# Developing and Evaluating New ICT Innovation System: Case Study of Korea's Smart Media Industry

Eungdo Kim, Daeho Lee, Kheesu Bae, and Myunghwan Rim

**The smart media (SM) industry has demonstrated that it has the characteristics to increase user innovative activities, enhance open innovativeness, and increase the segmentation of innovation value. This study introduces and evaluates an innovation system that reflects the characteristics of the SM industry. We categorize the SM industry into hardware, network, platform, and content industries and perform an AHP analysis (based on a survey of 96 experts) to evaluate the relative importance of the factors/factor groups affecting the creation of innovation. The results show that "collaboration activity" is a more important factor than other innovation factor groups (financial support, R&D, policy environment, human resources) in the SM industry. The results also show that the important factors/factor groups differ by industry.**

**Keywords: Innovation system, open innovation, user innovation, smart media industry, AHP.**

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Eungdo Kim (edkim@chungbuk.ac.kr) is with the Graduate School of Health Science Business Convergence, Chungbuk National University, Cheongju, Rep. of Korea.

Daeho Lee (interaction@skku.edu) is with the Department of Interaction Science, Sungkyunkwan University, Suwon, Rep. of Korea.

Kheesu Bae (ksbae@chungbuk.ac.kr) is with the School of Business, Chungbuk National University, Cheongju, Rep. of Korea.

Myunghwan Rim (corresponding author, mhrim@etri.re.kr) is with the Future Research Creative Laboratory, ETRI and the Department of Science and Technology Management Policy, UST, Daejeon, Rep. of Korea.

## I. Introduction

Over the past few years, the information and communications technology (ICT) industry has led the evolution of digital convergence [1] and made dramatic changes that have led to the growth of national economies around the world. In particular, the popularization of smart devices, such as smartphone, smart TV, or smart tablet, has promoted innovation within the industry, and products and technologies that include the prefix "smart" in their name now dominate many different industries, including, but not limited to, the ICT industry.

This paper defines the newly dominated ICT industry as the smart media (SM) industry to distinguish it from the existing ICT industry, because the SM industry is facilitated by the emergence of SM services. The SM industry provokes technological convergence, and converging technologies have distinguishing features, such as high rate of growth, high value of concentration of patent activity, and high technological influence [2].

Many researchers have tried to investigate innovation in the ICT industry in terms of innovation system theory and open innovation theory. However, the greatest limitation of innovation system theory is that it regards actors (for example, firms, governments, and universities) as the subjects of the innovation system. It also assumes that firms are the major actors in the creation of innovation. Open innovation theory, on the other hand, is also limited in that it regards actors as the subjects of innovation in a manner similar to innovation system theory. Open innovation studies were conducted on an actor's connections to different types of cooperating partners (for example, firms, universities, governments, users), levels (for example, upper, same, lower), types of networks (for example,

  
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technology cooperation, M&A, joint R&D), qualities (for example, period, type of contract, intensity, weak tie/strong tie), and different levels of diversity. In other words, these studies were conducted with a focus on the involvement of who, where, and what types of networks.

We found that no research has evaluated an innovation system that reflects the characteristics of the SM industry (that is, an increase in open innovativeness, an increase in user innovation, and the segmentation of innovation value). Thus, this paper is the first to introduce an innovation system for the SM industry and to evaluate the relative importance of factors/factor groups of the SM innovation system. We classify the SM industry into content, network, hardware, and platform layers according to Fransman [3] and assign 96 experts from the four different layers who have professional knowledge in an SM industry–related profession. We perform an analytic hierarchy process (AHP) analysis of the separate factors and factor groups to analyze their relative importance levels.

We have structured this paper in the following manner. In Section II, we present a definition and characteristics of the SM industry. In Section III, we introduce an innovation system that reflects three phenomena found in the SM industry. Section IV introduces the AHP methodology, and Section V presents the findings of the AHP analysis. In Section VI, we provide our conclusions and discuss implications for further research.

## II. Definition and Characteristics of SM Industry

Various definitions of SM service have been presented in recently published literature on the topic. Yoon [4] defines SM service as a convergent and comprehensive content service that can be expressed with smart devices, can mutually interact with users, and has no restrictions in time and space. Park [5] defines SM service as a communication service that can interact with both users and SM. It provides comprehensive convergence content without any time or space restrictions. Jin and others [6] define SM service as a convergent and comprehensive content service that employs new concepts, including electronic books, e-newspapers, and video clips. These concepts are delivered through N-smart devices, such as smartphones, tablet PCs, and smart TVs.

The SM industry is regarded as an industry that provides a smart ecosystem environment freely available without any restrictions in space and time for the applications and services with activated devices connected to the Internet [5]. Fransman [3] explains how the SM industry consists of networked elements (layer 1); converged communication and content distribution networks (layer 2); contents, applications, and platforms (layer 3); and final consumers (layer 4). Therefore, this paper classifies the SM industry into hardware, network, platform, and contents industries.

The characteristics of the SM industry differ from those of the existing ICT industry in terms of innovation, as exemplified by (*a*) an increase in user innovation, (*b*) an increase in the industry's open innovativeness, and (*c*) the segmentation of innovation values [7].

First, as the informational society continues to mature, the consumer's role continues slowly to evolve from that of a passive user to that of an innovator who generates innovations. It was Hippel [8] who introduced the concept of *user innovation*, describing it as a type of activity in which an individual may partake in an effort to address spontaneous needs and problems that may arise during the consumption stage. The individual may create an alternative product or improve an existing product. User innovation is significant because it is an initiatory and voluntary process. During this process, the consumer produces new value in existing products and services. In the SM industry, a realistic innovation situation is an environment where, similar to most other cases, the user is one of many different participants in the innovation process. These participants influence innovation by mutual structural assistance. Within the innovation frame of the SM industry, the user can be considered as a very important participant in the innovation system.

Second, as society enters the SM era, significant mergers among a number of industries have occurred due to the blurring of boundaries. In turn, this has led to the creation of new value by firms within individual industries and by firms that resulted from the aforementioned mergers [9]. Moreover, firms that are highly dependent on internal trading are attempting to converge with affiliated or subordinate firms in other industries. Therefore, it is now easier for firms to pass through structural boundaries during the innovation process. As a result, firms can engage more actively in communication with external environments. Thus, open innovativeness in internal and external communications, in general, within the industry has greatly increased [10]–[13].

Finally, the SM industry promotes the segmentation of innovation value. Within the SM industry, boundaries among industries are dissolving, and industries are creating new value through convergence and openness with one another. To suit both the needs of the ever-changing environment and the changing tastes of consumers, competitive new business models and services based on these models have begun to appear. Due to these changes, firms and actors are engaged in the production of innovation. As a result, innovation can emerge from the interaction between existing firms. It can also result from each innovation factor possessed by an innovation actor and from the interaction with other factors [3], [7].

## III. Developing New ICT Innovation System

Scholars have conducted ongoing research on factors that affect technological innovation. Based on previous research conducted on sources of innovation, these factors can be classified into tangible and intangible [14]; financial, technical, and intangible [15]–[16]; or financial support, R&D, human resources, and policy environment [17].

In addition to the four categories derived by Laursen and Salter [17], this paper also considers "collaboration activities" to be a fifth category. In innovation processes, the role of the external network (external capabilities that coordinate institutional resources) is very important for the creation of innovation.

In this study, collaboration activity is not limited to only R&D related activities; it is also related to other innovation factors that can occur within an innovation system. Smaller firms that have less resources and technology and limited R&D resources in comparison to bigger firms are more likely to rely on external networks for technological innovations. A number of recent studies have confirmed this hypothesis.[1)]

### 1. Financial Support

Research conducted since Schumpeter demonstrates that financial support and financial institutions are among the major factors in an innovation system. Also, they provide a strong impetus to induce new economic growth in a firm [21]–[22]. Finances can be injected into a firm in the form of direct support of the investment object or innovative project. This financial support can promote innovation [23].

Scholars believe that financial support provides assistance to innovative activities. From the perspective of a financial innovation system, the provision of financial support improves the technological capabilities of a research institute in relation to the financial market; government; and policy and regulatory issues [24]. Wonglimpiyarat [25] investigated the forms of financial support provided to high-tech development firms for advanced levels of technology. This study showed that support should be supplied in the form of angel funds or venture funds at the seed stage; grants and soft loans at the start-up stage; and by banks and the capital market at the growth stage. Several studies on innovation in a knowledge-based economy showed that the provision of financial support can enhance technical improvements and innovative activities in many sectors of the national innovative system via the efficient distribution of capital [26]–[27].

1) For instance, see [17]–[19], [20].

### 2. Research & Development

Traditionally, the realm of research and development (R&D) has been considered as the core strategy to produce innovation and economic growth by extending the technological capabilities of R&D subjects [28]. Several studies have proven that correlations exist between R&D investments, productivity, and growth rates [29]–[30]. In other words, R&D introduces outstanding products and process innovations due to the acquisition of high-quality technology derived from the firm as well as the public research field. This results in higher profits and improved growth. Mairesse and Mohnen [31] analyzed the effects of R&D on industry in their examination of the manufacturing industry in France. They also evaluated the effects of R&D on high-tech and low-tech industries. The results showed a positive correlation between R&D and innovation. The results also showed a greater degree of correlation in the low-tech field. Cameron and others [32] also empirically analyzed the correlations between firms' investments in R&D and the technological frontier. Their results proved that investments in R&D had a positive effect on the absorptive capacity of a firm.

### 3. Collaboration Activity

Many types of corporate activities have been developed to inspire innovation. However, R&D cooperation is the most common type of cooperation with other organizations. R&D cooperation has been increasing steadily as the cost of innovation increases [33]–[35]. A number of studies have shown that R&D cooperation is an important factor in the process of innovation. It can effectively absorb external technologies and knowledge. In addition, it is an effective way to exchange internal resources.

In an empirical analysis, Arora and Gambardella [36] demonstrated the importance of cooperation among enterprises in the fields of biotechnology, chemistry, and pharmaceutical development. Colombo [37] also performed an empirical analysis that demonstrated the importance of cooperation between firms in the information and communication industries. Additional research investigated the creation of corporate innovation in an examination of cooperative studies between corporations and colleges. An analysis of the German automobile industry by Peters and Becker [38] proved that firms can reinforce in-house capacities by cooperation with colleges. It was also shown that this type of cooperation can help firms use their capabilities and potential more effectively. In an additional analysis of the German manufacturing industry, researchers demonstrated that joint research with colleges can increase R&D possibilities and investments [39]. Kaiser [40] demonstrated in an empirical analysis that a firm that cooperated with others tended to invest more than other firms in the German service industry. To sum up, a number of studies have shown that a firm that implements cooperative R&D with other organizations can reduce uncertainty and realize cost reductions and economies of scale [39], [41]–[42].

### 4. Policy Environment

The environment that surrounds a firm (for example, the development of appropriate government policies) can affect the firm's innovative capability [28], [43]–[45]. The external environment, such as supporting policy and a high market demand, can influence a firm's innovative capability. This includes government policy and a competitive environment [44]. A number of studies have suggested that government support is an important factor that can affect corporate activities. Klaassen and others [46] showed empirically that government support for technology development and a grant policy can exert an impact on the capability expansion and cost reductions of firms involved in the wind-power motor industry in Denmark, Germany, and the United Kingdom. However, another study argued that government regulations delay and restrain the settlement of corporate innovation [28], [45].

### 5. Human Resources

A firm's use of its human resources (that is, a set of individuals who make up the workforce of an organization, business sector, or an economy) is one of the major factors that can affect its innovation. Tornatzky and Fleischer [28] and Lin [47] showed that the internal resource of manpower that possesses higher education and training can make a significant contribution to technical innovation. In addition, strong leadership by a firm's executive officers exerts a significant impact on a firm's adoption of technical innovation. Sorensen [48] conducted an empirical analysis of R&D performance and concluded that human resources that possess abilities above a certain critical factor have a positive impact on their firm's R&D performance. Ceh [49] studied experts, experienced workers, and the crucial factors needed to guarantee innovation.

In Table 1, we provide an outline of an innovation system. We classified innovative factors into five factor groups and categorized each factor into each factor group according to a review of the literature. We subdivided each factor into detailed activities that relate to other entities within the SM industry.

Table 1. Innovation system.

| Factor group | Factor | Actor | Researches |
|---|---|---|---|
| Financial support | Capital support | Firm | R.D. Cooper [10], C. Freeman [50], F. Malerba [51] |
| | Financial aid to private firms | Government | C. Freeman [50], K. Pavitt [52] |
| | Financial aid to public research | Government | C. Freeman [50], F. Malerba [51], K. Pavitt [52] |
| R&D | Technology development | Firm | K. Pavitt [52], J.S. Metcalfe [53], S. Nambisan [54], M.M. Montoya-Weiss and R. Calantone [55], J. Horbach [56], J. Love and S. Roper [57], B. Tether [58] |
| | Public research | University | K. Pavitt [52] |
| | R&D participation | User | E. von Hippel [59], W. Riggs and E. von Hippel [60], C. Lettl [61] |
| Collaboration activity | Creating links among actors | Government | K. Pavitt [52] |
| | Network activity | Firm | J. Love and S. Roper [57], B. Tether [58], H. Chesbrough [62], B.A. Lundvall and B. Johnson [63], C.J. Chen and J.W. Huang [64], D.J. Teece [65] |
| | Creating links with firms and governments | University | K. Pavitt [52], H. Chesbrough [62] |
| Policy environment | Supporting policy | Government | J.S. Metcalfe [53], F. Malerba [51], B. Tether [58] |
| | Innovation strategy | Firm | K. Pavitt [52], J. Horbach [56] |
| | Shaping market demand | User | J.S. Metcalfe [53], F. Malerba [51] |
| Human resource | Researcher and labor | Firm | K. Pavitt [52], C.J. Chen and J.W. Huang [64] |
| | Expert user | User | E. von Hippel [59], W. Riggs and E. von Hippel [60], C. Lettl [61] |
| | Trained expert | University | D.C. Mowery and N. Rosenberg [66], J. Love and S. Roper [57], C.J. Chen and J.W. Huang [64] |

## IV. Methodology

### 1. Sample

A survey was conducted of 120 professionals who worked for either the government, firms, or universities. With regards to the government employees, 40 professionals from the Ministry of Knowledge Economy, Electronics and Telecommunications Research Institute, National Information Society Agency, Korea Information Society Development Institute, Korea Electronics Technology Institute, Korea Internet Security Agency, Korea Creative Content Agency, Media & Future Institute, Korea Communications Agency, Korea Digital Media Industry Association, and related departments were chosen as participants. For the university sample, we chose 40 professors who were members of the Smart TV Forum, Korea Association of Smart Homes, Korea Smart TV Industrial Association, Korea Cable Television & Telecommunications Association, Korea Digital Cable Forum, and the IPTV forum. In addition, a number of professionals in the field of SM innovation were chosen as participants. Finally, for the industrial sample, we must note the variations in the numbers of personnel and sizes of different departments of interest. Therefore, to increase the validity of the survey result, we chose 40 personnel in the four aforementioned areas of the SM industry as participants.

Data was gathered by Korea Data Network, an agency specializing in surveys, to ensure consistency of the AHP survey. The online survey was distributed and gathered from September 27 to October 14, 2013. We achieved a retrieval rate of approximately 80%, and we validated the consistency of the data by considering consistency ratio (CR). It is agreed that the response has rational consistency when the derived value of CR is below 0.1, and the response is acceptable when the value is within 0.2 [67]. Therefore, this study used 0.2 as the consistency value to consider survey participants with low levels of understanding and to maximize the solubility of the retrieved information. By eliminating 5 inconsistent survey samples according to CR, we arrived at a total of 96 valid survey samples.

Table 2 shows the statistics of the survey distribution, retrieval rates for different institutions, and the consistency result.

### 2. AHP Analysis

AHP is a decision-making method that attempts to capture reviewers' knowledge, experience, and intuition by pairwise comparisons of the elements that constitute the decision-making hierarchical structure. AHP is employed in many areas when decisions must be made due to its theoretical simplicity and broad applicability. It is a useful approach for the prioritization of multiple alternatives in a situation where the optimal alternative must be chosen despite the existence of conflicting criteria, incomplete information, or any other form of constraint in resources [68].

AHP measures each element's weight and creates a pairwise comparison matrix. One normalized priority vector is calculated from this matrix for each level of hierarchy through the use of the eigenvalue method. When AHP is used, four stages of a decision-making structure configuration must be

Table 2. Statistics of survey distribution.

| Industry | Actor | Total survey distributed | Survey gathered | Inconsistent survey | Final valid sample |
|---|---|---|---|---|---|
| Content | Government | 10 | 10 | 1 | 9 |
| | University | 10 | 9 | 0 | 9 |
| | Firm | 10 | 8 | 1 | 7 |
| Software | Government | 10 | 9 | 0 | 9 |
| | University | 10 | 9 | 1 | 8 |
| | Firm | 10 | 8 | 0 | 8 |
| Network | Government | 10 | 8 | 1 | 7 |
| | University | 10 | 8 | 1 | 7 |
| | Firm | 10 | 7 | 0 | 7 |
| Hardware | Government | 10 | 8 | 0 | 8 |
| | University | 10 | 8 | 0 | 8 |
| | Firm | 10 | 9 | 0 | 9 |
| Total | | 120 | 101 | 5 | 96 |

followed — the collection of information for evaluation by pairwise comparisons, estimations of relative weights, aggregations, and decisions on priority levels.

When decision data is obtained by pairwise comparisons between decision-making factors, the relative weights of the information items are also estimated. A number of approaches to estimate such a weight exist, including the eigenvalue method, the use of arithmetic means or geometric means, and the least-squares method. However, when the consistency of the decision data is not complete, the eigenvalue method becomes the optimal approach to estimate the weight [67].

Let $C_1$, $C_2$, … , $C_n$ denote a set of elements, while $a_{ij}$ represents a quantified judgment on a pair of elements $C_i$, $C_j$, which is the element at row $i$ and column $j$ in pairwise comparison matrix $A$, and is calculated from $w_i / w_j$ $(i, j = 1, \ldots, n)$, where $w_1, w_2, \ldots, w_n$ are the weights of $n$ elements $A_1$, $A_2$, …, $A_n$. The problem then lies in the assignment of numerical weights $w_1, w_2, \ldots, w_n$ to $n$ elements $c_1, c_2, \ldots, c_n$ that reflect the recoded judgements. If $A$ is a consistency matrix, then the relationship between weights $w_i$ and the judgments $a_{ij}$ is simply given by $w_i / w_j = a_{ij}$ (for $i, j = 1, 2, \ldots, n$), as shown by equation (1) below.

$$A = \begin{matrix} C_1 \\ C_2 \\ C_3 \\ \vdots \\ C_n \end{matrix} \begin{bmatrix} w_1/w_1 & w_1/w_2 & w_1/w_3 & \cdots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & w_2/w_3 & \cdots & w_2/w_n \\ w_3/w_1 & w_3/w_2 & w_3/w_3 & \cdots & w_3/w_n \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ w_n/w_1 & w_n/w_2 & w_n/w_3 & \cdots & w_n/w_n \end{bmatrix}. \quad (1)$$

The elements of matrix $A$ are multiplied by the weight vector ($x$), yielding $nx$; that is, $(A - nI)x = 0$, where $x = (w_1, w_2, \ldots, w_n)$ and $n$ is an eigenvalue. Given that $a_{ij}$ denotes the subjective judgment of decision-makers with regard to the comparison and appraisal between decision-making factors, with the actual value ($w_i/w_j$) having a certain degree of variation, $Ax = nx$ cannot be established. Therefore, Saaty [69] suggests the largest eigenvalue, $\lambda_{\max}$, as follows:

$$\lambda_{\max} = \sum_{j=1}^{n} a_{ij} w_j / w_i. \quad (2)$$

If $A$ is a consistency matrix, then eigenvector $X$ can be calculated using the following formula:

$$(A - \lambda_{\max} I) X = 0. \quad (3)$$

Here, $\lambda_{\max}$ of the reciprocal matrix $A$ is greater than or equal to $n$. Therefore, in consistent pairwise comparisons, $\lambda_{\max}$ is identical to $n$. Saaty [70] proposed the utilization consistency index (CI) and CR to verify the consistency of the comparison matrix. CI and random index (RI) are defined as follows:

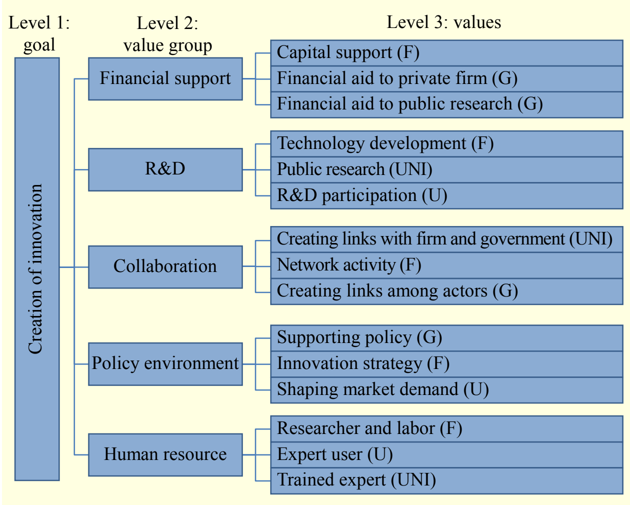


Fig. 1. Hierarchy for AHP modeling.

$$\mathrm{CI} = (\lambda_{\max} - n) / (n - 1), \quad (4)$$

$$\mathrm{CR} = (\mathrm{CI} / \mathrm{RI}) \times 100\%. \quad (5)$$

RI is the average consistency index derived from the inverse matrix created by the random establishment of a value between 1 and 9. RI represents the tolerance rate of consistency.

To achieve the highest-rated goal, the priority in each hierarchy must be derived through pairwise comparisons of each element of the hierarchy. Once this analysis is complete, an overall prioritization of the compound weight calculations and alternatives must be made. The integrated importance rate derived from this process becomes the rating-based points for alternatives subject to testing. It becomes critical during the finalization of priority ratings of different alternatives.

We chose Expert Choice 11, an AHP decision-making program, for the statistical analysis. Survey questions were divided into standard questions.

Figure 1 shows the structure of the AHP hierarchy. We chose the following five factor groups as Level 2 creation innovations: financial support, R&D, collaboration activities, supporting policy, and human resources. Innovations in the SM industry were generated from the sub-factors of Firm, Government, University, and User, and from a combination of these sub-factors. Level 3, in turn, consists of the sub-factors explained in Section III-2.

## V. Results

The priority analysis results of the high- and low-level questions and alternatives for the SM industry overall are illustrated in Table 3. For the hardware industry, the R&D factor group (0.266) appeared to have the largest weight,

Table 3. Weights of factor groups and factors.

| Value group | Value (actor) | Hardware industry | | | | Network industry | | | | Platform industry | | | | Content industry | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Weights of factor group (order) | Weights of factor | Weights of overall levels | Order | Weights of factor group (order) | Weights of factor | Weights of overall levels | Order | Weights of factor group (order) | Weights of factor | Weights of overall levels | Order | Weights of factor group (order) | Weights of factor | Weights of overall levels | Order |
| Financial support | Capital support (F) | 0.116 (5) | 0.221 | 0.025 | 15 | 0.194 (4) | 0.295 | 0.057 | 8 | 0.108 (5) | 0.363 | 0.039 | 11 | 0.187 (5) | 0.361 | 0.067 | 7 |
| | Financial aid to private firm (G) | | 0.505 | 0.059 | 9 | | 0.602 | 0.117 | 3 | | 0.361 | 0.039 | 13 | | 0.372 | 0.070 | 5 |
| | Financial aid to public research (G) | | 0.274 | 0.032 | 14 | | 0.103 | 0.020 | 15 | | 0.276 | 0.030 | 14 | | 0.267 | 0.050 | 13 |
| R&D | Technology development (F) | 0.266 (1) | 0.401 | 0.107 | 1 | 0.206 (2) | 0.601 | 0.124 | 1 | 0.252 (2) | 0.345 | 0.087 | 4 | 0.201 (3) | 0.343 | 0.069 | 6 |
| | Public research (UNI) | | 0.206 | 0.055 | 11 | | 0.206 | 0.042 | 12 | | 0.295 | 0.074 | 5 | | 0.285 | 0.057 | 12 |
| | R&D participation (U) | | 0.393 | 0.105 | 2 | | 0.193 | 0.040 | 13 | | 0.360 | 0.091 | 3 | | 0.372 | 0.075 | 3 |
| Collaboration activity | Creating links among actors (G) | 0.234 (2) | 0.301 | 0.070 | 6 | 0.230 (1) | 0.363 | 0.083 | 4 | 0.261 (1) | 0.267 | 0.070 | 7 | 0.211 (1) | 0.275 | 0.058 | 11 |
| | Network activity (F) | | 0.424 | 0.099 | 3 | | 0.534 | 0.123 | 2 | | 0.583 | 0.152 | 1 | | 0.572 | 0.121 | 1 |
| | Creating links with firms and governments (UNI) | | 0.275 | 0.064 | 8 | | 0.103 | 0.024 | 14 | | 0.150 | 0.039 | 12 | | 0.153 | 0.032 | 14 |
| Policy environment | Supporting policy (G) | 0.184 (4) | 0.279 | 0.051 | 12 | 0.200 (3) | 0.379 | 0.076 | 5 | 0.197 (3) | 0.320 | 0.064 | 8 | 0.193 (4) | 0.318 | 0.061 | 10 |
| | Innovation strategy (F) | | 0.477 | 0.088 | 4 | | 0.377 | 0.075 | 6 | | 0.322 | 0.063 | 9 | | 0.321 | 0.062 | 9 |
| | Shaping market demand (U) | | 0.244 | 0.045 | 13 | | 0.244 | 0.049 | 11 | | 0.358 | 0.071 | 6 | | 0.361 | 0.070 | 4 |
| Human resource | Researcher and labor (F) | 0.200 (3) | 0.374 | 0.075 | 5 | 0.170 (5) | 0.380 | 0.065 | 7 | 0.182 (4) | 0.160 | 0.029 | 15 | 0.208 (2) | 0.152 | 0.031 | 15 |
| | Expert users (U) | | 0.336 | 0.067 | 7 | | 0.325 | 0.055 | 9 | | 0.530 | 0.096 | 2 | | 0.537 | 0.112 | 2 |
| | Trained expert (UNI) | | 0.290 | 0.058 | 10 | | 0.295 | 0.050 | 10 | | 0.310 | 0.056 | 10 | | 0.311 | 0.065 | 8 |

followed by Collaboration activity (0.234), Human resources (0.200), Policy environment (0.184), and Financial support (0.116). When we analyzed the network industry, we found that Collaboration activity (0.230) was superior. The weightings of R&D (0.206), Policy environment (0.200), Financial support (0.194), and Human resources (0.170) followed, in that order. In the platform industry, we noted that the Collaboration activity factor group (0.261) is the most important, followed by R&D (0.252), Policy environment (0.197), and Human resources (0.182). Finally, the differences in the weights between the factor groups were small in the content industry (Collaboration activity (0.211), Human


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resources (0.208), R&D (0.201), Policy environment (0.193), and Financial support (0.187)).

Overall, it is noteworthy that Collaboration activity appeared to be the most important factor group for innovation for the network, platform, and content industries. The weight of Collaboration activity in the hardware industry was high as well, although it was lower than that of R&D. This result appears to be a reflection of the "open innovation" characteristic of the SM industry. This result demonstrates that the SM industry cannot survive alone. It must evolve by the formation of constellations based on the collaboration of different factors. In the low-level categories, "Network activity" showed high weights in all industries (highest in the platform and content industries), whereas "Creating links with firms and governments" showed a low weight.

The R&D factor group also showed a high weight (highest in the Hardware industry and second highest in the network and platform industries). However, the R&D factor group was third highest in the content industry, indicating that R&D is considered to be less important, while the weight of the "Public research" factor was low in all industries (eleventh place in the hardware industry, twelfth place in the network industry, fifth place in the platform industry, and twelfth place in the content industry). In addition, "R&D participation" ranked highly, except in the network industry (second highest in the hardware industry, third highest in the platform industry, and third highest in the content industry), meaning that R&D participation by users is very important in the SM industry.

In contrast, the financial support category showed significantly lower ranks in comparison with the other categories (fifth place in the hardware industry, fourth place in the network industry, fifth place in the platform industry, and fifth place in the content industry). Although a high level of financial support was the least important factor group for innovation, the low level of its sub-factor, "Financial aid to private firms," held the third and fifth rank in the network and content industries, respectively. This arose due to the characteristics of the network industry (requires a high level of initial investment) and the content industry (consists of small and medium-sized enterprises).

In the Human resources factor group, it is noteworthy that "Researchers and labor" showed a high weight in the hardware and network industries, whereas "Expert users" held second place in the platform and content industries. One can see this pattern in other factor groups as well. In the Policy environment factor group, "Innovation strategy" was more important in the hardware and network industries, whereas "Shaping market demand" was preferred as a critical factor for the promotion and growth of the platform and content industries. Additionally, in the R&D factor group, the weights of "Technology development" in the platform and content industries were lower than those of the hardware and network industries. That is, the platform and content industries prefer to forecast market demand using expert users rather than to develop new technologies and to apply them to products.

## VI. Summary and Concluding Remarks

In this study, we introduced and evaluated an innovation system that reflects the characteristics of the SM industry. As a result, the network, platform, and content industries appeared to have the greatest preference for "Collaborative activities" at Level 2, and the R&D factor group showed a high weight (highest in the hardware industry; second highest in the network and platform industries). In particular, a user's "R&D participation" was ranked second highest in the hardware industry and third highest in the platform and content industries — showing that a user's role in R&D is crucial for the creation of innovation. In the human resources factor group, "Researchers and labor" showed a high weight in the hardware and network industries, whereas "Expert users" held second place in the platform and content industries. 'Shaping market demand" was preferred as a critical factor for innovation, whereas the weight of "Technology development" was low in both the platform and the content industry. In governmental factors, the "Financial aid to private firms" showed a high weight in both the network and the content industry. In addition, "Supporting policy" was derived as a crucial factor for the creation of innovation in the network and platform industries. "Creating links among actors" holds a high rank in the hardware, network, and platform industries.

Based on the results of our analysis, we derived the following academic and practical implications. First, to promote innovation, the SM industry must ensure its continuous evolution into an open innovation ecosystem with the creation of factor constellations based on collaboration activity between innovation actors. "Collaboration activity" appeared to be the most important factor for innovation in the network, platform, and content industries, and the second most important factor in the hardware industry. As argued by Chesbrough [62], collaboration activity can inspire the introduction of external ideas and technologies that may create a variety of sources of innovation. These sources can accelerate internal innovation. The resulting innovation performance can then be commercialized to external sources. This may cause an increase in innovation and secondary benefits, as well as leading to the self-enrichment of innovation values.

Second, to support innovation in the SM industry, one must consider the *user* to be a producer who actively generates innovation. Our survey results showed that user-related factors were ranked second highest (after firm-related factors) in importance to innovation in the SM industry. This result demonstrates the growing importance of the role of the user in the SM industry [8]. It shows the need to transcend the traditional concept of the user as a consumer who purchases and consumes products. Governments, firms, and universities need to adopt a flexible stance toward users, considering them as innovation participants who play a key role in innovation.

Third, there exist significant differing viewpoints in the administrative supporting policies for different industries. Therefore, the government needs to play a responsible role to suit individual industry characteristics and needs.

This paper has the following limitations. In our research, we did not cover certain types of innovation, such as marketing innovation and process innovation. These types of innovation should be analyzed on the basis of factors and factor groups that induce innovation. We believe that doing so would be beneficial to show the different combinations of factors/factor groups that can induce innovation as deduced from different types of innovation. In addition, there should have been more innovation factors/factor groups that affect the creation of innovation, even though we derived the structure with extensive literature reviews.

With the application of the guidelines proposed here for innovation network management, we hope innovative concepts in the SM industry can make continuous progress with increased cooperation in an open innovation ecosystem.

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**Eungdo Kim** received his BS degree in information technology from York University, Toronto, Canada, in 2006 and his PhD degree in technology management from the Technology Management, Economics and Policy Program, Seoul National University, Rep. of Korea, in 2012. He is now an invited professor at the Graduate School of Health Science Business Convergence, Chungbuk National University, Cheongju, Rep. of Korea. His main research interests are science and technology policy; R&D management; and technology commercialization in the field of information communication technology and health industry.

**Daeho Lee** received his BS degree in electrical engineering from the School of Electrical Engineering, Seoul National University, Rep. of Korea, in 2001 and his PhD degree in economics from the Technology Management, Economics and Policy Program, Seoul National University, in 2011. He is now an assistant professor at the Department of Interaction Science, Sungkyunkwan University, Suwon, Rep. of Korea. His main research interests are telecommunications policy and Internet of Things.

**Kheesu Bae** received his BS and MS degrees in business management from Chungbuk National University, Cheongju and from Hanyang University, Seoul, Rep. of Korea, in 1997 and 1999, respectively. He then went on to receive his PhD degree in business management from Hanyang University, in 2004. Since then, he has been with the School of Business, Chungbuk National University. His main research interests are financial accounting contents and accounting information systems.

**Myunghwan Rim** received his PhD degree in economics from Hanyang University, Seoul, Rep. of Korea, in 2005. He has been with the Electronics and Telecommunications Research Institute, Daejeon, Rep. of Korea, after graduating from Hanyang Graduate School, since 1989. He has carried out techno-economic analysis projects related to information technology for 25 years. Between 1994 and 1996, he worked as a head of the R&D planning section at the Institute of Information Technology Assessment. He also worked as a visiting scholar at Stanford University, CA, USA, in 2006. He has published over 60 papers and reports about economic effects and technology strategies. His main research interests are technology policy; R&D management; and engineering economics in the fields of telecommunications, RFID/USN, digital content, and media.


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