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RESEARCH ON NEW TECHNOLOGY INNOVATION MODEL- APPLIED 3D PRINTING INDUSTRY BUSINESS ECOLOGY

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Abstract

Public interest in 3D printing as the next-generation technology is increasing and the potential and market size of the technology's convergence industry are increasing accordingly. This presents an opportunity to focus on the positive effects of 3D printing technology, which is also emerging as a manufacturing innovation and to discuss its market entry and development from an industry ecological perspective. To this end, this study analyzes the application value of3D printing technology as a value chain and business model. The study uses the innovative Betz (2011) model of the introduction of new technology to propose an ecological model that can be used for a convergence industry. The 3D printing industry was categorized into three main domains—industry convergence, industry support, and industry control—and the characteristics of each domain were defined. This study's analysis is based on a case of an R&D project carried out with government funding to solve the copyright problem in the 3D printing industry.

Keywords: Digital 3D Printer, 3D Printing Industry, Business Ecosystem, Managing, Technological Innovation.

1.Introduction

After US President Obama called 3D printing technology a "manufacturing industrial revolution" in 2013, the 3D printing industry became America's next innovation manufacturing industry, in the wake of the emergence of the green energy sector (Park, 2014). Major countries outside the US, such as the UK, are investing 3D printing technology. The 3D printing market is growing rapidly, with 3D printers now being bought by households. However, the new technology has limitations that are impeding qualitative growth and convergence with conventional industries. Several comprehensive and systematic government support strategies are required:

1. As 3D printers have turned a supplier-centered manufacturing process into a consumer-centered one, there is a need to establish a business ecology that focuses on organic relationship-building among suppliers, consumers and many other stakeholders.

2. 2. As the service market that enables increased 3D printer technology accessibility is expected to grow, many issues formerly limited to the 3D printer and printing-related industry must be solved. Issues such as legal regulations and the protection of intellectual property rights, duplication and certification require solutions urgently.

3. In short, 3D printing technology, in which digital content created through CAD serve as original sources, can achieve industrial vitalization when it produces comprehensive service innovation, including industrial and systematic support within the business

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ecology.

Therefore, this study analyzes the characteristics and application values of 3D printing technology as a conventional value chain and business model process and suggests an ecological cycle model to enable the technology's use as a convergence industry. This study is based on the case of Managerial Technology Development and Digital Contents Security of 3D Printing Based on Micro Licensing Technology, an R&D project carried out with government funding aimed at resolving copyright issues in the 3D printing industry.

2. Advanced Research

Business Ecology Theory

Current 3D printing technology is considered innovative and capable of changing the conventional industrial system by replacing conventional manufacturing systems. Such an influential technology has potential value as a convergence industry. It requires understanding the system by examining the influencing relationships among external and internal factors. The best way to analyze the structure of the commercialization of a new technology and seek ways to vitalize it is through business ecology theory, which has been in the spotlight recently, rather than strategic network theory or the value chain model, which deal with conventional market and industry structures.

Business ecology, a concept first introduced by Moore (1993), denotes an organism in the business world and an economic community consisting of interactive organizations that provide value to members/customers (Kim, 2012; Park & Park, 2014). Iansiti and Levien (2004) describe e-business ecology as a loose network of corporations (e.g., suppliers, retailers, outsourcing firms, related product manufacturers, technology providers) that affect the creation and provision of value to firms and those affected by them (Kim, 2012; Park & Park, 2014).

Service Innovation According to New Technology Introduction

Betz (2011) uses the innovation process seen in Figure 1 to explain the industry or business operation process and the introduction of new technology. Betz (2011) argues that a technology or market can grow when the technology and economic aspects are closely linked. It is also argued that service innovation is possible when a technology attains economic feasibility (Lim, 2014). It is argued that technology is finally settled as an industry in the market, not through simple technology settlement, but when the technology introduction and structure enable customers to gain utility value, during which process service innovation must also take place (Betz, 2011).

Betz (2011) suggests the model of business operations seen in Figure 1, based on the value chain of Porter (1985) and the industrial dynamics theory of Forrester (1961). Production and sales, in the middle, constitute the basic pillars connecting the supplier and customer

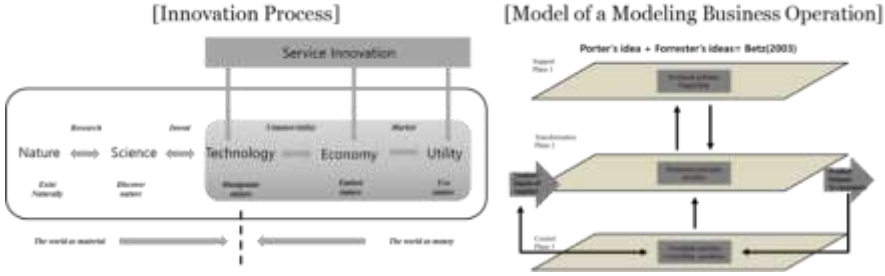

Figure 1: Innovation Process & Model of a Modeling Business Operation (Betz, 2011)

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through purchasing, production, inventory, and sales within the conventional industrial value chain. Combining the research on the behavior of industrial systems found in the industrial dynamics theory (Forrester, 1961), the domain of control and support that affects the industry's central pillar highlights the feedback structure needed to vitalize each industry.

Figure 2: Development Framework of Business Ecosystem

3D Printing Ecology Model Development Framework

As the research indicates, the model suggested by Betz (2011) is the only schematized research that explains individual industry and business operation processes during the introduction of new technology like 3D printing technology. This study examines both the 3D printing industry as a manufacturing industry and 3D printers and printing technology as a means of creating a convergence product. It thus analyzes 3D printing technology through the value chain process and using cases of printing output marketing within the business process. Accordingly, the study employs the framework shown in Figure 2 using the model laid out by Betz (2011) to suggest an integrated 3D printing industry ecology model of 3D printers and printing technology. The model is described below:

1. **Value Chain:** Analyzing business ecology requires defining its scope (Iansiti & Levien, 2004).The best way to do this is to use the value chain model, which helps reveal the linkages among the major agents (Thomas, 2008). The value chain is the linkage throughout a series of operations, functions, and processes directly or indirectly related to creating added value while corporations provide value to customers (Park, 2005).It is a two-way system in that a change in one operation affects the value and cost of the others (Kaplinsky & Morris, 2001).

2. **Business Process Analysis:** When the scope of the ecology has been defined through the value chain, specifying the business ecology becomes possible by determining the agents that provide the value and the business processes they are involved in. Previous industrial systems had distinct business boundaries, as each role was fixed, and were focused on a single industry. Creating added value by creating quality goods or services through new technologies like 3D printing has now become more common. Therefore, there is a need to establish a business process consisting of a series of operations that create customer value centering on the core business area that creates value within the diverse operations of the business ecology (Park & Park, 2014).

3. **Domain Definition:** Classifying the ecology into several business domains is the most useful way to schematize the complex business ecology model (Iansiti & Levien, 2004; Baghbadorani & Harandi, 2012).

3. 3D Printing Industry Business Ecology Model

Value Chain of 3D Printing Technology

According to Lim (2014), 3D printers cannot provide final value via the development of equipment or the technology alone. It can provide output of value only through convergence

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with related industries. Before examining how 3D printers operate through the value chain, this paper applies the Betz (2011) innovation modelto classify the three stages of input, process, and output.

In the 3D printing industry, going to the next stage involves switching from output to input; for the final output to have value, it needs to undergo standardization with the products that have already gone through the production and certification stages. Only then canconvergence output become a product with actual exchange value in the market and be priced accordingly. Figure 3 shows the value chain of the input, process, and output stages for 3D printers.

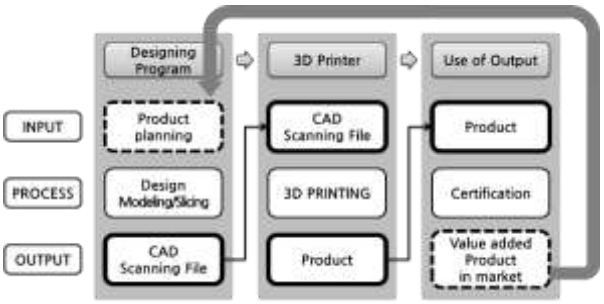

Figure 3: Value Chain in 3D Printing Process (refer to Lim, 2014)

3D Printing Technology Business Process

We have looked at the value chain process for 3D printing output prior to market introduction. The convergence industry output must prove its product value within the retail process of the manufacturing market. Figure 4 illustrates the business process of the printed output by stage:

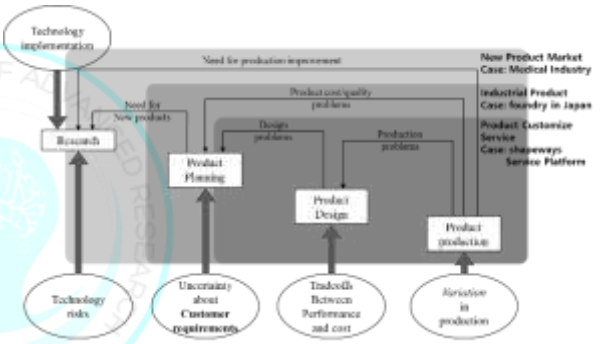

Figure 4: Business Process in 3D Printing Process (refer to Betz, 2011)

1. **Product Customize Service:** In the 3D printing output business, consumer-tailored product services can be most easily predicted. People can implement all kinds of designs using CAD through 3D printers. Shapeways in the US is a new platform that prints products using 3D printers without having to worry about inventory; this is a new business model that enables the easy duplication and retail of the general public's ideas. As a platform for product design, however, it must first resolve many problems, such as the rights to creators' ideas, the issue of duplication, product stability and certification, before 3D printing output can be retailed as merit goods.
2. **Industrial Product**: The business model that can be created through convergence with the conventional manufacturing industry highlights the importance of product price and quality. When considering the added value of individualized production beyond automation in terms of product planning and supply and demand, the benefits of advanced 3D printing technology outweigh those of conventional manufacturing using conveyer belts.
3. **New Product Market**: The medical industry is an example of a business model that can bring about innovation by producing an entirely new output; this is different from the two abovementioned cases. Prior research on and development of the output of 3D printers is important, and research on the usability and safety of the output must be conducted.

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4.Definition of 3D Printing Technology Domain

We have analyzed the business model through the final outputs and value chain of 3D printing technology, as 3D printer technology and printing output cannot be fully understood through the value chains of existing industries. We also found that, for the output to build a business model within the market in an integrated way, an environment in which added value can be created in the linkage relationship among diverse industries is needed. This paper thus suggests an ecosystem model that integrates the technological aspect (3D printer industry) and convergence aspect of the 3D industry. The application of this model to the 3D printing industry is shown in Figure 5. The characteristics and specific businesses of each domain in the 3D printing industry are as follows:

1. **Convergence Domain:** The industry convergence domain is the area of transformation domain suggested by Betz (2011) and consists of the conventional value chain processes of production and product sales through input–process–output. The 3D printing industry is a

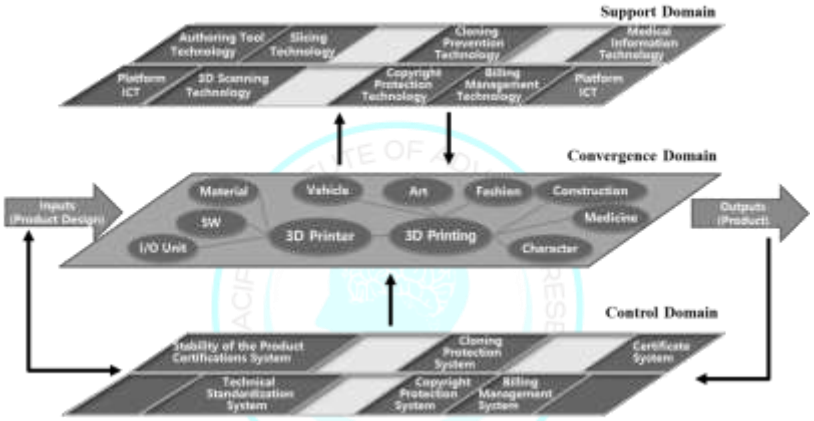

Figure 5: Modeling Ecosystem in 3D Printing Industry

convergence industry that can create output through convergence with other industries within is domain. This paper, thus, expands this particular convergence domainand explains it indepth.

The 3D printing industry is not a single industry but can be expanded into a convergence industry that can create added value through convergence between multiple industries. The output of service innovation created through the convergence between the 3D printing industry and other industries within the industry convergence domain is anticipated to be greater than what is being predicted. According to the Wholers' Report (2015), the representative industries being integrated with the 3D printing industry include the medical, automobile, construction, fashion, and design industries. In these areas, products are expanding their scope via convergence with the 3D printing industry, and issues concerning material development and printing technology advances for increasing product quality, as well as systematic support ranging from product quality certification to copyright, will need to be solved (Wholers Report, 2015).

4. **Support Domain**: The industry support domain supporting the industry convergence domain comprises all the indirect and additional support needed to achieve a certain goal,

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including relevant IT and software development and R&D.

Because CAD files are used for input in computers, non-professional access to conventional CAD programs is increasing. Other software programs are also being developed. Meanwhile, other authoring tools for use as 3D printer sources such 3D scanners and filming equipment are also being developed. In each industry, systems that can be linked with existing 3D printers are being developed through private R&D. The development of such support systems can lead to innovation in production and retail while simultaneously expanding the scope of the convergence industry through 3D printers and establish the grounds for the vitalization of the industry as well. When the consumer perspective is highlighted and the demand for individual idea products increases, such cases will increase, and the development of related technology should be much more crucial.

3. **Control Domain:** Including the systematic tools needed for the development of 3D printing industry together with the initial technology introduction, the industry control domain consists of the important factors in the external environment of the 3D printing industry, establishing the industry ecology.
Since 3D printers can realize users' ideas, external control and management of copyright protection and duplication prevention are required (Chung & Park, 2015). Moreover, when an idea is considered a single sales unit, the payment system needs protection and management (Yoon, 2015). The stability of the products is guaranteed by the technology standardization and stability of the printer manufacturing process and the verification of the stability of the materials being used. Since Korea is in the process of adopting a standardized system, product technology standardization and stability verification are very important (Ministry of Science, ICT, and Future Planning, 2014).

Conclusion and Implications

In analyzing the application value and characteristics of 3D printing technology based on an understanding of the market introduction of new technology, this study suggests ecological models of the 3D printing technology value chain, product business process, and 3D printer and printing industry in order to analyze the 3D printing industry from the ecological perspective.

Although the need of an ecological perspective in accordance with the convergence environment has been discussed (Kim, 2012; Park & Park, 2014), few studies have examined the related stakeholders from an ecological viewpoint or identified their relationships (Moore, 1993, 1996; Iansiti & Levien, 2004).
Unlike conventional technologies, 3D printing has more value when it creates a convergence with other industries than it has on its own. It is thus essential that the industrial characteristics of the 3D printer affect other industries organically. The value chain, a basic industry analysis model, was combined with the analysis model for the industry system to categorize the three domains of industry convergence, industry support, and industry control.

Of course, this study is limited in examining industrial ecology through a single model; a more detailed analysis on the relationship among all micro-stakeholders within the industry is essential. However, the study is significant in its proposal of an ecological model of 3D printer technology, which is radically changing the conventional industry through the service innovation model via the introduction of new technology. These research results will enable

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more detailed individual research on specific domains (e.g., convergence-support-control) and on each domain as a convergence area. Moreover, we hope that more research on the platform, which is central to the business ecology model, becomes available to enable more comprehensive and analytical research on the 3D printing industry ecology.

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