher levels of support provided to manufacturing may influence the innovative potential of services. Innovation policy is not adequately serving the needs of services firms. A comparison between the service and industry sectors concerning the percentage of companies that received public support to innovation activity shows that the former is less supported than the latter. <Table 3-36> indicates the share of enterprises which received public support for R&D, or other innovation activities, was two times lower in the service sector (2.2%) than in industry (4.4%). The same conclusion can be drawn from the data on the percentage of enterprises that used tax incentives and allowances in the years 2016-2018. Again, the percentage of service companies was lower compared to that in the industry, although in both sectors this percentage was quite low. In 2016-2018 only 1.8% of enterprises in the service sector used tax incentives and allowances for R&D or other innovation activity, while in industry it was 2.5%, as seen in <Table 3-37>.

It seems that policy instruments offered to enterprises aimed at raising the level of innovation do not take into account the specificity of the service sector. It should also be pointed out that in both service and industry sectors the most popular source of funds supporting R&D and innovation activity came from the European Union, but from other programmes than the "Horizon 2020" program for research and innovation. Only 0.7% service sector enterprises received support for R&D or other innovation activities from national government, while 1.7% service enterprises were supported from EU programmes other than Horizon 2020, as indicated in <Table 3-36>. These data confirm that more incentives for innovation offered to service companies at national level is indispensable.

<Table 3-36> Public Support of Innovation Activity in Poland in the Year 2016-2018: Industry and Services Compared

Category	Share of enterprises which received public support (grants, subsidies, preferential loans and/or credit guarantees/sureties etc.) (in %)									
	grand total	of which	from local or regional authorities		from national government units (ministries, government agencies, etc.)		from the European Union - from the Horizon 2020 Program for research and innovation		other support from the European Union	
		funds were used for R&D or other innovation activities	total	funds were used for R&D or other innovation activities	total	funds were used for R&D or other innovation activities	total	funds were used for R&D or other innovation activities	total	funds were used for R&D or other innovation activities
INDUSTRY	13.3	4.4	4.9	0.8	2.8	1.3	0.8	0.5	7.4	3.0
SERVICES	9.9	2.2	4.5	0.4	2.0	0.7	0.5	0.3	4.8	1.7

Source: Author's own elaboration based on Statistics Poland database (Table 20), https://stat.gov.pl/obszary-tematyczne/nauka-i-technika-spoleczenstwo-informacyjne/nauka-i-technika/dzialalnosc-innowacyjna-przedsiebiorstw-w-latach-2016-2018,2,17.html

<Table 3-37> Enterprises that Used Tax Incentives and Allowances in the Years 2016-2018

(Unit: %)

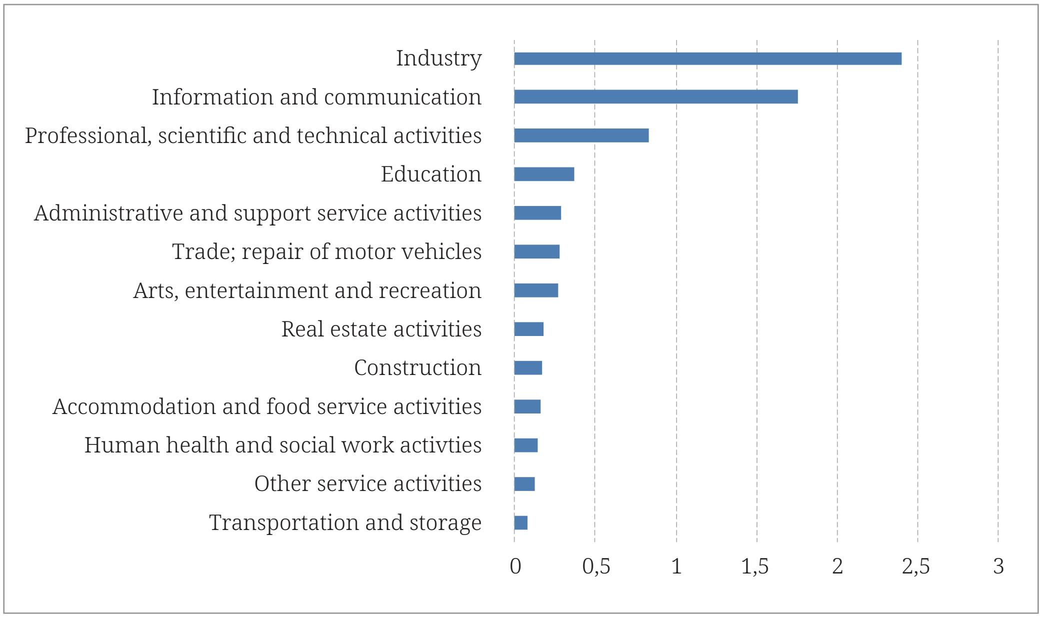
Activity	Industry	Service
Total	4.7	3.2
For R&D or other innovation activity	2.5	1.8
For all other types of business activity	2.6	1.6

Source: Author's own elaboration based on Statistics Poland database (Table 21), https://stat.gov.pl/obszary-tematyczne/nauka-i-technika-spoleczenstwo-informacyjne/nauka-i-technika/dzialalnosc-innowacyjna-przedsiebiorstw-w-latach-2016-2018,2,17.html

A similar conclusion stems from the analysis of data from the SL2014 database[9]. As part of the Smart Growth Operational Programme, i.e. the largest programme supporting the innovativeness of enterprises in 2014-2020, most contracts were signed with enterprises from section C (Industrial processing). The share of enterprises that received support in the framework of the programme by the end of 2019 in the total number of enterprises by section is presented in [Figure 3-29].

[Figure 3-29] Share of Enterprises Supported Under the Smart Growth OP 2014-2020 by Section

(Unit: %)



Source: Author's own calculations based on SL2014 (31 Dec 2019) and Central Statistical Office.

Service sectors are of considerable importance to national economies in Europe, as their output is used by other economic actors. Therefore, service innovation has the potential to

9 SL2014 is a database of projects financed from EU structural funds in the years 2014-2020 used by public administration for monitoring.

profoundly change the innovative activity of other sectors and catalyze the drive towards economic growth.

The development of policies to support innovation in the service sector needs to take account of the sector's specificities, which have an impact on how the sector innovates. These specificities include the interactive nature of services related to the involvement of customers in the innovation process, a relative absence of quality standards, and quite a low market transparency (which creates the risk of dissatisfaction once the service is delivered). As the analysis of barriers to innovation in the service sector conducted above shows, regulatory burden may be a challenge for innovative companies operating in the service sector which creates room for innovation policy measures.

Instruments supporting service innovation can be implemented at a few different levels, such as (European Commission, 2014, p. 14):

- the activity level (e.g. support to research on new business models);
- the company level (e.g. support to service start-ups);
- the sectorial level (e.g. improvements in overall business environment, enhancing networks and clusters development)
- the market level (e.g. deregulation/liberalization of service markets).

In Europe, a holistic and strategic approach to policy making is recommended to increase benefits from service innovations and their transformative power. However, policy measures addressed at the company and sectorial levels seem to have the strongest impact on boosting innovation in services (European Commission, 2014, p. 15). Moreover, policy recommendations regarding support to service innovation have to also take into account, on the one hand, factors that are the most important barriers to service innovation, but on the other hand drivers of change in the service sector.

This study concludes that there is a growing integration between traditional manufacturing and services, and more simultaneous connection of services through value networks can be observed. However, the service sector in Poland, and in particular the knowledge intensive services are still less developed and less innovative in comparison with EU countries. The most important barriers to innovation in services are: a lack of appropriate finance, a perception of excessive risk and the lack of qualified personnel. One of the reasons for this is the difficulty in accumulating profits associated with the fact that it is hard to achieve economies of scale in the services sector. This does not apply to KIBS, but in other service activities it is a severe limitation. As the majority of service companies are small in size and don't have appropriate collateral, they have limited access to external financing. Moreover, innovative activity involves risk and in this case collateral is even more required by financial institutions.

Public support should therefore facilitate access to finance for service innovation. Policy interventions in the form of loans or loan guarantees are needed to encourage enterprises, in particular SMEs, to develop innovative activity. This type of instrument addresses barriers at company level.

Another area of intervention applies to the sectorial level. There is a need to improve the overall business environment in the service sector as well as to reduce the barrier of skill shortages. Policy interventions at the sectorial level should be aimed at improvements in the quality of public services for entrepreneurs, facilitating professional development and offering a better environment for workers, as well as friendly immigration laws. Another dimension of these sectorial innovation policy interventions is related to facilitating cooperation and networking, which can be addressed by support to cluster development. Cluster initiatives may be used as regional organizations though which specific support services are provided or channeled to a group of enterprises and other innovation actors.

In addition to these policy actions that should be implemented at the company and sectorial levels, some activity level measures seem to be necessary.

Activity level measures are crucial for ICT implementation in the service sector as ICT has become a key technological driver and enabler of innovation in services. It also should be pointed out that ICT services are much more R&D intensive than the whole service sector, therefore public support to this kind of services could focus on strengthening the R&D base. Additionally, it is necessary to implement these new ICT solutions in the whole service sector; therefore innovation policy should promote diffusion of new ICT solutions in service companies.

The main conclusion of this study is that improvements in the framework conditions for service innovation and removing identified barriers to service innovation seem to be the best way to foster innovation in services in Poland. Direct support measures should focus on access to finance, collaboration and ICT development and implementation.

4.2. The Korean Case

4.2.1. Policy Measures for Innovation Activities

As presented in <Table 3-38>, there exist a variety of policy measures that the governments can implement to boost innovative activities within the private sector. They may apply tax deduction or exemption schemes regarding basic/applied research, technological commercialization and/or human resources development. They can directly provide grants or public subsidies to innovative activities or encourage private firms to take a part in national R&D projects. Another type of financial support is to enhance access to preferential credit and loan guarantee programs.

In addition, the governments can indirectly help private firms to facilitate innovative activities by providing human resource assistance and/or technological support, which includes the provision of human resources information, fostering skilled human resources and enhancing a standardization/accreditation system and expanding the R&D infrastructure. They can also use public procurement to promote product/service sales.

Last but not the least, the governments could take various measures to reduce the regulatory burden and create a favorable business environment for innovative activities, by eliminating regulatory conflicts with existing laws/practices, relaxing competition-restricting regulations or implementing temporary suspension for current regulations.

<Table 3-38> Typology of Policy Measures to Promote Innovation

Area	Policy Measures
Tax Credit	Tax deduction or exemption related to research, human resources development, and technological commercialization
Grants & Subsidies	Grant and/or subsidy provision, participation in national R&D projects
Credit & Guarantee Provision	Investment, loan, guarantee, technical financing support, guarantee-linked technology evaluation, R&D guarantee
Human Resources Assistance	Employment Support, education & training support
Technological Support	Support for technology development, commercialization/transfer, patents, & infrastructure construction/utilization
Accreditation	A certificate of business, technical product certification
Sales Promotion Support	Public procurement, preferential purchase, designation of excellent products
Deregulation	Introduction of negative regulatory system, temporary suspension/ease for current regulations, elimination of regulatory conflicts with existing industries Improvement of certification, testing and inspection systems, support for enhancing capacity on regulatory compliance

Source: Author's own summation based on the Korea Innovation Survey.

In any case, actual policy demands from the private sector is arguably the strongest criterion when the governments formulate and implement a package of public support for innovation activities. In this respect, we examine what preferences Korea's service firms have for government policy instruments and report the analytic results in <Table 3-39> and <Table 3-40>. The information again comes from the 2018 Korea Innovation Survey and the sample consists of service companies with experience utilizing any of these policy instruments. We find that firms engaging in KIBS seem to evaluate most policy-support measures for innovative activities more highly than other service sectors. In particular, the KIBS sector stresses the importance of policy measures related to tax breaks, technical support and certification. On the other hand, supporting human resource development and recruit is evaluated as another very important policy area when targeting the entire service industry.

As for deregulation measures, service companies emphasize the importance of eliminating regulatory conflicts with existing industries, especially those in the KIBS sector. Almost 20 of the surveyed firms in the KIBS sector perceive that the government should improve the regulatory framework for newly emerging services such as FinTech and smart cities. One more important observation is that more than one-fifth of service companies communicate the necessity of public support for enhancing individual firms' capacity for regulatory compliance.

<Table 3-39> Relative Importance of Policy Measures for Innovation in Services

(Unit: %)

Areas	Policy Measures	Overall Service Sector	KIS	KIBS
Tax credit	Tax deduction or exemption related to research, human resources development, and industrial technology	10.6%	11.7%	15.7%
Grant & Subsidies	Subsidy assistance, participation in national R&D projects, etc.	6.3%	6.7%	7.4%
Credit & guarantee	Investment, loan, guarantee, technical financing support, guarantee-linked	4.3%	4.2%	3.8%
Human Resources	Employment Support, education & training support, etc.	10.9%	10.3%	7.1%
Technology	Support for technology development, commercialization/transfer, patents, & infrastructure construction/utilization	10.0%	10.9%	14.3%
Certification	A certificate of business, technical product certification, etc.	11.1%	12.0%	17.5%

<Table 3-39> Continued

Areas	Policy Measures	Overall Service Sector	KIS	KIBS
Sales promotion	Public procurement, preferential purchase, designation of excellent products, etc.	3.4%	3.5%	2.6%

Note: Percentage of companies that evaluate the policy measure as important.
Source: Korea Innovation Survey (2018).

<Table 3-40> Relative Importance of Deregulation Measures

(Unit: %)

Areas	Policy Measures/Targets	Overall Service Sector	KIS	KIBS
Transition to a comprehensive negative regulatory framework	Application of the principle of ex-post regulation	5.9%	6.3%	2.3%
Temporary suspension/ease for current regulations	Regulatory free zones, regulatory sandboxes, etc.	5.9%	6.3%	2.2%
Elimination of regulatory conflicts with existing industries	FinTech, renewable energy, smart cities, drones, autonomous vehicles, etc.	16.6%	17.9%	19.7%
Relaxation of competition-restricting regulations	Removing unreasonable entry regulations, qualifications & restrictions	11.4%	12.2%	5.8%
Support for enhancing capacity on regulatory compliance	Manuals, education & training on regulations	21.6%	23.24%	24.1%

Source: Korea Innovation Survey (2018).

4.2.2. Korea's Policy Approach to Innovation in Services

Many countries are implementing policies to foster their service industries, but policy directions could differ from country to another. Some countries focus on improving intermediate services, especially for knowledge intensive services, to enhance productivity of the overall economy through backward and forward industrial linkage. Some other countries try to nurture the so-called "creative industry," comprising design, music, film and video, crafts, visual arts, and fashion, among many others. The main motivation of this approach is to create employment opportunities for creative workers and vitalize under-developed regions. Finally, there are countries that are implementing supportive measures to promote service exports.

<Table 3-41> Typology of Service Sector Policy

	Improving Intermediate Services	Nurturing Creative Industry	Promoting Service Exports
Policy Objectives	Establishment of virtuous circle between service and manufacturing sectors	Promoting Creative Industry as a national strategic sector	Improving external competitiveness of the Service Sector
Policy Measures	- Enhancing IT Utilization - Promoting KIS - Service Sector liberalization - Promoting innovative activities	- Promoting creative human resources & job opportunity for creative workers - Regional cluster for creative industry - Linking to consumer services (Tourism, etc.)	- Reducing corporate taxes - Promoting M&A - Supporting entry and exit of firms - Improving flexibility of labor market
Cases	Lisbon Strategy (EU, 2000) - Service for 21st Century (Germany, 1995) - Industry 4.0 (Germany, 2011)	- Creative Britain (UK, 1998), - Creative America(US, 2000), - Renaissance City Plan (Singapore, 1999)	- Industry Structural Vision (Japan, 2010)

Source: Author's own summation.

The Korean government has implemented a wide variety of service industry policies since the early 2000s. In the early stages, up until the early-2010s, Korea's service policy focused mainly on encouraging service exports. During the period, Korea experienced a continuous deterioration in the service trade balance, and thus the government supported a number of strategic sectors for expanding exports, such health/medicine, tourism, education, financial services and digital contents. However, as the importance of service intermediate goods expanded, and the need to prepare for the fourth industrial revolution increased, the Korean government began to make policy efforts to foster knowledge-based services in earnest after the mid-2010s. Therefore, it was only a few years ago that promoting innovation in knowledge-based services became the core of the service sector policy.

The Korean government proposed a "Strategy for promoting service R&D" in 2018 and a "Policy framework to develop high value-added services" in 2019, respectively. In addition, in order to effectively respond to the fourth industrial revolution and enhance productivity in the service sector, sector-specific strategies are also being prepared and implemented by several ministries. The notable examples are "I-Korea 4.0 (2018)" and "National strategy for artificial intelligence (2019)." Finally, to achieve Korean society's adaptation to the fourth industrial revolution, the Presidential Committee on the Fourth Industrial Revolution (PCFIR hereafter) was launched in 2017. In October 2019, PCFIR proposed "Recommendations to the Government for the Fourth Industrial Revolution." In this section, we briefly introduce each of the aforementioned policy documents to determine the Korean government's future direction and policy measures to promote innovation in services.

A. Policy Framework to Develop High Value-Added Services (2019)

This policy document presents a basic policy direction for Korea's service sector as a whole, and thus its coverage is quite broad. It focuses on enhancing innovation activities and vitality in the service industry with the ultimate policy objectives of expanding domestic demand, creating high-quality jobs and expanding growth engines. The detailed strategies and policy directions are presented in <Table 3-42>.

<Table 3-42> Strategies and Policy Directions of the Policy framework (2019)

Strategies	Policy Directions
Reducing policy discrimination on the service sector	- Expanding the fiscal, tax and financial support all services - Spending 70 trillion won (2019 ~23) to support promising services
Investing in basic infrastructure	- Improving the national statistics system on high value-added services - Facilitating service standardization - Investing 6 trillion won (2020~24) in public service R&D
Promoting convergence between manufacturing and service	- Developing a model product according to the designs provided by clients - Promoting the R&D service industry - Working on the Smart Service Project to provide service SMEs with ICT solutions designed to their needs
Building a regulatory foundation	- Working on the passage of the "Framework Act on Services Development" - Forming a Services Development Committee to work on a five-year plan - Nurturing professionals specializing in developing service products - Launching service research centers

Source: Ministry of Economy and Finance.

B. I-Korea 4.0 (2018)

With the intention of bringing Korea into a new digital era, "I-Korea 4.0" is the governmental strategy which contains a mid- to long-term action plan with strategies and projects for each ministry and public agency. It promotes four I's; Intelligence, Innovation, Inclusiveness and Interaction. I-Korea 4.0 aims at helping implementation of extensive 4iR actions, from both public and private sectors, within areas such as intelligent infrastructure, 5G, smart mobility, converging services and industrial production. Under I-Korea 4.0, thirteen technological areas are identified as "innovative growth engines." The government plans to invest a total of 9 trillion won by 2022 in these areas. According I-Korea 4.0, the government plans to redefine ICT R&D roles between the government and the private sector. While the government focuses on determining problems that need to be solved with ICT R&D, researchers will have more autonomy in technology and budget decisions. In addition, the government also concentrates on developing challenging and high-risk technologies that cannot be easily done by the private sector rather than short-term commercialization technologies, and promotes the creation of a research environment in which researchers can concentrate on one field for more than 10 years.[10]

<Table 3-43> Selected 13 Innovative Growth Engines under I-Korea 4.0

Intelligent Infrastructure	Smart mobile	Convergence Services	Industrial base
1. Big data 2. Next generation communication 3. Artificial Intelligence	4. Autonomous vehicle 5. Drone (UAV)	6. Customized healthcare 7. Smart City 8. Virtual augmented reality 9. Intelligent robot	10. Intelligent semiconductor 11. Advanced materials 12. Innovative new drug 13. Renewable energy

Source: Ministry of Science and ICT.

C. National Strategy for Artificial Intelligence (2019)

As mentioned, Korea has many advantages in utilizing AI, including high education attainment, high acceptance of new technology and well-developed ICT infrastructure, and high-tech manufacturing. Additionally, the Korean government aims to take advantage of these assets to foster AI as one of the next-generation growth engines. It announced the national strategy for artificial intelligence (National AI strategy hereafter) on October 2019, which contains quite an extensive set of action plans for vitalizing AI technology and its related industries. As described in <Table 3-44>, the national AI strategy focuses on three areas–AI building, AI usage and Ai harmonization–and proposes refined overarching strategies to be implemented across these three areas.[11]

<Table 3-44> Target Areas and Strategies of the National AI Strategy

Areas	Strategies and plans
Build AI	[Expand infrastructure] Push ahead with greater public sector data to be made freely accessible and strengthen the data mapping between public and private sectors, etc. [Secure competitiveness] Develop a new-concept AI semiconductor, and invest in R&D for next-generation AI, etc. [Improve regulations] Comprehensively convert or remove cumbersome regulations to create a more favorable environment for AI, come up with a basic legal system to govern AI, etc. [Nurture start-ups] Create AI investment funds, and promote exchanges of and cooperation with AI specialists, etc.

10 Detailed information of the roadmap, implementation scheme, the regulatory framework for each technological are can be found on the website of the Ministry of Science and ICT.

11 The full version of the National AI Strategy can be downloaded at https://www.msit.go.kr/cms/english/pl/policies2/__icsFiles/afieldfile/2020/03/23/National%20Strategy%20for%20Artificial%20Intelligence_200323.pdf

<Table 3-44> Continued

Areas	Strategies and plans
Make use of AI	[Nurture talent] Newly establish and/or expand fields of study or programs related to AI (majors) at universities, expand and develop various programs related to AI, etc. [Push for all-out use of AI across all industries] Push for and support projects that make use of large-scale data held by public institutions, and those that make use of AI across all industries (e.g., manufacturing, SMEs, healthcare & life sciences, transportation & logistics [Embrace digital transformation for a modern, digital government] Introduce AI to public services, provide customized services to citizens, etc.
Harmonize with AI	[Establish a job safety net - bridge the skills gap in the future workforce] Prepare tomorrow's workforce by increasing the percentage of job training in the areas of new technologies (e.g., programming for AI initiatives or data analytics and other related skills) [Prevent adverse effects] Respond to new types of adverse effects from AI-based technologies (e.g., AI-based cyber infringement, deepfake AI)

Source: Shin & Kim (2019).

4.2.3. Policy Options for Innovation in Services: Some Cases

As we have seen earlier, the policy measures currently implemented or planned by the Korean government to promote innovation in services are very extensive, and consequently, it is almost impossible to describe each of them in this paper. Instead, we would like to explain a number of distinctive policy tools that might have some policy implications for the Polish service sector.

A. Regulatory Sandbox

One of the special features of Korea's regulatory sandbox system is that, unlike other countries, it is applied not only to FinTech but also to other areas, including smart cities, autonomous vehicles, drones and robotics. In order to implement a regulatory sandbox in these areas, the government amended several laws and enacted a new law, as describe in <Table 3-45>. Those seeking the regulatory waiver should file an application for a special designation, and if approved, companies can test out their new technologies and services in the real market and readjust their strategies accordingly, while the government can swiftly improve related regulations based on real-life data.

<Table 3-45> Legal Provisions for Regulatory Sandbox by Area

	Framework Act on Administrative Regulations	Special Act on Promotion of ICT, Vitalization of Convergence Thereof, Etc.	Industrial Convergence Promotion Act	Special Act on Financial Innovation Support	Regional Special Area Act
Ministry in charge	Office for Government Policy Coordination	Ministry of Science & ICT	Ministry of Trade, Industry & Energy	Financial Services Commission	Ministry of SMEs & Startups
Enforcement date	July 2019 (Amendment)	January 2019 (Amendment)	January 2019 (Amendment)	April 2019 (Enactment)	April 2019 (Amendment)
Objective	Basic principles & directions on regulatory sandbox	Legal grounds for ICT regulatory sandbox	Legal grounds for regulatory sandbox on industrial convergence	Legal grounds for financial regulatory sandbox	Legal grounds for region innovation

Source: Author's own summation.

There are a number of cases in which the government is applying the regulatory sandbox system to the existing regulations, including installation of hydrogen fuel charging stations in Seoul, open payment services by FinTech firms, temporary deregulation of direct-to-consumer (DTC) genetic testing for serious diseases, and application of electric motor-driven kit to manual wheelchairs. As an example of the regulatory sandbox system in Korea, we introduce an overview of the financial regulatory sandbox case in <Table 3-46>.

<Table 3-46> Overview of Financial Regulatory Sandbox

Starting Date	- April 1, 2019
Legal Basis	- Special Act on Financial Innovation Support
Target	- New and innovative financial services that were not available to consumers due to current regulatory systems
Working Mechanism	- Designating as "Innovative financial services" after approval process - Regulations temporarily suspended, while new services being tested in the market. - Deferring or exempting regulations on licensing/business conducts, for up to four years (2+2 years)
Application Procedure	- Filing an application for designation, with plans for consumer protection and risk management - Reviewing by the Innovation Finance Review Committee - Final designation by the Financial Services Commission
Selection Criteria	- Innovativeness, potential consumer benefit, inevitability of exemption form current laws, service provider's capacity, scope of service, effectiveness of consumer protection plan, Impact on Financial Stability

<Table 3-46> Continued

Examples of Designated Services	- Combined banking and ICT services conducted by a bank based on mobile network - P2P (peer-to-peer) payment services, through which one can make credit card payments to others using a mobile platform or QR code is eligible for regulatory exemption - An "on-off" style insurance product such as travel insurance - P2P stock brokerage platform utilizing blockchain
Current Status	- 102 finTech firms designated as 'innovative financial services'

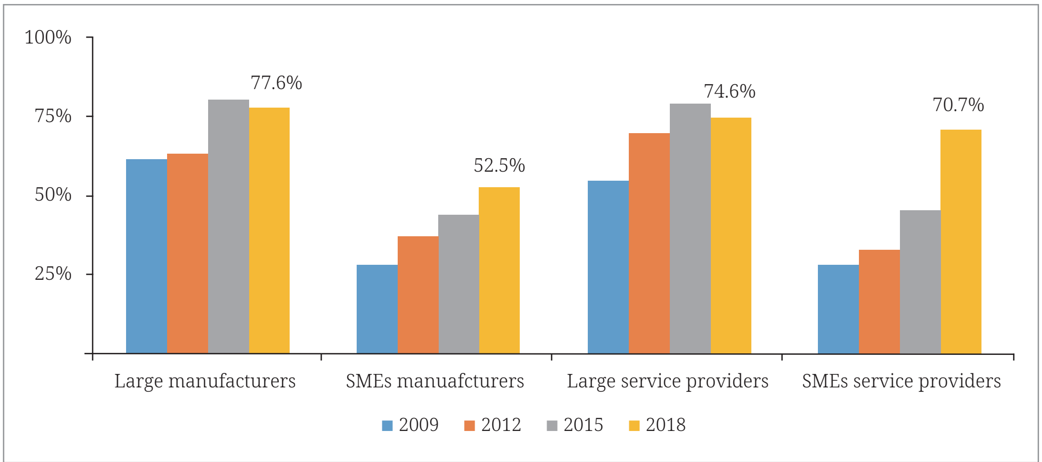
Source: Author's own summation.

B. Smart Factory

In order to promote innovations in services, one of the most important pre-requisites is arguably securing effective demands for knowledge intensive services. As discussed in <Table 3-23>, service demands consist of businesses in manufacturing, services and other industries, public sector, individuals and foreign consumers/companies. Among these, effective demands from SMEs in the manufacturing sector in Korea have been relatively weak, due to its industrial structure biased toward large manufacturers. For instance, as shown in [Figure 3-30], only a half of Korea's manufacturing SMEs apply information and telecommunication technology to their business. This is in stark contrast to 77.6% of large manufacturing giants, 74.6% of large service providers and 70.7% of service SMEs using IT for production and/or business activities. It is important that the government induces manufacturing SMEs to make more use of knowledge-based services, which contributes not only to enhance productivity of these firms but also increase market demand for knowledge intensive services.

[Figure 3-30] IT Utilization Rate by Sector/Size

(Unit: %)



Source: Statistics Korea Database.

The smart factory system could be an effective option in this case. Within the "Manufacturing Innovation Strategy 3.0 (Strategy 3.0 hereafter)," the Korean government has been trying to introduce innovation to the manufacturing process, including expanding the use of smart factories and developing core technologies related to smart manufacturing. A "smart factory" can be defined as "a manufacturing system which all business processes of planning, design, production, distribution and sales are automated, connected and integrated by various information and communication technologies." The government plans to set up 10 thousand smart factories by the end of 2020, to facilitate convergence between software and hardware technologies, raising about 972 million USD.

C. Improved Access to Public Data

Data are inarguably the most important asset in the digital economy, the limited accessibility to public data could be a critical factor to hamper sound and effective innovation activities. Although the Korean government has made a great effort to open public data, there still exists a shortage of reliable public data. In addition, additional costs in public data usage occur because data providers often adopt different data formats.

According to the national AI Strategy, more efforts will be made to make public data readily and freely accessible to the public. In particular, public data that helps to promote the use of AI in new industries would be identified proactively. A big data platform covering 10 areas, such as finance, transportation, communications and medicine, would be also made completely open to the public. In addition, whenever it is difficult to make particular data open to the public, for instance due to the protection of personal information, a project for the active use of data would be pushed ahead through which the private sector would access such data and develop an algorithm. Finally, to stimulate data utilization by the private sector, the government is also considering introducing an "AI voucher system," so that a company would be able to introduce the optimal AI solution that can be used for its products.

D. Framework Act on Services Development

Since the service sector comprises a wide variety of sectors, there are many laws and regulations applied to individual sectors. These laws and regulations are generally adopted separately for each relevant ministry in accordance with the intent of legislation in the individual sector. As a result, conflicts often arise between these laws and regulations. For example, in the case of Korea, some laws define knowledge intensive services differently relative to others. Such legal conflicts have served as a deterrent to the development of the service industry.

In this context, the Korean government drafted the "Framework Act on the Development of the Service Industry in 2011", a high-level law applied to the overall service industry. The purpose of this Act was to strengthen the competitiveness of the service industry by stipulating matters concerning the promotion system, targets and implementing procedures for the service sector policy. This act stipulates supporting measures for the service sector, including support for funding, taxation, R&D investment, human capital and sales expansion. It also seeks to select and support promising services, train professionals and designate and support specialized research centers.

Unfortunately, however, the adoption of the law has been pending because of opposition from interest groups, and the government continues to make great efforts to expedite the legislation of the law. In any case, it is worthwhile for other countries to consider preparing such laws to establish a stable legal basis for promoting service innovation.

References

Alarcóna, J.C, Aguilarb, R, & Galánca, J.L. (2019). Determinants of innovation output in Spanish knowledge-intensive service firms: Stability analysis throughout the economic crisis of 2008, "Structural Change and Economic Dynamics" 49, pp. 228-244.

Asheim, B. T.,& Gertler, M. S. (2005). Regional innovation systems and the geographical foundations of innovation. In Oxford Handbook of Innovation, J. Fagerberg, D. Mowery, R. Nelson (eds). London: Oxford University Press, pp.291–317.

Aslesen, H.W., & Isaksen, A. (2007). New perspectives on knowledge-intensive services and innovation. Geografiska Annaler: Series B, Human Geography, 89(sup1), pp. 45-58.

Barcet A. (2010). Innovation in services: a new paradigm and innovation model. In, The Handbook of Innovation and Services: A Multi-disciplinary Perspective, F. Gallouj F., Djellal F. (eds.). Edward Elgar Publishing, Cheltenham, Northampton MA, pp. 49-67.

Barras, R. (1990). Interactive Innovation in Financial and Business Services: The vanguard of the Service Revolution, Research Policy Vol. 19, Iss. 3 June 1990, pp. 215-237.

Bettencourt, L.A., Ostrom, A.L., Brown, S.W., & Roundtree, R.I. (2002). Client co-production in knowledge intensive business services. California Management Review, 44, pp. 100–128.

Boschma, R.A. (2005). Proximity and innovation: a critical assessment, Regional Studies, 39(1), pp. 61–74.

Braga, A., Marques, C.S., & Serrasqueiro, Z. (2017). Internationalisation Strategy of Knowledge-Intensive Business Services, Journal of the Knowledge Economy, Springer; Portland International Center for Management of Engineering and Technology (PICMET), 9(2), June, pp. 359-377.

Brunow, S., Hammer, A., & McCann, P. (2019). The impact of KIBS' location on their innovation behaviour. Regional Studies, 1-15. DOI: 10.1080/00343404.2019.1684463

Coombs, R., & Miles, I. (2000). Innovation, measurement and services: the new problematique. In: Innovation Systems in the Service Sectors. Measurement and Case Study Analysis, Metcalfe, S.J., Miles, I. (eds.). Kluwer Academic Publishers, Boston, Dordrecht, London, pp. 85–104.

Djellal F., & Gallouj F. (1999). Services and the search for relevant innovation indicators: a review of National and International surveys, Science and Public Policy, 26, pp. 218–232.

Doloreux, D., & Shearmur, R. (2012). Collaboration, information and the geography of inno vation in knowledge intensive business services, Journal of Economic Geography, 12(1), pp. 79-105.

Ehrentraud, J., Ocampo, D.G., Garzoni, L., & Piccolo, M. (2020). Policy responses to fintech: a cross-country overview, FSI Insights on policy implementation No 23, Financial Stability Institute, Bank for International Settlements.

Eichengreen, B. & Gupta, P. (2013). The two waves of service-sector growth, Oxford Economic Papers 65(1), pp.96-123.

European Commission. (2014). The Smart Guide to Service Innovation, Guidebook Series How to support SME Policy from Structural Funds, European Commission, Director ate-General for Enterprise and Industry.

European Commission. (2019).

European Innovation Scoreboard (2019).

Evangelista, R., & Sirilli, G. (1995). Measuring innovation in services, Research Evaluation 5, 207–215.

Flejterski, S., Panasiuk, A., Perenc, J., & Rosa, G. (2005). Współczesna ekonomika usług, Wy dawnictwo Naukowe, Warszawa.

FSB (2017), Financial Stability Implications from FinTech, Financial Stability Board.

Galindo-Rueda, F., Verger F. (2016), "OECD Taxonomy of Economic Activities Based on R&D Intensity", OECD Science, Technology and Industry Working Papers, 2016/04, OECD Pub lishing, Paris, http://dx.doi.org/10.1787/5jlv73sqqp8r-en

Gallouj, F., & Djellal, F. (Eds.) (2011). The handbook of innovation and services: a multi-disci plinary perspective, Edward Elgar Publishing.

Gallouj, F., & Djellal, F. (Eds.) (2010). The handbook of innovation and services: a multi-disci plinary perspective, Edward Elgar Publishing, Cheltenham, Northampton MA.

Gallouj, F., & Savona, M. (2010). Towards a theory of innovation in services: a state of art, in, The Handbook of Innovation and Services: A Multi-disciplinary Perspective, Gallouj F., Djellal F. Eds. Edward Elgar Publishing, Cheltenham, Northampton MA, pp. 27-48.

Giddens, A. (2007). Europe in the Global Age, Cambridge, MA: Polity Press.

Gnyawali, D.R., Srivastava, M.K. (2013). Complementary effects of clusters and networks on firm innovation: A conceptual model, Journal of Engineering and Technology Manage ment, 30(1), pp. 1–20.

Haakonsson, S., Kirkegaard, J.K., & Lema, R. (2020). The decomposition of innovation in Europe and China's catch-up in wind power technology: the role of KIBS, European Plan ning Studies, 1-19.

Hipp C., & Grupp H. (2005), Innovation in the service sector: The demand for service-specific innovation measurement concepts and typologies, Research policy, 34(4), 517-535.

HM Treasury. (2018). Fintech Sector Strategy: Securing the Future of UK Fintech, The Nation al Archives, Kew, London, www.gov.uk/government/publications

Hollenstein, H. (2003). Innovation modes in the Swiss service sector: a cluster analysis based on firm-level data, Research policy, 32(5), 845-863.

Howells J., Tether B.S., & Uyarra, E. (2007). Innovation in Business Services: From Technolog ical Adoption to Multiple, Complementary, Concurrent Changes. In: Business Services in European Economic Growth, Rubalcaba L., Kox H. (eds). Palgrave Macmillan, London, pp. 144-162.

IITP. (2018). ICT Level Survey Report 2018, Institute of Information and Communications Technology Planning and Evaluation.

Kim, S.J. Kim, E. M., Suh, Y., & Zheng, Z. (2016) The effect of service innovation on R&D activ ities and government support systems: the moderating role of government support sys tems in Korea, Journal of Open Innovation: Technology, Market, and Complexity 2016/2:5.

KISA (2019). 2019 Korea FinTech: Business Handbook.

KNF. (2017). Raport z prac Zespołu roboczego ds. rozwoju innowacji finansowych (FinTech), Komisja Nadzoru Finansowego, Warszawa, https://www.knf.gov.pl/knf/pl/komponenty/img/Raport_KNF_11_2017_60290.pdf

KNF. (2019). Rekomendacje Zespołu roboczego ds. rozwoju innowacji finansowych (FinTech) zrealizowane – w odniesieniu do listy określonych barier zawartych w Raporcie z prac Zespołu roboczego ds. rozwoju innowacji finansowych (FinTech)– na dzień 10.12.2019, https://www.knf.gov.pl/knf/pl/komponenty/img/Zespol_FinTech_Rekomendacje_sta tusy_10_12_2019.pdf

Kowalski, A.M. (2016). Poland, an emerging European ICT hub?, Baltic Rim Economies, Iss. 4, p. 25.

KPMG. (2018). 2018 Fintech100. Leading Global Fintech Innovators, H2 Ventures & KPMG, https://h2.vc/wp-content/uploads/2018/11/Fintech100-2018-Report_Final_22-11-18sm.pdf

Mazurek, K., Walczyna, M., Machał, A., Ruiz, K., Fujak, A., Widawski, P., Sas, M., Kuna, W., Brewiński, P., Borowik, M., & Niemczuk, B. (2017). FinTech Hub Polska. Jak sku tecznie zbudować centrum finansowe nowej generacji w Polsce, FinTech Poland, Ac centure, https://www.accenture.com/_acnmedia/PDF-67/Accenture-FinTech-Hub-Pols ka-Raport-2017.pdf#zoom=50

Mazurek, K., Walczyna, M., Uryniuk, J., Dziubak, P., Widawski, P., & Brewiński, P. (2018). Mapa polskiego fintechu 2018, Cashless.pl, FinTech Poland, Accenture, https://www.cashless.pl/system/uploads/ckeditor/attachments/1908/Mapa_Polskiego_Fintechu_2018.pdf

Metcalfe, J. S., & Miles, I. (Eds.) (2012). Innovation systems in the service economy: measure ment and case study analysis, Springer Science & Business Media.

Milbratz, T. C., Gomes, G., & Carmona, L.J.D.M. (2020). Influence of learning and service inno vation on performance, Innovation & Management Review, DOI 10.1108/INMR-02-2019-0020.

Miles, I. (2005). Knowledge intensive business services: prospects and policies, Foresight – The Journal of Future Studies, Strategic Thinking and Policy, 7(6): 39–63.

Milic-Czerniak, R. (2019), Rola fintechów w rozwoju innowacji finansowych, Studia BAS No 1(57), pp. 37-60.

Miroudot, S (2019). Services and Manufacturing in Global Value Chains Is the Distinction Ob solete?, ADBI Working Paper Series No.927.

Miroudot, S., & Cadestin, C. (2017). Services in Global Value Chains: from Inputs to Value-cre ating Activities, OECD Trade Policy Papers No.197.

Montresor, S., & Quatraro F. (2017). Regional Branching and Key Enabling Technologies: Ev idence from European Patent Data, Economic Geography, Vol. 93, No.4, pp. 367-396, DOI: 10.1080/00130095.2017.1326810.

Muller, E., & Doloreux, D. (2009). What we should know about knowledge-intensive business services. Technology in society, 31(1), 64-72.

OECD. (2005). Promoting innovation in services, Organisation for Economic Co-operation and Development, DSTI/STP/TIP(2004)4/FINAL.

OECD. (2006). Innovation and knowledge-intensive service activities, Paris: Organisation for

Economic Co-operation and Development.

OECD. (2017), OECD Science, Technology and Industry Scoreboard 2017.

OECD. (2017). Science, Technology and Industry Scoreboard 2017.

OECD (2019). Digital Innovation: Digital Innovation: Seizing Policy Opportunities, OECD Pub lishing, Paris, OECD Publishing, Paris. https://doi.org/10.1787/a298dc87-en

OECD/Eurostat. (2018). Oslo Manual 2018: Guidelines for Collecting, Reporting and Us ing Data on Innovation, 4th Edition, The Measurement of Scientific, Technological and Innovation Activities, OECD Publishing, Paris/Eurostat, Luxembourg, https://doi.org/10.1787/9789264304604-en

Oxford Insights and IDRC. (2019). Government Artificial Intelligence Readiness Index 2019.

Planes-Satorra, S., & Paunov, C. (2019, May). The digital innovation policy landscape in 2019. OECD Science and Innovation Policy Papers, 71.

Quinn, J.B., & Paquette, P.C. (1990). Technology in Services: Creating Organisational Revolu tions, Sloan Management Review, Vol. 11, No. 2, pp. 67-68.

Sinook Kang, Juneyoung Jang and Claudia Chong-Ah Hong (2019). Korean Government An nounces National AI Strategy to Bolster the Economy & Improve Living Standards by 2030, Legal Update, December 27, 2019.

Statistics Poland. (2013). Innovative activity of enterprises in the years 2010–2012 (in Polish: Działalność innowacyjna przedsiębiorstw w latach 2010–2012), Statistics Poland Statisti cal Office in Szczecin.

Statistics Poland. (2016). Innovative activity of enterprises in the years 2013–2015 (in Polish: Działalność innowacyjna przedsiębiorstw w latach 2013–2015), Statistics Poland, Statisti cal Office in Szczecin.

Statistics Poland. (2017). Innovative activity of enterprises in the years 2014–2016 (in Polish: Działalność innowacyjna przedsiębiorstw w latach 2014–2016), Statistics Poland, Statisti cal Office in Szczecin.

Statistics Poland. (2018). Innovative activity of enterprises in the years 2015–2017 (in Polish: Działalność innowacyjna przedsiębiorstw w latach 2015–2017), Statistics Poland, Statisti cal Office in Szczecin.

Statistics Poland. (2020). Innovative activity of enterprises in the years 2016–2018 (in Polish: Działalność innowacyjna przedsiębiorstw w latach 2016–2018), Statistics Poland, Statisti cal Office in Szczecin.

Tether, B.S., & Hipp, C. (2002). Knowledge Intensive, Technical and Other Services: Patterns of Competitiveness and Innovation Compared, Technology Analysis & Strategic Manage ment, 14:2, 163-182.

WEF (2019), the Global Competitiveness Report 2019, World Economic Forum..

Weresa, M.A. (2019). Technological competitiveness of the EU member states in the era of the fourth industrial revolution, Economics and Business Review, Volume 5 (19) Number 3, pp. 50-71.

Widawski, P., Brakoniecki, M., Borowik, M., Sterczała, p., Brewiński, P., & Olczak, M. (2017). FinTech w Polsce – bariery i szanse rozwoju, FinTech Poland, Obserwatorium.biz sp. z o.o., Centrum Prawa Nowych Technologii Wydziału, Prawa i Administracji Uniwersytetu Warszawskiego, http://fintechpoland.com/raport-fintech-w-polsce-bariery-i-szanse-rozwoju/

Windrum, P., & Tomlinson, M. (1999). Knowledge-intensive services and international com petitiveness: A four-country comparison, Technology Analysis & Strategic Management, 11(3), 391–408.

Witell, L. Snyder, H., Gustafsson, A., Fombelle, P., & Kristensson, P. (2015) Defining service in novation: A review and synthesis, Journal of Business Research, 69(8), pp.1-10.

Wolfe, D. (2009). Introduction: embedded clusters in a global economy, European Planning Studies, 17: 179–187.

World Economic Forum. (2013), Digitization for economic growth and job creation, Global Information Technology Report 2013.

Appendix 1

Case Study of An Innovative Service Sector Company

1. General Characteristics of CD PROJECT Company

CD PROJEKT develops and publishes video games for personal computers and video game consoles. The company was founded in 2002. Its flagship titles include The Witcher series of games, Thronebreaker: The Witcher Tales, GWENT: The Witcher Card Game and the upcoming futuristic Triple A role-playing game — Cyberpunk 2077.

The main area of activity of the CD PROJEKT is videogames, which is a growing branch of digital entertainment. “We create cutting-edge innovative entertainment and, thanks to our proprietary distribution platform, provide gamers from around the world with access to a vast pool of releases.” According the Polish classification of economic activity the company is classified in J 62 section (SOFTWARE AND CONSULTING ACTIVITIES IN THE FIELD OF COMPUTER SCIENCE AND RELATED ACTIVITIES), which belongs to KIS.

CD Projekt based its success on the design of high-budget videogames. The development studio focuses on role-playing games. It gained worldwide recognition for creating a series of games about The Witcher, Geralt of Rivia, of which both parts sold in excess of 8 million copies. It employs over 230 world-class Polish and foreign specialists in graphics, animation, programming and design. The company is also a global publisher of its games, successfully competing with foreign publishers, such as Microsoft or Ubisoft. The development studio has also created an original engine for the production of complex computer games - REDengine.

2. Development of The Company

Initially, CD Projekt dealt with the distribution of foreign titles in the domestic market i.e. translating games into Polish, along with materials such as guides and instructions. The founders decided that they would like to produce their own games and founded the CD Projekt Red Studio Ltd. company.

The Witcher appeared on the market in 2007, only in the PC version, after 5 years of work. CD The Project, immediately after the production of The Witcher, began to sell its title worldwide, which is associated with the specifics of the electronic entertainment industry

- no need to customize the game to each foreign market separately, as it is a standardized product offering exactly the same experience regardless of the country of purchase. When The Witcher was released to the world market, CD Projekt skipped the international stage and immediately entered the definition of a global enterprise.

A natural step for the management of CD Project was to start work on the continuation of The Witcher, which was achieved a few months after the completion of the first part. In addition, it was decided to diversify revenues, under which in 2008 the GOG.com website was created, initially offering old games adapted to modern computers, and currently being a digital distribution platform for a wide range of titles, which are additionally sold in versions without anti-piracy DRM protections, which are often a big problem for legal owners of a given production. The introduction of this service was the first bad decision of the management board and brought losses of PLN 20 million, furthermore the economic crisis of 2009 additionally hindered the financial situation of CD Projekt.

The management was therefore forced to restructure the enterprise. The successes allowed for continuous development of the company. In 2008 the GOG.com digital distribution platform was created.

In order to improve the organizational structure, CDP Investment Holding was created, which included the GOG.com digital distribution platform, as well as CD Projekt and CD Projekt RED. CD Projekt, thanks to a merger with Optimus S.A., managed to enter the Warsaw Stock Exchange and underwent several internal changes.

The company's financial problems officially ended in 2011, with the release of another part of The Witcher, based on the proprietary engine, The Witcher 2: Assassins of Kings. The new game, thanks to the globally recognized brand, and quality jump associated with the use of its own engine, surpassed the success of its predecessor and was also released on consoles, which involved the sale of up to 400 thousand copies of the game in the first week after the premiere.

The last part of the trilogy was released in 2015, and was released on personal computers and Xbox One and Playstation 4 consoles. The new title immediately became a global hit, achieving results that outshine all of the company's previous successes. During the month, the game spread in an incredible number of over 6 million copies and the awards won at numerous fairs have made The Witcher 3 officially become the most successful game in the history of electronic entertainment.

In addition to exporting its own games and selling foreign productions on the domestic market, the company also began to deal with the digital distribution of games around the world.

The company also attaches great importance to the development of the GOG.com platform, intending to gradually introduce payments in new currencies and translate it into more and more languages.

3. Innovation Activity

The company's mission is to be one of the top three companies producing so-called Triple-A high-budget, non-linear role-playing-games. Therefore, innovations are inscribed in the company's DNA. The company develops new solutions and adapts existing ones. In the case of product innovations, it employs a combination of solutions that are used globally, or other companies are beginning to use them and its own ideas. This is mainly due to the fact that there being many companies in the sector that create product innovations that are worth imitating. Everyone chooses a slightly different path, but every company surprise clients periodically, because the production cycle usually lasts two or three years. If one company develops unique solutions, then they become the standard, the canon of modern technology. "We have our ideas, our approaches, and when it comes to our core, our competitive advantage is the non-linearity of running the story". A good example of innovative activities is the animation department. There are tens of thousands of animation files in the game, which are responsible for every movement of each character. To make it look better, these tens of thousands must be replaced by several hundred thousand. With the use of new technology, the same team can create several hundred thousand variations of these animations. Display manufacturers increase the resolution and quality of displayed images so games must keep up with these trends, and therefore have to display more items in larger sizes often on the same hardware platforms.

The main motivation for introducing innovations is improving quality and creating new value for users, "If we want to achieve this quality, then we have to be innovative, we have to come up with something new to surprise clients, we can't go with the flow". Other issues, such as increasing profits or brand strengthening, are in further places. According to a representative of the company the key to success is to put yourself in the person of the client and deliver the best quality.

All employees can be involved in the process of creating innovation, from the concept artists, cartoonists, testers, programmers, artists, to directors. The company has a bonus system that rewards employees for various achievements and new ideas.

In general, this system motivates employees to share new ideas. The company introduced an open environment policy, which consists of many elements like for example coffee with the president, with the board, a suggestion box, in which employees put all innovative and non-innovative ideas, suggestions and so on. According to the management of the company such small things make up the open structure, which fosters creation.

Cooperation with research institutes is not undertaken. The company conducts its own research and development works. This is related to specific needs, "We have a policy that we have very few products, but once we make this product, it is very different from the previous one and often it is a big step not only in artistic but also technological terms".

4. Barriers

The company's biggest barrier to innovation is the insufficient number of qualified staff. The big problem is that the qualifications needed in the company are also partly used by other sectors that offer higher salaries, e.g. banking sector.

"Whether someone is writing an application to us or a bank application, these are the same applications. We often use the same programming languages and so on, but of course there can be much higher earnings, and simpler work above all."

The company uses a lot of incentives to keep the team and recruit new employees. Employees get a gratification if they recommend a new worker.

"We try to keep those we have, that is, all bonuses, amenities in the company, massages, gyms, a very extensive system bonus, which is designed to keep as many talents as possible in the company. So keeping people, looking for new, of course all ways at home and abroad, headhunters, recently even taking over other companies, acquiring new ones, and for some time now we are starting to enter this area of education, because we are doing our event, called Promiseland in Łódź."

Legal regulations and a poor business environment are an important barrier, in particular, this applies to frequent changes in the law. A management representative noticed that there are many inconsistencies in regulations or omissions. For example, the company was granted the status of a research and development center and intended to benefit from a tax credit for research and development. However, it turned out that a new provision was introduced stating that if revenues come from licenses, they are capital revenues that do not qualify for the R&D tax credit. According to the company representative, the legislator did not take into account that games and applications are sold under license, so all the revenues come from licenses. Similarly, the company experienced a surprise when the rules for applying increased tax deductible costs were changed. Sudden changes in regulations that do not allow for appropriate adjustments on the business side cause confusion and suspension, and then the need to change the rules of operation.

The company representative pointed out that in other countries, such as Canada, England, France, or the United States game productions are subsidized due to the fact that they are perceived not only as hi-tech industries that create a lot of added value and exports, but also as a cultural promotion. These kinds of policy instruments are insufficient in Poland. Small programs appear from time to time, such as the development of creative sectors from the Ministry of Culture and National Heritage, which co-financed game prototypes, but this is a drop in the ocean of needs.

One of the barriers is also a limited cooperation with scientific institutes. According to the company's management representative, this is due to the way research entities operate. “(...) it's about publications, not creating start-ups and selling them, for example, as it sometimes happens in the west, that people from universities strive to enter into cooperation with entrepreneurs, to create a solution and then sell them, for example, as a separate company. (...) often people from Polish universities know less than our specialists, so we can't expect them to come up with any innovative solutions. That's why they just teach the basics of our industry so that someone just comes to us as a junior and starts working. So here we have difficulty when it comes to cooperation.”

5. Conclusions

The experience of an innovative company operating in the KIS sector shows that competing with high quality is the main element determining the global success.

The business model is based on a very specific unique product that is only released when it meets all objectives and assumptions concerning quality. This is a slightly different philosophy than that observed among other companies operating in this business field. Usually, companies have a two-year cycle during which they prepare a new game. It is launched in the state the team had managed to develop. According to management, it is better to release fewer products, but those that make an impression.

The company uses an open policy model; all the employees may suggest what ideas can be implemented. Innovations are not the domain of management; all the employees participate in this process. The company appreciates people who have ideas and want to share them. The incentive system is designed so that superiors can appreciate the efforts of company workers.

Barriers that limit innovation are related to the low availability of qualified staff and to inconsistent legal provisions and their frequent changes. Legal changes should always be preceded by consultations, and most importantly - companies should be given time to prepare for the changes.

The company's representative points out the insufficient support for companies operating in the creative sector. This may not be a barrier, but a factor that limits the possibilities of innovative development. Instruments similar to earlier programs implemented by the Ministry of Culture would be particularly appreciated. Support for creating prototypes is especially needed.

The last issue is cooperation with research institutions and universities. It seems that after the legislative changes that have taken place recently, behavioral changes should follow. Only then both parties - business and the scientific community - will be able to benefit from cooperation.

Appendix 2

Case Study on Servicification - Samsung Electronics

Samsung Electronics started its business in 1969 as a subcontracted producer for 12-inch TVs, and later emerged as one of the world's largest manufacturers. It ranks 15th in terms of the size of net revenues among Fortune Global 500 companies in 2019. It also is the second largest R&D investors in the world after Alphabet. Samsung is also the world patent leader with 76,638 active patent families, which is more than double the number held by IBM.

<Appendix Table 3-1> World's Top 5 R&D Investors

Rank	Company	Industry	Country	R&D (billion Euro)	R&D Intensity (%)
1	Alphabet	ICT Services	U.S.	18.3	15.3
2	Samsung Electronics	ICT Producers	Korea	14.8	7.8
3	Microsoft	ICT Services	U.S.	14.7	13.4
4	Volkswagen	Automobiles	Germany	13.6	5.8
5	Huawei	ICT Producers	China	12.7	13.9

Source: 2019 EU Industrial R&D Investment Scoreboard.

Samsung Electronics consists of four business divisions; Consumer Electronics (CE), IT Mobile (IM), Device Solution (DS) and Harman (See Table A.2). As of 2019, around 46.6% of its net revenues come from IT Mobile division, followed by Device Solution division (31.7%).

<Appendix Table 3-2> Production and Net Revenue (2019)

Business Division		Major Products	Net Revenue (US$ bill)	Share (%)
Consumer Electronics (CE)		TVs, Monitors, Refrigerators, Washing machines, Air conditioners, etc.	38.4	19.4
IT Mobile (IM)		HHPs, network systems, computers, etc.	92.0	46.6
Device Solution (DS)	Semiconductor	DRAN, NAND Flash, Mobile AP, etc.	55.7	28.2
	DP	OLED smartphone panel, LCD TV panel, Monitor panel, etc.	26.6	13.5
Harman		Head units, infotainment systems, telematics, speakers, etc.	8.6	4.4
Others			▽23.3	▽11.9
Total			197.9	100.0

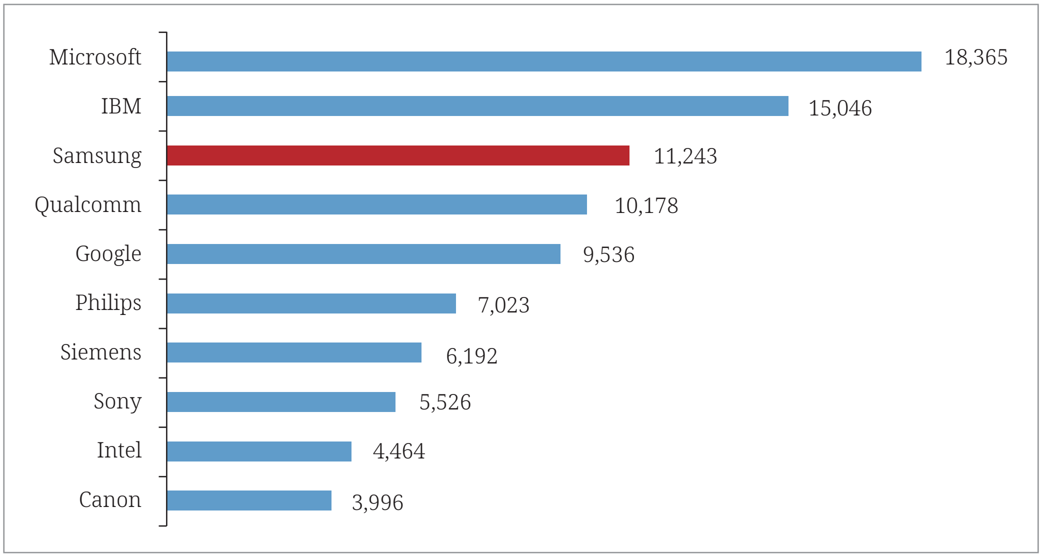
Source: Samsung Electronics, Business Report 2019.

Samsung Electronics holds the number one position in terms of the world market share for a wide variety of products: 42.8% for D-RAM (27 consecutive years), 38.5 percent for NAND flash (17 years), 36.6% for SSD (13 years), 45.0% for Smartcard IC (13 years), 29.0% for TV (13 years), 20.3% for smartphone (8 years), among many others.

Samsung Electronics is now implementing various initiatives to become a world leader in building and vitalizing the ecosystem of innovative businesses for the digital economy. In 2018, Samsung Electronics pledged to invest 22 billion US dollars in new flagship areas such as AI, 5G mobile technology, electronic components for autos, and the biopharmaceutical business. Samsung anticipates that AI technology will drive rapid industrial transformation all around the world, while the next-generation 5G technology will create great opportunities in autonomous driving, IoT and robotics.

Particular attention is drawn to AI, with around 70% of the world's data produced and stored on its products. Samsung has an ambitious plan to incorporate AI to all the devices that it produces by 2020. Samsung's most critical competitive edge over its competitors in the world market, such as Apple and Google, lies in its capacity to optimally combine between hardware and AI software through various experiments based on its own production facilities. Although Apple is defined as a hardware company, it does not have its own production facilities. Taiwan's Foxconn has been in charge of producing Apple products, failing to flexibly cope with the market's diversified demands. Likewise, Google has attempted to make inroads into hardware since it took over Motorola in 2011 with an investment of $9 billion, but has failed to make any significant gains. As depicted in [Figure A.1], Samsung Electronics is now becoming one of the world's top three companies in terms of the number of AI patents. As of January 2019, it has a total of 11,243 AI patents in the world, followed by Qualcomm and Google.

<Appendix Figure 3-1> Companies with the Most AI Patents



Source: Iplytics

It should be noted that most of Samsung's R&D activities in cutting- edge technologies are implemented through in-house servicification. We can clearly see this by looking at changes in its employment structure. In 2006, Samsung Electronics employed more than 84 thousand regular employees, and only around 24.2% of them engaged in service tasks. On the other hand, while this company has more than 100 thousand regular employees in 2018, more than a half of them are those performing service tasks, most notably R&D. Meanwhile, outsourcing of services is not active, as most services are carried out within the enterprise. As shown in the table, the ratio of outsourcing expenses to total sales has stagnated at 1~1.6% during the 2006-18 period.

<Appendix Table 3-2> Servicification of Manufacturing firms: The Case of Samsung Electronics

(Unit: %)

Year	Service Occupation Share	R&D / Sales Ratio	Outsource Expenses / Sales Ratio	Export Share
2006	24.2	9.5	1.1	81.4
2012	45.9	7.1	0.0	37.9
2018	53.5	8.8	1.6	57.6

Source: Samsung Electronics.

Samsung Electronics is currently operating 14 R&D centers in 12 countries in the world. On the top of that, since 2017 it has opened 7 global AI research centers in several countries, including Korea, the U.S., U.K., Canada and Russia. Samsung plans to significantly expand its research capability, increasing the number of advanced AI researchers to 1,000 across these global AI Centers.

In 2017, Samsung Electronics merged the DMC Research Center and the Software Center, which are in charge of future technology research in the CE and IM divisions, into "Samsung Research." The reason behind it is to generate synergy for future convergence technologies and to play a central role in securing advanced technologies for the future, such as artificial intelligence (AI), IoT and security. Samsung Research will serve as a hub for future high-tech research and development that will lead 24 research hubs and some 20,000 R&D workers worldwide.

In addition, based on its extensive expertise in technology and start-up investments, Samsung is considering expanding its venture incubation program to both external and internal start-up projects and provide software training. Finally, in cooperation with the Korean government, Samsung is going to establish software education centers across the country. It will contribute to nurture skilled software talent and help create new job opportunities. The centers will train 10,000 students and job candidates, and also provide employment consulting services for the next five years.

Appendix 3

Classifications of the KIS Sector: NACE vs KSIC

	NACE Code (rev.2)	KSIC Code (rev.9)	Division
High-tech KIS	59	59	Motion picture, video and television programme production, sound recording and music publishing activities
	60	60	Programming and broadcasting activities
	61	61	Telecommunications
	62	62	Computer programming, consultancy and related activities
	63	63	Information service activities
	72	70	Scientific research and development
Market KIS	50	50	Water transport
	51	51	Air transport
	69	71	Legal and accounting activities
	70	71	Activities of head offices; management consultancy activities
	71	72	Architectural/ engineering activities; technical testing/analysis
	73	71	Advertising and market research
	74	73	Other professional, scientific and technical activities
	78	75	Employment activities
	80	75	Security and investigation activities
Financial KIS	64	64	Financial service activities, except insurance/pension funding
	65	65	(Re)insurance and pension funding, except compulsory social security
	66	66	Activities auxiliary to financial services/insurance activities
Other KIS	58	58	Publishing activities
	75	73	Veterinary activities

Source: Eurostat and Statistics Korea

04

CHAPTER

Next Generation Policy for Digital Transformation of SMEs in Slovakia

Youngsoon Chang (Myongji University)
Artur Bobovnicky (Slovak Innovation and Energy Agency)

Keywords
Digital Transformation, Digitalization, Small and Medium sized Enterprise, Informatization Policy, Fourth Industrial Revolution

Next Generation Policy for Digital Transformation of SMEs in Slovakia

Youngsoon Chang (Myongji University)
Artur Bobovnicky (Slovak Innovation and Energy Agency)

Summary

The main purpose of this study is to provide the Slovak government with practical recommendations on digital transformation of Small and Medium sized Enterprises (SMEs). To achieve this goal, this study analyzes the status of the digital transformation of Slovakia to identify related issues, and investigates Korean cases to derive applicable ways for SMEs of Slovakia. The results can be used to strengthen the competitiveness of companies and the national economy by promoting the digitalization of SMEs in order to cope with the rapidly changing world economic environment

Digital transformation can be defined as utilizing Information and Communication Technologies (ICT) for fundamental changes in all areas related to the operations, such as strategies, organization, processes, business models, and communications. It is evolving from basic digitization to becoming the link between virtual and real worlds. Many countries drive digital transformation to restore industrial competitiveness, and ICT is perceived as a key driver of economic growth. They also have tried to solve the mid- and long-term changes in the environment, such as population structure change and climate change, as well as social problems such as transportation, healthcare, and employment using digital transformation.

The Slovak government has also been working on strategies for digital transformation. The 2030 Strategy for Digital Transformation of Slovakia is a framework for cross-sectional government strategy that defines the policy and priorities of Slovakia. The heart of the Slovak digital transformation strategy is to realize a data economy similar to that of the European Union, and it is pushing to strengthen technologies such as Artificial Intelligence, Block Chain, Data Analysis, Data Security, High Performance Computing, and Internet of Things. The Slovak Ministry of Economy established the Action Plan for Smart

Industry Slovak Republic to provide support to industrial companies. Despite ongoing digital transformation in accordance with the plan, some issues arise regarding the digital transformation of SMEs. Many companies agree on the necessity for digital transformation and the introduction of smart factories, but they are not well aware of specific ways and detailed component technologies to implement it. There is a lack of national resources (costs, manpower, technology, etc.), specialized organizations, and detailed action plans to support the digital transformation of SMEs. The level of digitalization and the awareness of digital transformation vary by industry, and the gap between large foreign firms and local SMEs is wide. Also, the number and capabilities of ICT companies to support digital transformation are insufficient, and the domestic market for ICT-related businesses is not large.

In order to establish a digital transformation strategy for SMEs in Slovakia, the experiences of Korea are analyzed. Korea's enhanced competitiveness, through innovation to overcome the foreign exchange crisis in 1997, and its digitalization was used as the major tool for innovation in all organizations, including SMEs. Korea designed methods to digitalize many companies at the same time at low cost, and applied them successfully. Korea was able to proceed with the transformation easily through social awareness and minimized corporate and users' resistance to digitalization. In order to improve the informatization level of many companies in a short time, Korea has developed and distributed standardized information systems and provided joint support for manufacturing and ICT businesses to strengthen their capabilities simultaneously. For innovation of SMEs, Korea established a specialized organization, Korea Technology and Information Promotion Agency for SMEs (TIPA). TIPA is the key institution for manufacturing and technical innovation. It performs R&D and digitalization supports simultaneously.

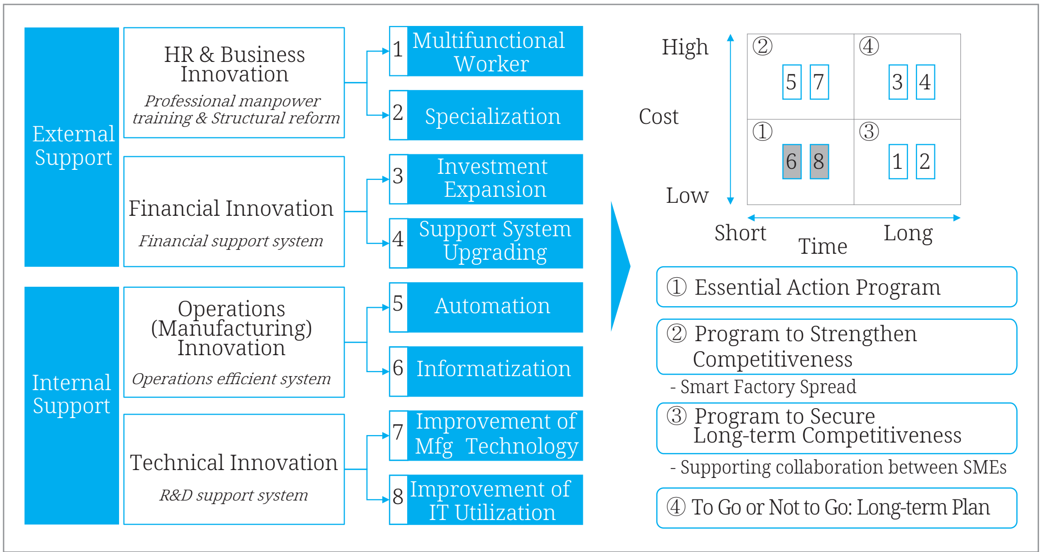
Taking the major issues of Slovakia in digital transformation of SMEs into consideration, some policy alternatives appropriate for Slovakia are derived based on Korea's digital transformation policies. 'Build an Organization Dedicated to Seamless Digital Transformation and Innovation Support for SMEs and Startups', 'Diagnosis of Information Level and Consulting to Improve the Enterprise's Recognition of Digital Transformation', 'Bold Initial Investment for Quantum Jump and Development of Reference Model or Standard Application', 'Support of Large Companies', and 'Setting Future Growth Engines of Slovakia' were suggested. Among other things, it is necessary to diagnose the existing level of digitalization of SMEs and to prepare specialized institutions for the centralized input of budgets for rapid development and operation of information plans. In addition, the key factors are cooperation with global conglomerates that have entered Slovakia, development of standardized information systems, and simultaneous support of ICT companies and manufacturing companies to prepare investment resources and to expand the ICT market.

1. Introduction

1.1. The Evolution of Digital Transformation

Increasing market transparency is turning customers into well-informed merciless buyers, and it is becoming harder for companies to differentiate their offerings from those of competitors, which results in fierce competition on price and quality. It is only through continuous innovation and improvement of their products and services or clear price advantages that companies are able to maintain their competitive position over the long term at all (Bailom, Matzler, & Tschemrnjak, 2007). In a time when prevailing megatrends and disruptive innovations are rapidly changing our way of doing business, only companies that are rapidly and constantly adapting would be able to accelerate their growth further. The adaptation quality–a reaction to significant, lasting, and non-reversible change in the company's value creation logic–is key definition of transformation. Transformation matters far beyond any single company. It matters for the shareholders, financial markets, employees, local communities, pension holders, industrial clusters, ecosystems, regions, and governments. Therefore, many countries and companies need to build deep innovative capabilities, and are adopting and utilizing digital transformation as an important strategy for transformation.

[Figure 4-1] Direction for Strengthening Competitiveness of the Manufacturing Industry



Source: Seo (2015).

In order to improve the competitiveness of the manufacturing industry, four areas of innovation are generally needed–human resources (HR) & business innovation, financial innovation, operations innovation, and technical innovation. The four areas can be divided into eight smaller parts and the eight parts can be divided into four subgroups according to implementation time and cost as shown in [Figure 4-1]. As detailed in the figure, informatization and improvement of Information Technologies (IT) utilization is an essential action program to increase competitiveness at a low cost in a short period of time. In fact, many Small and Medium-sized Enterprises (SME) want financial support, but it is very expensive and time consuming.

Digital transformation can be defined as utilizing Information and Communication Technologies (ICT) for fundamental changes in all areas related to the operations, such as strategies, organization, processes, business models, and communications. It is evolving from basic digitization to becoming the link between virtual and real worlds. <Table 4-1> shows the development stage of digital transformation in terms of business automation. Many SMEs may be in phase 2 or 3. In phase 2, the unit work is digitalized and in phase 3, called the cross-functional integration phase, each unit's work is linked and integrated. Phase 4 means the initial stage of process automation with smart factories. The final phase is to connect the virtual world and the real world. That is, to perform optimization by portraying reality with a virtual world, and to reflect the optimized virtual world in reality. Many companies want to create new business as well as to improve efficiency through digital transformation. Therefore, the goal of government support for digitalization should also be changed from operations efficiency to new business creation or value creation.

<Table 4-1> Development Steps of Digital Transformation

Phase		Major Content
Phase I	Digitization	- Digitization of data - Analog Data → Digital Data
Phase II	Digitalization of Unit Work	- Perform unit work using ICT - Manual work → Automation
Phase III	Cross-Functional Integration	- Achieve efficiency through sharing and utilizing data between automated unit tasks - Business process reengineering - Independent work → Linked and Integrated work
Phase IV	Automated/ Autonomous Organization	- Business automation using robot - Robot-human collaboration - Minimize human intervention in work
Phase V	Link between Real World and Virtual World	- Perform optimization by portraying reality with a virtual world (IoT, cloud, big data, mobile, AI) - Reflect the virtual world in reality (robotics, 3D printing)

Source: Author.

1.2. Digital Innovation Strategies of Some Countries

Many countries drive digital transformation to renew industrial competitiveness, and ICT is perceived as a key driver of economic growth. They have also tried to manage the mid- and long-term changes in the environment, such as population structure change and climate change, as well as the social problems such as transportation, healthcare, and employment, using digital transformation. In order to overcome the foreign exchange crisis in 1997, Korea enhanced its competitiveness through innovation, and digitalization was used as a major tool for innovation in all organizations, including SMEs. Korea designed some methods to digitalize many companies simultaneously at low cost, and applied them successfully. <Table 4-2> shows the background of digital transformation in the United States (US), European Union (EU), Germany, and China and their innovation strategies.

Many countries have tried to lead the Fourth Industrial Revolution and strengthen their competitiveness. In the US, ICT and internet service companies are leading this innovation. The EU has been focusing on the digitalization of SMEs. The EU is also implementing a digital single market strategy to expand the ICT market. The digitalization of the US has been led by the private sector, but in the EU, the digitalization has been led by the government. China has tried to build an innovation ecosystem focused on internet platform companies, and to promote startups. Especially, ICT enterprises pursue active partnerships with the government for promoting startups.

Although the innovation strategies and methodologies of each individual country are different, there are several things in common. Data-driven innovation, focus of support on leading areas, and open innovation are considered as important factors. Data is the core asset of the enterprise and fuel the innovation, and data collected globally is a key competitive component for exploring new business areas and models. The main components of the innovation strategies are quite similar in each country, but the starting point or details are different. There is a need for choosing key areas or elements of digital innovation for clarifying the focus of policy. Digital industry innovation requires government, business and researchers, along with openness between countries and cooperation among ministries. Most countries consider SMEs and start-ups as important sources of innovation.

There is one thing to keep in mind in digital transformation. As digital transformation requires high level of infrastructures and technologies in general, it is possible for few advanced countries to monopolize the fruits of digital transformation. Many companies have tried to construct smart manufacturing systems in their home countries or in advanced countries with a large market. In other words, companies that went abroad in search of relatively cheap wages and raw materials have set up innovative platforms called smart factories, accelerating their return to their home countries, which is called reshoring.

<Table 4-2> Background and Strategy of Digital Transformation in Some Countries

Country	Background	Digital Transformation Strategy
US	- Reflections on economic structure for short-term performance - Establish a foundation for long-term economic growth and job creation	- Digital Single Market Strategy for Europe - Led by government - Focused on digitalization of SMEs and technology commercialization
EU	- Decreased economically active population and reduced economic growth - Consolidate the digital market and create a joint innovation base by eliminating digital barriers in the market barriers - Secure competitiveness against US and China	- Innovation based on SMEs - Promoting digital innovation centered on manufacturing - Starting discussions in academia and industry, and promoted by government policy
Germany	- Decrease the economically active population and aging of skilled workers - Respond to climate change - Continue economic growth and create industrial competitiveness	- Dominated by ICT and internet service companies, and revitalizing traditional manufacturing companies - Led by private sector - Government focuses on Big Data, IoT, solving public problem using ICT, and information protection system
China	- Decrease of the working population and aging of the population - Gain global digital competitiveness - Secure the high value of traditional industry	- Major global market - Social innovation using ICT - Building an innovation ecosystem focused on internet platform companies - Promoting startups (IT enterprises takes active partnership with the government)

Source: Author.

1.3. Contents and Methods of Research

The purpose of this research is to analyze Slovak digital transformation initiatives, to benchmark the policies and programs of Korea, and to make practical suggestions for establishing concrete policies for digital transformation of SMEs. To achieve the objectives of this study, the research is carried out in three phases: As-Is Analysis, Benchmarking, and Strategy Development. The As-Is Analysis phase analyzes the needs and progress of digital transformation in Slovakia. The Benchmarking phase will focus on introducing Korean cases, especially information support system for SMEs. In the Strategy Development phase, some policies are suggested and various issues that may arise in the process of promoting digital transformation and changes management will be presented.

Section 2 describes the current status and policy issues in Slovakia. In Section 3, Korean experiences in digitalization of SMEs are explained, such as step-by-step ICT support policies, big bang style diffusion, simultaneous capacity building, and collaboration. Finally, Section 4 proposes feasible policies in several aspects as follows, combining the current status of Slovakia and Korea experience: organization, diagnosis of information level, quantum jump, and future growth engine.

2. Current Status and Policy Issues in Slovakia

2.1. Slovakia and Fourth Industrial Revolution

Slovakia needs modern and efficient support policies and initiatives that will complement companies, mainly SMEs, in the process of transformation into new growth opportunities. The process of identification of future policies and initiatives has revealed several topics that could improve companies' competitiveness. When analyzing the current development of smart industry and relevant supporting policies, Slovakia uses the following approach with five relevant areas of assessment:

- Collaboration and collaborative dynamics, identifying engagement of different actors, linkages and dynamics of linkages between actors over time - various types and number of collaborations, capacity to collaborate;
- Innovation and innovative capacity, focusing on staff competence development, knowledge exchange among companies and universities, capacity to innovate, collaborative research and innovation projects, new products/services introduction;
- Competitiveness and international attractivity, focusing on entrepreneurship, new companies' establishment, start-up and spin-off establishment, attraction of investments or talents, entry into new markets;
- Firm level economic performance, focusing on growth of revenue, productivity;
- System level, focusing on broader spillover effects on the region, e.g. regional growth, resilience/capacity for transformation, changes to European/national/regional innovation system or policies.

Practically, since Slovakia's accession to the EU, the dependence on the EU structural funds as the main source for financing of the development of research and innovation persists. This results in a still very low share of R&D expenditure by the private sector. With 0.41% of GDP in 2018, Slovakia is counted among the worst EU countries. This emphasizes the strong need to create sustainable tools to support research, development and innovation within the state budget, respectively creating new funding models that motivate private sector involvement. The Ministry of Economy is striving for systemic improvement in the field of Industry 4.0 (I4.0) through measures in the Action Plan of the Intelligent Industry of the Slovak Republic. On an even larger scale a new Smart Specialization Strategy will be a key document for the near future until 2027 (Research and Innovation Smart Strategy Specialization (RIS3) 2021-2027), which will not only provide a detailed mapping of relevant aspects of economic development, but will also identify the main areas and tools of support. Specific measures should cover in particular:

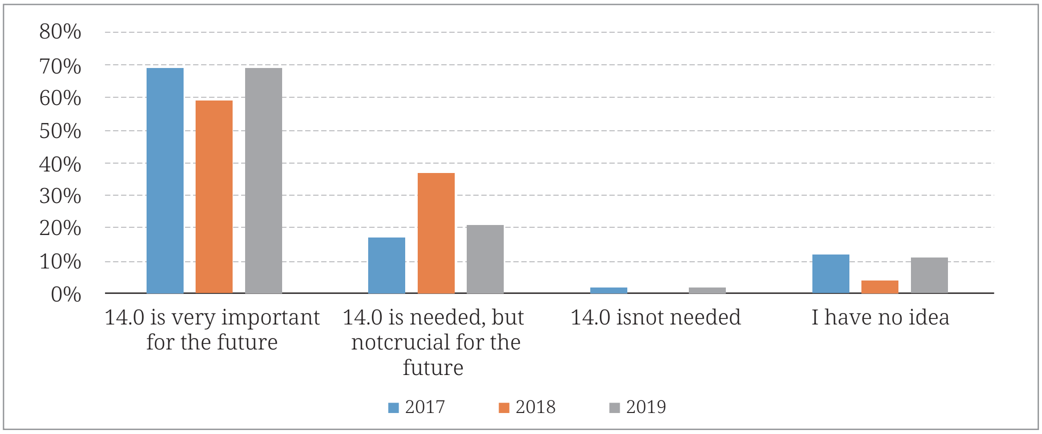
- Clear setting of priorities - in terms of sectoral, thematic, but also financial focus (both in relation to the Slovak Republic and the European Structural and Investment Funds (ESI Funds));
- Clarification of competencies across state administration bodies, but also subsidiary organizations;
- Support for cooperation between research institutes, universities and the private sector and the transfer of know-how and technology;
- Support for the so-called clustering - merging into natural clusters in order to increase competitiveness or make technological solutions available to a wide portfolio of entities;
- Support for international cooperation and the creation of international teams and consortia, both at the national and international level;
- Support for joint projects, use of Visegrad Group (V4) and EC tools, including the creation and continuous updating of a pool of complex research and development projects to address national economic issues relevant to Slovakia and the EU;
- Open approach to the identification and elimination of the causes of Slovakia's lagging behind in the field of research and industrial innovation;
- Gradual transformation of the character of the Slovak economy, towards the creation of space for the application of new trends such as artificial intelligence, virtual reality, blockchain, as well as for the benefit of other components of the economy such as. services (which would reduce dependence on dominant sectors);
- Support for innovation in new areas - health, social affairs, quality of life and support for new, related markets;
- Reform of the education system and labor market policy not only towards the elimination of differences between them, but also towards the development of new skills and competences needed for the 21st century.

Support instruments should use in full the principle of complementarity of financing, combining the state budget and ESI Funds. The state should strive for an appropriate combination of different forms (e.g., repayable, non-repayable aid) avoiding the distortion of healthy competition and entrepreneurship.

In addition to direct support for R&D and innovation in enterprises, for example through cooperation with the research and development environment, whether from the state budget or ESI funds, we can also highlight activities aimed at the use of innovative and digital technologies with the help of Digital Innovation Hubs (DIH). These will mainly serve the needs of SMEs in the ongoing digitization, which we perceive as one of the key tasks that the Ministry of Economy of the Slovak Republic (MoE SR) covers within its competences and implementation of the Smart Industry Action Plan.

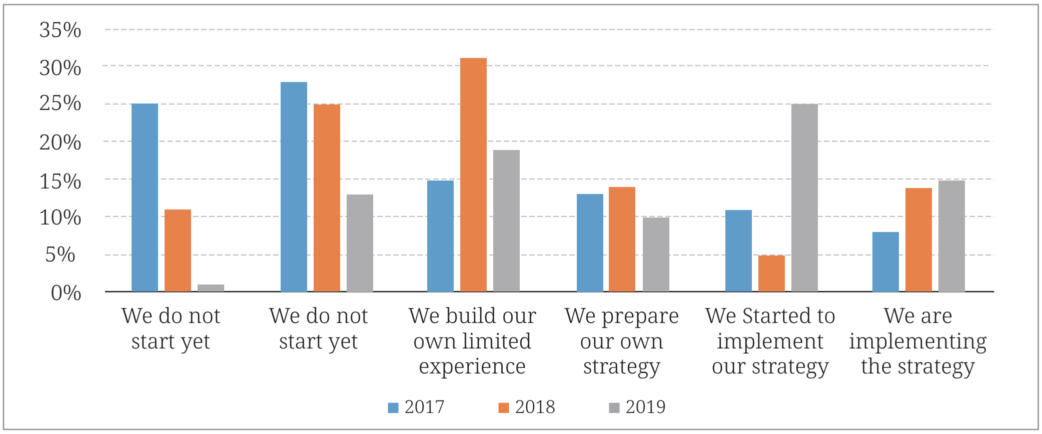
The Smart Industry Concept for Slovakia (hereinafter referred to as the "Concept") was submitted by MoE SR to an inter-ministerial comment procedure on 19 August 2016. The target group of the concept were industrial enterprises in the Slovak Republic (including SMEs). The material addressed stakeholders for identification of the most important areas that should be analyzed, with the next step being drawing up an action plan with concrete measures. In 2018, the Action Plan for Smart Industry was adopted, and proposed measures are characterized by the interconnection of industry, companies, public administration, education, and the public. A necessary prerequisite for the success of the concept and action plan is to inform the stakeholders about the nature and positive and negative aspects of the concept, which is in the field system support for research, development and innovation in accordance with RIS3. Awareness is especially important for entities for which the advent of I4.0 poses the greatest risks, e.g. traditional industries and small and medium-sized enterprises that are part of supply chains. The importance of communication and information sharing is confirmed by results of the survey, executed by Industry4UM (Industry Forum, national Industry 4.0 platform) in the years 2017-2018-2019. The survey results in [Figure 4-2] through [Figure 4-4] also show that: i) Slovak companies recognize the importance of I4.0 in coping with the Fourth Industrial Revolution. ii) The introduction of smart factories is increasing every year and the level of smart factories is increasing. In addition, a quarter of survey respondents, as of 2019, have established strategies to introduce smart factories and plan to implement them. iii) More than 40 percent of companies believe that the digitalization will not cost much. This can be interpreted as showing that companies will not spend much on the introduction of smart factories, which means that they are pushing for the introduction of smart factories in a way that can actively utilize current facilities rather than overhauling the factory.

[Figure 4-2] Importance of I4.0 perceived among Slovak companies



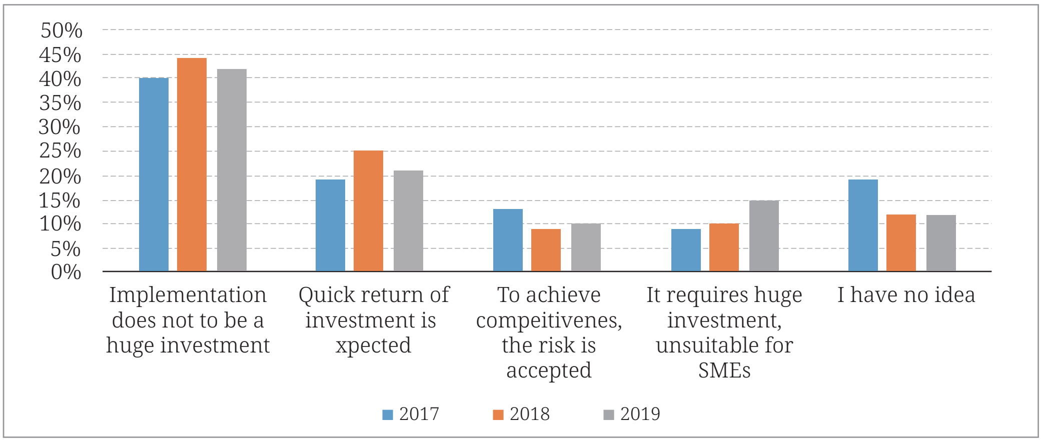
Source: https://industry4um.sk/vyhodnotenie-prieskumu-industry-4-0-sr-2017/.

[Figure 4-3] Intensity of implementation of digitization among the Slovak companies



Source: https://industry4um.sk/vyhodnotenie-prieskumu-industry-4-0-sr-2017/.

[Figure 4-4] Intensity of implementation of digitization among the Slovak companies



Source: https://industry4um.sk/vyhodnotenie-prieskumu-industry-4-0-sr-2017/.

An important component of the concept is also the support of applied research and the commercialization of its results. Another important factor in the involvement of companies in I4.0 is financing of R&D. The concept, therefore, proposes the interconnection of state budget resources and EU structural funds. Funding tools can be innovative public procurement, innovative partnerships, or pilot projects in individual areas such as energy, healthcare, transport, and cities.

The initial activities associated with the implementation of the concept can be divided into three areas:

- Creation of an Intelligent Industry Platform: this platform should act as the managing authority of the concept. It should be interdisciplinary in nature, with participants from state institutions and other key players from the smart industry. Within the platform Ambassadors will be selected for each industry, respectively prioritizing who will promote and support the implementation of recommendations relevant to the area that the ambassador will represent
- Carrying out sectoral analysis: these analyses should evaluate the potential impact of the proposed activities and provide input for action plans below and to decide on the need to implement further ones' steps in a specific sector
- Development of a sectoral action plan: The medium and long-term objectives should be set out in the priority plan areas defined in the RIS3 strategy (such as information and communication technologies, materials research and nanotechnologies, sustainable energy and energy, etc.). The Action Plan should also propose objectives, activities and projects related to Slovak entities, but also international cooperation

The concept contains recommendations divided into six areas:

i) Awareness raising and cooperation

- An information campaign on smart industry technologies and their benefits
- Pilot projects and test environments for the Internet of Things
- Elaboration of a manual for the implementation of the Intelligent Industry
- Improving the preparedness of traditional industries (including small and medium - sized enterprises) for the Internet of Things (access to finance and business education skills)
- Internationalization of companies

ii) Industry 4.0 Oriented Research

- Support for applied research in order to achieve a 70:30 ratio to basic research
- Elaboration of Industry-Oriented Research Agenda 4.0 in line with the RIS3 strategy
- Creation of sector-oriented consortia, composed of representative industries, startups and academia dealing with applied research; the role of consortia will be to lead research, development and commercialization of technology
- Notifying about the possibilities of involvement of Slovak producers in EU research projects

iii) Smart factories and production

- Support for the development and introduction of new technologies and materials,
- Reference architecture - standardization for companies, products, services, and digital platforms as a tool for horizontal integration
- Supply chains as a network of collaborator and integrator smart factories, connected to the Internet of Things
- Support for digital supply networks based on EU Digital Single principles Market that will use Big Data

iv) Access to finance

- Linking private investment with public funding
- Promoting innovation through innovative partnerships and innovative public Procurement; the aim of the innovation partnership is according to the Public Procurement Act (Public Procurement Office
- development and subsequent purchase of goods, construction works or services, resulting from developments, provided that they meet the requirements and the maximum cost contractually agreed between the public the contracting authority and the partner or partners
- Funding that will allow for a shorter development periods and faster deployment its results into practice

v) Labor market, education, and skills

- Analysis of industry requirements for individual skills and short-term and medium-term shortcomings in the provision of these skills
- Creation of curricula in accordance with the requirements of Industry 4.0
- Providing new, specialized skills in areas such as informatics, programming, business skills

- Integrated educational platforms for industry and academia for the purpose of knowledge transfer and innovative engineering
- Support of the National Coalition for Digital Professions established by the Slovakia IT Association in 2014

vi) Legislative environment enabling innovation and e-Government

- Developing the necessary skills in the public sector
- Open Data and Big Data - securing acquisition, flow and commercial use and protection of data
- Intelligent state administration based on the use of data
- A transparent and effective public digitization plan, including Mobile e-Government
- Future-proof regulation, which do not constitute barriers to innovation; digitization impact assessment (DIA - Digital Impact Assessment) and innovation (IIA - Innovation Impact Assessment) in the framework of the impact assessment process (RIA – Regulatory Impact Assessment)
- Active involvement of state institutions in the implementation of the Intelligent industry

2.2. Assessment

2.2.1. Collaboration and collaborative dynamics

Slovakia sees an absence of interconnection in research capacities with the industrial sector. It not only weakens businesses, but also the educational institutions themselves, which they would not have without partnering with large companies' capacity to develop talent and new projects. RIS3 has addressed this weakness, but a very strong fragmentation of responsibilities, with a silo culture dominating state institutions, are resulting that only few measures are supporting this interconnection (Ministry of Economy policy instrument "Innovation Vouchers", where it is mandatory to establish a link between an R&D institution and a company). Another very positive example is the establishment of the Smart Industry collaborative platform Industry4UM. This platform is hosting regular events, knowledge sharing days and conferences, including very specialized events, for example industry cyber security (November 2019). The approach presented by SIEA, in preparation of new RIS3 document for years 2021-2027, has a chance to focus more on collaboration and collaborative dynamics, working with priorities for Slovakia based on attractivity of particular trend/technology and feasibility for Slovakia - available capacities in R&D in all areas (academia and private sector).

2.2.2. Innovation and innovative capacity

In Slovakia there is a long-standing public debate regarding the need to reform the education system at all levels, from primary to higher education. This reform should include the creation of applicable interdisciplinary curricula and training programs, from which students would gain qualifications widely applicable in practice. In this regard, it is necessary that companies and corporations have helped to integrate education into production processes. From this collaboration, support could be made for staff exchanges, and an exchange of know-how between the production sector, companies, and academia. The result would be an improvement in theoretical as well as practical knowledge, professional and technical skills, and the promotion of creativity. Due to the expected significant shortage of highly qualified workers in the near future, it is also necessary to support the retraining of the workforce through more efficient use of training centers to make full use of the potential of the Slovak workforce.

Within the Operational Program Research and Innovation, six calls were announced under the auspices of the Ministry of Economy of the Slovak Republic and the Ministry of Education, Youth and Sports focused on supporting intelligent innovations in industry, supporting excellent research teams' strategic research. Incentives have also been provided to the business sector for R&D activities, creating new science and research sites or expanding existing ones, creating new jobs and new partnerships between the private and academic sectors. Support for the participation of research and development organizations in the Slovak Republic in international cooperation projects, including participation in EU programs, is provided through a national project and several calls under the responsibility of the Ministry of Education, Youth and Sports as well as the Ministry of Economy of the Slovak Republic.

2.2.3. Competitiveness and international attractivity

The problem of insufficiency and unavailability of private resources in the area of investment in processes digitization. It is essential to create space to increase economic incentives for Business Investment in Digitization and Industry 4.0. The main reasons why Slovak companies invest little in the innovative development are underdeveloped financial market and the overall weak financial condition of the companies. They need to move to segments with higher production added value. This may, in the short term, weaken the level of competitive advantage that Slovakia currently has, and that is based on affordable labor costs. However, in the long run it can increase the share of such newly created value in the revenues of companies themselves, which will bring increased return on investment in I4.0. There are several measures supporting internationalization: grants for participation at selected international fairs (SARIO and SBA), support of start-up programs, including incubation and acceleration (SBA, SIEA, Civitta), certification of industrial cluster organizations (SIEA). However, in general, it is still rather unsystematic and unpredictable.

Support for the participation of research and development organizations in the Slovak Republic in international cooperation projects, including participation in EU programs, is provided through national projects and four calls under the auspices of the Ministry of Education, Youth and Sports of the Slovak Republic, which reflect either exclusively or the needs of smart industry. The MoE SR supported this goal by announcing a call to support the involvement of SMEs in the 2nd phase of the "SME Instrument" program within the Horizon 2020 program.

2.2.4. Firm level economic performance

There are several forerunners in digitization and I4.0 in Slovakia. The number of companies that are following them is growing, currently the COVID-19 pandemic has caused a huge impact on economic performance not only with the forerunners, but on the whole economy. We see that this could jeopardize future development and future competitiveness of national economy, unless properly managed with systematic support measures.

Support for enterprises, especially small and medium-sized enterprises, in the ongoing digitization is one of the key tasks that the Ministry of Economy of the Slovak Republic, within its competencies and the implementation of the action plan of the intelligent industry, covers. One of the ways to ensure access to the use of innovative and digital technologies for companies as well as public sector entities are digital innovation hubs (CDI or DIH). For this purpose, the MoE SR commissioned a feasibility study for the creation of a Digital Innovation Hub (ECDI / EDIH) in the Slovak Republic. The study provided the client with a description of the current state (identification of the innovation environment in Slovakia), a proposal for an optimal ECDI model for the conditions of Slovakia, a strategy for its establishment and a description of international cooperation. Based on the outputs from the study, as well as cooperation with the Office of Viceprime Minister for Digitization and Investments (further ÚPVII), which covers the topic of digitization in Slovakia, the MoE SR continues to take steps towards the establishment of a digital innovation center.

2.2.5. System level

Not only companies should adapt to digitalization. The public sphere itself needs to improve its readiness to incorporate digital infrastructure by increasing staff skills and improving systems being used. Slovakia therefore needs to transfer both industry and public services to the modern technological infrastructure where it will be possible to prepare the country for the digital factories Slovakia needs to place more emphasis on supporting public dialogue, especially in the first phase of preparation new regulatory proposals. This preparation must be a fundamental aspect of regulatory processes, the outcome of which should take the form of setting norms and standards for digitization. Another area is to correctly set regulatory approaches towards standardization. The absence of these approaches, which is also criticized by the Concept of Smart Industry for Slovakia, leads to a shortage in innovative use of real-time public data, which means that the public administration does not have the data necessary to digitize and create an efficient e-government. The new legislation must focus on promoting innovative solutions in the form of intellectual property protection, in the spirit of needs of smart industry and new industries in the digital age. ÚPVII is producing several strategies (visit at ÚPVII in October 2019), but much less real measures that would improve current situation.

For the development of new solutions (Industry 4.0) and technologies development of infrastructure, which in Slovakia lags significantly behind other countries in Western Europe, is urgently needed. The first form of infrastructure is the technological infrastructure needed for connecting devices to the Internet of Things, which is the basis for the introduction of digitization. However, to achieve a higher degree of penetration of Industry 4.0 technologies into individual areas economy will also need to invest in urban and interurban infrastructure – transportation infrastructure.

One other big problem at the system level is the fragmentation of STI support. In Slovakia there are three ministries responsible, as of May 2020, for STI support – Ministry of Science, Education and Sport, MoE SR and UPVII. Except in the latter one, the ministries have several subordinated agencies without real coordination of activities (except some initiatives more on personal than system level).

Information concerning the built and renewed infrastructure from European Union funds will help the actors in application practice, including the intelligent industry, to make available the "Catalog of Research Infrastructure of the Slovak Republic" prepared by the Research Agency.

With the advent of new technologies and technological innovations based on working with data, the importance of securing the data space, the so-called cyber security. In effect from 1 January 2019, the Smart industry was included as a separate subsector within the amendment to Act no. 69/2018 Coll. on cyber security within the competence of the MoE SR. To define security standards and ensure the principles of cyber security, the MoE SR participates in the IPO demand call "Increasing the level of information and cyber security in the ISVS / ITVS subsector" with a project entitled "Increasing the level of information and cyber security of the MoE SR". With this step, it will be possible to use the financing of the area of creating security solutions by which the MoE SR will perform tasks in accordance with Act no. 69/2018 Coll. on cyber security, and thus also for the Intelligent Industry subsector.

The Ministry of Labor and Social Affairs of the Slovak Republic, within the Human Resources Operational Program, implements in the period 2019 - 2023 the national project "Sector-driven innovations to an effective labor market in the Slovak Republic", which aims to purposefully define skills of a qualified worker. Predicting the need for skills in accordance with the development of the labor market, forecasts of the development of the labor market and better identification of the demand for skilled labor are provided through the national project Forecasts of the development of the labor market in the Slovak Republic II. A significant amount of funds was invested through the national projects "Education of job seekers" and "Education of young job seekers" in projects related to raising qualifications, respectively retraining of job seekers, ensuring the development of human resources, their competencies for the needs of the labor market (measures Reaps +, Compas +).

2.3. Slovakia's Awareness of the Digital Transformation

In order to understand and map the needs of companies in the field of research and development, the MoE SR, in cooperation with SIEA, prepared a secondary analysis that evaluates the impact of selected global trends and megatrends on the functioning of Slovak companies. The analysis summarizes the needs of small and medium enterprises, and outlines recommendations that could help remove existing barriers in the area. This has been followed by mapping the situation regarding awareness and attitude to the topic of intelligent industry and the introduction of new technologies into operations as well as into everyday life. The MoE SR, in cooperation with SIEA, conducted two public opinion polls in 2019. The first survey was conducted on a sample of 251 companies (SMEs + large companies with more than 25 employees), represented by companies with purely Slovak ownership, foreign minority and foreign majority capital. In terms of technological level, the so-called high-tech as well as low-tech companies were included. The second survey was a quantitative statistical survey of the general population aged 15-55 years, whose main goal was to find out what the general population knows, how they understand and evaluate digital technologies, the so-called period 4.0, and at what level is their knowledge of the intelligent industry. 400 people were contacted by phone or electronically (e-mail), women and men were comparably represented, approximately equally from all regions. The survey revealed the following findings:

- 66% of companies have developed a strategy for corporate development of production in the context of intelligent industry, as well as a strategy for investment in modern production machines and technologies;
- More than 88% of the companies feel a shortage of professionally educated high school graduates, the shortage of labor is growing in proportion to the size of the company;
- Medium-sized companies feel for the lack of professionally educated university graduates the most;
- More than 50% of the respondents do not have sufficient information on concepts such as intelligent industry, process automation, test environment, advanced materials, augmented or virtual reality;
- Despite these facts, almost all respondents (97%) agreed that the smart industry is an important tool for reducing costs, entering the market faster with a given or better (innovated) product or business model, as well as a tool for addressing skills shortages;
- The main barriers in the implementation of smart industry methods are considered by most companies to be a lack of knowledge about the topic, and a lack of qualified human resources to implement the necessary measures. Companies report problems with a lack of standards as well as a lack of sectoral organization which is a platform to support and exchange experiences. The lack of financial resources remains a predominant problem;
- Almost half of the surveyed companies (45%) are still unsure of computer security technologies such as IoT, Cloud computing, Big Data, etc;
- More than half of the companies state that they are not economically ready to implement the tools of the smart industry; they do not have prepared and motivated employees who have sufficient skills and professional competencies to work in an IP environment;
- Only 1% of the surveyed companies have a plan to adopt the skills needed to implement the technologies and principles of the smart industry;
- Only 1% of companies have confirmed that they already have connected production data, which is available for decision-making and problem solving in real time. More

than 83% of companies do not have access to real-time data.

The second survey was a quantitative statistical survey of the general population aged 15-55 years, whose main goal was to find out what the general population knows, how they understand and evaluate digital technologies, the so-called period 4.0, and what they know about smart industry. 400 people were surveyed, including women and men, approximately equally from all regions. The survey was conducted by e-mail or telephone. The survey showed that:

- Most respondents use a mobile phone / smartphone the most (78.5%), of which the younger population uses it daily;
- Of the applications, e-mail and the Internet are the most widely used;
- Almost 40% of respondents were not aware of concepts such as artificial intelligence, intelligent industry, and virtual reality;
- The concept of “robotics” is known to almost all respondents, as well as the concepts of 3D printing and chatbot are partially known in the population;
- The public has very weak awareness about the terms rapid prototyping, fablab, blockchain.

2.4. Several Issues in Slovakia

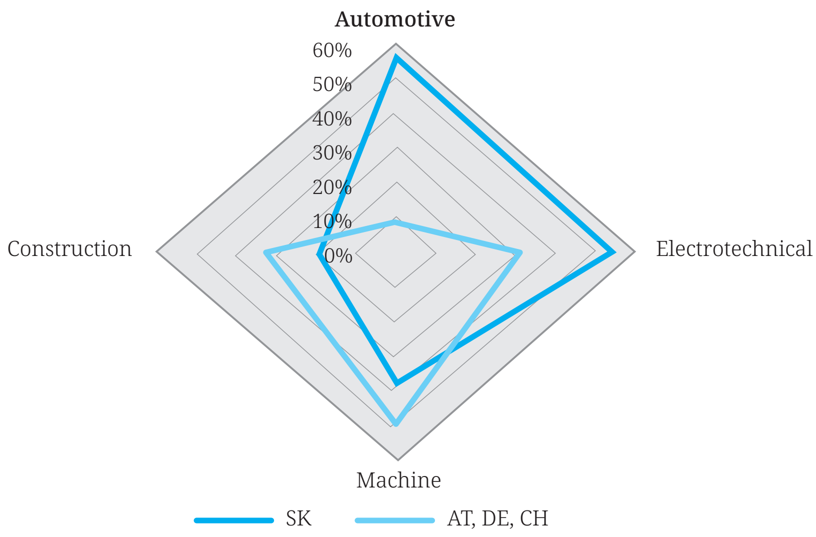
Looking at the challenges facing Slovakia, the analysis identifies several weak spots. Slovakia should address these in the near future to fulfill its goal to digitize processes in all areas of life – public administration, government and of course companies´ processes. The main areas of improvement for public administration have been identified as follows:

- Support for radical changes in educational policy ;
- Support for physical and IT infrastructure completion;
- Support for the legal system (data protection, legal liability, trade restrictions);
- Improve STI support structure (more focused and less fragmented).

In implementing all the proposed recommendations, and in engaging in proper dialogue with the business sector on excessive burdens in terms of administrative burden and unnecessary regulation, Slovakia could grasp the digitization processes in the right way and make full use of their comparative advantage in favor of the Slovak economy and employees. As an example of such activity we can highlight processes aimed at the use of innovative and digital technologies with the help of DIH. These will serve mainly for the needs of SMEs in the ongoing digitization, which we perceive as one of the key tasks that the MoE SR covers within its competences and implementation of the Smart Industry Action Plan. The expected benefits would be turned into concrete results that could put Slovakia among the leaders of the new industrial revolution. Industry 4.0 and digital transformation will affect the world´s and European Union's economy for the next decades, and therefore it is essential that Slovakia does not remain lagging behind.

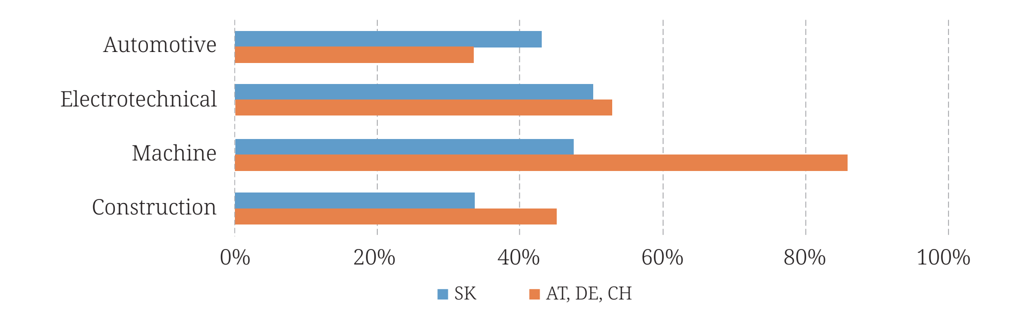
According to the previous KSP reports, the Ministry of Economy and Finance and KDI (2017, 2018), Slovakia has several problems related to digital transformation of SMEs. SMEs' awareness on the smart innovation is low and related government organizations do not exist. As shown in [Figure 4-5] and [Figure 4-6], the rate of introduction of new technology is highest in automotive industry. If Slovakia and other countries are compared, there is a higher awareness of investment for innovation in the automotive industry than machine and construction industries in Slovakia. However, most of the auto assembly plants belong to foreign companies. The auto assembly plants are foreign cooperates, and among the top 40 auto parts firms, 38 originate from foreign nations. In addition, domestic applied R&D centers are insufficient, and most R&D centers originated from foreign countries as in the automotive industry. Therefore, more domestic firms should make an effort to gain competitiveness.

[Figure 4-5] Percentage of Introduction of New Technology for Automation



Source: Papula *et al.* (2019).

[Figure 4-6] Recognizing the Importance of R&D Investment



Source: Papula *et al.* (2019).

3. Korean Experience

3.1. Specialized Organization for SMEs

For innovation of SMEs, specialized organizations such as the Korea Technology and Information Promotion Agency for SMEs (TIPA), the Korea Smart Manufacturing Office (KOSMO), the Korea SMEs and Startups Agency (KOSME), and the Korea Foundation for Cooperation of Large & Small Business, Rural Affairs (KOFCA) were organized. <Table 4-3> shows the roles of the organizations.

<Table 4-3> The Roles of Korean Specialized Organizations for Supporting SMEs

Organizations	Major Roles of the Organizations
TIPA	- R&D support: Startup growth and technological development, Re-challenge technology development Project, Process quality technology development project, Industry-academy-research collaboration technology development project - Digitalization support: Support for business, support for digitalization of manufacturing
KOSMO	- Creating new business models for SMEs' manufacturing innovation - Spread of smart factories - Analyzing performance and raising public awareness
KOSME	- Finance: Customized support based on a company's growth stage (Startup - Growth - Re-Start) - Consulting: Business diagnostics to identify problems and offer customized solutions - HR development: ex) establish college courses teaching skills needed by SMEs through an agreement among SMEs, colleges, and workers
KOFCA	- Large and Small Business Cooperation: Large enterprises support innovation and smart factory construction of SMEs - Small and Small Business Cooperation: Business collaboration among SMEs to encourage specialization of enterprises

Source: Author.

TIPA is the key institution for manufacturing and technical innovation. It does R&D and digitalization support simultaneously. KOSMO is a sub-organization of TIPA for manufacturing innovation through smart factories. It creates a new business model for SMEs' manufacturing innovation, spreads smart factories, analyzes performance, and raises public awareness. KOSME supports financial and HR innovation, providing customized support based on a company's growth stage and provides consulting services. Through an agreement among SMEs, colleges, and workers, KOSME has a program to establish college courses that teach skills needed by SMEs. KOFCA promotes cooperation between SMEs as well as between large and small companies.

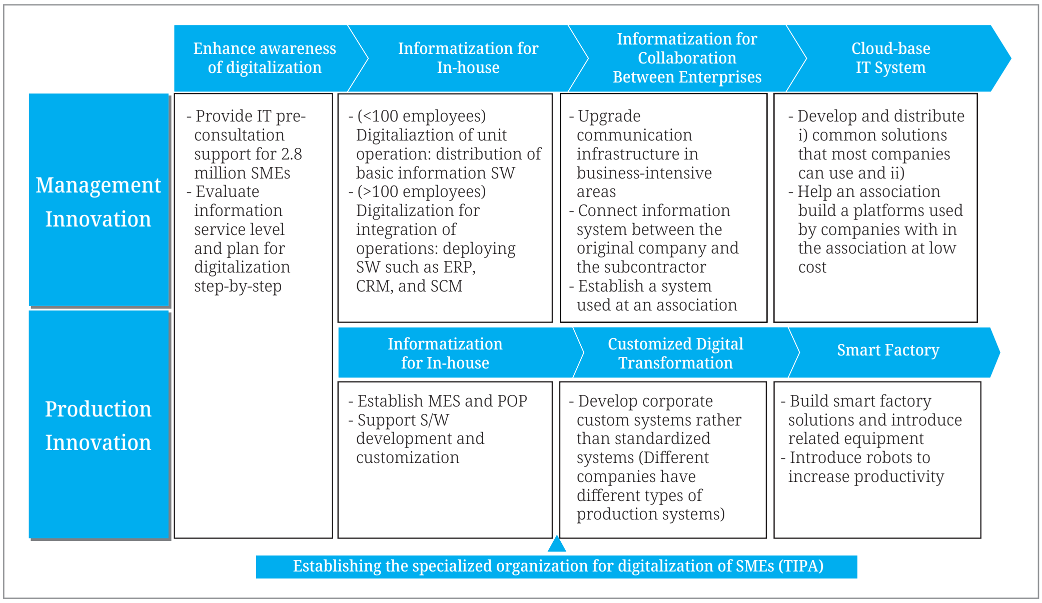
Korea also established the Presidential committee on the Fourth Industrial Revolution (PCFIR) for government-private partnership, which develops national master plans and strategies for innovation. This committee derived the Korea Innovative Platform and it also runs a program for regulatory and system reform called Hackerthon. The main roles of PCFIR are as follows:

- National master plans and strategies related to the Fourth Industrial Revolution
- Executive plans and major policies for various ministries regarding the Fourth Industrial Revolution
- Measures to support the advancement of science and technology and the development and innovation of core technologies necessary for the Fourth Industrial Revolution
- Strategies to foster new industries and services created through the integration of new intelligent technologies into existing industries

3.2. Step-by-Step ICT Support Policy and Digital Transformation Framework

The policy for supporting the digitalization of SMEs was started with a focus on enhancing the awareness of informatization, and evolved to customized and cooperation support. Recently, mainly cloud-based IT systems and smart factory systems are supported. To enhance awareness of digitalization, the government provided IT pre-consultation and evaluated information at the service level. In regards to management innovation, in-house informatization was supported, according to the size of the company. Subsequently, informatization for collaboration between enterprises was supported. Information systems between prime industries and subcontractors were established, and a system to be used by associations was also constructed. In recent years, cloud-based IT systems were supported. Common solutions that most companies can use, and also specialized solutions for specific industries, were developed and distributed. The government helped associations build platforms used by companies within the association at low cost. For production innovation, customized systems, rather than standardized systems, were developed as different companies had different types of production systems. The digitalization has spread rapidly since TIPA was established. [Figure 4-7] depicts the development of Korean policy to support digital transformation of SMEs.

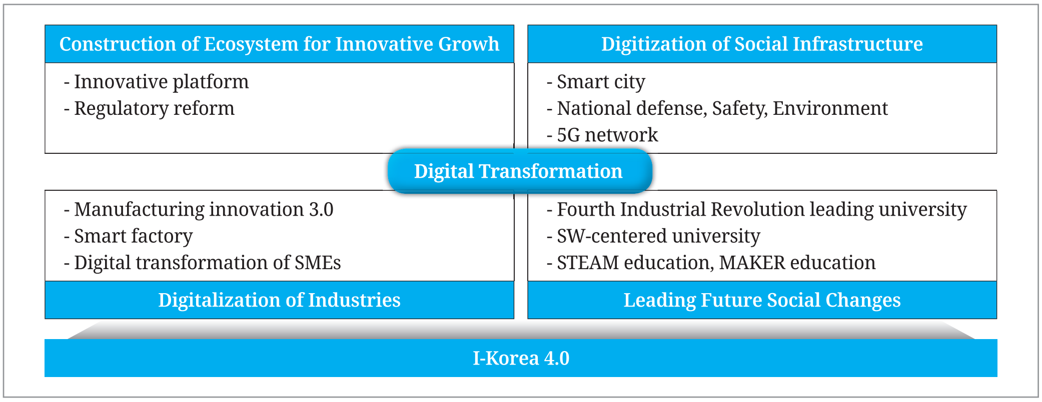
[Figure 4-7] Development of Korean Policy for Supporting Digitalization of SMEs



Source: Author.

Korea established 'i-Korea 4.0' as a policy brand for the Fourth Industrial Revolution, which symbolizes intelligence, innovation, inclusiveness, and interaction. Based on the i-Korea 4.0, the digital transformation strategy framework of [Figure 4-8] was built. It is composed of construction of ecosystem for innovative growth, digitalization of social infrastructure, digitalization of industries, and leading future social changes. Korea also selected three strategic investment fields and eight leading businesses to accelerate innovation growth. Among the three strategic fields, Data & AI, Hydrogen Economy, and Training of Innovative HR, Korea decided to invest the most in Data & AI. It also will invest the most in the smart factory business among eight smart solutions.

[Figure 4-8] Digital Transformation Strategy Framework



Source: Author.

<Table 4-4> Investment for Innovative Smart Solution

(Unit: USD million)

Strategic Field	Investment (2019)	Leading Business	Investment (2019)
Data & AI	1,490	Future Car	760
Hydrogen Economy	110	Drone	120
Training of Innovative HR	340	New Energy Business	870
		Bio Health	350
		Smart Factory	1,030
		Smart City	130
		Smart Farm	240
		Fin Tech	10

Source: Ministers Meeting on Innovation Growth (2018).

3.3. Customized Policy and Big Bang Style Support

Based on the results of prior consultations and the size of the company, the direction for supporting informatization was set. For information system unadopted companies or companies with less than fifty employees, basic S/W for efficient unit work was distributed, such as basic production information system Material Requirement Planning (MRP). In order to raise efficiency of unit operation, for companies with less than one hundred employees, digitalization by Enterprise Resourc e Planning (ERP) was promoted. For a company with more than one hundred employees, the government supports integration of enterprise resources by constructing In-house information system such as ERP, Customer Relations Management (CRM), Supply Chain Management (SCM), Manufacturing Execution System (MES) and Point of Production (POP) system.

According to the diagnosis of factory information systems, the system levels are divided into four: basic, intermediate 1, intermediate 2, and advanced, and based on the level, the direction of support for smart factory is determined. At the basic level, production performance, history, and defect management are carried out, in intermediate 1 level, automatic aggregation of facility data using sensors is possible. In intermediate 2 level, real-time factory control is possible, and at the advanced level, autonomous production is possible based on the own judgement of the facility system.

[Figure 4-9] Customized Policy for Digital Transformation and Smart Factory

Pre-Consulting (Diagnosis)	Information System Unadopted Companies	# of Employees: 20 ~ 49	- Distribution of Basic S/W for efficient unit work (basic production information system such as MRP) - 18,000 companies (2001~2003)
	Efficient Unit Operation	# of Employees: 50 ~ 99	- Digitalization of unit operation by ERP - Basis for integrated management and production information system - 9,000 companies (2001~2003)
	Integration of Unit Operation	# of Employees: >100	- Integration of enterprise resources by constructing In -house information system such as ERP, CRM, SCM, MES and POP - 3,000 companies (2001~2003)
Diagnosis of Factory Information System	Basic		- Production performance, history, and defect management - Collects utilization data such as bar code and RFID
	Intermediate 1		- Production and quality management by collecting and analyzing real-time production information - Automatic aggregation of facility data using sensors
	Intermediate 2		- Real -time factory control - Real -time system -facility link through PLC(controller)
	Advanced		- Autonomous production based on the own judgment of the facility system - Wire or wireless communication with multi -functional intelligent robot

Source: Author.

[Figure 4-10] Big Bang Style Support

Initial Support for Digital Transformation(2001~2003)

Stage (size)	Information System Unadopted Companies (<100)	Integration of Unit Operation (>100)
Number of target companies	60,000	10,000
Number of supported companies	28,000	3,000

50% of Target Companies

- A large budget is set to support multiple enterprises simultaneously in a short period of time
- Balanced development is possible by reducing the digitalization gap between firms

Support for Smart Factory

Stage (size)	2017	~2022
Number of target companies	60,000	
Number of supported companies	5,000	30,000

50% of Target Companies

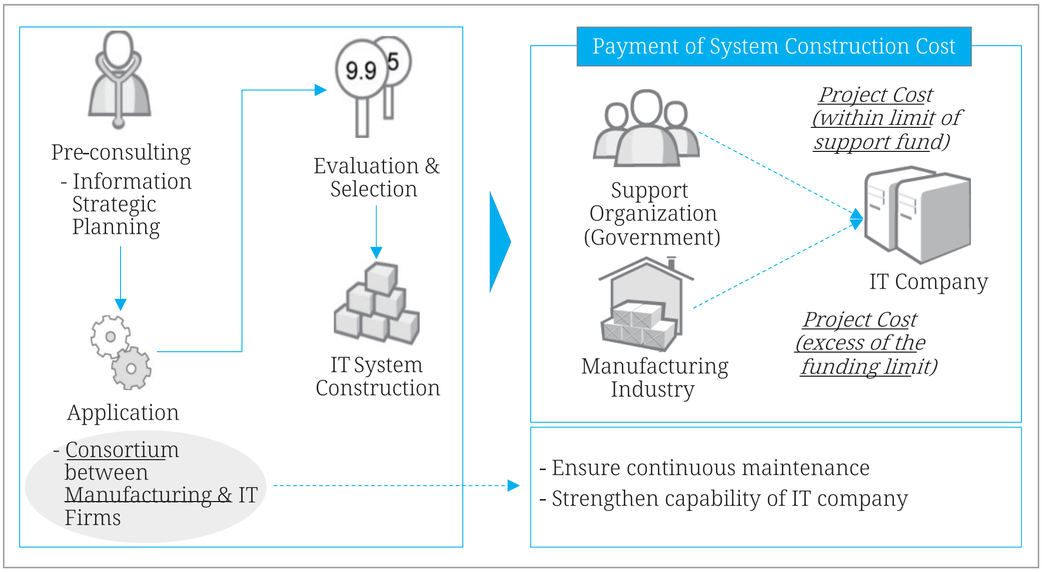
Source: Author.

The Big Bang style means that a large budget is created for many enterprises simultaneously in a short period. Korea had to secure the power of corporate innovation to overcome the foreign exchange crisis in 1997, and the digitalization has been used as the major tool for corporate innovation. Therefore, Korea designed ways to digitalize many companies simultaneously. In the initial support for digital transformation, from 2001 to 2003, about 50% of target companies were supported. Even with recent Smart Factory support, the goal is to support 50% of target companies. The Korean government aims to distribute smart factories to 30,000 out of 60,000 manufacturing companies with more than 10 employees by 2020. To apply the Big Bang style policy, large budgets should be set. However, by reducing the digitalization gap between firms as soon as possible, balanced development may be possible.

3.4. Simultaneous Capacity Building

Simultaneous capacity building is a very important characteristic of Korean policy, which supports a consortium of manufacturing and IT companies. Korea has laid the foundation for the sustainability of digital transformation of manufacturing industries by strengthening the capabilities of IT companies. [Figure 4-11] shows the procedures for simultaneously supporting ICT companies and manufacturing SMEs. The first step is pre-consulting. According to the result of the consultation, a consortium of manufacturing and IT firms is organized. After that, the supporting agency evaluates the consortium's proposal. The government pays project costs from within the support fund and manufacturing industry pays the remaining costs in excess of the funding limit. This simultaneous capacity building can ensure continuous maintenance, strengthen capability of IT companies, and expand domestic market IT. In order to promote digitalization of SMEs, it is very important that the government improves local IT companies' capability and expands the IT market.

[Figure 4-11] Procedures for Supporting ICT of SMEs



Source: Author.

3.5. Collaboration

The Korean government encourages support from large companies for win-win development with SMEs. It also supports cooperation between SMEs to develop new business models and strengthen the specialty of SMEs. This collaboration for smart factories is executed by the central government working with local governments, central government working with large companies, and by "Smart Meister Consulting". The Smart Meister Consulting is to use retired experts from large enterprises. The smart factory construction consulting, technical support, and follow-up management are conducted by these retired experts. For example, Samsung Electronics agreed to earmark 50 million dollars by 2022 to support distribution of smart factories, and POSCO ICT Consortium will invest 60 million dollars over three years. Additional supports from large enterprises such as sales support are also possible.

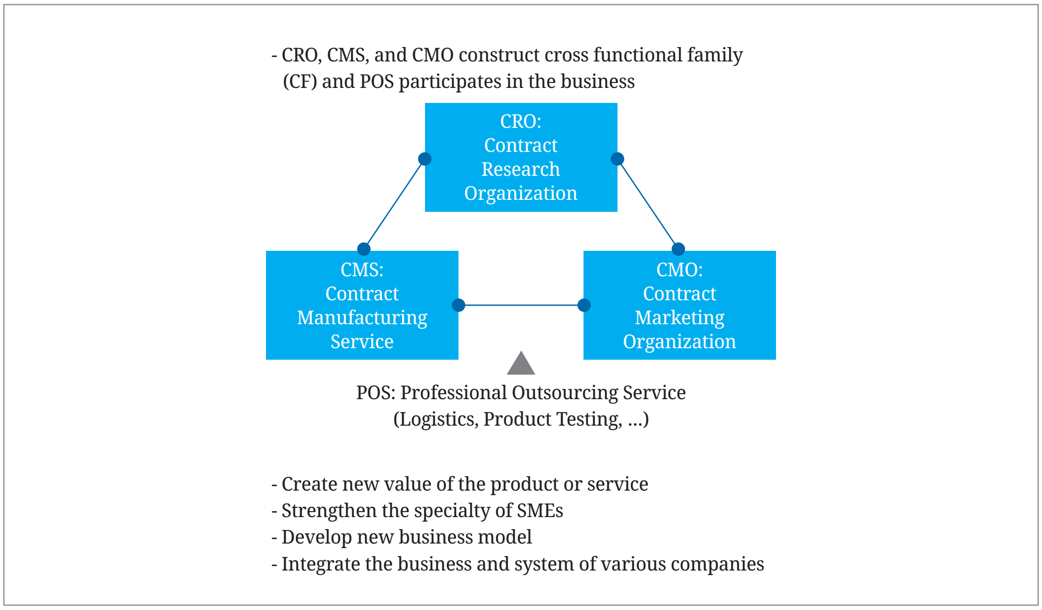
The Korean government has also promoted collaboration between SMEs. It supports the consortium of specialized SMEs such as Contract Research Organization (CRO), Contract Manufacturing Service (CMS), and Contract Marketing Organization (CMO). The aim is to create new value in the product or service, to strengthen the specialty of the SMEs, to develop new business models, and to integrate the business and systems of various companies.

<Table 4-5> Smart Factory Support for SMEs through Collaboration

Collaboration Type	Contents
Central Government + Local Government	- Local governments set up distribution plans that reflect regional characteristics, and the central government and local governments match funds to support deployment costs - Government: Local Government: SME = 4:2:2
Government + Large Company	- Samsung Electronics agreed to earmark a total of 50 million dollars by 2022 to support distribution of smart factories - POSCO ICT Consortium invested a total of 60 million dollars over a three-year period - Additional support from large enterprises such as sales support - Government: Large Company: SME = 3:3:4
Smart Meister Consulting	- Retired experts from large enterprises conduct the smart factory construction consulting, technical support, and follow-up management

Source: Author.

[Figure 4-12] Collaboration among SMEs



Source: Author.

3.6. Supporting Programs for Constructing Smart Factories

The government operates various programs to build and distribute smart factories and has achieved the desired results. The major support programs are: New Smart Factory Introduction, Smart Factory Upgrade, Pilot Smart Factory Construction, and Specialization by Industry. The government helps companies without smart factories to introduce them by supporting up to 50% of the total cost. The smart factory upgrade program develops the existing system to improve utilization and add more smart factory facilities and connection systems. The pilot smart factory program is to support the construction of pilot plants, which can be benchmarked by SMEs that are introducing smart factories. The government also supports the implementation of specialized solutions needed by unique manufacturing process or industries.

<Table 4-6> Supporting Programs for Constructing Smart Factories and the Effect of the Programs

(a) Programs

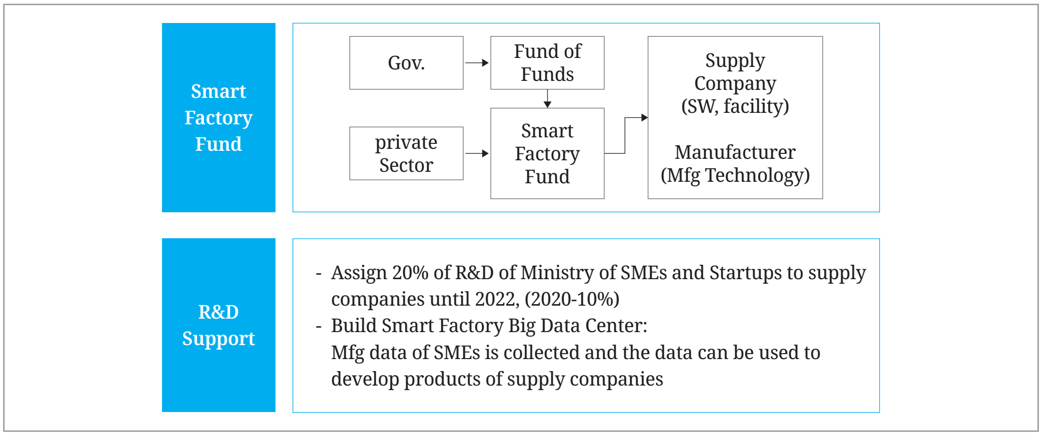
Program Name	Main Contents
New Smart Factory Introduction	- Help Companies without Smart Factories to Introduce it (0.1 million dollars, 50% of the total cost)
Smart Factory Upgrade	- Develop the existing system to improve utilization and add more smart factory facilities and connection systems (0.15 million dollars)
Pilot Smart Factory	- Support the construction of pilot plants, which can be benchmarked by SMEs introducing smart factories (0.3 million dollars)
Specialization by industry	- Support the implementation of specialized solutions for unique manufacturing process (industry) (0.1 million dollars)

(b) Effects

Item	Effect
Increase Employment	3.0 people (+)
Improve Sales	7.7% (+)
Rate of Reduction of Industrial Accidents	18.3% (-)
Improve Productivity	30.0% (+)
Improve Quality	43.7% (+)
Reduce Cost	15.9% (+)
Meet Delivery Time	15.5%

Source: Author.

[Figure 4-13] Capacity Development for Supply companies of Smart Factory



Source: Author.

As a result of this support, the productivity and quality were improved and costs were reduced. In particular, the government is pushing for the development of funds and construction of manufacturing data centers to strengthen the competitiveness of smart factory suppliers. The government created seed money and raised smart factory funds from the private sector and supported the supply companies, such as SW, and facility companies. The government has a plan that assigns 20% of R&D funds for SMEs to supply companies until 2022. The government will build a smart factory data center where manufacturing data of SMEs is collected, and the data can be used to develop products of supply companies.

4. Policy Recommendations

4.1. Direction of Policy for Supporting Digital Transformation of SMEs

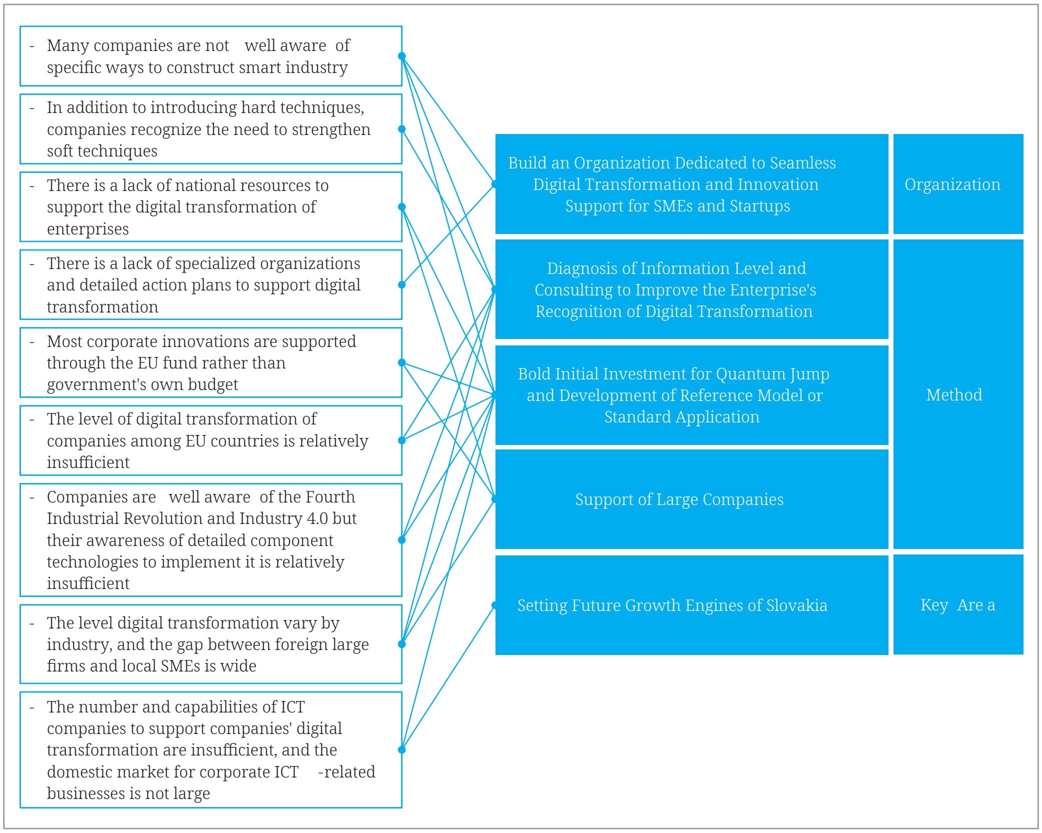
Based on the status and range issues of the Slovak and Korean experience, this section outlines the direction of the strategy to support the digital transformation of Slovak SMEs. The main issues are summarized as follows:

- Businesses agree on the need for digital transformation (especially the introduction of smart factory), but they are not well aware of specific ways to introduce it.
- In addition to introducing hardware or hard techniques, such as information systems to support innovation, companies recognize the need to strengthen soft techniques such as problem-solving skills and teamwork.

- There is a lack of national resources (costs, manpower, technology, etc.) to support the digital transformation of enterprises.
- There is a lack of specialized organizations and detailed action plans to support digital transformation of the entire country and all businesses.
- Most corporate innovation is supported through the EU fund rather than government's own budget.
- The level of digital transformation of companies among EU countries is relatively insufficient.
- Companies are very well aware of the Fourth Industrial Revolution and Industry 4.0, but their awareness of detailed component technologies to implement it is relatively insufficient.
- The level of digitalization and the awareness of digital transformation vary by industry, and the gap between foreign large firms and local SMEs is wide.
- The number and capabilities of ICT companies to support companies' digital transformation are insufficient, and the domestic market for corporate ICT-related businesses is not large.

Taking these issues into consideration, some policy alternatives appropriate for Slovakia were derived based on Korea's digital transformation policies – ‘Build an Organization Dedicated to Seamless Digital Transformation and Innovation Support for SMEs and Startups’, ‘Diagnosis of Information Level and Consulting to Improve the Enterprise's Recognition of Digital Transformation’, ‘Bold Initial Investment for Quantum Jump and Development of Reference Model or Standard Application’, ‘Support of Large Companies’, and ‘Setting Future Growth Engines of Slovakia’ – as shown in [Figure 4-14]. Above all, it is necessary to establish an organization exclusively responsible for supporting the digital transformation of SMEs, which would establish detailed support strategies and implement them efficiently. In addition, it is important to establish policies by accurately diagnosing an enterprise's information level, and to develop an implementation plan for raising the level of ICT suppliers, as well as manufacturing industries, through short-term investments. To realize this, it is deemed necessary to consider building and operating a reference model for smart factories and distribute it to all the enterprises based on it.

[Figure 4-14] Main Issues Proposed Digital Transformation Policy of Slovakia



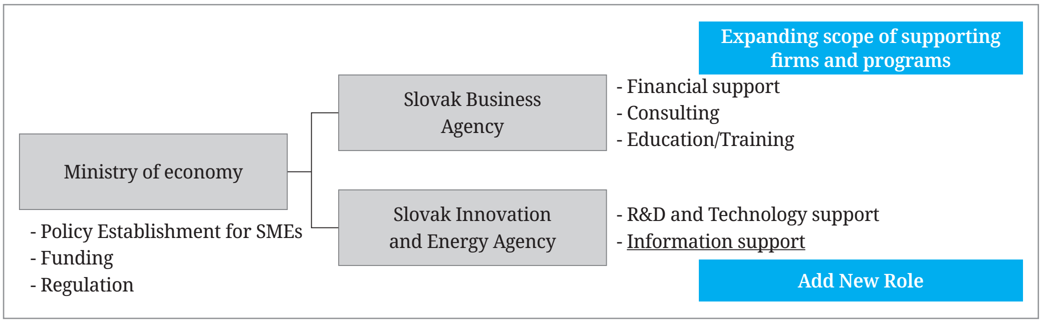
Source: Author.

4.2. Organization: Build an Organization Dedicated to Seamless Digital Transformation and Innovation Support for SMEs and Startups

Slovakia has established and continues to operate the Slovak Business Agency (SBA). SBA was founded in 1993 through a common initiative of the EU and the Slovak Republic to foster SMEs. However, most of the support is focused on start-ups or companies preparing to start their own businesses. SBA provides internships, overseas inspections, funding, incubating, and MAKER space through national business center and about 300 companies annually start their own businesses with the help of NPC. In Slovakia, the series of supports for SMEs according to the growth stage of the company is somewhat insufficient. The urgent task is to strengthen programs to support post-start up business growth and innovation and the institutions that implement them. The Slovak Innovation and Energy Agency (SIEA) implements two operational programs: Research and Innovation and Quality of Environment. The aim of the Research and Innovation support is to increase the quality and efficiency of production and technology, and the Quality of Environment is to reduce energy intensity and increase the use of areas of ecological interest in company. SIEA has also implemented a national project to raise awareness of the importance of innovation among SMEs and among students. However, a specialized agency or program to support the digital transformation of SMEs has not been well established.

Therefore, for the purpose of planning and effective implementation of informatization of SMEs in Slovakia, it is proposed to set up a new information promotion agency, or to give SIEA an additional role supporting digital transformation of SMEs. Also, it is necessary to expand the role and programs of SBA in supporting all SMEs that have entered growth, maturity, or decline stage beyond the start-up period. Then, the role of SBA is similar to that of Korea SMEs and Startups Agency (KOSME) and SIEA is similar to Korea Technology and Information Promotion Agency for SMEs (TIPA).

[Figure 4-15] Expanding the Role of SME Support Organizations



Source: Author.

'Industry 4UM', a group of IT companies, is being run in order to improve the preparations of companies for the digital transformation. Industry 4UM shares information related to digital transformation and the market situation, strengthening the network for information sharing among experts, and makes policy suggestions to the government to support companies' digital transformation. Recently, it is working on a project to build and operate a smart factory test bed with support from the EU. However, there is a limit to expanding various projects at the national level due to the lack of substantial participation and support from government agencies in Industry 4UM. Thus, a new organization that supports the enterprise's digital transformation will be able to manage and actively support Industry 4UM and use it as a pool of suppliers for the enterprise's digital transformation.

4.3. Method 1: Diagnosis of Information Level and Consulting to Improve the Enterprise's Recognition of Digital Transformation

Management thinker Peter Drucker is often quoted as saying that "If you can't measure it, you can't manage it and you can't improve it". Further, Bill Gates (2013) quoted Rosen as saying in his book, "Measuring tools allowed inventors to see if their incremental design changes led to the improvements needed to build better engines. Without feedback from precise measurement, invention is doomed to be rare and erratic. With it, invention becomes commonplace.", stressing that feedback through measurement is the most important foundation for innovation. This is also highly valid for the information about an enterprise. When the information level of an individual enterprise, or an industry as a whole, can be accurately measured, an enterprise's innovation through digital transformation can be possible and effective. In this regard, Korea established a legal basis for the assessment of the informatization level of SMEs in 2004, and annually evaluates the level of digital transformation, and reflects the results within policy. In Slovakia, in order to design and implement digital transformation policies and specific programs for SMEs, it is necessary to develop and periodically evaluate Slovakia's unique measurement tools.

In Korea, the survey on the level of information of SMEs is conducted by TIPA, an information service support organization for SMEs, for the following purposes: First, to obtain and diagnose objectively and comprehensively time series data on SMEs information level. i) By evaluating the information level of SMEs every year, the government not only appraises the current status and development stage of informatization but also presents the direction of government support for strengthening international competitiveness in macro terms. ii) It provides the basis data for setting mid- to long-term goals of informatization support and establishing policies for promoting digital transformation by continuously examining the achievement of major goals of policies for SMEs. iii) Priority of policies for narrowing the informatization gap between large and small enterprises and supporting customized digital transformation by industry size is derived. iv) Problems with information support projects and policies currently implemented are determined and the directions for improvement are presented. The second objective is the enhancement of informatization awareness and the establishment of successful promotion strategies through comparisons of the level of informatization with competitors and successful cases. See [Figure 4-16].

[Figure 4-16] Objective of Survey on the Information Level of SMEs

Final Goal	The spread of digital transformation of SMEs and the improvement of management through government support and voluntary investment
Sub Goal	Generating various statistical data for the 'Plan-Do-See' of informatization policies for SMEs
Government Side	- Generating statistical data for a comprehensive understanding of the information level of SMEs - Finding a utilization model of information level assessment of SMEs - Proposing feasibility and checking performance of the investment for digital transformation of SMEs
SME Side	- Awareness of the importance of digital transformation of CEO and other decision makers - Recognizing the importance of enhancing corporate competitiveness through informatization - Acquisition basic data for decision making

Source: Ministry of SMEs and Startups and Korea Technology and Information Promotion Agency for SMEs (2019).

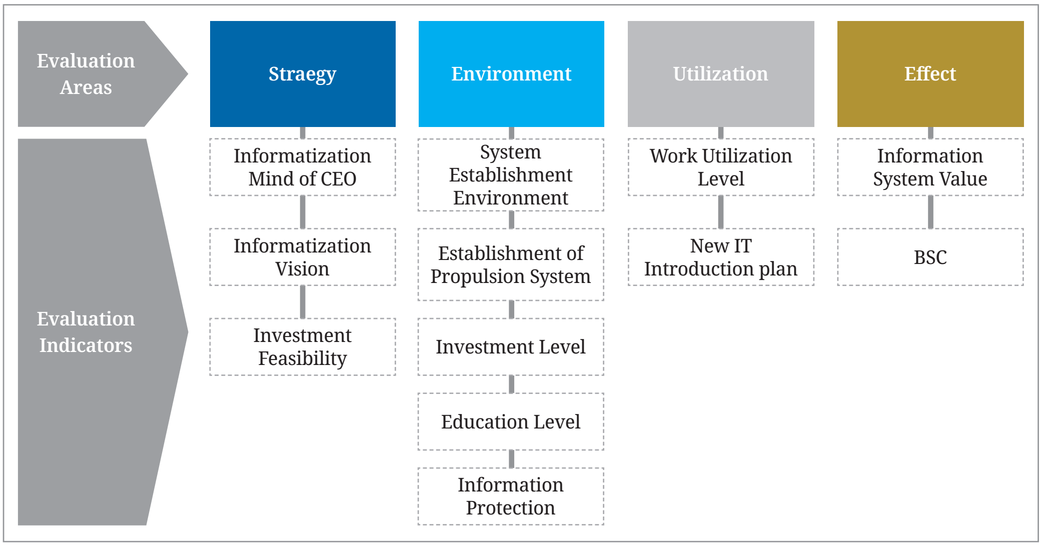
<Table 4-7> Informatization Level of SMEs and Required IT Solutions

Stage	Informatization Introduction	Unit Informatization	Integration Within Enterprises	Cooperation Between Enterprises	Strategic Innovation
	Initiation	Automation	Integration	Collaboration	Innovation
Score	~ 30	30~50	50~60	60~80	80~
Work Characteristics	- Personal informatization	- Unit work informatization - Work efficiency improvement	- Integration of all work - Integration among management hierarchy	- Informatization of work between companies	- Creating a new business - Carve out a new market - New biz model - Process innovation - New service and product
IT Solution	- PC utilization	- Unit application - Early CRM	- ERP, KMS, EDW, EKP	- SCM, EDI, SRM	- SEM, BSC

Source: KDI (2019).

The Korean government diagnoses SME informatization levels and provides applicable solutions along with designating areas where intensive support is required. Korea divides SMEs IT levels into five, and evaluates the level of the company based on informatization score. For example, companies with less than 30 points are assessed as in an initial step and are advised to use PCs for their work. Currently, the average level of SMEs in Korea is around four points. Therefore, the goal can be set to complete the system for inter-enterprise connectivity and to prepare for the use of IT for strategic innovation. Through the investigation and analysis, and individual company can establish its own digitalization strategies. Also, the government can see the overall status of SMEs and use it as data for setting the national-level digital transformation support programs. The evaluation system consists of four areas (strategy, environment, utilization, and effect) and 12 indicators. The assessment started in 2005 and the evaluation index has been continuously improved. Currently, indicators related to big data, smart factory, and management innovation were added. For detailed indicators, see [Figure 4-17].

[Figure 4-17] Informatization Level Evaluation System

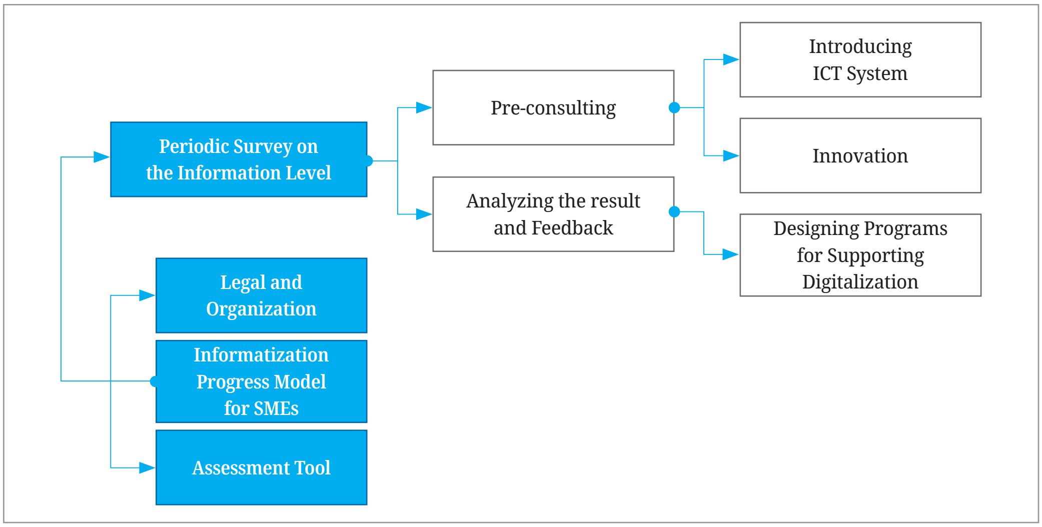


Source: KDI (2019).

SMEs can roughly understand which areas may be focused upon for improvement through the diagnosis of information level, but there are difficulties in preparing specific improvement plans due to the lack of specialized IT personnel. Therefore, it is necessary to provide professional consulting services to establish specific information planning after the IT level diagnosis. The consulting services for SMEs should be provided in the field of management innovation and technological innovation as well as in the field of informatization. Korea started consulting businesses for SMEs in 2005, and the consulting support project is still ongoing. The government supports consulting costs of up to $15,000 USD per company in various areas, including smart factory construction, servitization of manufacturing company, collaboration between SMEs, and information security. According to the survey on the attitude of SMEs to the use of support programs, interest in the use of consulting and information services increased most significantly.

In this respect, it is necessary for Slovakia to first establish a legal and organizational basis for diagnosing information levels of SMEs, and to develop, and periodically use, measuring tools appropriate to the situation in Slovakia. By utilizing the diagnostic results, specific digital transformation support plans at the national level will be established, raising the awareness of companies about digital transformation, and inducing corporate innovation. In addition, prior consulting should be conducted to introduce an information system that is substantially helpful to the innovation of enterprises. By giving the newly established organization proposed in Section 4.2 a role in the diagnosis of the level of informatization, continuous monitoring will be carried out and the results will be continuously reflected in the upgrading of policies.

[Figure 4-18] Diagnosis of Information Level

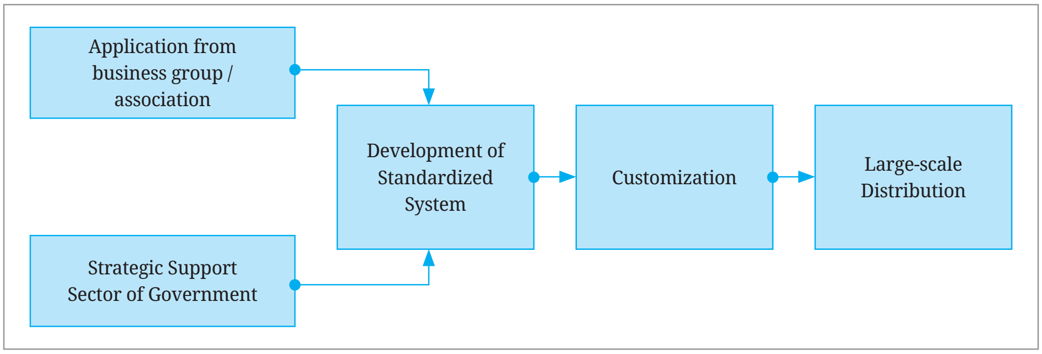


Source: Author.

4.4. Method 2: Bold Initial Investment for Quantum Leap and Development of Reference Models or Standard Applications

As a latecomer to digital transformation, it is necessary to simultaneously support many companies in the early stages in order to catch up with advanced countries and secure corporate competitiveness. The effect of such large-scale simultaneous support has already been verified in Korea. For large-scale support to be successful, standard systems should be developed and pilot projects will be carried out for verification of developed systems. For example, if an ERP system is planned to be distributed, it is desirable to first develop a standard ERP package suitable for small and medium-sized Slovak enterprises through ICT firms, and to distribute it after some modifications have been made according to the needs of the demand companies. The development of standardized systems that can be commonly used by all enterprises will greatly reduce the time and cost of distributing information systems. In particular, it would be a useful way to support the development and distribution of information systems that are commonly available to each company through an association of similar companies. Also, it would be considered beneficial to help associations build cloud-type platforms and solutions that can be co-utilized at low cost. In Korea, the support method has changed from support of individual companies to support for companies in similar industries whose business processes can be standardized.

[Figure 4-19] Development and Diffusion of Standardization Systems



Source: Author

According to the SBA(2019), micro-enterprises (96.8%, 542,525) account for the largest share of the total number of active business entities, and significantly lower share was achieved by small (2.6%, 14,328) and medium-sized enterprises (0.5%, 2,988). Most Slovak SMEs lack the resources for operating their own information systems, so it is necessary to distribute and support standardized process automation systems that are easy to use.

<Table 4-8> Number of Active Slovak Enterprises by Enterprises' Size Category in 2018

Size category	Total number	In %
Microenterprises (0-9)	542,525	96.8%
Small enterprises (10-49)	14,328	2.6%
Medium enterprises (50-249)	2,988	0.5%
Large enterprises (250 and more)	680	0.1%
SME in total	559,841	99.9%
Enterprises in total	560,521	100.0%

Source: Slovak Business Agency (2019).

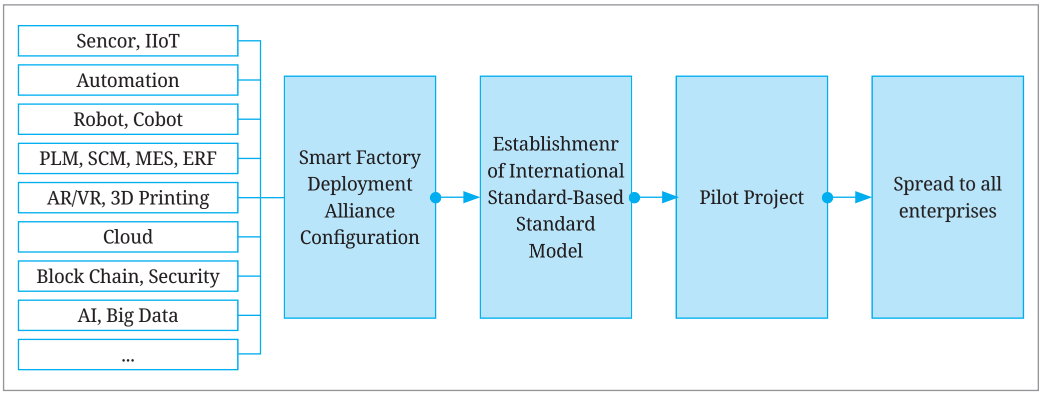
In order to support the construction of smart factories, Korea is enhancing the efficiency of support by dividing the level of smart factories into five stages through the diagnosis of manufacturing companies and standardizing systems that should be supported at each stage. For example, the deployment of sensing and automation Industrial Internet of Things (IIoT) are supported in the first stage and ERP, PoP, and MES are constructed for those in the second stage. In addition, pilot smart factories for each industry and region are selected and rapidly distributed to similar businesses after conducting pilot projects. In this process, an alliance composed of smart factory suppliers is formed to rapidly develop a standard model for pilot plants. As the standard model is applied to dozens of factories, the effect of improving technology and economic efficiency of suppliers can be achieved. In Slovakia, it is also necessary to consider strategies to rapidly spread to the entire enterprise after forming a consortium of suppliers having smart factory technology, and establishing and operating a standard pilot plant by the consortium.

<Table 4-9> Support Systems Based on Smart Factory Level in Korea

Level	Level 1 (Ready)	Level 2 (Automation)	Level 3 (Optimization)	Level 4 (AI Brain)	Level 5 (Autonomous)
System	Sensing, Automation IIoT	MES, ERP, PoP, DAQ, Robot, AGV	Cloud/Edge IioT, AR/VR, 3D Printer, 5G	AI, Big Data, Blockchain	CPS, Connected Enterprise

Source: Author.

[Figure 4-20] Pilot Project and Spread through Alliance of Smart Factory Suppliers



Source: Author.

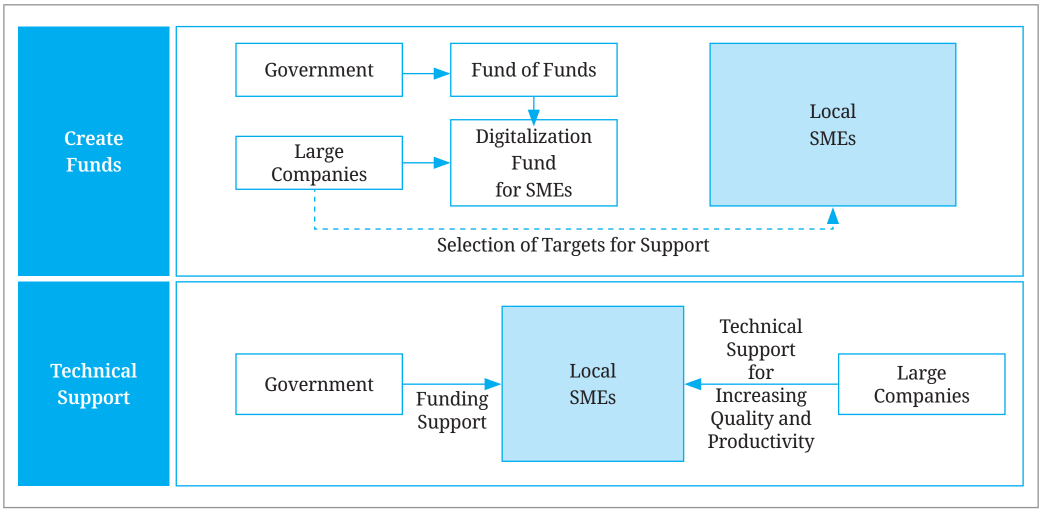
4.5. Method 3: Support of Large Companies

In Slovakia, Samsung Electronics, Kia Motors, Volkswagen, PSA Group, and Jaguar Land Rover have set up plants. Mechanical engineering related to finished cars accounts for 46.8% of total industrial output. It is clear that if a foreign company withdraws from Slovakia because of changes in the market situation, the business environment of Slovakia, and business environment and corporate policy of the country invested in Slovakia, it will have a great impact on the Slovak economy. In this regard, innovation by small and medium-sized local enterprises is essential for the sustainable growth of Slovakia, and support for the growth of local SMEs through foreign large firms is necessary for the successful growth of the Slovak manufacturing industry. In particular, it is a very urgent matter to strengthen the technical capacity of local companies in Slovakia to act as partners to large companies in Slovakia. Therefore, the Slovak government should utilize large companies to create funds to strengthen SMEs' innovative capabilities and let the large enterprises support local SMEs to improve their productivity and quality.

In Korea, large corporations and the government cooperated to create funds for smart factories, as illustrated in [Figure 4-13]. In addition, in order to innovate the productivity and quality of SMEs, large companies actively promoted the 'Single ppm Movement' to drastically improve the quality through guiding related small and medium-sized enterprises. In order to draw such support from large companies, most of all, small and medium-sized enterprises in Slovakia should be able to become suppliers of large companies in the future. Otherwise, there is a limit to attracting support from large companies.

It is important for the government to create a platform to encourage large companies to participate in business for boosting support for SMEs. This requires the creation of supporting funds for SMEs and the government's policy programs to support the quality and productivity of suppliers of large companies such as [Figure 4-21]. As mentioned earlier, local Slovak SMEs should be incorporated as suppliers to global conglomerates.

[Figure 4-21] Support SMEs of Large Companies with Government

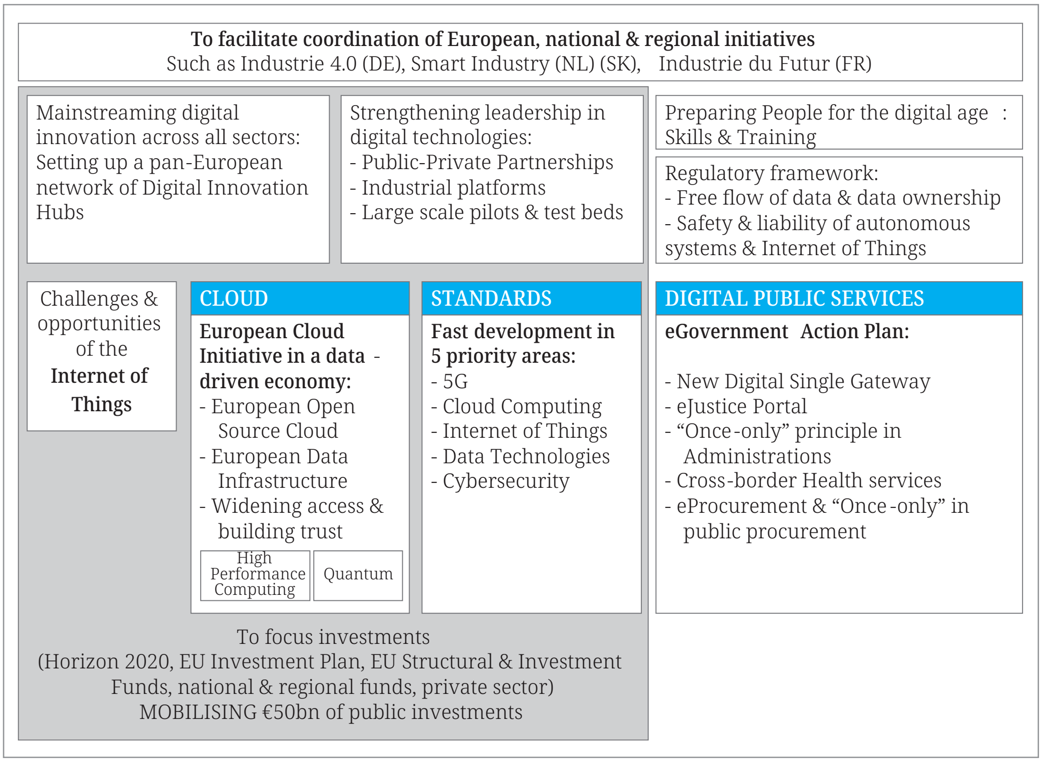


Source: Author.

4.6. Key Area: Setting Future Growth Engines of Slovakia

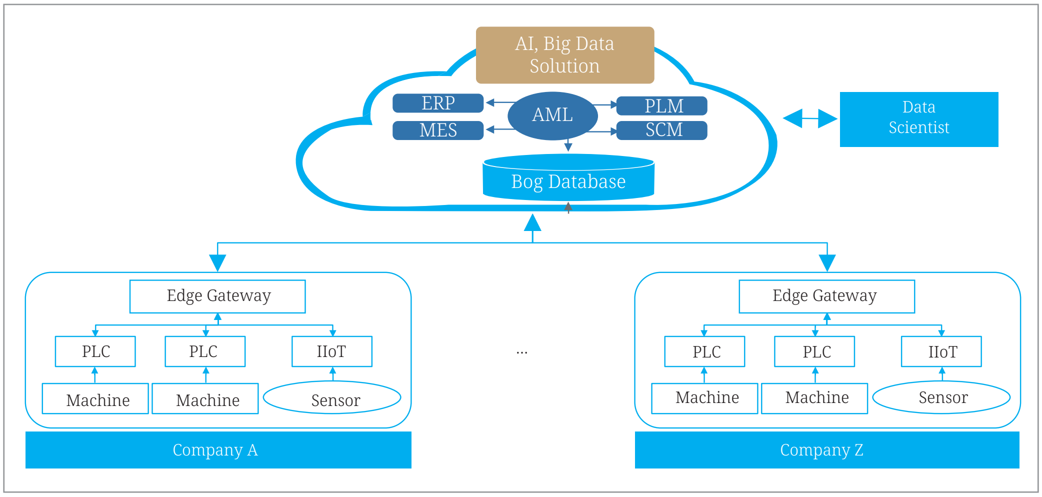
To lead the Fourth Industrial Revolution and efficiently support smart solutions and technologies, the leading and strategic area should be determined first. The EU has established and pursued the Digital Single Market (DSM) strategy to achieve economies of scale, and unlike the U.S., digital transformation is being strongly led by the government. The Digitizing European Industry strategy, as seen in [Figure 4-22] focuses on digitalization of SMEs and technology commercialization. The EU emphasizes establishing a data economy, and sets 5G, cloud computing, IoT, data technology, and cybersecurity technologies as priority areas for development.

[Figure 4-22] Framework of Digitizing EU Industry



Source: European Commission.

[Figure 4-23] Cloud-based Smart Factory Concept



Source: KOSMO (2020).

In Korea, it has also selected the data economy as an important innovation growth engine, along with the hydrogen economy, and is making a great deal of investment. To realize this, SMEs are being induced to utilize cloud ERP, MES, PLM, and SCM solutions in projects to develop smart factories. The data collected into the cloud is analyzed by data scientists to provide customized services for each company and sell for generating new value. The introduction of cloud-based systems is helping SMEs realize smart factories at a minimum cost, and serves as the foundation for a digital economy at the national level.

Through a short term strategy of Slovakia during 2019-2022 (Office of the Deputy Prime Minister of the Slovak Republic for investments and information, 2019), the heart of Slovak digital transformation strategy is to realize a data economy similar to that of the EU, and it is pushing to strengthen technologies such as AI, Block chain, data analysis, data security, high performance computing (HPC), and IoT. Considering both this and the size of Slovak enterprises, it is desirable to consider a cloud-based system if the government supports the establishment of small business information systems and smart factories.

References

Bailom, F., Matzler, K., and Tschemrnjak, D. (2007), Enduring Success, Palgrave McMillan, New York.

Bill Gates (2013), “My Plan to Fix the World's Biggest Problems”, The Wall Street Journal.

BMWi. (2016), Digital Strategy 2025.

Digital Retail Consulting Group (2017), Why Digital Transformation Now?.

KDI (2015), 2014/15 Knowledge Sharing Program with Colombia: ICT Policy for Productivity Improvement of Small & Medium Manufacturer in Colombia.

KDI (2017), 2016/17 Knowledge Sharing Program with Visegrad Group: Science, Technology, and Innovation Policies for Economic Development: Korea and Visegrad Group.

KDI (2018), 2017/18 Knowledge Sharing Program with Visegrad Group: Innovation Policy for SMEs in the Era of Industry 4.0.

KDI (2019), Indicators Development for Diagnosing Informatization Level of Small and Medium Enterprises.

KIEP (2017), The Fourth Industrial Revolution in Major Countries and Growth Strategy of Korea: U.S., Germany and Japan Cases.

KOSMO (2020), Government Support Strategy for Smart Manufacturing Innovation.

Lee, H.B. and Lee, O. (2016), “Study on the Informatization Policy Evaluations and Directions for Small and Medium Enterprises (SMEs)”, Journal of the Korea Academia, Industrial Cooperation Society, Vol.17, No.10, pp.655-665.

Ministers Meeting on Innovation Growth (2018), Innovative Platform: The Strategic Direction of Investment for Innovative Growth.

Ministry of SMEs and Startups and TIPA (2019), 2018 Survey on the Information Level of Korean Small and Medium Enterprise.

MSS (2018), Smart Manufacturing Innovation Strategy Report for SMEs.

OECD (2017), Key Issues for Digital Transformation in the G20.

OECD (2018), Going Digital in a Multilateral World.

Office of the Deputy Prime Minister of the Slovak Republic for investments and information (2019), Strategy of the Digital Transformation of Slovakia 2030.

Papula, J., Kohnová, L., Papulová, Z., and Suchoba, M. (2019), "Industry 4.0: Preparation of Slovak Companies, the Comparative Study", in Smart Technology Trends in Industrial and Business Management (pp.103-114), Springer, Cham.

Platform Industries 4.0 (2017), Map of Industry 4.0 use cases.

SAP (2018), The Digital Era, the Direction of Four Steps for Corporate Development.

Slovak Business Agency (2019), Report on the State of Small and Medium-Sized Enterprises in the Slovak Republic in 2018.

http://ec.europa.eu/information_society.

http://www.kosmes.or.kr/sbc/SH/MAP/SHMAP001M0.do.

https://ec.europa.eu/digital-single-market/en/policies/shaping-digital-single-market.

https://smart-factory.kr.

https://www.4th-ir.go.kr.

https://www.tipa.or.kr.

https://www.win-win.or.kr.