A Study on Korean Emerging Industries' Types and Strategies of Industrialization

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1. Purpose and Scope of Research

With the commencement of a new technology-driven era called the fourth industrial revolution, new products and services are expected to be produced and industries developed. As innovative technologies that have great impact on overall industries and society are emerging, new types of industries are expected to be created through various processes of fusion to meet new demand caused by the development of society.

As uncertainties in domestic and overseas business environments are growing, Korean industry will face greater difficulties in its competitive positioning in the global market if the country fails to find new growth engines to drive the economy in near future. As Korea's industries move beyond the existing "follower" strategy and pursue a "leader" strategy and achieve structural advancement, the Korean government should take pre-emptive mea-

sures by promoting new growth-engine industries. Korea needs to develop new industries through higher policy efficiency and commercialization from a new perspective on growth engines based on Korea's competitive edges that have been strengthened during the development of major industries.

This research aims to analyze the characteristics of twelve emerging industries to classify them and seek measures to further promote their industrialization by considering the different characteristics of those industries so that Korea can efficiently develop new growth engines where the country has competitive advantages. This research seeks to suggest an industrialization strategy customized to each type of industry.

The scope of research is the twelve emerging industries selected by the researchers of this report among new growth engine industries suggested by the government and other major public organizations in Korea.

2. Success and Limitations of New Growth Engine Industry Policy

As the result of industrial development policy from the 1980s, Korea has successfully nurtured a number of core industries, and some of them have changed their position in the global market from "followers" to "leaders." D-RAM semiconductors (in the 1980s), automobiles (in the 1990s), very large high value-added ships, LCD panels and secondary batteries, and 4G mobile communications (in the 2000s) are leading cases of successful industrialization supported by industrial development policy. The existing industrial

development policy has focused on development as "followers."

In particular, efforts to increase R&D investment to develop new technologies and strengthen the market position of new-generation products have been substantially successful. Korea is a leading country in the global market in terms of mobile communications by developing new advanced technologies from 3G to 5G. In the case of the display industry, Korea has successfully developed next-generation application technologies on high-definition LCD, OLED, and flexible displays. In terms of secondary batteries, Korea tried to catch up with Japan but now has a strong global position by participating in the battery market for electronic vehicles.

From a performance perspective, it is widely recognized that Korea has failed to make success corresponding to the size of policy support because there is no emerging industry that can replace current core industries as growth engines. In the case of advanced industries that have been deemed as new growth engines to substitute core industries, efforts to develop markets have not been sufficient. The fact that Korea's policy support has focused on the manufacturing industries where Korea is strong shows both the success and limitations of policy implementation. Businesses included in the policy to develop new growth engines are mostly in the manufacturing industries that already have a certain level of global competitiveness such as automobiles, semiconductors, displays, mobile communications, shipbuilding, biotechnology, and robots. In the service sector, which has a weak foundation, content and software businesses have leading positions but have not contributed much to creating new industries through fusion with other industries, nor have they developed capabilities to lead the global market.

Korea's emerging industry policy has produced a few successful cases but has limitations in terms of nurturing new growth engines to drive future economic growth. First, the policy fails to develop new industries and core technological competitiveness as new growth engines. Second, the policy lacks a comprehensive medium- and long-term strategy that considers changes in business environment and vision. Reasons that the policy fails to make overall success include short-term efforts to meet demand, a focus on short-term performance, the selection of excessively wide range of industries to be nurtured, inefficient implementation of policy due to lack of coordination among ministries and comprehensive implementation systems, and unclear division of duties among ministries. To implement a strategy and policy customized to each stage of industrial development requires comprehensive medium- and long-term efforts. Third, the policy has an absence of a clear definition of the role of the government and the division of roles between the government and the private sector to go beyond the "follower" position and promote innovation, and it lacks a recognition of the connection between the accumulation of knowledge-based capital and socio-economic effects of technology-driven policy and industries. The quantity of intellectual property has increased substantially, but the absence of a balanced policy that considers the market environment and demand in value chains has caused failure in the qualitative growth of knowledge-based capital which can lead to industrial competitiveness. Fourth, there is a lack of effort to promote an ecosystem for emerging industries by encouraging participation from various parties of interests. Vitalizing the ecosystem for emerging industries requires a variety of policies

to encourage consumer participation (from the demand side) and acceptance.

3. The Concept and Scope of Korean Emerging Industries

□ The Concept and Criteria of Korean Emerging Industries

In this research, Korean emerging industries are defined by five aspects: the advancement of industrial structure, response to future demand, potential to expand a competitive edge, potential of industrial growth led by the private sector, and the time necessary for industrialization. Emerging industries promote the advancement of industrial structure which leads economic growth and continues to create quality jobs, and they have large potential demand with great impact on both society and economy. They enable the country to have a global competitive edge based on domestic technologies and resources and have high potential of private sector-led growth supported by demand for investment in the private sector. And the time period required for industrialization of those industries should be considered to enhance the suitability of policy goals.

It is difficult to define clearly the criteria for emerging industries; thus there have been different criteria on emerging industries depending on the times. In the 1990s and 2000s, more attention was paid to innovative basic, source, and core technologies, while after the 2000s, the development of next-generation technologies and industries to lead economic growth was critical. Recently, new criteria for emerging industries have been identified. During the term of former President Lee Myung-bak, marketability and rip-

ple effects were the core elements of emerging industry criteria, while connection to green growth was used as a supplementary criterion. However, the current Korean government has selected nineteen emerging industries in consideration of growth potential, competitive edge, potential to create creative industrial ecosystems, and ripple effects from the perspective of developing drivers for future economic growth.

Setting reasonable criteria for emerging industries requires agreement on the goal of the emerging industry policy and an understanding of the concept of emerging industries. Factors such as Marketability, industrial ecosystems, and ripple effects, which are the existing elements of criteria, are still important factors, and technological characteristics, industrial structure, and market characteristics may be added.

Regarding this, there are essential elements that should be considered: First, as it is difficult to predict the risks of emerging industries, industries with large potential demand that are recommended by various entities (universities, companies, etc.) should be considered. Second, emerging industries should be nurtured within the industries where Korea has a competitive edge to enable sustainable industrial growth. Third, the government's policy on emerging industries should focus on industries with great ripple effects and high potential to contribute to national competitiveness, and roles and responsibilities should be shared with the private sector at lower levels where the private sector can play a leading role. Last, the policy should focus on business areas where companies can advance into relevant markets and industrialization can start within five to ten years (in the medium term) depending on the maturity

of markets. Meanwhile a separate strategy is needed for the business areas that should be developed in the long term.

□ Emerging Industries with High Potential and Their Elements

In the first step, the twelve industries that were analyzed and classified in this research were selected based on domestic and overseas literature reviews. The selection process was not based on detailed criteria, but major emerging industries both at home and abroad were included.

In the second step, the elements of each industry were selected for research and analysis of corporate information in emerging industries. The elements include major products, parts, and services of each emerging industry. Industrialization can be promoted only when such elements are developed across the board. As each element was going to be linked to standard industry classification, elements were selected based on whether such links could be found easily. Then, each element of the twelve emerging industries was matched with an industry code from the Korean Standard Industrial Classification (KSIC). Each element was assigned a relevant five-digit subclass code from the 9th KSIC. In most cases, the scope of the five-digit code was larger than that of each element. Thus industry codes were assigned for each element of the emerging industries. As a result, each of the twelve emerging industries were matched with about 10-20 industrial classification codes as shown in Appendix 3. Then analysis was conducted on the data of companies included in those industry codes to classify emerging industries.

Figure 1. Emerging Industries and Selection of Elements

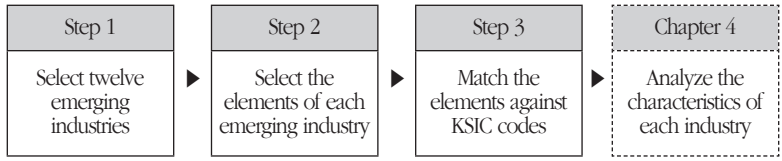

Table 1. Twelve Emerging Industries and their Elements

Name of Industry	Elements (core components, technologies, and services)
Intelligent robotics	Detection and recognition sensors, interaction between human beings and robots, robot AI, control, operation and equipment, network infrastructure
Smart factories	Application systems, equipment control, data collection, data-based manufacturing process, security, analysis of industrial data, industrial communications and networks
3D printing	Materials, equipment and systems for 3D printing, 3D scanners, 3D design software, optimized product design for 3D printing, related services
Drones	- Ground control equipment: real time control computers, antennas and trackers, broadband transmission equipment, communications controllers
	- Aerial vehicle: sensors, multi-spectrum cameras and sensors for shooting, small battery parts, rotary wing motors
	- Service: aerial wireless data communications services, information cloud systems
Smart cars	LiDAR, image sensors, automotive sensors, V2X communications modules, digital maps, automotive infotainment systems, telematics systems, electronic controller components for self-driving systems, wireless communications–based services
Big data/cloud computing	Distributed storage systems, computer hardware for storage and processing of big data, network virtualization software, analysis software, wireless data communications services, cloud based on IoT data, big data–based services
Smart healthcare	Genome and biomedical big data analysis software, smart sensors (biomedical sensors and MEMS-based sensors), visualization solutions for medical big data, real-time analysis of information measured by wearable devices, PHI heterogeneous platform connection services, data clouds that use personal health information, biomedical big data services

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Name of Industry	Elements (core components, technologies, and services)
Health technology	Medical micro robots, GPS sensors and medical magnetic field controllers, genome and biomedical big data analysis software, biological tissue chips, micro-robot medical technology interface services, separation and examination equipment, pharmaceutical and medical product production and support equipment, biotechnology-based product production equipment, bio-scanners, CRO (Contract Research Organization) services
Plant factories	Eco-friendly materials, varieties of seeds with functional specialties, CRT fluorescent lamps, high-pressure sodium lamps, LED equipment, nutriculture facilities and composition change sensors, automation equipment, productive capacity prediction systems, domestic and overseas crop information systems, resource recycling systems
Smart content	Future devices for content experience, a variety of sensors, wearable output units, immersive virtual simulators, system integration and evaluation of wearable devices, content production equipment, immersive content, next-generation communications equipment and services
Renewable energy	ESS, energy prosumer projects, energy management systems, micro-grids
New materials	Advanced nonferrous materials, carbon materials, other new materials, advanced material processing systems

4. Typology Indicators of Emerging Industries and Analysis of Their Characteristics

□ Analysis Overview

The twelve emerging industries were defined through the combination of KSIC subclass codes, and thus quantitative data analysis of companies included in each code could be performed. In addition, to reflect qualitative characteristics that are difficult to gain from the corporate database, a survey was conducted on each of the KSIC codes assigned to the emerging industries, which was used to develop supplementary indicators.

For corporate data to be used as quantitative indicators, the cor-

porate database of Korea Enterprise Data, a company specializing in corporate credit information and rating service in Korea, was used. Data on all financially sound companies that were included in the subclass business types (a total of 82) of each emerging industry were extracted from the corporate database. Data on 23,571 companies were used to analyze quantitative indicators.

For qualitative indicators, the results of a survey on leading companies included in the subclass business types of each emerging industry were used. The survey included questions that aimed to obtain indicators which could be hardly found in the corporate database. The survey was conducted on the 82 subclass business types as well. As a result, responses from 419 companies in 81 subclass business types excluding satellite communications businesses were used for analysis.

The typology indicators were established by combining the quantitative and qualitative indicators based on the corporate data and the survey, as shown in table 2. For the typology indicators, three groups of technological innovation, industrial structure, and market characteristics were set, and five typology indicators were selected for each group. For the relative comparison of the size of each industry, all of the indicators are normal values calculated from the mean and standard deviation of the twelve industries. Normal values are useful to directly compare each industry with the others regardless of the absolute size of a value or unit.

Several indicators calculated from the corporate database were based on indicators (sales, operating profit, employees, assets, etc.) mainly used for general analysis of the characteristics of industries, but some indicators were selected for differentiation at the industry

Table 2. Typology Indicators

	Indicator	Subclass indicator(s)	Value for indicator	Calculation	Applicable year for analysis	Measure-ment
Techno-logical innovation	R&D con-centration	Ratio of R&D to sales (%)	Normal value	(Ordinary R&D expense / sales) × 100	2014	Corporate database
	Intellectual property rights con-centration	No. of pat-ents per 100 employees (number of patents/ person)	Normal value	(Sum of patents / sum of employees) × 100	2014	Corporate database
	Ratio of intangible assets	Ratio of intangible assets (%)	Normal value	(Sum of intangible assets / sum of total assets) × 100	2014	Corporate database
	Source technology	Use of source tech-nology	Normal value	Average of responses with 5 point scale	(Current)	Survey
	Technology update	Use of most up-to-date technology	Normal value	Average of responses with 5 point scale	(Current)	Survey
Industrial structure	Fusion with manufac-turing	Fusion with manufactur-ing sales*	Normal value	Calculation by utilizing the proportion of the sum of manufacturing sales out of the sum of sales (0–50)	2014	Corporate database
	Productivity	Labor value added productivity (KRW mil-lion/person)	Normal value	(Total amount of value added / total number of employees)	2014	Corporate database
	Corporate size	Sales (in KRW mil-lions)	Average of normal values	Average sales	2014	Corporate database
		Total assets (in KRW millions)		Average of total assets	2014	Corporate database
	Size of intermediary goods	Ratio of B2B sales (%)	Normal value	Ratio of B2B sales among B2B, B2C, B2G, and others	(Current)	Survey
	Value chain concentra-tion	Sum of squares of ratio of an element in value chain**	Normal value	Average of sum of squares (Herfindahl-Hirschman index) of ratio of materials, parts, finished goods, distribution, service and others	(Current)	Survey

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	Indicator	Subclass indicator(s)	Value for indicator	Calculation	Applicable year for analysis	Measure-ment
Market character-istics	Market con-centration	Ratio of sales from top 1% companies (%)	Normal value	(Sum of sales from top 1% companies in terms of sales / total sales) ×100	2014	Corporate database
	Profitability	Ratio of op-erating profit to sales (%)	Normal value	(Sum of operating profit / total sales) ×100	2014	Corporate database
	Growth potential	Sales growth (%)	Average of normal values	[(2014 total sales - 2010 total sales) / 2010 total sales] ×100	2010 2014	Corporate database
		Total asset growth (%)		[(2014 total assets - 2010 total assets) / 2010 total assets] ×100		
	Pace of market changes	Pace of mar-ket changes	Normal value	Average of responses with 5 point scale	(Current)	Survey
	Consumer sensitivity	Consumer sensitivity	Normal value	Average of responses with 5 point scale	(Current)	Survey

Note : *As the ratio of manufacturing sales gets closer to 50% of total sales, the indicator value increases (to 50 at the maximum).
**If a company engages in only one element in a value chain, the value for the indicator is 1 (maximum value). The more elements a company engages in, the smaller the indicator value is.

level. The indicators on fusion with manufacturing and market concentration cannot be measured at the company level but are meaningful at the industry level. In the case of qualitative indicators, if amount variables such as sales or operating profit are directly used, a size factor such as current market size could affect the analysis of industrial characteristics. Thus, except for some inevitable cases, all typology indicators represent ratios for the comparison of relative sizes among the industries, rather than directly using absolute values such as sales.

□ Calculation of Emerging Industry Typology Indicators

In the first step to classify emerging industries and analyze their characteristics, the values of the typology indicators were calculated. As companies for analysis were selected according to the standard industrial classification of Korea, only a few of them directly engage in any of thetwelve emerging industries. But the companies selected are highly related to the emerging industries. In particular, they encompass various technologies, products, and services which consist of the emerging industries, and thus are deemed to reflect the characteristics of the emerging industries from a broad perspective.

The result of the calculation shows that the R&D concentration indicator of all companies analyzed was about 2.1%. The ratio in the health technology industry was 3.3%, the highest among the twelve industries. The concentration of intellectual property rights of all companies was 0.8 patent per 100 employees. Like R&D concentration, the health technology industry had the largest number of patents (1.3). The overall ratio of intangible assets was 4.8%, with the ratio in the 3D printing industry being the highest at 8.0%. The source technology indicator calculated from the survey was 3.2, slightly higher than ordinary. Similarly, the technology update indicator was 3.3. By industry, health technology (3.5), new materials (3.4), and 3D printing (3.3) had high indicators on source technology. In terms of technology update, smart content (3.6), smart healthcare (3.5), and smart factories (3.5) showed a high level of utilization of advanced technologies.

The indicator on fusion with manufacturing was 26.7 overall.

The indicator for the smart content industry was near the maximum value (49.9). That means the ratio of manufacturing to non-manufacturing (services, etc.) in the industry is almost the same. In terms of productivity, the amount of value added per employee was KRW 61 million across the board. The new materials industry had the highest level of productivity with KRW 93 million, followed by plant factories (KRW 72 million), health technology (KRW 69 million), 3D printing (KRW 69 million), and big data/cloud computing (KRW 62 million). Regarding corporate size, the average sales of all companies analyzed was about KRW 10.3 billion, and the average of total assets was about KRW 11 billion. The corporate size of the new materials industry was the largest (KRW 15.1 billion in average sales) and that of the drone and smart car industries were next highest (KRW 13.4 billion in average sales each). The indicators on the size of intermediary goods and value chain concentration were calculated from survey results. The size of intermediary goods refers to the ratio of B2B transactions in respondent companies. The average indicator value of all companies surveyed was about 70.1%. The indicator on value chain concentration shows how many elements a company engages in, among various elements in a general value chain such as materials, parts, finished goods, distribution, and services. The average indicator of all companies surveyed was 0.8, showing that most of the companies focused on one or two elements.

In terms of market concentration, the top 1% of companies accounted for 41.3% of total sales in their industry. The 3D printing industry had the highest market concentration ratio of 46.4%, while the health technology industry showed the lowest of 32.7%, mean-

ing there is a relatively weak dominance of leading players in the market. The overall average of the profitability indicator was 5.4%, and the indicators for 3D printing and health technology were higher (6.3% and 5.9%, respectively) than the other industries. The indicator on growth potential was about 32.8% in terms of sales and 47.6% in terms of total assets. The renewable energy and 3D printing industries showed the highest growth potential of 43.3%, followed by smart factories (42.2%). In terms of total assets, the 3D printing industry was the highest (59.8%). The average indicator on the pace of market changes was 3.2, and that on consumer sensitivity was 3.3, slightly higher than ordinary.

Next, the typology indicators for the twelve emerging industries were calculated. To objectively analyze differences between each industry, the mean and standard deviation of the subclass indicators of the twelve industries were used for standardization. In the case of a typology indicator such as corporate size and growth potential that has two subclass indicators, the average of normal values of the two subclass indicators was calculated.

Table 3 and table 4 show the result from calculating the typology indicators of each emerging industry. The results of standardization show that all of the indicators were converted to a distribution with the mean of 0 and standard deviation of 1. Thus if a subclass indicator is same as the mean, the applicable typology indicator is 0. If a subclass indicator is higher (by the size of standard deviation) than the mean, the applicable typology indicator is 1. Through this calculation, the relative size of the typology indicators of each industry can be easily identified.

Table 3. Typology Indicators of Emerging Industries

Indicators	Intelligent robotics	Smart factories	3D printing	Drones	Smart cars	Big data/ cloud computing
R&D concentration	0.715	0.436	-0.146	0.205	0.405	-0.838
Intellectual property rights concentration	0.111	0.4	0.365	-0.601	-0.506	-1.733
Ratio of intangible assets	0.431	0.612	2.047	-0.572	-0.582	-0.16
Source technology	0.077	0.525	1.204	-0.362	-0.987	-1.393
Technology updates	0.881	1.163	-0.345	-0.297	-0.314	-1.487
Fusion with manufacturing	1.062	0.873	0.781	-0.159	0.005	-0.87
Productivity	-0.73	-0.261	0.399	-0.694	-0.588	0.216
Corporate size	-0.877	-1.061	-1.057	1.085	1.073	0.323
Amount of intermediary goods	-0.756	-0.836	0.225	0.485	-0.267	-0.77
Value chain concentration	-0.504	-0.665	-1.828	-1.237	0.848	0.609
Market concentration	0.844	0.265	1.958	-0.727	-0.942	0.208
Profitability	-1.39	0.098	1.881	-1.238	-1.387	0.764
Growth potential	0.178	0.735	1.661	-0.861	-0.935	-0.685
Pace of market changes	0.729	-0.547	0.81	0.979	0.941	1.725
Consumer sensitivity	0.95	0.464	0.981	-0.436	0.207	-0.083

Table 4. Typology Indicators of Emerging Industries

Indicators	Smart healthcare	Health Technology	Plant factories	Smart content	Renewable energy	New materials
R&D concentration	-0.798	2.27	-1.175	0.524	0.109	-1.707
Intellectual property rights concentration	-0.724	1.762	0.347	0.292	-1.306	1.592
Ratio of intangible assets	-0.707	0.386	-1.293	0.59	0.967	-1.72
Source technology	-1.519	1.449	0.39	0.179	-0.908	1.344
Technology updates	1.021	0.047	-0.884	1.972	-0.658	-1.098
Fusion with manufacturing	0.919	-1.332	-1.321	1.324	0.303	-1.584

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Indicators	Smart healthcare	Health Technology	Plant factories	Smart content	Renewable energy	New materials
Productivity	-0.205	0.418	0.68	-0.415	-1.51	2.69
Corporate size	0.17	1.041	0.249	-0.878	-1.492	1.423
Amount of intermediary goods	0.268	0.671	-0.081	-1.408	-0.219	2.687
Value chain concentration	0.538	1.354	1.486	0.532	-0.777	-0.356
Market concentration	-0.501	-1.875	0.197	-0.189	-0.566	1.329
Profitability	-0.004	1.301	-0.352	-0.424	0.694	0.058
Growth potential	-0.727	-0.294	-0.269	0.397	1.479	-0.679
Pace of market changes	-1.239	0.18	-1.685	-0.486	-0.882	-0.524
Consumer sensitivity	-1.721	0.228	-0.92	2.073	-0.872	-0.872

5. Classification and Analysis of Characteristics of Emerging Industries

Some of the typology indicators that represent the different characteristics of each industry show similar features. In this chapter, such similar indicators are combined. Through factor analysis, the 15 typology indicators were combined into three composite factor indicators. Classification of the industries was based on the composite factor indicators. Each factor was named through a combination of the indicators that are strongly related to the factor. Factor 1 was named "innovation-speed" as it had a positive relationship with R&D concentration, consumer sensitivity, technology updates, and fusion with manufacturing. Factor 2 was named "innovation-cumulation" as it was related to concentration of intellectual property rights, source technology, productivity, and amount of intermediary goods. Factor 3 was named "demand-customized" as it had a positive relationship with growth potential, market con-

centration, intangible asset ratio, and profitability while the factor had a negative relationship with value chain concentration and corporate size.

The calculation of the composite factor indicators showed that in terms of innovation-speed, smart content (1.6), health technology (1.4), intelligent robotics (0.8) and smart factories (0.8) had high indicator values. In those industries, the pace of technological and market changes is fast and R&D activities are very aggressive. In contrast, the indicator for new materials (-1.7), big data/cloud computing (-1.1), and plant factories (-0.8) was low. Those industries are believed to experience slow technological changes and be more dependent on basic technologies. Thus they are expected to focus on facility improvement and development of intangible assets such as software, rather than spending large R&D expenses.

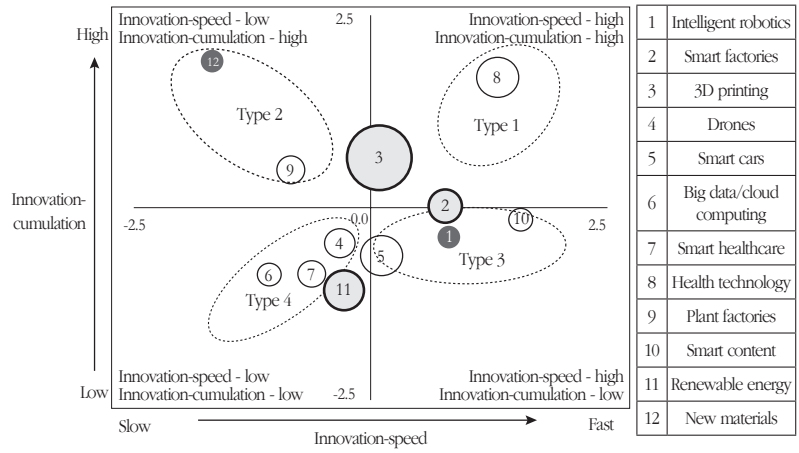
In terms of innovation-cumulation, new material (2.0) and health technology (1.7) showed substantially higher indicators, and 3D printing (0.6) and plant factories (0.4) were slightly higher than the average of the twelve industries. Those industries tend to seek market competitiveness by using their cumulative knowledge and technologies. Renewable energy (-1.1), big data/cloud computing (-0.9), and smart healthcare (-0.9) showed relatively low indicators. In the case of those industries, elements which are difficult to be identified in quantity (software programs, business models, etc.) have greater impact on business performance rather than cumulative capabilities such as intellectual property rights. In particular, a development process (which is cumulative) that requires a long time and large costs is not a barrier to entry into the market; thus start-ups such as venture companies can enter the market easily

compared to the other industries.

In terms of demand-customized, the indicator value (2.4) for 3D printing was very high, and that for renewable energy (0.9) and smart factories (0.6) were higher than the average of the all industries. In those industries with a high demand-customized indicator, the growth of specialized companies that meet niche market demand is higher because of high growth potential and profitability of the industries. In addition, the average corporate size in those industries is relatively small, but the intangible asset ratio is high, and companies in those industries engage in a broad range of business areas across their multiple value chains. In contrast, the indicators for smart cars (-1.3) and health technology (-1.2) were low, and smart healthcare (-0.6), drones (-0.6), and plant factories (-0.5) showed relatively low indicators. Those industries have low growth potential, and their corporate size is large. Moreover, companies in those industries tend to focus on one value chain and are believed to focus on meeting existing demand, rather than increasing profitability by meeting new demand.

Based on the Composite Factor Indicators, the twelve industries were classified into five types as shown in figure 3 and table 5. Each type includes 1-3 emerging industries, and the types were named in consideration of their characteristics based on the Composite Factor Indicators. Type 1, which had high Innovation-speed and innovation-cumulation indicators, was named "rapid-cumulation." Type 2, which had a high innovation-cumulation indicator but a low Innovation-speed indicator, was named "gradual-cumulation." Type 3 had a relatively high innovation-speed indicator and thus was named "innovation-speed." Type 4, which was believed

Figure 2. Classification of Emerging Industries



○ Demand-customized (0.5 or higher) : Type 5
● Demand-customized (from 0 to less than 0.5)
○ Demand-customized (less than 0)
Diameter of circles : proportional to normal values

Note : the location of each industry in the quadrants is based on the Composite Factor Indicators (a mean of 0 and standard deviation of 1).

Table 5. The Result of Classification of Emerging Industries

	Name of Type	Composite Factor Indicator			Emerging Industries
		Innovation-speed	Innovation-cumulation	Demand-customized	
Type 1	Rapid-cumulation	High	High	-	Health technology
Type 2	Gradual-cumulation	Low	High	-	Plant factories and new materials
Type 3	Innovation-speed	High	Medium	-	Intelligent robotics, smart cars, and smart content
Type 4	Innovation-fusion	Low	Low	-	Drones, big data/cloud computing, and smart healthcare
Type 5	Demand-customized	-	-	High	Smart factories, 3D printing, and renewable energy

to have the characteristic of innovative fusion (which is difficult to explain only with the innovation-speed and innovation-cumulation indicators), was named "innovation-fusion." Type 5, which showed a high demand-customized indicator, was named "demand-customized."

In detail, Type 1 (rapid-cumulation) shows high innovation-speed and cumulation indicators. The industries in Type 1 have a high R&D concentration ratio against sales compared to the other emerging industries, thus actively participate in R&D. They also have high indicators on consumer sensitivity and technology update, which means the pace of technological changes in those industries is fast. They also have strong cumulative capabilities related to technological innovation as shown in the indicators on intellectual property rights concentration, source technology, and productivity. Type 2 (gradual-cumulation) has a high innovation-cumulation indicator like Type 1, but the pace of technological innovation is relatively slow. Indicators on intellectual property rights concentration, source technology and productivity are high but the R&D concentration indicator is low. Indicators on consumer sensitivity, technology updates, and fusion with manufacturing are also low, which means the industries in Type 2 are not sensitive to technological changes. That is, companies that have technological capabilities such as source technology and productivity, rather than rapid innovation, lead the market.

Type 3 (innovation-speed) industries show a high pace of technological innovation. Their indicators on innovation-culmulation are ordinary, but the innovation-speed indicator is high. Companies in the Type 2 industries take active measures for technological

innovation as shown in the ratio of R&D investment to sales, and have high levels of fusion between manufacturing and service. The pace of technological changes required in their markets is high due to high consumer sensitivity and technology update indicators. But financial performance including productivity, growth potential, and profitability is weak compared to the pace of innovation. Thus it is believed that market demand cannot keep up with technological innovation.

The Type 4 (innovation-speed) industries show a slow pace of technological innovation, and their indicator on innovation-cumulation is also low. Their R&D concentration ratio compared to sales is lower than the other types, and indicators on technology update and consumer sensitivity are low as well. Indicators on source technology and intellectual property rights are also low, thus the Type 4 industries have low levels of cumulative technological capabilities. Thus they have stronger capabilities to develop new products or service models based on existing technologies rather than development of innovative technologies or cumulation of knowledge.

Type 5 (demand-customized) shows a higher demand-customized indicator compared to the other types. The levels of innovation-cumulation or Speed are different among the Type 5 industries, but they have a similarity of strong capabilities to meet various market demands, rather than R&D investment or cumulative technological capabilities. In other words, whether they can provide customized products or services is more important than technological capabilities.

The analysis of the characteristics of each type represents classi-

fication in terms of technological characteristics, corporate size and composition, and corporate activities, which are general indicators for companies and industries. Technological characteristics can be divided into technology update and culumation. The rapid-cumulation and innovation-speed types show high ratios of R&D concentration and sensitivity to consumers as they experience rapid changes in technology, and recently developed technologies are more likely to be commercialized. But the gradual-cumulation and innovation-fusion types show a slow pace of technological change and thus have a low ratio of R&D investment, and up-to-date technologies are less likely to be commercialized. In terms of corporate size and composition, the rapid-cumulation and gradual-cumulation types that require large-scale technological development in the long term have large corporate sizes, and there are few start-ups and newcomers in the market. But the innovation-speed, innovation-fusion, and demand-customized types show that a number of start-ups and mid-sized companies enter the market.

The characteristics of corporate activities in an industry are classified according to the areas of investment. Companies in the rapid-cumulation type industries are likely to focus on source technology related to their products, especially research in basic science and commercialization. The industries in the gradual-cumulation type also invest in source technology but focus more on utilizing existing technologies and enhancing productivity rather than on new technologies. The industries in the innovation-speed type invest more in new application technologies than in source technologies and thus show a high indicator on R&D concentration and strive to apply up-to-date technologies to their products. The

industries in the innovation-fusion Type invest more in the application of existing technologies to various areas and the development of business models rather than in the development of source or new application technologies. The demand-customized type tends to make investments to strengthen technological expertise in certain areas in order to meet requirements from specialized technologies. In particular, the industries in this type sometimes seek to expand into the entire value chain in order to enhance their specialty in niche markets.

6. Industrialization Strategies for Emerging Industries

Chapter 6 analyzes the direction for the industrialization strategies of the emerging industries and the order of priority for the industry types in each policy. The direction of policy support should consider preparation for sources of future industrial competitiveness, improvement of platforms for industrial fusion, open innovation, and change in the perspective about nurturing emerging industries.

First, a new approach to the source of industrial competitiveness is needed in consideration of changes in the industrial paradigm. In terms of demand, the key is capabilities to meet various demand in a timely manner. With such capabilities, efforts should be made to create innovative products and services. In terms of supply, the optimization of the entire supply chain including upstream and downstream industries is very important. Efficiency in the supply of products and services should be enhanced substantially through various collaboration including outsourcing, open innovation, and

partnerships.

Second, more attention should be paid to the growth of companies that provide a platform for various services. Global leading IT companies have products and services that are widely used across the world and have dominant positions in the market by establishment of an exclusive economic ecosystem with partners or software developers. Moreover, such large platform providers collect and analyze huge volumes of customer data to enhance their product or service competitiveness, which is expected to create virtuous cycles. Korean companies need to establish small platforms that target new niche markets, even if not large-scale platforms.

Third, industries should seek open innovation. Recently, open innovation receives increasing attention because costs for technological development have jumped due to rapid technological evolution and the shorter life of products, while it is almost impossible for a company to continue to monopolize knowledge. In particular, to prepare for the era of the fourth industrial revolution, industries need to move towards open innovation 2.0. Up until now, open innovation has focused on a leading role by private companies, bilateral relationships, participation led by companies, and R&D efficiency. As the pace of changes in the business environment is increasing, open innovation should be developed further to encourage fusion between technology and society/culture, participation from various sectors of society, and more business opportunities.

Last, existing approaches toward the development of emerging industries should change. This is not about whether a policy to nurture those industries should be implemented, because the necessity to develop emerging industries is already widely recognized

and such policy has been actively implemented. What is important is to reach consensus on the scope, period, purpose, and methods of such policy. Wide consensus from participants such as private sector companies, the government, venture companies, and others

Table 6. Order of Priority in Major Policy Support

Major Policies		Type 1 (Rapid-cumulation)	Type 2 (Gradual-cumulation)	Type 3 (Innovation-speed)	Type 4 (Innovation-fusion)	Type 5 (Demand-customized)
1) Support for technological development	1) Development of source technologies	●	●	○		
	2) Development of application technologies	●	○	●		○
2) Promotion of commercialization	1) Expansion of pilot projects				○	●
	2) Promotion of technology transfer			○		●
	3) Support for standardization and certification	○		○	○	○
3) Support for expansion into new markets	1) Marketing support at home and abroad	○	○		○	
	2) Expansion of public procurement					●
4) Improvement of infrastructure	1) Improvement of financial systems	○	○	○	●	○
	2) Expansion of tax credits			●	●	○
	3) Nurturing of professionals	●	○	●		○
5) Improvement of legal systems	1) Introduction of negative lists			○	●	○
	2) Improvement of intellectual property rights systems	●	○	○		

Note : In order of priority regarding policy support: ● > ○.

(financial institutions, venture capitals, supporting organizations, etc.) will have great impact on the success of the policy to nurture emerging industries. This has been somewhat overlooked during the process of implementing the policy. As establishing new industries requires a lot of effort and a long time, reaching consensus is important in order to design and implement a comprehensive medium- and long-term strategy.

Policies to promote the industrialization of the emerging industries were divided into five areas (support for technological development, promotion of commercialization, support for expansion into new markets, improvement of infrastructure, and improvement of legal systems), and the order of priority was analyzed (table 6).

Support for technological development in the emerging industries should be differentiated depending on the type of the industries. First of all, a framework for customized support should be established in consideration of technological levels. Various technologies used in the emerging industries have different levels of advancement and have different characteristics regarding commercialization. In other words, policy support for industries that require source technologies should differ from that for industries that focus on application technologies. Development of source technologies requires high levels of innovation and large-scale investment in the long term. According to the classification of the emerging industries in this research, the rapid-cumulation and gradual-cumulation types have the highest priority in policy support for development of source technologies, and the innovation-speed type takes the second highest priority.

Development of application technologies is more important in

industries that need to develop technologies in a shorter term compared to source technologies and that are sensitive to technological changes. To swiftly apply up-to-date technologies to products, developing application technologies is more efficient for the product and service perspectives rather than research on basic science, and selective R&D investment is needed. The rapid-cumulation and innovation-speed types, which have high innovation-speed indicators, take the highest priority in the development of application technologies. The demand-customized type also takes a relatively higher priority as the application of up-to-date technologies in their market is important as well.

A policy to promote the commercialization of new technologies should take into account market demand and industrial structure, unlike the policy to support technological development. For this purpose, pilot projects should be expanded to support the development of product and service business models through fusion between manufacturing and service. In particular, this is important for the innovation-fusion and demand-customized types: In the innovation-fusion type industries, their major corporate strategy is to create service business models through the application of existing technologies to various industrial sectors. In the demand-customized type industries, creating niche markets by responding to various market demands is important. New business models for new markets have many difficulties with commercialization due to regulatory or technological limitations, and it is hard to maintain profitability although the business models are successfully commercialized. Thus potential problems should be prevented by checking regulatory or technological issues through pilot projects

such as "Regulation-Free Zones".

Regarding policy support for commercialization, the commercialization of technologies through open innovation is recently expanding with an increasing number of success stories showing that the fusion of technologies from various sectors, rather than technologies from a single company, more readily lead to commercialization. But technology transfer among companies involves multiple issues such as technology valuation and certification and disputes over the ownership of technologies, which requires policy support. In particular, policy support should give priority to a platform for technology transfer or a valuation system. The innovation-speed and demand-customized types need a policy to promote technology transfer most, and the rapid-cumulation and innovation-fusion types take the second highest priority. Technological fusion among industries and companies is required for rapid commercialization of technologies, and technology transfer should also be promoted to develop technologies customized to certain markets.

To support the commercialization of technologies, the standardization and certification of technologies are also important. Particularly, procedures to verify the safety and quality of new technologies are getting more complex, and international technological standards and certification act as restrictions on the commercialization of new technologies as free trade expands internationally. Most of the industries based on new technologies need greater support for technology standardization and certification, but the highest priority should be given to the rapid-cumulation type, and it is also important for the innovation-speed, innovation-fusion, and demand-customized types. The rapid-cumulation and innova-

tion-speed types require new technologies to be applied quickly, and thus support for standardization and certification is needed to reduce time consumption and expenses. In the innovation-fusion and demand-customized type industries, start-ups or small companies find it difficult to deal with expanded standardization and certification systems when applying new technologies to various areas.

When companies in emerging industries move from R&D development to commercialization, expansion into new markets and exports are important. In this case, policy support for expansion into new markets should consider the level of technological development. In other words, such policy support is needed when finished products, core components (including modules), or service business models are developed, rather than at the time of development of materials or parts.

If policy support is provided for marketing in new markets, it will be more effective for the rapid-cumulation and innovation-speed types. The industries in those types are highly sensitive to the consumer market and have a large portion of B2C business. Thus consumer preference and lifestyle, the functional aspects of products (rather than up-to-date technologies themselves), and connectivity with other areas are expected to be more important factors.

In addition to marketing support, expansion of public procurement may be considered as a method to support market expansion in the public sector. Emerging industries have weaker positions in terms of reliability, safety, and marketing compared to existing products or services. Thus active support for market expansion at the government level is needed. Support through public procure-

ment will help reduce burdens on companies at the early stage of market expansion and improve consumers' perception. The public procurement policy is expected to be effective for the industries in the demand-customized type which expand new businesses by developing new niche markets.

Financial systems are closely related to capital that companies need to operate their businesses smoothly and are important infrastructure that have impacts on all industries. In particular, markets for emerging industries are immature and there are uncertainties about technological success, which increases the necessity to improve financial systems to support emerging industries. The industries in the innovation-speed type seek technological innovation aggressively through R&D activities but have high risks for commercialization and satisfying market demand. Thus they have high priority in the financial support policy. The innovation-fusion type requires innovation in services rather than technology, and in this case, funding is important to successfully launch new services.

Tax credit is related to the provision of various tax benefits for R&D or facility investment, and employment of professionals in emerging industries. As there are huge uncertainties about the possibility of companies in emerging industries to succeed, tax credit can help reduce business risks of such companies. The industries in the innovation-speed and innovation-fusion types have strong demand for expanded tax credit, and the tax credit policy is expected to be highly effective in those types.

Human resources are also an important factor of infrastructure for emerging industries. Professionals that can effectively apply new technologies or external innovative resources to businesses should

be nurtured. In particular, government-level support is required in that nurturing professionals in emerging industries is related to changes in education systems including universities. Moreover, education for existing human resources is also increasingly needed as technologies and the industrial environment are changing fast. This research shows that the rapid-cumulation and innovation-speed types have the highest demand for a policy to nurture professionals, as those industries experience rapid technological changes.

Last, the improvement of legal systems is also essential to the development of emerging industries. If laws or regulations put burden on production or sales, it undermines the expansion of emerging industries. In contrast, if legal systems provide support effectively, the industries can overcome hurdles at the early stage of business and grow quickly. Most emerging industries need a certain level of support from better legal systems as they do not reach industrialization.

Regulatory improvement is expected to have great impact on the development of emerging industries. In particular, the introduction of negative lists across the board is urgently needed regardless of the industry types. The existing system of positive lists establishes a broad standard on all sectors and deregulates only some industries. The negative list system has regulations that are applicable only to certain areas required for emerging industries. The negative list system is expected to be highly effective for the innovation-fusion type because the industries in this type are likely to experience conflicts with existing regulations while introducing new technologies in existing industries. In addition, the negative list system is also needed for the innovation-speed and demand-cus-

tomized types as the industries in these types are likely to be faced with regulatory issues regarding commercialization.

Improvement of the intellectual property rights system is also critical to the emerging industries, especially to the rapid-cumulation type where products based on rapid innovation or fusion are launched frequently, or to the gradual-cumulation type where protecting source technology is important. Policies related to intellectual property rights are also expected to be effective in the innovation-speed type that shows a higher level of activities related to patents of new technologies, registration, and utilization of new design.