A study on the evolution of post-smartphone technologies in the 5G technology environment

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Abstract

As the smartphone market becomes saturated, an innovative device equipped with new features is expected to appear soon in mobile communications. In particular, various possibilities were raised regarding the alternative technologies that can develop post-smartphones, which are differentiated from the current smartphones, as Korea commercialized the 5G infrastructure for the first time in the world. Under these circumstances, the Korean government announced the "5G+ Strategy for Realizing Innovative Growth" in April 2019, vowing to build an innovative industrial ecosystem quickly while creating various convergence services based on the 5G infrastructure. As described above, the policy importance of the alternative technologies that will develop post-smartphones is increasing, but the theoretical study on the technology evolution of post-smartphones has not been systematically conducted until now. This study reviewed the alternative technologies that can develop post-smartphones through documentary research, and data mining analysis was performed on the research result using actual data. The policy priority was also set quantitatively for the alternative technologies of post-smartphones in order to determine the alternative post-smartphone technology that the government should focus on given the constraint of limited resources. As a results, autonomous vehicle(43.68%) was found to be most important, followed by artificial intelligence(17.4%) and Internet of Things(13.1%), among alternative technologies that could develop into the post-smartphone.

Keywords: Smartphone, Post-Smartphone, Internet of Things, Big data, Network Evolution

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1. Introduction

The smartphone has been developed as a portable computer that creates and transfers information, and it has been replacing the traditional cellular phone continuously. In other words, the crisis of the stagnant mobile phone market was overcome with the development of smartphones. As a typical example, Apple has become the number one smartphone manufacturer by rapidly seizing the market share from traditional leading manufacturers such as Nokia and Ericsson. The Apple business model is called “mobile ecosystem,” and it has been recognized as the most innovative success story of the ICT industry.

The smartphone market has led the growth of the ICT industry in recent years, but its growth rate is rapidly stagnating. In particular, the growth rate is gradually dropping as most mobile subscribers in major developed markets have already purchased smartphones. Specifically, global smartphone shipments stood at 330.4 million units in the first quarter of 2019, which was a 4% decrease from the previous year (345.4 million units). Likewise, most leading companies are experiencing difficulties in management due to stagnant growth. Samsung Electronics’ sales decreased from 7.82 million units to 7.18 million units(0.9% decrease), and Apple’s market share dropped to 13.0%. the gap between Apple and Huawei, which enjoys the second largest market share, is widening even further. Note, however, that Chinese companies such as Huawei, Oppo, and Xiaomi are continuously sustaining their growth trend by selling mid- to low-end phones in the domestic market.

Global leading companies are seeking various technological innovations that converge smartphones with new future technologies to overcome the saturation crisis of the mobile communication service market, as the conditions of the smartphone market are becoming tougher. In other words, those companies are trying to develop post-smartphones equipped with new features and forms by applying new innovations to conventional smartphones. Virtual reality, autonomous vehicle, Internet of Things, artificial intelligence, drones, and wearable devices are cited as innovative technologies that are expected to develop post-smartphones.

Under these circumstances, commercial interest in the development of post-smartphones is growing, and various possibilities were raised regarding the alternative technologies that can develop post-smartphones as Korea commercialized the 5G infrastructure for the first time in the world. In other words, Korea can be an important case of the test bed for developing post-smartphones in the 5G environment. Although interest in post-smartphones is growing, almost no theoretical research has been conducted on the alternative technologies that can develop as post-smartphone in the 5G technology environment.

Therefore, this study reviewed the concept of post-smartphones theoretically and analyzed which alternative technology has the potential to develop as a post-smartphone through document research and data mining model. In addition, the policy priority of promising alternative technologies, which can develop as a post-smartphone, was set to draw implications.

2. Previous Studies

2.1 Concept of a post-smartphone

The concept of a post-smartphone is discussed in earnest as the current smartphone market is saturated and the commercialization of the 5G network demonstrates a new technological possibility. Studies on the concept of the post-smartphone can be grouped as described below.

First, the post-smartphone is defined as new media in the hyper-connected era. According to Kim Jihyeon(2013), the post-smartphone era is an ICT era after smartphones and will be a ubiquitous era wherein computing is possible using nearby things, which used to be possible inside the computing device only [1]. Lee Jeongah & Sim Sumin(2014) also defined a post-smartphone as the media after the dawning of the hyper-connected society and the entry of the smartphone market into the maturity period [2]. Here, hyper-connected society refers to a society that connects everything including people, data, and things over the network in line with the development of the Internet and communication technologies.

Second, some approaches emphasize the characteristics of the service provided to consumers instead of defining the concept of the post-smartphone directly. According to Sim Sumin (2014), the post-smartphone depends on user-oriented personalization as well as the ability to provide stable services seamlessly, maintaining that this ability will be the source of competitiveness of next-generation smart devices [3]. Lee Minseok(2015) referred to the post-smartphone era as the era that will dawn after the post-PC generation and forecast that data-centric personalized services will lead the market in this age [4]. In other words, the post-smartphone is a device that can realize service optimized for an individual.

Third, Song Gibong, et al(2018) defined the concept of the post-smartphone from the viewpoint of technological evolution [5]. In other words, the post-smartphone means a device that can realize a trusted reality, which they defined as an innovative technology wherein knowledge and information are exchanged and they recognize each other in real time as the physical world and the cyber world are automatically connected for everyone in a convenient, safe, and visible manner.

Table 1. Core competence in the post-smartphone era

<table>
<tr><th></th><th colspan="2">Post-PC</th><th colspan="2">Post-smartphone</th></tr>
<tr><td rowspan="2">Keywords</td><td rowspan="2">Mobile</td><td rowspan="2">Manufacturing capability</td><td>Data</td><td rowspan="2">Software capability</td></tr>
<tr><td rowspan="2">Personalized service</td></tr>
<tr><td>Device</td></tr>
<tr><td>Core competitiveness element</td><td colspan="2">Process</td><td colspan="2">Developer, open source
Community, Culture</td></tr>
</table>

Source: Lee Minseok (2015)

Table 2. Concept of trusted reality technology

Type	Main content
Everyone	Should be provided to the stakeholders of the ecosystem in an open way
Conveniently	User convenience should be considered first
Safely	Privacy and data reliability should be secured
In a visible state	"See-Thru Communication" should be possible
Connected automatically	The real world and the cyber world like the Internet should be connected naturally
Communicating in real time	CPS, which is a networking technology with no time delay in communication, should be guaranteed

Source: Song Gibong, et al (2018)

Therefore, the post-smartphone can be defined as a device with the technological possibility of personalized services satisfying users' needs in the hyper-connected society that will come after the age of maturity of the smartphone.

2.2 Related technologies of the post-smartphone

As described above, the post-smartphone does not simply refer to a device after the smartphone but can be defined from the perspective of technology evolution such as user-optimized services and possibility of new technology innovation. Accordingly, which technologies will be linked to the existing smartphones to develop a new post-smartphone emerges as a very important issue in order to define clearly the concept of the post-smartphone. For example, wearable devices drew attention as an alternative technology for the post-smartphone around 2014. Nonetheless, there has been criticism that it is no longer an alternative technology due to the privacy issue and screen size.

With such background, major communication service providers were expecting post-smartphones to be released in earnest from 2019 when 5G was commercialized. In other words, the commercialization of 5G is seen to provide an opportunity for overcoming the stagnation of the smartphone market, with the smartphone rapidly creating the post-smartphone market by linking with various alternative technologies(Maeil Business Newspaper, 2019) [6]. As of June 2019, Korea and U.S. were the first in the world to have commercialized 5G.

Accordingly, various theoretical attempts have been made to find alternative technologies that will overcome the limitations of the existing smartphones and open up the new post-smartphone era. Currently, artificial intelligence, virtual reality, autonomous vehicle, and Internet of Things are considered viable alternative technologies that can develop post-smartphones. In particular, many studies including SPRI(2019) analyzed that 5G commercialization can be an essential infrastructure that can practically implement the Internet of Things(IoT), artificial intelligence, autonomous vehicle, and virtual reality.

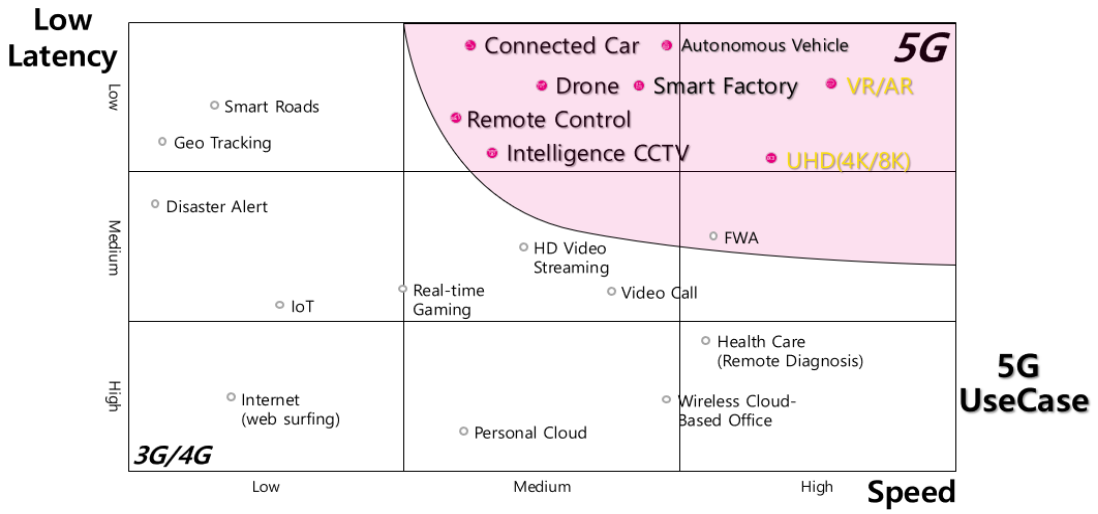

Fig. 1. 5G commercialization and technology portfolio

Source: Lee Jinhyeok (2019) [7].

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The following section describes the alternative technologies that are expected to develop post-smartphones by forming a supplementary relationship with the existing smartphones:

2.2.1 Autonomous vehicle

Autonomous vehicles refer to the means of transport wherein the vehicle recognizes the driving environment, determines the risk, plans the driving route, and operates the vehicle autonomously even though the driver does not drive the vehicle. This type of vehicle is composed of the sensing system, central control unit, and actuator, requiring advanced technologies such as robot and computer science, GPS, precision sensor, and electronic control. The spread of these autonomous vehicles is expected to reduce the driver's driving burden and increase production activities and leisure in the car, enabling vehicles to function as a new device differentiated from smartphones.

As a result, all countries of the world are rapidly preparing for the new car era by implementing the temporary operation system of the self-driving car and allowing autonomous vehicle operation in a limited manner. Currently, the operation of self-driving cars is legally allowed in the U.S., Germany, and Singapore. Other countries are also gradually increasing the operation of self-driving cars by keeping pace with technological development. The Korean government introduced a trial operation permission system for self-driving cars in the "Automobile Management Act" in February 2016 and enacted the "Act on the Commercialization Promotion and Support of Self-driving Cars" in April 2019 to establish a legal basis for implementing various support policies such as infrastructure establishment, R&D, and deregulation.

2.2.2 Virtual reality

Virtual reality(VR) and augmented reality(AR) are also recognized as an alternative technology of the post-smartphone. In other words, conventional media such as the PC and smartphone simply use the virtual world on the screen, but virtual reality can realize three-dimensional virtual space using the computer and the VR headset. Simply put, virtual reality enables the user to feel that the virtual space is real through the interaction with the five senses such as hearing and touch as well as voice and motion recognition (Ryu Hanseok, 2015) [8].

Kim Haeseok(2018) forecast that virtual reality(VR/AR) will create a new market as a core technology of the fourth industrial revolution and highly evaluated its technical feasibility. In particular, high scalability is also regarded as a strength of virtual reality(VR/AR) because VR can be utilized by various smart devices that have spread up to now [9]. Apple and Google, which are leading the smartphone OS, highly evaluate the technical feasibility of virtual reality AR/VR while setting up an aggressive business strategy. In particular, Apple recently developed the AR Kit in the iOS 11 version to distribute various VR/AR applications, and Google also distributes AR Core using the Android OS as a new development tool.

In comparison, only an initial market is formed in the domestic VR market with focus on the VR/AR experience facility, and it is still growing gradually mainly through B2B transactions and support policies of the government. With Korea commercializing the 5G technology for the first time in the world in April 2014, however, communication service providers are actively developing and distributing VR applications in the area of computer games and sports games.

2.2.3 Artificial intelligence

Artificial intelligence(AI) is a technology that enables machines to learn from experience such as “speech recognition” and “natural language processing,” adjust the existing knowledge according to new input, and work in the same way as people.

Since artificial intelligence can be applied to various devices besides the existing smartphones, it is considered to be the most scalable post-smartphone technology. Currently, artificial intelligence is applied to the smart speaker and the like only, but it is expected to spread to other fields where it has not been used in the past, including automobiles, smart factories, and robots. In particular, Google developed Android Pie a new operating system that applied the machine learning of AI in June 2018.

As an initial market is formed in earnest in the domestic AI market, various products using the voice intelligence platform are released for general consumers(B2C). Three communication service providers (SKT, KT, LGU+) and Kakao are releasing and competing over the AI platform and upgrading their services continuously(Commercialization Promotion Agency for R&D Outcomes, 2018) [10]. Samsung Electronics also developed its AI platform “Bixby,” which was designed to be used as a new intelligent interface rather than simple business support. Samsung Electronics is considering applying the intelligent interface to existing smartphones first and linking it with various smart devices in the long term. In other words, Samsung Electronics plans to support customers in using smart devices intuitively and conveniently by allowing them to input various kinds of information such as voice, touch, text, and image using artificial intelligence.

2.2.4 Internet of Things

The Internet of Things refers to a technology providing consumers with new services that cannot be provided by individual objects only by connecting tangible or intangible objects in the world in various ways. Simply put, it means that things are connected with each other Internet, or the "Internet" is composed of numerous things. SPRI(2019) expects the 5G network to contribute to the spread of the Internet of Things decisively because it is "hyper-connected," a technical characteristic that enables seamless transmission at high speed [11].

Domestic Internet subscribers numbered 8.22 million as of December 2018; this was a 25.9% increase from the same period last year. Likewise, demand for vehicle control, remote control, and wearables increased significantly. Specifically, there were 1.75 million subscribers to vehicle control services such as location-based services and telematics, 3.08 million subscribers to remote control services such as facility monitoring and remote meter reading, and 1.26 million subscribers to wearable devices including smart watches.

Nowadays, three mobile communication service providers are actively promoting the Internet of Things to overcome the stagnation of the smartphone market, such as deploying a dedicated network for the Internet of Things. For one, SKT is trying to provide real-time security services by commercializing "LTE Cat.M1" as a dedicated network for the Internet of Things and acquiring security company ADT Caps. On the other hand, KT gives an impression of safe Internet of Things services to users by strengthening security(e.g., personal data protection) through the application of blockchain technology to the Internet of Things network. Finally, LGU+ is seeking to differentiate itself from other communication service providers by releasing Internet of Things services that are close to the user's daily life using "IoT@home," the Internet of Things platform for households.

3. Research models and methods

3.1 Research models

There is growing expectation for post-smartphones as a new growth engine after the saturation of the smartphone market. In particular, the necessity of nurturing post-smartphones quickly is emphasized in Korea, which commercialized the 5G network for the first time in the world, in order to create new innovative services differentiated from the existing smartphones. On April 8, 2019, the Korean government announced the "5+ Policy," which is designed to create an opportunity for new innovative growth exceeding the growth of the existing smartphones using the 5G network.

Accordingly, this study reviewed the alternative technologies that are likely to develop as post-smartphones in the 5G environment through empirical analysis and analyzed the policy priority among alternative technologies. **Fig. 1** below summarizes the detailed research models. In the first phase, the concept of post-smartphone is defined theoretically, and the market trends of alternative technologies that can converge with the existing smartphone are studied. In the second phase, the alternative technologies of post-smartphones are analyzed and checked quantitatively, and the policy priority by alternative technology is set using the AHP model. In the third phase, implications are suggested as to how alternative technologies such as artificial intelligence, virtual reality, autonomous vehicle, and Internet of Things will develop technologically by putting the analysis results together.

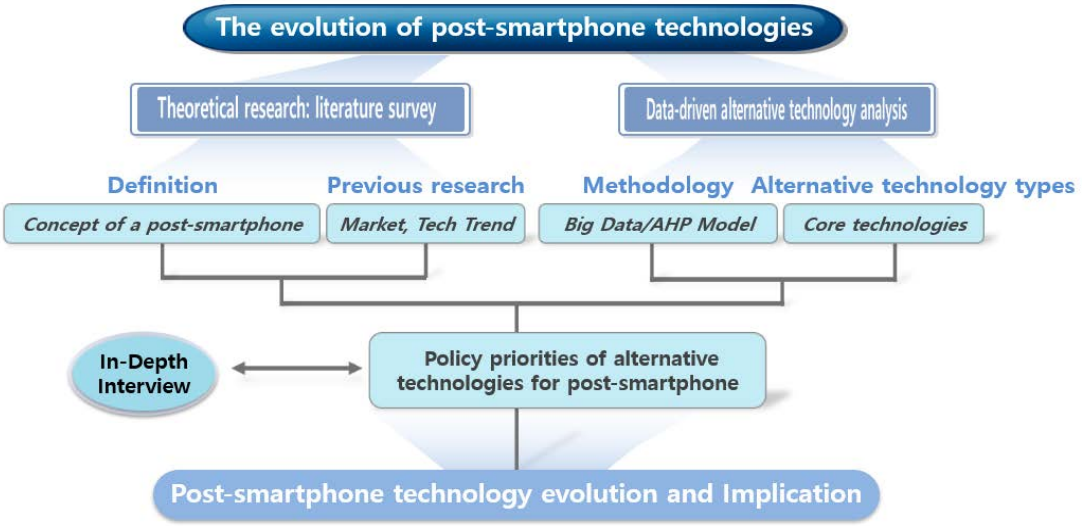

Fig. 2. Post-smartphones, design structure of the research model

3.2 Research methodology

As a big data analysis technique, data mining was used to identify the alternative technologies of post-smartphones. The AHP model was used to analyze the priority among the identified alternative technologies.

3.2.1 Data Mining

Text mining, which is widely used as a data mining analysis technique, was performed. Trends of interest were analyzed based on the frequency of key words, with the correlative words, commonly used words, examined at the same time.

First, text mining as one of the major techniques of big data analysis refers to a process or a technique of finding new useful information in unstructured text data. Specifically, text mining is a specific type of data mining that refers to the process of finding information that the user is interested in among the large-scale data. Since the text mining technology is based on the natural language processing technology, it can be applied to various areas, such as document classification, document clustering, information extraction, and document summarization.

Second, correlative words(or commonly used words) analysis refers to a methodology that enables extracting the connection among the language appearing in text and the network of concepts. Any data composed of the language can be analyzed, including everyday conversations in oral languages and interview, and broadcasting languages can be used as analysis data besides the text composed of written languages.

3.2.2 AHP (Analytic Hierarchy Process) model

The AHP(hierarchical analysis) model was applied for reasonable decision making to set the priority among alternative technologies that can create post-smartphones. This methodology is a model that determines importance by analyzing the evaluation factors quantitatively for reasonable decision making. The AHP model is a priority analysis methodology proposed by Thomas L. Satty. Importance is determined by quantitatively analyzing the evaluation factors using qualitative knowledge. This model has the advantage of evaluating factors by reflecting

the qualitative opinions of various stakeholders and experts. In other words, the AHP analysis method is a decision-making method that is useful for determining the optimal alternative by comprehensively reflecting the knowledge, intuition, and experience of experts through pair-wise comparison of the factors that influence decision making.

3.2.3 Topic Modeling

Topic modeling, one of the data mining techniques, is a statistical model algorithm that extracts significant subjects(topics) from unformatted text data(Blei, D., Carin, L., & Dunson, D, 2010) [12]. The application of this algorithm has been gradually expanding because it can probabilistically analyze the context in a large amount of text to extract highly interpretable subjects. The algorithm mostly used in topic modeling is the Latent Dirichlet Allocation (LDA) extracts keywords by estimating and then probabilistically calculating which topics existing in each text by calculating both the distribution of words for each subject and the distribution of subjects for each document(Nam, C. H., 2016) [13].

4. Analysis results

4.1 Alternative technology types of post-smartphones

The alternative technologies that would develop create post-smartphones were analyzed using the data mining technique, considering the fact that the 5G infrastructure was commercialized for the first time in the world. For this purpose, frequency analysis and topic modeling were performed among data mining techniques to find technical associations between the 5G infrastructure and smartphone. News articles provided on the Internet were collected as the data for frequency analysis and topic modeling. The collected text documents were analyzed after refining words by applying the morpheme dictionary(NIADic), and inaccurate and unnecessary words were deleted.

For the analysis, the morpheme dictionary(NIADic) was provided by the Ministry of Science and ICT(MSIT) and the National Information Society Agency(NIA) at the K-ICT Big Data Center. This dictionary version increases the number of morphemes that can be used for data analysis, as it can derive up to five times' more morpheme than the existing morpheme dictionaries(e.g., SejongDic). In other words, the new morpheme dictionary has the advantage of increased accuracy and reliability in association analysis, because it can secure a large number of vocabularies.

News articles were collected from the target data using keyword search(5G, technology), and a total of 22,934 items were collected excluding 23,951 duplicate articles. Subsequently, a list of words was created in order of frequency in the target articles, and incorrect and unnecessary words that are irrelevant to the subject were then deleted to arrange those words at a level suitable for final analysis.

A total of 59,703 morphemes(nouns, adjectives, adverbs, verbs) were finally analyzed. Among the articles about 5G-related alternative technologies, 5G itself was found most frequently(13,101), followed by autonomous vehicle, AI, communication, virtual reality, and Internet of Things. The result of data mining analysis on newspaper articles proved that major technologies considered to be the alternative technologies of post-smartphones are also found frequently on newspaper articles. Newspaper articles by year are likely to describe reality well because those articles are reported by hands-on workers in the related industry regarding the actual field such as industry and technology trends.

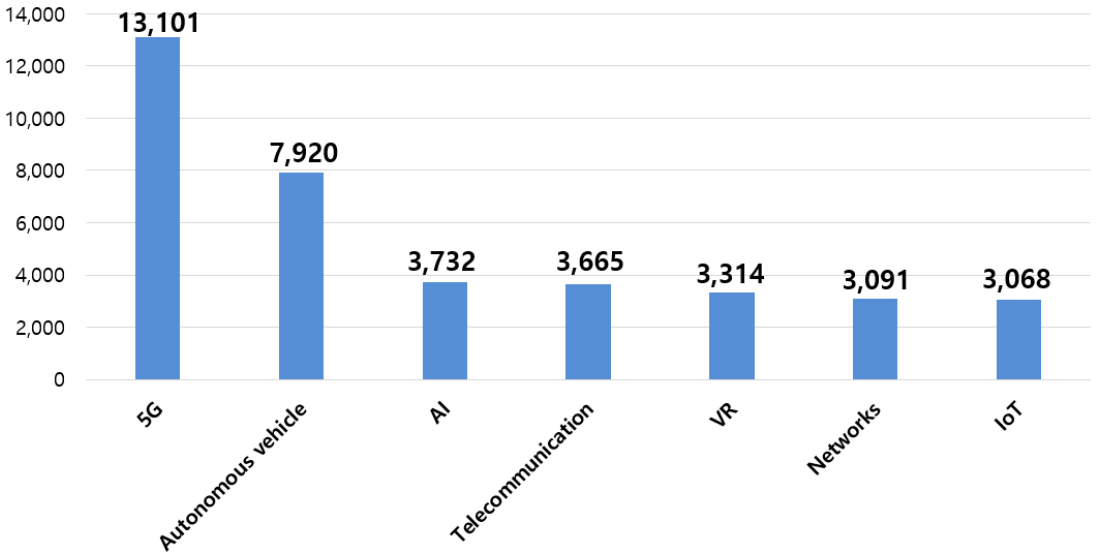

Fig. 3. Associated word frequency between 5G and related technologies

4.2 Policy priorities of alternative technologies

Among autonomous vehicle, virtual reality, artificial intelligence, and Internet of Things, which are emerging as the alternative technologies for post-smartphones following the commercialization of 5G infrastructure for the first time in the world, there are increasing discussions as to which technology is important in terms of policy. The reason is that the Korean government and corporations need to make an effective decision urgently regarding which alternative technology should be focused on when developing post-smartphones, in order to foster strategically competitive post-smartphones in the global market. Accordingly, this section analyzes the policy priorities of the alternative technologies of post-smartphones using the AHP model.

4.2.1 Survey details

The AHP model for developing post-smartphones is composed of two phases. The first phase is the survey on the effective evaluation criteria to determine the superiority of alternative technologies, and the second phase is paired comparison by alternative technology according to the evaluation criteria. First, four criteria(marketability/attractiveness, ease of implementation, possibility of diffusion, and market formation level), which are widely used as the criteria for evaluating an innovative service theoretically, were applied as the evaluation criteria for the alternative technology's excellence(NIA, 2017) [14]. Here, marketability/ attractiveness involves evaluating the attractiveness level of a particular technology, and its sub-criteria include the prospect for market size, profitability prospects, and contribution to related industries. Ease of implementation involves evaluating how easy it is to implement a particular technology, and its sub-criteria include the possibility of technology implementation and infrastructure establishment, legal and policy limitations, and ease of funding. Diffusion time involves evaluating how quickly a particular technology can be diffused, and its sub-criteria include technology provision time and time of availability. The market formation level involves evaluating whether the market of a particular technology has been created sufficiently, and its sub-criteria include the participation of stakeholders in the industrial ecosystem and likeability of the main subject. Second, statistical analysis was conducted

through the paired comparison of alternative technologies after carrying out a survey on the effective evaluation criteria. The evaluation target is the four alternative technologies that were found to be highly related to the 5G technology according to literature search and data analysis. In other words, a paired comparison survey was conducted as to which technology is more important among the four alternative technologies of autonomous vehicle, artificial intelligence, virtual reality, and Internet of Things.

The AHP model consists of procedures that collect the data using an expert questionnaire and analyze those questionnaire items statistically. Therefore, the composition of the experts included in the questionnaire is most important in the AHP model. In this context, a survey was conducted from May 10, 2019 to 30 May on policy institutes that have studied policies and technologies and conducted market analysis for post-smartphone development for a long time, communication service providers, and research and academic experts. An in-depth interview was also conducted with the same experts to understand the AHP analysis result accurately. The experts who participated in the survey are as follows: three research directors of the Korea Information Society Development Institute(KISDI) who study the communication policy of the Korean government; three research directors of the Korea Information & Communication Industry Institute(KICI) who study 5G infrastructure policies; three research directors of the Electronics and Telecommunications Research Institute(ETRI) who study technology policies; three professors who majored in ICT policies; nine 5g technology strategy team leaders of communication service providers(including the chief technology strategy officer of each of the three major communication service providers), and size content providers.

4.2.2 Results of analyzing the evaluation criteria priorities

The importance of evaluation criteria for the alternative technologies of post-smartphones was in order of the possibility of diffusion → market formation level → ease of implementation → marketability/attractiveness. The result indicates that the possibility of diffusion and the market formation level are relatively important among the various evaluation criteria, in order for various alternative technologies to develop into post-smartphones by converging with the existing smartphones. In other words, how quickly a particular technology can be diffused in the initial stages and how to secure subscribers over a certain size are the key to success for the technology to develop into the post-smartphone. The fact that the evaluation criteria associated with securing critical mass in the early phases were highly evaluated usually means that the post-smartphone market in the 5G environment has the characteristics of a platform business, not a device business. Many studies in literature suggest the basis that the smart device in the 5G environment is actually a platform business.

Table 3. Weighed value analysis result of the evaluation criteria

Type	Eigen Vector	Rank
A. Marketability/Attractiveness	0.1323	4
B. Ease of implementation	0.2389	3
C. Possibility of diffusion	0.3574	1
D. Market formation level	0.2714	2

Table 4. Priority analysis results of alternative technologies

Type	Eigen Vector	Rank
A. Internet of Things	0.1314	4
B. Autonomous vehicle	0.4368	1
C. Artificial intelligence	0.1704	3
D. Virtual reality	0.2615	2

4.2.3 Priority analysis results of alternative technologies

When the importance of alternative technologies was evaluated based on the evaluation criteria, autonomous vehicle(43.68%) was found to be most important among alternative technologies that could develop into the post-smartphone, followed by artificial intelligence(17.4%) and Internet of Things(13.1%). In other words, autonomous vehicle is the most promising post-smartphone technology in terms of overall ranking. The study result is meaningful since it suggests the priorities of alternative technologies that could develop into the post-smartphone through empirical analysis, considering the 5G network. Simply put, each of the autonomous vehicle, virtual reality, artificial intelligence, and Internet of Things was understood to be important as the core technology for the post-smartphone since the commercialization of the 5G infrastructure. Note, however, that it was the first attempt to understand the priorities of those technologies quantitatively.

The following describes the ranking of the alternative technologies in more detail according to the individual evaluation criteria:

First, autonomous vehicle(43.6%) was found to be the dominant alternative technology of post-smartphones; this means that many experts are expecting its full-scale commercialization soon after the pilot operation. In particular, the enactment of the “Act on the Commercialization Promotion and Support of Self-driving Cars” by the National Assembly in April 2019 acted as an important factor, because institutional arrangement is made in advance for safe, efficient autonomous vehicle. In addition, the world’s first commercialization of the 5G infrastructure seems to have significant impact, because technical support for ultra-low latency and hyper connection -- which are indispensable for the autonomous vehicle -- became feasible. In other words, Korea can secure a competitive advantage in this field because it has both the technological infrastructure and institutional potential. Experts believe that the autonomous vehicle is highly likely to function as a new device differentiated from the smartphone, and that the convergence of communication and transportation technologies is essential for the autonomous vehicle to develop into the post-smartphone. Simply put, there is a need to create the industrial ecosystem of self-driving cars as soon as possible through close cooperation between communication service providers, car manufacturers, IT companies, and parts companies. As a result, autonomous vehicle garnered the highest score in all the evaluation criteria excluding marketability/attractiveness, and it is considered to the most promising alternative technology of the post-smartphone.

Second, consumers were found to recognize highly the early commercialization of virtual reality(26.15%) since 5G commercialization with focus on music, game, and sports broadcasting as well as the three-dimensional effect and sense of reality. The Pokémon GO game released in 2017 is the most obvious example showing the impact of virtual reality. This

is because Pokémon GO, Samsung Electronics, Apple, and LG Electronics have installed virtual reality functions in their smartphones as an essential feature. Experts highly evaluated the potential of virtual reality but pointed out the limit of a small screen size when implementing virtual reality in existing smartphones realistically. In other words, direct interactions should be possible between the smartphone and object, like the words "the world on the screen," for virtual reality to function as the post-smartphone. Experts expect it to take time. Nonetheless, they found it noteworthy that communication service providers are actively releasing various virtual reality applications to differentiate their 5G smartphones after the commercialization of 5G. Simply put, virtual reality can be a viable alternative technology of the post-smartphone if those service providers distribute more virtual reality contents and user experience is accumulated. As a result, virtual reality received the highest score in marketability/attractiveness and a high score in other evaluation criteria.

Third, artificial intelligence(17.04%) is used in various smart devices and products after it is installed in the smartphone in the form of voice AI and vision AI. Major service providers such as Apple, Google, and Samsung are continuing to invest in artificial intelligence, believing that it can broaden the utilization scope of smartphones and create synergy effects with other devices. Nonetheless, they forecast that artificial intelligence will play a supplementary role for smartphones until voice can be recognized at a level similar to that of natural language processing and institutional issues such as privacy and leak prevention are solved satisfactorily, despite the evaluation that artificial intelligence is the most promising alternative technology of the post-smartphone. It was also pointed out that the domestic source technology for artificial intelligence has a considerable technological gap with advanced countries, even though the technical feasibility of artificial intelligence is indeed high. In other words, we need to select and concentrate on other competitive technologies.

Fourth, Internet of Things services(13.14%) are released with focus on vehicle control, remote control, and wearable devices, and Internet of Things service subscribers are increasing. Note, however, that it is not yet evaluated as an alternative technology for the post-smartphone. There is also a limit to the rapid growth of the Internet of Things due to hyper-connection, one of the technical characteristics of the 5G infrastructure. This is because the Internet of Things was technically possible in the 4G infrastructure, but it was found to have improved the profit model of mobile communication service providers insignificantly. As a result, the Internet of Things was regarded as a simple complementary service to existing smartphones, and it received low scores in all evaluation criteria as well as the lowest score among the alternative technologies of the post-smartphone.

Table 5. Alternative technology priorities by evaluation criteria

Evaluation criteria	Alternative technology	Eigen Vector	Rank
A. Marketability/Attractiveness	a1. Internet of Things	0.2415	3
	a2. Autonomous vehicle	0.2959	2
	a3. Artificial intelligence	0.1317	4
	a4. Virtual reality	0.3308	1

B. Ease of implementation	a1. Internet of Things	0.1097	4
	a2. Autonomous vehicle	0.4402	1
	a3. Artificial intelligence	0.1918	3
	a4. Virtual reality	0.2584	2
C. Possibility of diffusion	a1. Internet of Things	0.1074	4
	a2. Autonomous vehicle	0.4938	1
	a3. Artificial intelligence	0.1665	3
	a4. Virtual reality	0.2323	2
D. Market formation level	a1. Internet of Things	0.1285	4
	a2. Autonomous vehicle	0.4273	1
	a3. Artificial intelligence	0.1755	3
	a4. Virtual reality	0.2687	2

5. Conclusion

This paper reviewed the alternative technologies that can create post-smartphones in the rapidly changing 5G environment through documentary research and analyzed the review result through data mining using actual data. In addition, the policy priority of the alternative technologies was set quantitatively using the AHP model in order to decide the post-smartphone technology that the government should concentrate on given the constraint of the limited resource.

Four technologies were found to be the promising alternative technologies of post-smartphones in the 5G technology environment(autonomous vehicle, virtual reality, artificial intelligence, and Internet of Things) according to the analysis result. The same result was found in theoretical literature search and data mining analysis. In other words, the capability of converging the four technologies(autonomous vehicle, virtual reality, artificial intelligence, and Internet of Things) with the existing smartphones to create new innovative services and products can create post-smartphones.

The importance of evaluation criteria for the alternative technologies of post-smartphones was in order of the possibility of diffusion → market formation level → ease of implementation → marketability/attractiveness. How quickly the alternative technology can be diffused in the initial stages and how to secure subscribers over a certain size are important

for the technology to develop into the post-smartphone. The fact that the evaluation criteria associated with securing critical mass in the early phases was highly evaluated means that the post-smartphone market in the 5G environment can be recognized as a platform business.

When the importance of alternative technologies was evaluated by evaluation criteria, autonomous vehicle(43.68%) was found to be most important, followed by artificial intelligence(17.4%) and Internet of Things(13.1%), among alternative technologies that could develop into the post-smartphone.

In conclusion, this study is significant in that it presents the first empirical analysis of the priority of alternative technologies that can grow into post-smartphones in connection with 5G networks. The results can have a significant effect on the policy decision-making by the government seeking new innovative growth engine to replace stagnant smartphones and the business strategy of ICT companies developing new business models under the 5G technological environment.

Although innovative technologies that can be the new growth engine after the stagnation of smartphones have been debated in Korea, the academic interest in post-smartphone technology has not been high. As such, this study methodically examined the background and current status of discussion on post-smartphone technological advancement in Korea and other countries and gathered experts′ opinions to suggest the technical management implications of the priority of new alternative technologies in the mobile phone market after the introduction of 5G. In particular, this study is academically meaningful in that it combined the existing analytic hierarchy process(AHP) methodologies and topic modeling in a new theoretical attempt. Moreover, since Korea was the first country in the world to commercialize the 5G technology, Korea′s experience in post-smartphone technology advancement can be an important benchmark for other countries intending to introduce the 5G technology.

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