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Research on Growth Mechanism of Platform Ecosystem

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Abstract

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The smart-revolution restructured the previous industrial organization and started the new ICT ecosystem, which consists of four layers: content, platform, network, and device (represented by the acronym C-P-N-D). Recently, platform providers (PPs) have been increasing their value by being the intermediary between content providers (CPs) and users. However, as the platform ecosystem grows in size, the likelihood of unfair contracting between PPs and CPs may increase. This sudden growth of the platform ecosystem may cause problems of platform openness. In addition, giant platforms may cause CPs to seek only short-term profits by discouraging them from retaining their uniqueness. This problem is further amplified by the users when they stop exploring for specific content or information that they want. The negative feedback caused by the phenomena could greatly reduce content diversity and limit the users' choice of content. Finally, the lack of idea pools would hinder CPs from coming out with creative content, which is the energy for sustaining the growth of a platform ecosystem. Most studies hitherto have focused on individual actor's strategy, but little effort has been put into trying to understand the growth mechanism of the platform ecosystem and the role that PPs play in platform openness, especially with regard to diversity and creativity of CPs. This dissertation aims to find the mechanism of sustainable growth of a platform

ecosystem and suggest the framework for platform ecosystem dynamics by examining three studies used to theoretically and empirically verify the hypotheses introduced in this dissertation.

Chapter 3 focused on the relationship between platform openness and productivity of CPs using stochastic frontier analysis and meta-frontier analysis. By comparing two representative open and closed platform ecosystems, the analysis helped to figured out how platform openness, as the degree of strictness in content selection, influences the productivity of CPs. The results indicate that the closed platform ecosystem achieves a higher average efficiency within the ecosystem than the open platform; however, the open platform achieves a higher efficiency than the closed platform in terms of meta-frontier. This means that platform openness may help CPs achieve higher efficiency in the long run.

Chapter 4 focused on the influence of giant platforms on content diversity and how the study found the evolutionary mechanism of platform ecosystems by using a simulation. The major findings are as follows. First, the users' active will to find alternative sources of content may aid in the recovery of decreased content diversity. Second, the ratio of CPs that retain their uniqueness of content to all CPs is positively correlated with internal diversity. When consumers start actively trying to find their hidden needs by diversifying their source of information, CPs may also try harder to meet the users' hidden needs by retaining their uniqueness. Third, high content diversity influences the increasing peak point of average performance of the whole platform ecosystem. In other words, content diversity is the source of creativity, which is an important factor for a platform ecosystem to grow sustainably.

Chapter 5 focused on the co-evolution and evolutionary trajectory of a platform ecosystem. The analysis was conducted by drawing a map of the platform ecosystem network based on consumer preference in Korea from 2010 to 2013. By considering the characteristics of each year's network topology and analyzing the changing trends of each node's centralities, network evolution can be understood. The result of the experiments supported a conclusion that the platform ecosystem evolved from PP and CPs' effort to adopt the shaken technological environment and users' selection. In addition, each user had not only formed a distinctive media repertoire, but the media repertories also contained a great deal of similarities as well. These similar repertories can be grouped

into several communities. Therefore, in order to create value in the platform ecosystem, PP, CPs, and even users need to cooperate with each other.

Through three studies, this thesis suggests the sustainable growth mechanism of a platform ecosystem. As a platform opens the selection process, internal content diversity can be maintained and enable CPs to achieve long-term efficiency. Internal content diversity raises the probability of creating innovation which could meet the consumer's hidden needs, thereby providing energy to the whole ecosystem. In addition, openness of a platform influences the CPs' will to retain uniqueness of content indirectly and this willingness increases content diversity. Also the users' will may increase the diversity of their source of information, and their repertoire plays a significant role in increasing internal content diversity. All of these processes are interdependent among the PPs, CPs, and users. Therefore, to achieve sustainable growth of a platform ecosystem, we need a holistic view of promoting the actors' will and creating an environment where the value of creativity is appreciated.

This thesis gives several managerial and policy implications. First, PPs should open their platforms technologically and compatibly. The selection process of CPs has driven long-term efficiency of their ecosystem. Second, content and application service providers need to focus on retaining their own uniqueness and increase their market power from the initial phase. Governments should also encourage CPs to create new content, which is the energy of growing a platform ecosystem by creating a failure-friendly atmosphere. This thesis proposes a new theory of the platform ecosystem dynamics academically and provides the philosophical base of public policy and strategy of firms by understanding the value of creativity and diversity for sustainable growth of the platform ecosystem.

Keywords: platform ecosystem, co-evolution, platform openness, economic efficiency, content diversity, content creativity, meta-frontier, genetic-algorithm, network-analysis

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Contents

List of Tables

List of Figures

Chapter 1. Introduction

1.1 Research Background

The nature of ICT is different from other technologies; it locks consumers to a specific technology and creates a strong network effect in the ICT industry (Heinrich, 2014). This characteristic enables an emerging technology to create new standards through the changes of the technological landscape. For instance, when Apple Inc. (referred to as Apple in this dissertation) created the iPhone 3G, it was considered the start of the smart-era. The creation of the iPhone restructured the industrial organization and gave rise to the new ICT ecosystem. The ICT ecosystem consists of four layers represented by the acronym C-P-N-D: content, platform, network, and device. Apple's strategy was to create value and maximize it by positioning the company's devices in the center of the new ICT ecosystem (Tiwana, Konsynski, & Bush, 2010). Apple was able to capitalize on this strategy by focusing mainly on centralizing the value at the platform layer (Kenney & Pon, 2011).

However, the evolution of ICT does not follow the traditional path dependence and platform literature (Kenney & Pon, 2011). Platforms of various forms are emerging and re-shaping the ecosystems of older operating system (OS)-centered platforms of the mobile technology. In the platform ecosystem, the participants are able to separate themselves from the existing ecosystem to form their own ecosystem. Platforms based on

social network services (SNS) such as Facebook, LinkedIn, and Daum Kakao[1] are well-known examples of new platforms that can operate independent of other existing platforms.

On the demand side, the platform ecosystem has significantly changed the way users acquire content. Users can conveniently access a vast array of content from any location at any time. Contents are uploaded to their personal smart devices via a platform such as an internet site. The platforms recommend content that fit the users' needs and thus minimizes the effort required for users to search for content. The change in the way platforms distribute content allows users to choose from a variety of media (platforms) and content (information) for their own repertoire. In addition, users also act as co-creators of value in the platform ecosystem and not only as consumers (Van Dijck, 2009). Several innovations resulting from new combinations of platform and content are being adopted by users. Some of these innovations add value to the users on the demand side. As innovation and adoption cycles progress, platform ecosystem continues to coevolve with content.

[1] Kakao is a leading instant messaging service application provider in Korea. It also started various services adding to its existing network capacity and differentiated its position against the traditional mobile OS platforms.

1.2 Problem Description

As the platform ecosystem grows in size, the likelihood of unfair contracting between platform providers and content providers may increase. Platform providers, playing the role of the gate-keeper, could abuse their market power by having total control of the platform gate (Ballon & Van Heesvelde, 2011; Hargittai, 2000a), the only way for users to connect with content providers. Another problem in the platform ecosystem is that many small or medium-sized content providers tend to seek short-term profits, leading them to focus mainly on increasing the number of clicks to maintain business. As a result, retaining content uniqueness in the ecosystem is an issue because many content providers resort to imitating more successful content (Doyle, 2013). These problems have an adverse effect on the demand side; users become discouraged from searching for specific content or information because of the difficulty of finding better content with better quality than the ones recommended by a platform (Hargittai, 2004). This can potentially lead to more serious problems because the information or content on the platform is highly related to the user's life. Negative circulation of platform ecosystem will inevitably decreased content diversity (Napoli, 2011b), thus limiting users from being able to freely choose content for their repertoire. In the future, content creativity may become decreased, and sustainable growth of platform ecosystems may become more challenging.

Scholars have been studying the platform ecosystem by using theoretical lenses. The main stream of their research is to develop a strategy to achieve platform leadership (For

example, see Cusumano, 2010; Cusumano & Gawer, 2002; Zhu and Iansiti, 2012). Scholars have also conducted research on the demand side to identify the causes of consumer migration platform to platform in a competitive environment (Xu, Venkatesh, Tam, and Hong, 2010), to find ways to grow the content industry by regulating platform providers (Ballon and Van Heesvelde, 2011; Feijoo, Gómez-Barroso, Aguado, and Ramos, 2012), to find factors of a platform that are more recognized by developers (Hilkert, Benlian, and Hess, 2011b; Holzer and Ondrus, 2011), to develop ways to visualize the platform ecosystem network (Basole, 2009), and write literature reviews and introduce new theoretical lenses (Tiwana et al., 2010). However, little effort is needed to understand the growth mechanism of the platform ecosystem on a holistic view with regard to the role of platform openness, content diversity, and creative content. Even if all of the studies up to this point have the perspective of an ecosystem, they could not be used to develop a platform strategy that fosters sustainability and contains the principles of creativity and diversity, which is the nature of platform ecosystem.

1.3 Research Objectives

The purpose of this study is to find the mechanism of a platform ecosystem dynamics for sustainable growth and suggest a strategy for each actor: platform providers (PPs), content providers (CPs), government, and users. To find the growth mechanism of a platform ecosystem and suggest implications, three studies are used to verify the hypotheses with empirical analyses.

1.4 The Growth Mechanism of Platform Ecosystem

This dissertation proposes the growth mechanism of a platform ecosystem. For sustainable growth, a platform ecosystem needs a constant flow of “energy”. The energy in this case is the creative content that enables CPs to supply the new demand from the consumers (Kristensson, Magnusson, & Matthing, 2002). Innovation through combining ideas from the past is able to unbalance the equilibrium and fuel capitalism (Schumpeter, 1934; Yusuf, 2009). Likewise, without an effort in attempting to explore the consumers’ hidden needs, the platform ecosystem will be difficult to grow. One way to promote creativity, which enables CPs to explore the hidden needs, is by securing diverse pools of ideas even if this can take a long period of time (Page, 2008).

Three external forces provide a way to maintain content diversity. First, PPs need to be willing to open their platform technology to content providers. Openness of platforms provides CPs with favorable conditions to create unique content, which also leads to diversity in the platform ecosystem (Hilkert, Benlian, & Hess, 2011b). Second, CPs also need to be willing to retain the uniqueness of their content. If CPs focused mainly on building their business with PPs by getting the attention of the users, most CPs would end up being similar to each other, and content diversity would erode. Finally, the user’s willingness to diversify the source of content is needed to maintain content diversity.

Furthermore, the respective roles of the three actors of a platform ecosystem are closely interconnected. For example, if users have access to a diverse array of content but only through one platform, there would be no incentive to search for other unique content.

However, if many CPs provided high quality content through various platforms, users would be more inclined to use these other platforms. Therefore, retaining the uniqueness of content is needed to stimulate the will of the users. PPs, CPs, and users are all affected by one another, and this dynamic helps the platform ecosystem continue in its evolution.

In order to obtain sustainable growth of a platform ecosystem, first, the platform needs to open the selection process. Opening the selection process will help to maintain the diversity of the internal content and enable CPs to achieve long-term efficiency. Second, internal content diversity raises the probability of creating something new, providing a stimulus (energy) to the whole ecosystem. In addition, platform openness indirectly influences the content providers' will to retain the uniqueness of the content, and this will increase content diversity even further. The users' will also plays a significant role in raising content diversity by diversifying the platforms. All of these processes are interdependent on each other. Figure 1.1 illustrates the growth mechanism of a platform ecosystem followed by the hypotheses related to each step of the framework.

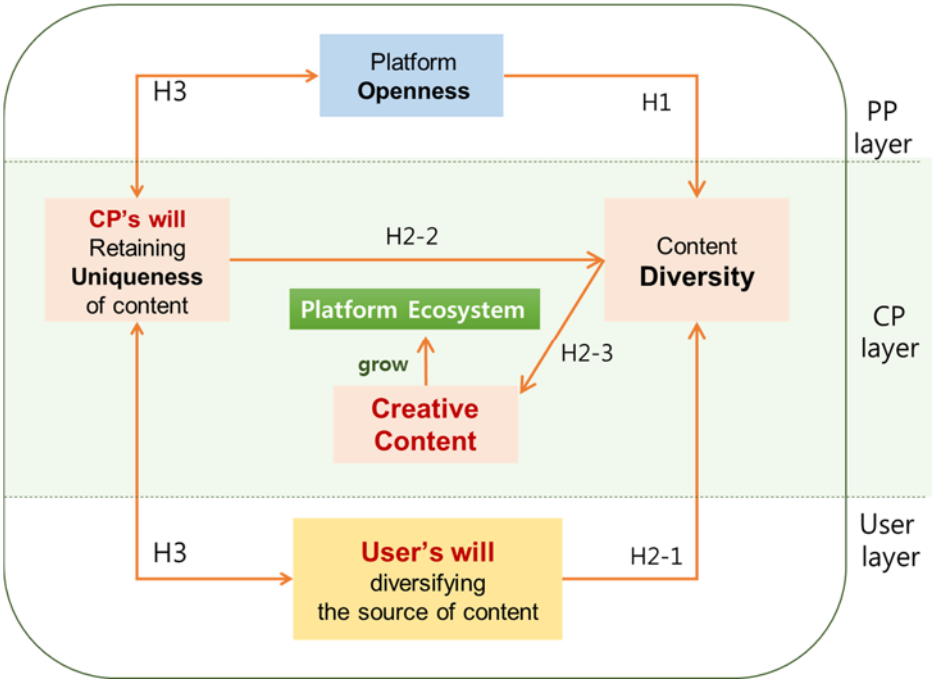


Figure 1.1 The framework of the growth mechanism of a platform ecosystem

Hypothesis 1. *Openness of platform is conducive for maintaining content diversity and content providers' long-term efficiency.*

Hypothesis 2-1. *The will of the user to diversify their source of information is important for revitalizing content diversity in the platform ecosystem.*

Hypothesis 2-2. *The will of the content providers to retain their uniqueness and not imitate indiscriminately also influences content diversity.*

Hypothesis 2-3. *Internal content diversity is the source of creativity and this provides energy to the whole platform ecosystem sustainability.*

Hypothesis 3. *Platform ecosystem co-evolves with PPs, CPs, and the users.*

1.5 Thesis Outline

This thesis consists of seven chapters with three essays. Chapter 1 introduces the dissertation, and Chapter 2 builds a theory on platform ecosystem by constructing the framework of a platform ecosystem and deducing the hypothesis based on the flow of related studies. Three essays confirm the hypotheses in Chapters 3, 4, and 5. Chapter 6 examines the results of the essays and discusses the policy implications. Lastly, Chapter 7 sums up the contents of this dissertation.

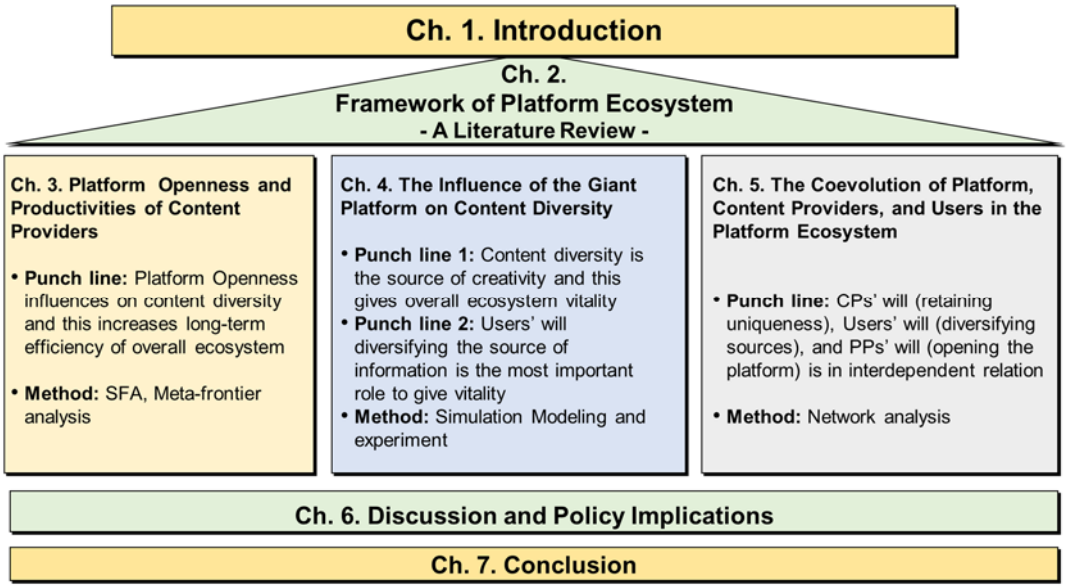


Figure 1.2 Thesis outline

1.6 Contributions

Firstly, this thesis makes contributions by suggesting a new theory of the platform ecosystem dynamics from an academic point of view. In addition, the thesis provides the philosophical base of public policy and strategy of firms by examining the main values for sustainable growth of a platform ecosystem. Secondly, it proposes strategic implications to each agent: PPs, CPs, government, and the users. These implications may be applied to future strategies of platforms with advanced technology, such as the Internet of things (IoT), to create new values in the new platform ecosystem.

Chapter 2. Theory of Platform Ecosystem: A Literature Review

2.1 Research Stream: From Traditional IO to Economics of an Ecosystem

Recently, regarding industrial dynamics as an ecosystem is becoming a trend. In the view of industrial organization, as technological complexity and interdependency between firms increase, firms have difficulty sustaining abnormal profits even with competitive advantage. It is difficult to explain why some firms fail even when they possess strong market power, good resources, and a good strategy. However, when this phenomenon is analyzed by looking at the industrial dynamics as an ecosystem, a better understanding of the dynamics can be obtained and used to make sound business decisions. Therefore, even if a firm has great market power, it should consider the sustainability of its ecosystem because all firms are closely interconnected through a feedback chain.

Many scholars cannot agree on how to explain the source of competitive advantage and abnormal profits. Several research flows exist on this subject, but this thesis reviews research stream from traditional industrial organization (IO) to the economics of an ecosystem. Through this review, this thesis aims to find the position which is the best fit for explaining the future ICT industry and propose the advantages and disadvantages of each theory.

2.1.1 Traditional Industrial Organization (IO)

In classical IO economics, a market of a product or a service is classified by one of the following structures: competitive market, monopoly, and oligopoly (Albarran, 2013). Each market structure has a unique characteristic and varies according to the type of competition. In other words, a firm's performance is dependent on the type of market structure that it is in. This is called the 'structure-conduct-performance (SCP) paradigm'. In the case of a competitive market, since there are no entry barriers for new entrants, anyone wanting to enter the market can participate in the market competition. However, when there is perfect competition, the state of the market is at equilibrium and the profits of all the firms equal zero. In contrast, in the case of a monopoly or oligopoly, incumbents set the entry barrier by utilizing their economies of scale[2]. This barrier protects their abnormal profit and price power from newcomers that enter the market.

However, competitive advantage in the view of SCP is possible in specific situations and market structures (Young, Smith, & Grimm, 1996). In addition, the strict assumption that all firms are homogeneous has limitations when used to explain competitive advantage of a specific firm's capability. Since the question 'why do some firms succeed compared to others?' cannot be answered by the SCP paradigm, other perspectives are needed which allows heterogeneity among the firms. Caves and Porter (1977) suggested the concept of 'mobility barrier' allowing the heterogeneity among the firms. According to this concept, a firm has its own strategic routine that is not changed easily. As time

[2] By increasing output, the burden of fixed cost is spread, setting a limit on price, which is difficult for newcomers to match, and this mechanism works as an entry barrier (Bain, 1954).

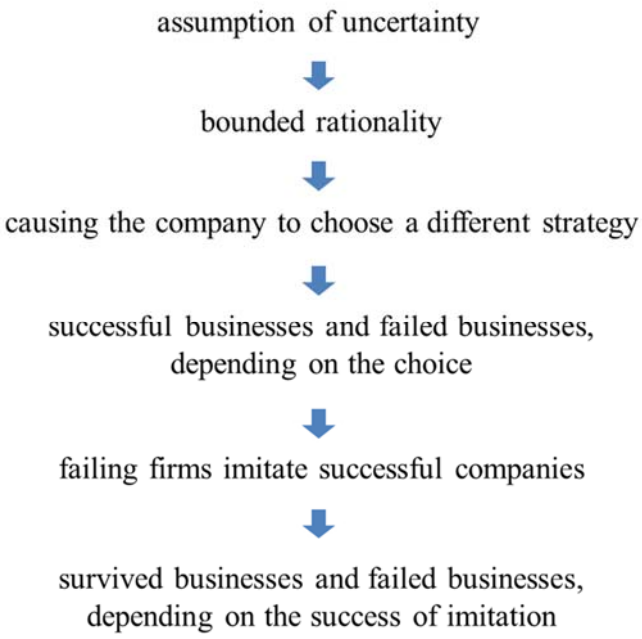
passes, a firm's capability has been accumulated, and this creates a 'mobility barrier' which hinders firms from other strategic groups from entering. However, this concept also has limitations because it assumes perfect rationality exists in the market.

2.1.2 Emerging of Evolutionary Economics

By casting a doubt about ‘rationality’, a fundamental assumption used in classical economics, a new theory of evolutionary economics was created. If all companies were rational thinkers and always made rational choices, profits in a competitive market would be highly accurate and flow with predictable static aspects. However, modeling from such an unrealistic assumption can eventually lead to erroneous implications or regulations in a rapidly changing technological environment. Sidney G. Winter, who was inspired by Armen A. Alchian, opposed the idea of omniscient rationality by suggesting ‘bounded rationality’ which is used to describe a market that is always uncertain. Bounded rationality suggests, since every firm has different qualities and quantities of information, a firm could make decisions based on only the individual firm’s benefit and not by using rationality.

According to Alchian (1950), who came up with the concept of evolutionary economics, ‘luck’, ‘adaptive behavior’, and ‘realized profit’ are the determinants of a firm’s success or failure under large uncertainty. Adaptive behavior is the behavior of choosing actions such as imitation, benchmarking other companies or innovation, and differentiating from other companies through continuous trial and error. Realized profit is the profit from commercialization of their technology or product in order to sustain a viable business. As it is difficult to accurately predict the change of the market environment due to uncertainties, the survival of a firm ultimately depends on luck. According to Winter (1971), who is developing a form of Alchian’s theory systemically,

the process of competition and survival of a firm is suggested in the following mechanism:



This process reflects the actual competition dynamics compared to static competition in classical economics. The area regarding selection and decision making should be considered in Winter's study of firm's heterogeneity. Firms are classified into five groups based on their earnings: profit, break-even, loss, zero plant, and potential entrant. These selective types of firms vary in decision making styles. Firms in the profit group will carry out aggressive R&D investment on existing technology based on their profit. Firms in the break-even group will also invest in older technology. In the loss group, however, firms will attempt to change their technology in search of new opportunities. This model shows how Alchian's model is different from that of Winter's because it includes the

aspect of continuing investment of successful firms as well as ‘luck’, the basic element of evolutionary economics.

2.1.3 Economics of Innovation

In 1978, Sidney G. Winter combined Schumpeter's theory with that of Richard R. Nelson into evolutionary economics. According to Nelson and Winter (1978), the phenomenon where most of the revenue is earned by a few concentrated companies can be explained by 'technological innovation' and not by 'economies of scale'. In other words, creative destruction is enabled by radical innovation under Schumpeterian competition. According to this theory, it is possible for a firm with a static entry barrier to rapidly lose its competitive advantage. This theory is very useful when scholars explain the recent rapidly changing ranks of large firms and the phenomenon of 'catch-up'. Therefore, if a firm does not initiate successive trials to innovate itself, its chances of survival in the market is greatly reduced. However, since 'winners' are more capable of investing aggressively in R&D in order to develop new technology, Nelson and Winter's theory suggests that positive feedback of winners called 'dynamic barrier' does exists. This is similar to the mechanism that follows the 'winner-takes-all' hypotheses in the world of increasing return to scale.

2.1.4 The World of Increasing Return to Scale

Until the early twentieth century, the relationship between market and business was explained by the principle of diminishing return to scale, a theory by Alfred Marshall. According to Marshall, a leading firm cannot produce all the products to meet the total demand, therefore the equilibrium price and market share can be predicted. The theory of diminishing returns had useful applications in an era when the product leading the market was one that relied highly on resource capacity and productivity rather than on technology. However, starting from the middle of the twentieth century, Marshall's theory of diminishing returns has become increasingly ineffective due to a shift in the market toward one that is highly dependent on a technology. A world of increasing returns, where a technology or a firm can seize the market and continue to lead it, has arrived.

Brian Arthur (1989) explained technological competition in the modern-day, high-tech industry using the principle of increasing return to scale. According to Arthur (1989), the increasing returns in a technological competition has three characteristics: impossibility of predicting the market due to uncertainty, possibility of a specific product to dominate the market, and the existence of a specific product with inferior technology. These characteristics are caused by high initial development cost, network effect, and inertia effect to the consumer. In the technological competition, getting more install base in the initial phase is an important strategy to sustain competitive advantage, and it can be impossible to predict which technology will dominate.

2.1.5 Economics of a Two-Sided Market

In 2000, Jean. M. Tirole, well-known for his contributions in regulatory economics, started to focus on the various individual markets such as telecom, energy, bank, and patent. With the help of his colleague Jean C. Rochet, Tirole suggested the concept of a two-sided market. Caillaud and Jullien (2001), Evans and Schmalensee (2008), and Armstrong (2006) are also important studies that followed the two-sided market economics.

Two-sided market is a concept that is used to study platforms that generate profit by promoting mediation between two different groups. For instance, Internet search engines such as Google or Naver are two-sided platforms that help consumers find content and CPs find consumers. By providing this type of service, the search engine provider can generate revenue from keyword advertisements. The two different markets on both sides create an indirect network effects, and both sides are inter-linked with each other which can create a feedback effect. In other words, a platform mediates the two-sided market internalizing the indirect network effect and transaction costs by creating positive feedback. The two-sided market is a concept that is widely being studied in economics and also used in many antitrust cases. In fact, the first academic paper to have been written on the two-sided market was motivated by the antitrust issues concerning credit card interchange fees (see William Baxter in 1983). However, it can be difficult to find clear principles on two-sided market analysis (not in the major flow of economics). This leads to the study of multi-sided platforms which can be applied to various situations and

provide unique insights to economists, policymakers, and businessmen.

How can a two-sided market be distinguished from a one-sided market? Although most markets seem to have the characteristics of a two-sided market with intermediaries in simple markets, some markets clearly exhibit the characteristics of a two-sided market when they have a high degree of network externality. In a two-sided market, markup (price minus cost) does not increase proportionally as the elasticity of demand and marginal cost increase, rather it is moved by the elasticity of demand on the other side of the market (Rysman, 2009). Therefore a PP has to consider the demand from each side of the platform, and the effect the demand of one side has on the other. For instance, at Amazon.com, there are two types of markets the company manages: one is a one-sided market where goods are bought at a whole sale price and sold at a retail, and the other is a two-sided market in the form of a platform making it possible for a great number of providers to suggest a retail price to their customers.

A literature on the two-sided market could be seen as a part of the literature on network effect. While the literature on network effect focuses on the adoption of innovation, mainly the determinants of optimal network size, the literature on a two-sided market focuses primarily on the actions of the intermediate, specifically on pricing and strategic openness. Although pricing is an important strategy for PPs, there are no standard rules to follow for achieving the social optimum. For example, consumers can obtain news content from an Internet platform without paying a fee. Consumers can also receive rewards when they use their credit cards through the platform. However, they pay

a fee for game content on a game console platform. A problem that can arise in a two-sided platform is that PPs can be viewed as a monopolist that applies price discrimination, or dynamic pricing. Openness is another issue for PPs. The issue is related to the number of sides a PPs allows CPs to participate in and whether or not to provide compatibility with other platforms.

Although these dedicated studies regarding two-sided market economics have been ongoing and provide useful insight to the study of the platform and industrial field, there are limitations when they are used to show a clear optimum point or for explaining unique cases. If it is possible to distort the market or to disregard the consumers' hidden needs through the market power of a giant platform, the phenomenon is unable to be shown through an economic model. To overcome the limitations and explain a new phenomenon holistically, economics in the view of an ecosystem has started emerging.

2.1.6 Economics in the View of Ecosystem

A perspective on economics that is emphasized often is economics viewed as an ecosystem, where there is symbiosis between entities. Entities that share finite resources and pursue coexistence rather than compete with one another can survive longer. According to Moore (1996), a representative scholar of business ecosystems, an ecosystem is described as a community sharing a common goal for survival and evolution. It can be compared to the relationship between the Earth (platform) and its living things (third parties). An ecological point of view is introduced because the concept of value creation has changed; all of the participants in the ecosystem (producers, platforms, government, and users) become co-creators of value and not one-way value from producer to consumer. This is especially true when users become more active when changing of their position from consumer to prosumer. In other words, when changing from a value chain to a value network, competition expands to fit the concept of co-evolution. This indicates that a perspective on economics can be limited when trying to explain an economic phenomenon without systemic thinking.

This is not the first time that a biological view for explaining social phenomenon was introduced. Systemic approach introduced by sociology is one representative case. This is the method of applying the various biological principles to see the organization as a living organism interacting with its environment. In the computer science field, Holland (1992) recognized that previous algorithms that looked for optimal solutions often gave erroneous solutions or remained a local optimal solution. Thus, he created a genetic

algorithm (GA) that mimics the mechanism of an organism evolving to adapt to an environment and found that GA had a more precise algorithm to reach a global optimal solution. In the field of physics, through the complex theory, which is used to analyze social phenomena by embracing the complexity of nature and focusing on macroscopic emergence, complex phenomena can be explained using a power law graph. Lastly, digital technology, which makes information technology more innovative, is similar to the way living organisms store their DNA. The code of life is preserved by four sequences in DNA: A (Adenine), G (Guanine), C (Cytosine), T (Thymine). Digitalization also follows these storage rules by using only two bits: 0 and 1. Due to the binary characteristic of digitalization, vast amounts of data and knowledge can be accumulated and retained. These similarities support the idea that digital technology can be derived from living organisms.

Fransman (2007) introduced the ecosystem layer model (ELM) in order to analyze the structure of the new ICT ecosystem which consists of content, platform, network, and device layer (C-P-N-D). The goal of ELM is to help analyze by sectors and figure out appropriate firm strategies and government policies. Unlike the previous models, ELM has the distinction that it conceptualizes the ICT ecosystem as a set of functionalities.

The advantages of economics in the view of an ecosystem are as follows. First, it enables an understanding of the interdependency and complex interactions in a system by conceptualizing the ICT sector as a system. Second, it is able to show the role of other actors when adjusting the actions in the system. Third, it helps to analyze firm

specialization and strategy. Fourth, it helps to analyze the power of a different evolution of the industrial structure formed in the different layers. Sixth, it also explains the role of certain core firms in an ICT ecosystem and the importance of the user's role.

2.2 The Growth Mechanism of Platform Ecosystem

In order to understand the growth mechanism of the platform ecosystem based on the previous literature stream from traditional industrial organizations to economics of ecosystems, this chapter will focus on the research flow regarding platform ecosystems, especially in the ICT ecosystem, and find the nature of content, the influence of platform openness on CPs, and user's role in the platform ecosystem.

2.2.1 Previous Research on Platform Ecosystem

The concept of the platform ecosystem varies depending on the industry perspective. For example, Gawer (2009) defines a platform as a building block which can be a product, a technology, or a service that is able to develop a complementary product, technology, or service upon the basis of other firms. On the other hand, Fransman (2011) defines a platform as a system supporting complementary economic activity and shaping symbiotic interactions. Some papers limit the term "platform" to a module that adds content or software (Tiwana et al., 2010); others consider a platform to be an ecosystem providing CPs with an environment (Cusumano & Gawer, 2002; Hilkert, Benlian, & Hess, 2011a). For example, Apple created an ecosystem that embraces all mobile value chains from the smartphone device to the OS and content, and Google's Android OS-based smartphone ecosystem incorporates many non-Apple smartphone device manufacturing companies and content providing companies. Apple's iPhone operating system (iOS) had over 1,300,000 applications as of September 2014; Google's Android OS had 1,466,565

applications as of January 2015. This data shows that each community can grow into a large ecosystem based on each mobile OS platform.

The main area of focus within the platform ecosystem research is “platform leadership” and the examples of platform leader firms, such as Amazon, Microsoft, Qualcomm, and Cisco. These companies are good examples to use to identify the strategic implications in the initial phase of this type of research. Cusumano (2010), who studied the beginnings of platform strategy, stresses the importance of the management of technology and business strategies of the leader firms in the platform business (See, Cusumano, 2010; Cusumano & Gawer, 2002). In order to understand the demand side of the market, research has been conducted by several authors to find out why consumers migrate to other platforms in a competitive platform environment. According to Xu, Venkatesh, Tam, and Hong (2010), technology awareness, external influences (friends, media, etc.), and complementarity are the main factors that affect consumers’ platform migration. Studies considering both supply and demand sides also exist, which mainly focus on the first mover advantage in a platform-based two-sided market. According to Zhu and Iansiti (2012), technologies and industries that have high network externality obtain a first mover advantage. On the contrary, if the quality of the technology is more important than network externality, new entrants obtain a portion of the market share.

Studies from the developer’s perspective also exist; these studies focus on the affects that platform policies have on third parties. Hilkert et al. (2011b) analyzed the platform ecosystem through surveys and interviews. In their research, they asked respondents how

they viewed the degree of platform openness and which environments enabled them to develop content and applications with ease. Developers recognize the openness of a platform in two different dimensions: technically open and open in the market. The study found that there are additional open factors that have yet to be identified. Holzer and Ondrus (2011) also clarify that the most important factor of the growth of an ecosystem is the comfort of developers when developing content and software, particularly in the mobile game industry. Feijoo, Gómez-Barroso, Aguado, and Ramos (2012) suggest the policy implications and regulations that could enable CPs to grow along with PPs in the view of CPs. In addition, there are several studies related to visualizing the platform ecosystem network using the network analysis methodology. Basole (2009) showed how platform ecosystems have evolved over time. According to Basole (2009), Symbian dominated the platform market in the early days of the mobile platform ecosystem. Today, iOS and Android are currently taking control in reorganizing the ecosystem.

The studies that possess an evolutionary perspective of the platform ecosystem are as follows. From the economic point of view, Katz and Shapiro (1994) authored the seminal paper on network effects and system competition and adopted the evolutionary perspective of the platform ecosystem. Tiwana et al. (2010) authored a review paper about platform ecosystems and considerations for further study. They analyzed how the co-evolution of endogenous design and governance choices by platform owners and the dynamics of their exogenous environment influence their evolutionary dynamics from four theoretical lenses (modular systems theory, evolutionary selection, real options

theory, and bounded rationality). However, these studies have limitations because the theories were not empirically tested. This thesis follows the concept of Fransman's (2007) ICT ecosystem (content-platform-network-device-user) and focuses on the relationships among the CPs, PPs, and users.

Scholars define the concept of the ecosystem in various ways, and they all have different boundaries for the ecosystem mainly because setting precise boundaries of an ecosystem is nearly impossible to do. In the view of a firm, any resource that is intertwined with the firm and critical to its business could be included in the boundary of the firm's ecosystem. The boundary can be the size of a strategic group or industry and even the size of all the businesses combined globally. Therefore, a complex ecosystem needs to be subdivided into business domains.

Although the platform ecosystem can be considered a meta-ecosystem, for the simplicity of analysis, the smaller ecosystems that exist within it are considered. The borders of the smaller ecosystems can be defined based on the degree that the offered value (content, application, service) is compatible and complementary (den Hartigh & Tol, 2008). By this definition, in the case of the platform ecosystem, PPs and any business actor associated with the platform may be considered an ecosystem, CP, or user.

In Chapter 3, the platform ecosystem has two representative platforms and CPs that provide their content to those platforms. Chapter 4 assumes there is one giant platform and experiments with several hypothetical scenarios within this condition. Chapter 5 includes broader boundaries of an ecosystem because it consists of several media

platforms, diverse content, network, and device providers. Generally this thesis follows the concept of the platform ecosystem much like that of Fransman's (2007) ICT ecosystem, which consists of C-P-N-D. Of the four layers, the author narrows down the concept into a platform ecosystem, which consists of PPs, CPs, and users.

2.2.2 The Nature of Content Layer (Creative Industry)

The origin of the term ‘content’ stems from multimedia content which was used by the European Union starting in 1990. Analog and digital are two types of multimedia content. Content can also be separated into the types by materiality and immateriality; however, the content mainly discussed in this thesis will be the form that is distributed by digital media. In addition, content is defined not only by the content in the media, but also by the holistic service used for meeting the users’ needs such as communication and transaction. The origin of the content layer in the ICT industry comes from the art and culture industry (Deuze, 2007), and the original content from this industry are rapidly being digitalized with the development of network and device technology. This enables the content layer to naturally enter the new ICT ecosystem. The content layer is characterized as having a great diversity of media including music, books, games, films, television broadcasting, cultural spaces, software, and advertising (Abadie, Maghiros, & Pascu, 2008).

Content businesses have a high risk of losing the initial cost of creating content due to the difficulty of production and forecasting demand (Doyle 2013). Therefore, distribution of content is more likely to be run by conglomerates. For example, a film of a blockbuster caliber, which is a capital-intensive content, is produced mostly by conglomerates. However, conglomerates do not bother to produce films with low probabilities of gaining popularity from consumers. Usually it is the medium or small-sized firms that are trying to find the hidden needs of the consumers. The trial and error activity of the medium to

small-sized firms plays an important part in the development of innovative content. However, content can easily be replicated. When a content is produced and gains popularity, similar products or services may spring up everywhere. The reason why this is more of an issue for the content layer than any other layer is that content is not a technology but an idea; therefore it is more susceptible to imitation when the idea has been exposed but difficult to protect using laws.

In regards to regulation of platforms, it is useful to apply the concept by Ballon and Van Heesvelde (2011). The platforms are classified into four types: (1) neutral platform such as Google Search, (2) broker platform such as Facebook, (3) enabler platform such as Intel, and (4) integrator platform such as Apple. Regulatory issues could vary depending on the type of platform. When dealing with broker and integrator platforms, which are platforms that have control of the customers, regulators should be concerned with the customer lock-ins due to switching costs and price squeezing by CPs. However, for enabler and integrator platforms, which are platforms that have control over assets, regulators should be concerned with the refusal to deal and lock-ins by CPs. Therefore, these types of platforms should be regulated by addressing the issues of reducing diversity. When numerous CPs and customers exist on a platform but do not have the means to directly connect with one another, platforms contract with CPs on one side and gather consumers on the other side, resulting in a two-sided market. If CPs have various platforms to provide their content and if consumers have low switching costs to switch to other platforms, the likelihood of fair contracting between platforms and CPs would be

high, and many CPs would have equal opportunity to succeed in the platform. However, if a platform gains enough popularity and consumers are unwilling to search for new content or do not want to endure the cost of switching platforms, it is very difficult for CPs to contract with the platform.

Hypothesis 2-1. *The will of the user to diversify their source of information is important for revitalizing content diversity in the platform ecosystem.*

Hypothesis 2-2. *The will of the content providers to retain their uniqueness and not imitate indiscriminately also influences content diversity.*

2.2.3 Platform Openness and Growth of Platform Ecosystem

2.2.3.1 The Concept of Platform Openness

Before the smart-media era, network operators, working as gate keepers, had strong relationships with mobile manufacturers and tight controls of the various mobile services, so only the selected content providers could contract with the network operators (Bodic, 2009). However, as open mobile platforms such as iOS and Android emerged, the structure started to take on a different form. Many developers were able to get direct access to mobile platform resources, and network providers had lost some of their controlling power (Holzer & Ondrus, 2011). Platform providers took over network providers' positions by offering applications in the open market. In the early stage of smart-media era, Android and iOS were not the first movers in the mobile platform market; there was competition among several mobile platforms, but Andriod and iOS eventually took control of most of the market. The success of Andriod and iOS can be attributed to the software platforms' attractiveness of opening their platforms to third parties (Hilkert et al., 2011a).

So far, scholars agree that an open market strategy with the pursuit of co-existence is a dominant strategy in the current ICT environment. However, there are clear side-effects of openness in the perspective of managing complementors (Tiwana et al., 2010). Tiwana et al. (2010) mentioned governing platforms requires a delicate balance of control by a platform owner and autonomy among independent developers. Moreover, finding

optimal levels of openness is crucial for firms that create and maintain platform ecosystems (Eisenmann, Parker, & Van Alstyne, 2008; West, 2003). However, it is difficult to study platform openness because this fairly new concept has not been universally defined. Nevertheless, regional definitions do exist and are adopted for research focus. Each literature defined the type and concept of platform openness its own way. A review of the related literature and the concept of platform openness is described in Table 2.1.

Table 2.1 The concepts of platform openness in several related literatures

Type of Openness	Concept	In the Case of Android and iOS
Considered Platform Openness (Eisenmann et al., 2008)	A platform is considered open • if the contribution, the development, the usage, and the commercialization is not restricted, or • if all existing restrictions are reasonable and equally applied to all participants • Openness is classified into four roles of platform mediating CPs, users, PPs, and platform sponsors.	• **Similarity:** Two platforms are considered open because all existing restrictions are reasonable and equally applied to all participants. • **Difference:** Two platforms are open to the users but there exists different degrees to which they allow CPs to use their platform.
Horizontal or Vertical Openness of Platform (Boudreau, 2010)	• Opening a platform horizontally: giving up some control by licensing the platform to competitors, • Opening a platform vertically: granting external developers access to the market of complementary applications	• **Similarity:** Two platforms are both open vertically but closed horizontally

Perceived Platform Openness (Hilkert et al., 2011a)	• PPO: A platform's degree of openness as perceived by its complementary application developers	• Two platforms are different to the extent of which developers feel the openness
Platform Openness on the Level of Integration (Holzer & Ondrus, 2011)	Platform can take different roles in the application market. • Some are interested in full integration and control of the entire distribution process, • while others might take responsibility in some parts only. • Four different possibilities: full-integration, portal integration, device integration, and no integration	• iOS (full-integration): The provider of the platform has strict control over device manufacturing, platform, and application sale in its app store • Android (portal-integration): The platform concentrates on the application development and application sales in its app store, <u>not on device manufacturing</u>
IT Service Platform Openness (Gebregiorgis & Altmann, 2012)	The level of interoperability, portability, and usability • Facilitating data and application migration among different IT service platforms • Allowing programmers to choose the development environment	• **Similarity:** Two platforms are closed with regard to interoperability and portability, and open with regard to usability because they are not open horizontally but easy to use for users.

2.2.3.2 The Role of Platform Openness in Platform Ecosystem

The policy of a platform affects CPs within the ecosystem and may be able to change the entire environment. Therefore, different policies of various PPs induce CPs to change their behavior to adapt and survive in the environment. These changes have accumulated over time, and CPs currently have significantly different characteristics from one another. Different platform environments, such as platform architecture and governance, transmute the overall ecosystem by changing the preferences of developers and the behavior of customers in different ways (Tiwana et al., 2010). When exploring the Android and Apple ecosystems, the two distinct platform environments exhibit difference in terms of the number of applications, the number of participating devices, the degree of innovation and creativity, and even the composition of the CPs in their ecosystems (Gawer & Cusumano, 2012; Hilkert et al., 2011a; Ku & Cho, 2011; Tiwana et al., 2010).

It is clear that platform openness has trade-offs. When it comes to the relationship between platform and content providers, platform is inherently dependent on a continuous supply of complementary creative content. In this case, opening a platform vertically to external developers possibly increases the CPs' diversity (Chesbrough, 2003; Von Hippel, 2005). On the other hand, vertical openness could pose problems for the platform provider. It could be harder to orchestrate and coordinate resources because more stake-holders are involved (Almirall & Casadesus-Masanell, 2010; Greenstein, 1993). In addition, the platform provider may also lose its control over the complementary players after assigning the production of complements to them (Economides & Katsamakas,

2006).

According to the Ballon and van Heesvelde (2011) typology of platforms, the iOS platform is classified as an integrator platform with control over both assets and customers. Google Search is classified as a neutral platform. However, because the Android platform was originated by the iOS iTunes market (Feijoo et al., 2012) and it controls a value proposition of assets and customers, the Android platform is also regarded as an integrator platform. A significant difference between Andriod and Apple is that Android opens the content selection process when CPs enter their ecosystem and eases the task of developers when CPs want to update their content. On the other hand, Apple strictly closes and controls the content selection, which is the remaining controversy of non-transparent discretionary approval process for CPs (West & Mace, 2010). According to Apple's policy, developers' work has to be approved by Apple when they update their content, which may end up burdening the developers. On the other hand, the Google Play store provides all functions for production, registration, distribution of content, and even payment without any restrictions. Recent statistics show that the size of the Android ecosystem has surpassed the size of Apple's[3]. The example of Apple and Andriod shows that the number of CPs that want to provide their content through the platform can be increased or decreased based on the platform company's policy. As the number of CPs within the ecosystem declines, the number of customers within the ecosystem would also decrease because the motivation and incentive for producing and

[3] http://www.diffen.com/difference/Android_vs_iOS

purchasing activities diminish, thereby decreasing the overall ecosystem. However, it is still arguable whether the open platform strategy to increase volume is always better for developers. In recent developers' forums (Worldwide Developers Conference "WWDC" for Apple developers and Google's I/O event), the most frequent question asked was why developers still prefer to write for Apple first[4], even though Android phones outsell Apple's iPhones; this observation implies that the number of install bases is not the only factor for selecting a platform for CPs and that other important factors exist that are critical to maintaining the whole ecosystem.

There are two advantages of the iOS platform ecosystem for the CPs. First, CPs are able to use iOS's low conflict system, enabling a high efficiency for developing applications. The low conflict system indicates that Apple integrates the value chain of content (content, platform, and devices), reducing complexity, and encouraging application developers to optimize efficiently to their ecosystem. Second, they are easily accessible to power users with a high willingness to pay. On the other hand, the disadvantages are limitations in developing content and business models because of low flexibility, which limits creativity. Apple integrates the content, platform, and device layers, cutting the transaction cost and locking their customers into their ecosystem. CPs also have various direct and indirect channels to Apple (Hagel, Brown, & Davison, 2008), so they are able to communicate with Apple's power users (i.e., iTunes Store, App Store, iBookstore, and the Mac App store are major CPs in the Apple ecosystem). This special

[4] http://www.theguardian.com/technology/appsblog/2012/jun/10/apple-developer-wwdc-schmidt-android

business model would raise the efficiency, reducing the conflict among layers, but there are limitations in developing the unique creativity of developers (Holzer & Ondrus, 2011).

The advantages of the Android platform ecosystem include a high level of flexibility in developing content, compelling the CPs to innovate and experience failure if necessary. According to Ku and Cho (2011), this factor provides CPs with a highly cooperative and business-friendly structure. This advantage gives vitality to the ecosystem through improving the probability of producing creative content. More creative content can be created because this structure enables a large number of CPs to enter the platform and challenge others without much restriction or burden of not being selected, thus promoting more diversity in the platform ecosystem. On the other hand, a disadvantage is low developing efficiency, as development needs more human and material resources to optimize the difference.

2.2.4 Diversity as a Role of Producing Vitality in the System

Biological diversity is the most important index of checking the sustainability of the system in ecology. As an ecosystem evolves, the things that are living within it might fail to adapt to the new environment when the system fails to keep proper levels of biological diversity. When an environment changes rapidly, living things adapt by combining their genes. For this reason, they must secure diverse genes even though some genes might seem useless right at the moment. Ultimately, an extinction of one species in an ecosystem can lead to a destruction of the entire ecosystem. Then, when does the diverseness decline to dangerous levels? Selection mechanism is the most important factor to modulate the level of diversity in nature. On earth, nature is the rule maker of the system and the platform on which diverse living things inhabit. So far, nature has been a successful manager of maintaining a proper level of bio-diversity. If nature applied the wrong selection mechanism like greed and searched for the fittest organism, it would grow efficiently in the short run, but as diversity decreases rapidly, the system would not likely adapt to the changing environment in the long run. Therefore, a proper level of diversity is not only the target but also the requisite for sustainability. This concept of diversity management could also be applied to our society.

In the beginning of the new ICT ecosystem, platforms had to lower the interdependency of the platforms, CPs, and devices based on their technology for high efficiency. In order to lower interdependency, platforms had to manage various environments including content, platform, network, and device. Apple is one of the best

examples of a platform with integrated management. However, with this kind of integrated platform business, it is difficult to secure the diversity of content due to the biased selection mechanism (C. Lee, Lee, & Hwang, 2014). According to Kauffman (1996), the effective evolution toward one-way with high speed seems to rise rapidly toward the top of the fitness landscape, but in many cases it is only a local peak. If a living thing stays stuck in the local peak, it will eventually die out. Therefore, the best strategy for a firm is to increase their chances of making many combinations of genes and strategies, increasing their diversity of technology, content, and alliance under the rapidly changing environment like the digital convergence of today. From this diversity, the innovation will be able to expand quickly (Posen, Lee, & Yi, 2013). In addition, as the consumers' needs change rapidly, managers and policy makers should avoid locking in on only one technology for keeping diversity in the ecosystem.

Diversity is also a reservoir of creativity. Schumpeter (1934) defined the concept of innovation as a new combination, and when it comes to creativity, it is a mental process in which two or more ideas come together in the mind to create a new combination of ideas and useful thoughts. This is the consensus by most of the researchers who study creativity. Recently, in the academic field, the number of collaborations between different areas has been increasing, and this convergence leads a new study trend. The reason for the collaboration is simply because the payoff is huge. According to Uzzi and Spiro (2005), the number of papers by individual researchers is decreasing while the number of papers by collaboration among hetero research groups, and even among hetero academic

fields, has been increasing every year. This is because researchers are looking for ways to find various combinations of knowledge in order to publish ‘A’ class journals, and they know it is becoming more difficult to construct new knowledge by recombining knowledge in the similar fields. This suggests that the combination between the new and different things gives vitality in an ecosystem.

In the field of media and communication, there has been early recognition of the importance of diversity (pluralism of media and journalism). Throughout the media, including broadcast, diversity has been considered a key principle and concept for evaluating the performance of the media and industry and establishing a policy based on this evaluation (De Jong & Bates, 1991; Napoli, 2001). The fact of which the issue of diversity in media is considered important, though there has been general consensus about the importance of diversity early on, shows how difficult it is to establish the precise indicators. It is not clear the extent to which regulators should limit the dimensions of diversity. In addition, even if the diversity index is set, it is hard to quantify into a number, and it is also a great challenge to measure the data because, in most cases, each dimension is not independent of one another but instead in some ways correlated. Therefore, despite the consensus regarding diversity being an important factor in establishing regulative policy of content and media, the definition of diversity or sub-components of the concept of diversity has not been easy to agree on.

The diversity in media is defined as the extent or range of the selection of the different types of programs provided by the broadcasters for the audience (Cass, 1981; Grant,

1994). Mainly it is measured by the number of different types (genre or content) that are provided for the audience within a specific time period. While the definition of diversity is not clear, diversity seems to be defined as the existence of various things. The concept of diversity is a complex principle of crossing both social attention to prevent a monopoly and economic attention to promote the expressions of minorities (Napoli, 2001). Owen and Wildman (1992) break down diversity into three dimensions: (1) product diversity to the extent of how many variations in different attributes of a specific product or service exist, (2) idea diversity to the extent of how many different ideas, analyses, and critics exist, and (3) access diversity, which means that the media as a gate keeper never excludes a particular point of view for social issues. This paper follows Owen and Wildman's (1992) philosophy of access diversity.

Content diversity is divided into external and internal diversity. External diversity is the number of the population as being seen as it is. Internal diversity is not superficial but an index to measure the extent of how different content is among all the content in a population. It is much like a gene of a living organism; if the DNA of content are similar one another, phenotypic characteristics are revealed similarly. Of course it is possible that phenotypic characteristics look similar or different even if genotypic characteristics are different or similar. However, it is genotype diversity not phenotype diversity that is more important in the ecosystem because phenotype characteristics are expressed by the combinations of genotype diversity on a gene level. Therefore, securing genes which do not have good phenotypic characteristics but are unique and different from other genes

influences not only an individual but also the whole ecosystem (Whitham et al., 2006). It shows that the number of traits of a gene in an ecosystem is the most important index of sustainable growth.

Hypothesis 2-3. *Content internal diversity is the source of creativity and this provides energy that is sustainable to the whole platform ecosystem.*

2.2.5 The Role of User in the Platform Ecosystem

Today, the ICT ecosystem does not only consists of C-P-N-D but also the user. In the smart media environment, users can select digital content based on their preferences and even combine the content through a variety of media to create their own repertoire. In this way, the user is not just a consumer but a co-creator of value and prosumer of information. In addition, the user plays a role in determining the direction of evolution on the top side of the platform ecosystem. Without the adoption of new products or service by users, there is no diffusion of a new product or service no matter how innovative it is.

A social network service (SNS), which is a good representation of a platform where the users become value co-creators, lets users produce their own content. The value of a SNS depends on the number of the users and the quality or quantity of content they produce. Therefore, understanding the users' motivation for participating in the production of high quality content provides important implications for the value co-creation strategy (Roberts, Hughes, & Kertbo, 2014).

Hypothesis 2-1. *The will of the users to diversify their source of information is important for revitalizing content diversity in the platform ecosystem*

Studies on value co-creation have flowed into three streams. The first stream is the concept of user-innovation. This is the flow of study on the technical management aspect which suggests that when the innovator group becomes the leading user, they could create

innovation and value. The second stream is the concept of crowd-sourcing. This focuses on the source of resources, which means that knowledge could be shared and created from many unspecific crowds in an open form. The third stream is about open-innovation. This is a way of approaching the value creation through involving developers or consumers outside of firms rather than limiting to the resources within the enterprise. These three flows of studies seem to be different, but there is a common sense that the role of the user is the source of creativity in a platform ecosystem.

In addition, change in the users' needs is an important variable for survival of firms much like changes in an environment is important for survival of living things in the view of ecology. But the problem is firms have been neglecting consumers, an important factor for surviving in a competitive environment. Considering the success of Apple and Google, the reason for their success is because they were able to meet the hidden needs of the consumers rather than focus on innovative trials and the ability to execute them. Furthermore, most of the goals of platform strategy are related to making profit during the consumer lock-in, not to suggest the users' role under the giant platform environment. There are two types of lock-ins: lock-in by platform and voluntary lock-in by the users themselves. However, as the size of a platform increases, the role of the users cannot avoid being limited, and this discourages the users' to diversify their repertoire, which reinforces the effects of a lock-in.

Hypothesis 3. *Platform ecosystem co-evolves with PP, CP, and User.*

Chapter 3. Platform Openness and Productivities of Content Providers

3.1 Introduction

The information and communication technology (ICT) industry consists of four layers: content, platform, network, and device (C-P-N-D) (Arlandis & Ciriani, 2010; Fransman, 2007). Content layers in the ICT industry can be characterized by a great diversity of media genres including music, books, games, films, television broadcasting, cultural spaces, software, and advertising (Abadie et al., 2008). Content flows via a platform and arrives at a device through a network. Recently, because many people mainly consume content on their mobile 'smart' devices (Westlund, 2010), the most important success factor for network, device, and platform operators entails which media brands, applications, and content they provide (Feldmann, 2005). In addition, a decisive factor of customer surplus is derived from new combinations of products or services (Curran & Leker, 2011). These phenomena reflect the shift the PP's negotiation power and power to innovate toward the content layer. The innovation and increased efficiency of the content layer may attract more consumers and increase the profit gained from the other three layers (Arthur, 1989).

Even though the effect of innovation in the content layer of the ICT ecosystem is growing, the other layers are no less important. Because all four layers are connected with

each other, whether one layer succeeds or fails influences the whole ICT ecosystem (Moore, 2006). Therefore, it is important to support the stability of every layer in order to innovate and develop ICT (Iansiti & Levien, 2004a; Katz & Shapiro, 1994; Tiwana et al., 2010). Additionally, managers and policymakers in the ICT ecosystem should develop a strategy that aims at growing the entire ecosystem while understanding mutual dependence and the principles of co-existence and co-prosperity (Iansiti & Levien, 2004a).

Specifically, the platform layer is directly relevant to the innovation and development of the content layer (Hilkert et al., 2011a). In the mobile industry, the platform-based ecosystem is rising and accelerating because the interaction between many developers and customers is only possible through a platform (Gawer & Cusumano, 2012). The platform mediates the content and consumers, and therefore it plays a pivotal role in a two-sided market, where CPs and consumers are on either sides of the platform (Eisenmann, Parker, & Van Alstyne, 2006). A two-sided market has the following two characteristics. First, it possesses direct network externality in which a consumer feels that a product or service is more useful when many people around him or her use the product or service (Katz & Shapiro, 1994). Second, a two-sided market is characterized by positive feedback through indirect network externality. When a consumer plans to buy a product with increasing returns in the production of complementary products, he or she behaves as if there were indirect network externalities (Clements, 2004). This indirect effect alters the consumer’s utility function before purchasing the product. If there is a

critical advantage of applications in a particular smartphone ecosystem, it gradually locks in customers and makes the ecosystem more attractive. This positive feedback reinforces the advantages of a relatively large platform ecosystem (Arthur, 1989; Katz & Shapiro, 1994). Therefore, a platform ecosystem could attract developers and users, providing the environment in which services and products can be created well and therefore adding more value to the system (Katz & Shapiro, 1994). For example, a platform provider (PP) attracts more consumers when it has more creative content providers (CPs). Likewise, because CPs also need more potential customers, they will choose a PP that has more users.

Considering the information above, which platform environment will enable CPs to grow most efficiently? Currently, the two prominent mobile platforms, Google Inc. (referred to as Google in this thesis) and Apple Inc. (referred to as Apple in this thesis), play a common role in facilitating market communications between CPs and consumers. However, they have different policies placed on the evolutionary direction of platform ecosystems. From the CPs' viewpoint, the main difference between these two platforms is the content selection process. The evolutionary process consists of two major steps related to expanding variety and selection of the content. The different platform policies result primarily from the selection process, referred to as openness in this thesis. If a PP controls the quality of all its content, it plays a significant role in decision making when the content enters the ecosystem. The evolutionary selection would not be fully open to consumers because the consumers cannot participate in choosing the content. However, if

a PP allows CPs to enter freely, consumers or CPs then play the selector role, rather than the PP. This selection scheme causes the ecosystem to evolve differently.

According to Holzer & Ondrus (2010), the differences in the platform types and platform provider strategies result in different working situations for developers. Iansiti and Levien (2004b) introduced a productivity index to assess the health of the entire ecosystem, and they also demonstrated that the productivity of the Internet service layer plummeted when platform firms, such as Yahoo and AOL, began to charge abnormally high fees to third parties. Consequently, PPs pursued short-term profits rather than long-term optimization of the global ecosystem, and the entire ecosystem collapsed during this period. Therefore, a platform's characteristics and policies alter the nature of the ecosystem and the productivity of the third parties. However, from the CP perspective, there is a lack of empirical research on the efficacy of platform ecosystems to help CPs determine the best system. There have been numerous prior studies that focused on PPs (for example, see Cusumano & Gawer, 2002; Eisenmann, Parker, & Van Alstyne, 2008; Gawer & Cusumano, 2012; Iansiti & Levien, 2004; Xu, Venkatesh, Tam, & Hong, 2010); they provided insights on how firms may obtain platform leadership and the role of the leader firms in the growth of the overall ecosystem. However, these studies lack conclusions at the industry level regarding the overall ecosystem (Basole & Karla, 2012; Tiwana et al., 2010), and few sources of literature regarding the participants at the periphery of an ecosystem (Selander, Henfridsson, & Svahn, 2013). There are also several limitations when focusing solely on the theoretical, social, or methodological aspect of

visualizing an ecosystem network analysis. There are several papers that focus on CPs in a platform ecosystem, such as Hilkert et al. (2011a), however, these are primarily surveys and interviews that have limitations in terms of suggested implications. Therefore, there is a need for an empirical analysis of how CP performance varies depending on a chosen platform.

Therefore, this chapter empirically analyzes how two PPs with different levels of openness influence the efficiency of CPs in the mobile digital content industry. It aims to determine which characteristics of the platform make CPs more productive from an evolutionary perspective. To show the existing differences between CP productivity within iOS and Android, this paper uses surveys to gather data from 102 mobile CPs in Korea. The CPs are categorized into three groups (iOS only content providers, Android only content providers, and content providers to both iOS and Android) to compare the technical efficiency within each group and between the groups. This chapter will provide information that prior research could not provide and will present strategic implications for CPs operating through mobile platforms. In addition, this dissertation aims to derive meaningful implications from this analysis for telecommunications policy makers to promote the innovation and growth of the content industry.

3.2 Case Study of Platform Openness: iOS and Android

As mentioned in 2.2.3. Android and iOS have several similarities in the view of considered platform openness (Eisenmann et al., 2008) and horizontal or vertical openness of platform (Boudreau, 2010). Firstly, two platforms are considered open because all existing restrictions are reasonable and equally applied to all participants. Secondly, they are both open vertically but closed horizontally because, while they can both open the application market to CPs vertically, they cannot be compatible with each other on a horizontal level.

Despite the above similarities in the design of the ecosystems, iOS and Android differ when it comes to the degree to which they allow CPs to use their platform as defined by Eisenmann et al. (2008), the extent to which developers feel the openness as defined by Hilkert et al. (2011), and the degree of integration in their platforms, as defined by Holzer & Ondrus (2010). Firstly, two platforms are different when it comes to the degree to which they allow CPs to use their platform. For developers trying to enter the ecosystem, iOS seems to set a higher entry barrier in the following three ways:

① iOS charges a higher fee for joining the ecosystem (minimum US 99 dollars/year) compared to Android (US 25 dollar onetime fee)

② iOS does not allow the developers to join its ecosystem before approving them, while Android allows the developers to join its ecosystem upon payment of a membership fee

③ iOS restricts developers from using computers other than Mac machines for development purposes, while Android allows the freedom of choice to use any machine.

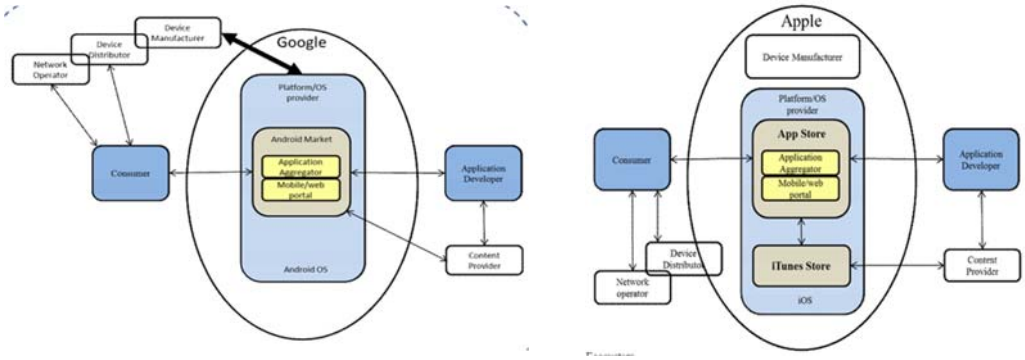
Secondly, two platforms are different when it comes to the extent to which developers feel the openness. According to Hilkert et al. (2011), perceived platform openness consists of two facets: technical platform and distribution channel. Table 3.1 shows the details of the facets. Developers might feel the different degree of openness between Android and iOS by each facet of platform openness. Unfortunately, however, there are very few studies on the comparison of two platforms based on the PPO framework.

Table 3.1 Framework of perceived platform openness facets (Hilkert et al., 2011)

Technical Platform	Distribution Channel
• Exchange among complementors	• Transparency of terms and conditions
• Technical documentation	• Restrictive terms and conditions
• Technical support by provider	• Transparency of rules on content
• Learnability of technical standards	• Restrictive rules on content
• Availability of development tools	• Transparency of market mechanisms
• Technical interoperability	• Communication with end-users
• Functional range	• Financial entry barriers
• Technical performance	• Availability of distribution channel

Lastly, the two platforms are different in regards to the degree of integration in their platforms. iOS, a full-integration platform, organizes its ecosystem by strictly controlling the entire process from device manufacturing, to development platform management, to application distribution. Similar to iOS, Android has full control of its google play store (Android application market) but does not manufacture any devices. Instead, it has a

strong relationship with independent device manufacturers and lets them enter its ecosystem. Figure 3.1 shows the simple diagram comparing the two platform ecosystems in the concept of platform openness.



Android platform ecosystem iOS platform ecosystem

Figure 3.1 Comparing Android and iOS platform ecosystems in the view of platform openness concept (Roshan Kokabha, 2012)

In the perspective of evolution, the main difference between the two platforms is the content selection process. Content selection process determines the openness of a platform by gauging the strictness of a platform when selecting its content. This chapter focuses on the selection process of CPs because the problem of finding the right degree of vertical platform openness arises from a fundamental trade-off known as diversity vs. control (Boudreau, 2010). A significant difference is that Android opens the content selection process when CPs enter their ecosystem and when CPs want to update their

content. On the other hand, the iOS platform strictly closes and controls the content selection, which is a controversy of non-transparent discretionary approval process for CPs (West & Mace, 2010).

When the content publishing processes between the two platforms are compared, the iOS platform has a tougher selection process than the Android platform. Existing quality control by the iOS platform is applied in two ways. The first is a strict review process.

- *iOS imposes a review process for an application before allowing it to be published. The review process can take from a week to a few months, and might result in the acceptance or rejection of the application. The review process applies to all submitted applications, either they are new versions of the already existing applications or are totally new.*
- *Android does not apply any review requirements on an application and allows it to be published immediately on the Android Market upon submission by the developer.*

The second is an approval system.

- *According to Apple's policy, the developers' work have to be approved by Apple when they update their content. This policy can be a burden to developers.*
- *Google Play store provides all functions for production, registration, distribution of content, and even payment without any restrictions.*

According to Roshan Kokabha (2012), the main difference between Apple and Google's ecosystem is the different levels of control on the applications that enter their application stores; *Apple has its strict control system and Google has its open sharing system*. Based on the reasons above, this chapter concludes the main difference between the two platforms from an evolutionary perspective is a content selection process, and Android has a higher degree of openness than the iOS platform.

3.3 Meta-frontier Analysis and Research Design

The traditional methods for measuring the efficiency are the regression analysis approach, the productivity index approach, and the ratio analysis approach. The regression analysis approach, using the parametric efficiency estimation, estimates the relation between the input and output and then compares the expected and real outputs. This method could influence the result depending on the assumed distribution and reliability is reduced if the sample is small. The productivity index approach uses the index, which is the ratio of the output to input, and it varies with using total productivity, partial factor productivity, and total factor productivity. This method has the advantage of being useful for measuring the efficiency of the entire firm, considering the total input and output simultaneously. However, it has the disadvantage of making the identification of where inefficiencies exist difficult. The ratio analysis approach is used to calculate the financial ratio, which explains the management situation, and then compare it with the industry standard or a specific firm's index. It presents a direct comparison with other companies or industry standards. However, it is a relative value, not an absolute value.

Recently, frontier analysis has overcome the disadvantages of the traditional methods. It estimates the efficiency frontier first and then evaluates each firm's relative efficiency. The frontier analysis can be categorized into data envelopment analysis (DEA) or stochastic frontier analysis (SFA), depending on how the efficiency frontier is determined. DEA is a non-parametric estimation method, whereas SFA is a parametric estimation. SFA identifies where the inefficiency originates and can produce various statistical

hypothesis tests and real panel data. Cullinane et al. (2002) insist that SFA is the best efficiency estimate if the economic model is designed well. Therefore, this paper uses SFA to evaluate the average efficiency of the group.

The purpose of an efficiency analysis through SFA is to analyze which companies produce more output than others in the same industry, even when all companies exhibit the same quantity of input (Coelli, Rao, O'Donnell, & Battese, 2005). However, this method is not able to reflect the different characteristics of different regions in a country or the difference between strategic groups in an industry because it groups all firms in an industry into one group (O'Donnell, Rao, & Battese, 2008). While dummy variables for each group within an industry are able to reflect the difference, it is also impossible to compare between groups because there are no production functions that consider between-group differences.

A meta-production function is based on the assumption that firms within different groups (i.e., countries, technologies, strategies) have potential access to the same technology (Hayami & Ruttan, 1970); this function can therefore be regarded as the envelope of neoclassical production functions. In other words, if there is a well-defined group within an industry, there is a meta-frontier function that envelops all groups and makes it possible to compare between-group efficiency from the distance between the meta-frontier and group frontier (O'Donnell et al., 2008). This technology gap ratio (TGR) indicates the technology gap between the technology currently available to firms in given groups and the technology available to the whole industry (Hayami & Ruttan, 1970).

Recently, several papers investigated ICT industry using the meta-frontier analysis. In the meta-frontier analysis, comparisons are made based on firms with different kinds of productions (D. Lee & Hwang, 2011), with different strategic groups (Hong, Lee, & Hwang, 2011), and from different nations (Yang, Lee, Hwang, & Shin, 2013). For example, D. Lee and Hwang (2011) use meta-frontier analysis to compare different content industry groups in order to determine whether discrimination by ISP exist or not. Hong, Lee, and Hwang (2011) compare different strategic groups of technology-based operators by using meta-frontier analysis. These groups include vertically integrated, horizontally integrated, and isolated system operators. In addition, Yang et al. (2013) uses meta-frontier analysis in order to compare the efficiencies of telecommunications operators under different national policies. On the same line of the research stream, this dissertation uses SFA and meta-frontier analysis to compare two different groups: the iOS and Android platform ecosystems.

This paper aims to analyze the technology gap among the CP groups that provide content to different platforms. As mentioned above, there are two dominant platforms, iOS and Android, and this paper categorizes CPs into three groups: CPs that only provide content to iOS, CPs that only provide content to Android, and CPs that provide content to both iOS and Android. Each group's efficiency was estimated as follows:

$$Y_{it(j)} = f(x_{it(j)}, \beta)e^{V_{it(j)} - U_{it(j)}}$$

$$, i = 1,2,\cdots,N_j, \ t = year, \ j = group(iOS, Android, Both) \quad \cdots\cdots\cdots\cdots\cdots\cdots \text{Eq. (1)}$$

where $Y_{it(j)}$ denotes the output for the i-th firm within the j-th group in the t-th period; $x_{it(j)}$ denotes a vector of firm i's input set within the j-th group in the t-th period; βs are coefficients of each input set on the frontier line; $V_{it(j)}$s are random variables following identically and independently normal distributions of $\mathrm{N}(0, \sigma^2_{v(j)})$; and $U_{it(j)}$ denotes appropriate inefficiency and follows the distribution $\mathrm{N}(\mu_{it(j)}, \sigma^2_j)$.

Assuming that the model in Equation (1) is an exponential function, Equation (2) can be created. Through this equation, the within-group technical efficiency (TE) can be calculated.

$$Y_{it} = e^{x_{it(j)}\beta_{(j)} + V_{it(j)} - U_{it(j)}} \quad \cdots\cdots \text{Eq. (2)}$$

As mentioned previously, to compare among groups, the meta-frontier production function needs to be defined. The meta-frontier production function of all CPs was designed as follows.

$$Y^*_{it} \equiv f(x_{it}, \beta^*) = e^{x_{it}\beta^*}, i = 1, 2, \cdots, N \quad \text{and} \quad N = \sum_{j=1}^{R} N_j, \quad t = year \quad \cdots\cdots \text{Eq. (3)}$$

β^* is the vector of unknown meta-frontier parameters that satisfies $x_{it}\beta^* \geq x_{it}\beta_{(j)}$ for all technology groups. Therefore, the meta-frontier function accounts for the group frontier. From Equations (2) and (3),

$$Y_{it} = e^{-U_{it(j)}} \times \frac{e^{x_{it}\beta_{(j)}}}{e^{x_{it}\beta^*}} \times e^{x_{it}\beta^* + V_{it(j)}} \quad \cdots\cdots \text{Eq. (4)}$$

For Equation (4), the technical efficiency from the meta-frontier (TE*) was derived by multiplying the technical gap ratio (TGR) and the technical efficiency (TE).

$$TE^* = \frac{Y_{it}}{e^{x_{it}\beta^* + V_{it(j)}}} = \frac{e^{x_{it}\beta_{(j)}}}{e^{x_{it}\beta^*}} \times \frac{Y_{it}}{e^{x_{it}\beta^* + V_{it(j)}}} = TGR_{it} \times TE_{it} \quad \cdots\cdots \text{Eq. (5)}$$

Figure 3.2 shows a simple visualization of the meta-frontier concept. There are four frontiers: group 1, group 2, group 3, and the meta-frontier, which envelops the other three frontiers. Let X be a firm within group 1 and Y be a firm within group 3. SFA makes a weak comparison between the efficiency of X and Y. By introducing the meta-frontier, however, it is possible to compare between firms within other groups. For example, the TE of firm X is $\overline{OA}/\overline{OB}$ and that of firm Y is $\overline{OD}/\overline{OE}$. It appears that X is a more efficient firm than Y, but it is not possible to say which firm is more efficient because they belong to different groups. Based on the meta-frontier analysis, however, it is possible to explain which is more efficient through the TE* and to analyze which group has more potential from TGR. In Figure 3.2, the TE* of X is $\overline{OA}/\overline{OC}$ and Y is $\overline{OD}/\overline{OF}$, and the TGR of X is $\overline{OB}/\overline{OC}$ and Y is $\overline{OE}/\overline{OF}$. Then, we are able to recognize that Y is a more efficient firm than X from the meta-frontier analysis and that Y has a much higher technical gap ratio and efficient potential than X because Y is able to be placed closer to a

meta-frontier with the same input.

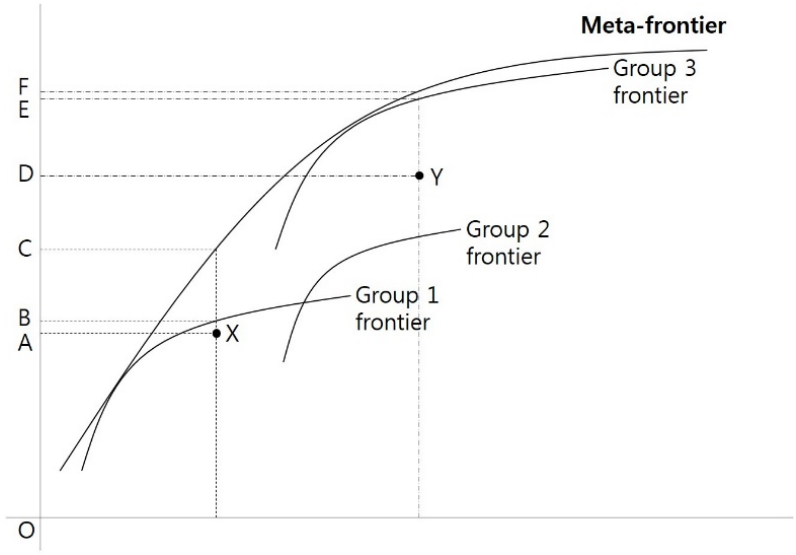


Figure 3.2 Meta-frontier analysis diagram

This empirical essay categorizes the CPs into three groups (iOS, Android, and both platforms) to analyze the technology gap among the CP groups that provide content to different platforms. First, the author estimates the TE by group (iOS only content providers, Android only content providers, and content providers to both iOS and Android) using SFA. Subsequently, the author estimates the meta-frontier containing all groups and analyzes the efficiency difference between the groups, thereby finding the effect of the policies of iOS and Android on the overall mobile content ecosystem.

3.4 Data and Variables

This chapter analyzed the frontiers based on the results of a survey of 102 mobile CP firms in Korea. The survey included the platform a company used for publishing products or services and accounting data from 2000 to 2012, providing 13 years of panel data. The group that provided content only to Android included 19 firms (128 observations); the group that provided content to only iOS included 10 firms (59 observations) and the group that provided content to both platforms included 73 firms (497 observations). In 2012, the South Korean market share of Android mobile OS was 90%, Apple was 9%, and others were 1%. Most CPs were starting to provide their content on both mobile OS platforms in 2012, and the ratio of the sample reflects the market share of the mobile OS in South Korea. The number of observations is 684, which excludes missing values. Table 3.2 shows the number of observations in the sample by content category and their details.

Table 3.2 The number of firms by content category in the sample (684 observations)

Content Category	Detailed Category	Observations	Both (Android & iOS)	Android Only	iOS Only
Game	all games	157	128	19	10
e-book	books, publications, magazines	44	37	0	7
Music	music related services such as sound sourcing, ring back tone, background music, streaming, etc.	20	4	13	3
Apps Related to Lifestyle	healthcare service application, transportation information, news, cartoon, online shopping, etc.	139	119	0	20
Video Service	broadcasts, movies, animation, digital character services	73	43	30	0
Education	online/storage educational programs	78	45	20	13
Advertisement	direct or indirect advertisement	54	46	8	0
Solution Application	platforms or services related to content providing	98	62	33	3
SNS	social network services	21	13	5	3
Total Observations		684	497	128	59

3.4.1 Output Measure

It is difficult to measure the efficiency of CPs. From a broader perspective, digital content includes products from many creative cultural industries, such as media information and services provided by ICT industries. Therefore, this chapter follows the efficiency analysis of non-manufacturing industries and the service industries, as did Keh, Chu, and Xu (2006). Therefore, the output value was measured by total sales.

3.4.2 Input Measure

There are several ways to measure the input of a service area, and they vary greatly depending on the appropriate sub-sectors (Heshmati, 2003). However, to measure the input, the overall frame consists of three factors: labor, capital cost, and material cost. First, labor is the main factor of producing services and creating content. In this paper, labor is quantified by the total number of employees in a firm. Second, material cost is measured by operating expenses in each year, and it consists primarily of sales and administrative expenses such as marketing. Third, capital cost is measured by the total assets in each year. Table 3.3 shows the descriptive statistics of input and output variables in the data.

Table 3.3 The descriptive statistics of the input and output variables in the data

	Output Measure	**Input Measure**		
		Labor	**Material Cost**	**Capital Cost**
	Sales (1,000 won)	Total Number of Employees (Person)	Operating Cost (1,000 won)	Total Amount of Assets (1,000 won)
Minimum	3	1	3	5
1st Quarter	397	10	240	100
Median	1,464	20	796	328
Mean	67,768	540.1	8147	135,129
3rd Quarter	5,110	41.5	2922	1,000
Maximum	4,100,000	31,480	224,454	9,642,174

3.5 Results and Analysis

In each group, the parameters of the stochastic frontier model are estimated by FRONTIER 4.1 using the random effects time-varying production model. The parameters of the meta-frontier function were obtained by MATLAB R2010a. Table 3.4 presents the estimation results.

Table 3.4 Estimation results for the stochastic frontier model and meta-frontier analysis

	Android group		**iOS group**		**Both groups**		**Meta-frontier function estimate**	
	Estimate	**Std.err**	**Estimate**	**Std.err**	**Estimate**	**Std.err**	**LP**	**QP**
Constant	2.969	1.203	5.657	1.623	2.853	0.813	5.657	5.657
b1	-0.173	0.301	-0.957	0.631	-0.245	0.222	-0.563	-0.613
b2	0.197	0.647	-1.443	1.069	0.314	0.286	1.198	1.090
b3	0.844	0.199	1.269	0.375	1.011	0.179	0.103	0.160
b4	-0.017	0.028	0.019	0.065	0.034	0.020	0.043	0.046
b5	0.018	0.111	-0.096	0.308	0.060	0.066	0.128	0.110
b6	0.047	0.042	-0.134	0.064	0.016	0.021	0.089	0.079
b7	0.149	0.094	0.032	0.201	-0.003	0.059	-0.053	-0.055
b8	-0.151	0.124	0.276	0.285	-0.077	0.058	-0.219	-0.191
b9	-0.021	0.038	0.090	0.119	-0.022	0.035	0.029	0.035

Through the parameters of estimating the group frontier and meta-frontier, the statistics of TE, TGR, and TE* by each of the three groups are presented as follows in Table 3.5.

Table 3.5 SFA estimates of technical efficiencies and meta-technology ratios

TE

Group	Mean	St.dev	Min	Max
Android	0.804	0.091	0.654	0.986
iOS	0.891	0.104	0.652	0.984
Both	0.778	0.098	0.495	0.987

TGR

Group	Mean	St.dev	Min	Max
Android	0.391	0.094	0.219	0.528
iOS	0.339	0.126	0.189	0.591
Both	0.862	0.120	0.496	0.995

TE*

Group	Mean	St.dev	Min	Max
Android	0.317	0.091	0.165	0.433
iOS	0.289	0.071	0.185	0.385
Both	0.669	0.116	0.390	0.878

Upon analyzing the TE values sorted in descending order, it is evident that iOS > Android > Both. CPs belonging to the iOS group have a higher average efficiency (0.891) by developing and supplying content according to the rules of the iOS platform policy, whereas CPs in the Android group have a low efficiency (0.804) due to investing resources in the optimization of each device and OS by modulating to open policy platforms. CPs in the “both” group have the lowest average efficiency (0.778) due to the difficulty of complying with the rules of both iOS and Android.

TGR is the index of how far the group frontiers are from the meta-frontier. Comparing the two platforms, the results show that the TGR of Android is 0.391 and that the TGR of iOS is 0.339; therefore, the Android group ranks higher in this measure than iOS. In other words, a platform ecosystem maintaining an open and flexible policy is more efficient from the viewpoint of the meta-frontier than from the platform ecosystem. As mentioned above, even though the iOS group has a higher within-group efficiency, the Android group has greater potential to get closer to the meta-frontier.

In addition, CPs providing content to both platforms are far more advanced than CPs focusing on only the iOS or Android platform. Because developing content for both platforms can be difficult and expensive for startup companies, there is a “firm size effect” on the ability to distribute content to both platforms and a “firm age effect” on the ability to develop content for both platforms. To test this hypothesis, this chapter uses an econometric model. In the model, the independent variables include the size of the firm, which is measured by total employees and the age of the firm, and platform dummy

variables which indicate to which platform a firm provides its content. The dependent variable is technical efficiency. Because it ranges from 0 to 1, a Tobit model was selected to estimate the parameters. The model used in this estimation is as follows.

$$TGR_{it} = \beta_0 + \beta_1 size_{it} + \beta_2 age_{it} + \beta_3 D(Android)_i + \beta_4 D(iOS)_i + \varepsilon_{it} \qquad \text{Eq. (6)}$$

Table 3.6 shows the results of this analysis. The size of a firm affects the firm's technical efficiency significantly, while the age factor is not significant. In addition, the parameters of dummy variables that represent the effect of focusing on one platform strategy are all negative values, which imply that focusing on one platform is not a salient strategy for CPs. This result shows that if a CP earns profits in one platform market, it might invest labor and capital to develop the same content for another platform, and if it succeeds in this expansion, it would have two channels in which to distribute content and would therefore be able to communicate with customers of both platforms and have the experience of developing for both platforms. This positive cycle serves to differentiate this group from other groups of firms.

Table 3.6 Tobit model maximum likelihood estimation

	Estimate	Std. error	t value
(Intercept)	8.443e-01 ***	0.008	109.481
Size (otal emp)	4.271e-06 ***	0.000	5.112
Age	-9.075e-05	0.001	-0.134
D.android	-4.764e-01 ***	0.010	-47.927
D.ios	-4.769e-01 ***	0.017	-28.636
sd.eps	7.014e-02 ***	0.003	27.011
sd.mu	1.016e-01 ***	0.004	28.640

3.6 Discussion

This chapter compares the two different platform ecosystems, which are representative of open and closed platforms. The results indicate that the closed platform ecosystem achieves a higher average efficiency within the ecosystem than the open platform. In terms of meta-frontier analysis, the open platform achieves a higher efficiency than a closed platform. An open ecosystem has a higher efficiency in the long term. Because the nature of creating content necessitates novelty and involves significant uncertainty, minimizing risk and maximizing the value of content are critical for CPs (Doyle, 2013). Apple manages the novelty and uncertainty risks in the selection process. This quality control helps a CP maximize its value once the CP enters the ecosystem. This hypothesis is supported by a higher observed TE for the Apple group. In the case of Android, the selection rule does not belong to a PP, but to CPs, which indicates that Android transfers risk management to CPs. Because it is unknown how consumers will respond or what will work (Caves, 2000), this environment presents CPs with a difficult selection process. This initially explains the low TE, but in the long run, CPs belonging to Android have the potential to achieve high efficiency because they achieve a higher TGR.

There is one more reason for the high average efficiency of the iOS group. The iOS platform can address conflict (Ku & Cho, 2011). During the evolution of an ecosystem, reducing conflict is important (Almirall & Casadesus-Masanell, 2010; Cusumano & Gawer, 2002). Many solutions to various problems conflict with one another, which reduces overall performance. Strategies for integrating value chains and strict control of

the overall layers allow Apple to minimize conflict, which also results from a simple evolutionary system. Apple successfully reduces interdependency. By maintaining a strict policy, Apple requires that third parties follow its rule not to deviate from its developmental environment. This strategy involves limiting the number of technical languages or distribution channels, maintaining the product quality of third parties, and developing efficiency. According to Kauffman (1996), because interdependency exists among actors in a system, interaction among actors may hinder the evolution toward a higher position. When multiple third parties attempt to evolve simultaneously, it would be difficult to sustain the coherence of the evolving trajectory of the entire system because of its high complexity. Apple maintains their closed policy by not opening the role of content selection.

This chapter defines the openness of the platform as the degree of strictness in content selection when CPs want to enter the platform ecosystem and finds that the different degrees of openness make the CP's productivity, which is the average TE and TGR, different. Then, what is the exact role of openness in the evolution of an ecosystem and how does the open system achieve long-run efficiency? This chapter concludes that the role of openness is to produce a greater diversity in the ecosystem, allowing third parties to enter freely. In this environment, creative content, which is the new combination among diverse pools, is likely to be promoted. Whereas this process requires a long time, it will help the platform ecosystem grow sustainably. The iOS ecosystem focuses on a strict selection process, in which it is difficult to generate diversity. On the other hand, the

Android ecosystem focuses on diversity. Many developers are comfortable with Android, and they are able to publish on the Android platform while maintaining their unique value with fewer constraints. Therefore, the diversity can be continuously produced in the system.

This chapter shows that the open system produces high TGR. The question is whether the open platform has always been able to win the platform competition in the long run or not. The case of Atari might be able to answer this question. The Atari video game platform was an open ecosystem in the late 1970s. It allowed anyone to develop game software and did not play the selective role that the Android platform does. However, the ecosystem collapsed in 1983 even though there were numerous third parties that developed game software. This illustrates that a completely open system, without any control in the platform layer, may collapse. In the case of the Atari platform, developers had released numerous imitative games to realize immediate gains, but consumers became less interested because of the similarities among the games. Eventually, the Atari platform began to lose its uniqueness, causing the entire ecosystem to become damaged. Atari's history shows that the system of openness does not always work. However, it can work when the platform controls the level of genuine diversity[5] of third party products or services.

Finally, this chapter finds that the CPs providing their content to both platforms achieve much higher TGR than CPs providing their content to only one platform (either

5 The different types of diversity are defined in Chapter 4.

the Android or iOS group). What is the meaning of expanding to the other platform in the view of the first phase of CPs? Content providers are able to provide their content to both iOS and Android platforms. Additional effort is required to develop the content for both platforms because migrating between platforms comes at a considerable cost (Xu et al., 2010). However, if CPs can handle the development and distribution costs, they are able to approach both iOS users and Android users (Hagel et al., 2008), which makes it possible to establish a stable profit structure. For a firm with sufficient resources and human assets that focuses on one growing platform, it could be a good strategy to expand to another platform and potentially develop additional efficiency in the long run.

In the current ICT ecosystem, PPs and CPs are not only business partners, they are two groups sharing a common objective in the ecosystem. Currently, there are two platform options for CPs to choose from: iOS and Android. These two major PPs have different rules, and the differences between mobile ecosystems as provided by iOS and Android are increasing.

This chapter analyzes which platform ecosystem allows CPs to be more efficient. The results shows the iOS group achieves high average efficiency with low variance among the three groups. From the meta-frontier viewpoint, Android group firms have a higher efficiency level than iOS group firms. In addition, the group providing content to both platforms is the most efficient because of the economies of scale. Therefore, there is no distinctly advantageous platform for CPs during the early stage of their growth. However, if a CP is successful, it would be good strategy to expand its investment in the other

platform.

This chapter has two significant contributions. First, it empirically compares the differences between the performances of the CPs on different platforms by proposing a novel method that can be applied to compare these complex systems. Second, the roles of diversity and how diversity works in the new ICT ecosystem in the long run are discussed.

Chapter 4. The Influence of the Giant Platform on Content Diversity

4.1 Introduction

The innovation of the smart phone, started by Apple, caught the interest of consumers of all demographics, which sparked a demand for smart devices all over the world. This demand allowed platform providers, especially for mobile OS platforms, to take on the role of a mediator between CPs and consumers. Soon, portal services on the Internet had also gained leverage on smartphone users. The influence of PPs had grown in the ICT ecosystem because of their unique and necessary position (Hargittai, 2004). This trend can be both an opportunity and a disaster for CPs which are usually small or medium sized firms. As PPs open their market to third parties, small sized CPs benefit from the opportunity to connect with users, but at the same time, they are highly dependent on the PPs. As a result, PPs could discriminate against CPs or contract unfairly by abusing their market power (Hyenyoung, 2012). Lawmakers cannot find the justification to regulate PPs because markup data is not transparent and there does not seem to be any entry barriers (Hargittai, 2007).

One of the problems that may occur as platforms become too large in size is that the diversity of the content may decrease (Doyle, 2010; Napoli & Karppinen, 2013). As PPs become increasingly large, the role of selecting content shifts from the consumers to the

platform, and CPs become more interested in meeting the platform's needs rather than the users' hidden needs, which is unknown to both users and CPs. Therefore, CPs may give up maintaining the uniqueness of their content if they cannot benefit from having a contract with giant platforms. These dynamics can drive the content diversity downward and damage the overall health of the platform ecosystem. In other words, a few content selected by the platform would generate more profit, but the contents that were not chosen lose the opportunity to be exposed at all to the users (Doyle, 2010; Hargittai, 2000b). Although users can find the content they are searching for on a platform, the quantity and quality is still insufficient to meet their hidden needs. When CPs do not try to identify these hidden needs, they become less inclined to develop more creative content.

There is debate on whether the government should have the power to regulate a platform or not (Ballon & Van Heesvelde, 2011). Consumers have some onerousness with changing platforms when they are searching for content (Xu et al., 2010), and the burden of searching might be lessened if a giant platform recommends content that consumers may like. Furthermore, previous measurements of content diversity have captured only the exposed size of the population, such as the quantity of content in a platform. (Champion, Doyle, & Schlesinger; Napoli, 2011a, 2011b). These measurements are usually increasing, however it does not reflect the true diversity of the content in a platform. Therefore, a study is required to propose a new way to measure true diversity. The origin of the content layer is art and culture. This creative industry flourished by

maintaining diversity and encouraging trial and error and not through biased selection (Doyle, 2010, 2013). Therefore, an absence of diversity on the content layer would gradually damage the whole ICT ecosystem. In regards to this situation, this chapter proposes the following questions: Can a giant platform that is widely used by consumers treat small and medium-sized content providers fairly? Under the giant platform ecosystem, could content diversity be maintained appropriately? If not, how can content diversity be recovered when it is in a decreasing trend?

According to Hargittai (2000b), since giant platforms, such as portal sites, act as the gate-keepers between CPs and users, a need for non-profit portal sites free from advertisers exist. Also, users should be aware of their behavior because they may become complacent on the recommended content from the platform. Hargittai warned that without non-profit platforms, giant commercial portals would be bias towards content that are provocative and not educational or public.

This chapter examines the effects of content diversity in the platform ecosystem and provides evidence regarding how the platform influences the level of diversity of content. Firstly, this chapter introduces the problem of decreasing content diversity. Secondly, it explains the mechanism of content providers' evolution. Thirdly, it suggests a model to reflect dynamics of a platform ecosystem, which resembles biological evolution. Simulation based on genetic algorithm mirrors the characteristics of platform ecosystem. The simulation can be used for experimental purposes to find how the system changes content diversity and under what conditions. Fourthly, several policy experiments are

carried out to examine the circumstances where content diversity can be recovered. Lastly, the chapter concludes with the simulation results and discussion.

4.2 The Mechanism of Evolution in the Relationship Among Platform, Content, and Users

In order to build the evolutionary model to show the relationship among PPs, CPs, and users, an understanding of the process of contracting between business entities is needed. The consumption of content by consumers through a platform consists of three steps: (1) CPs create their own content and upload them to a platform in order to start a contract with the platform. (2) A platform selects CPs to contract with based on its preference, and (3) consumers select content from the platform. At the end of this process, CPs are paid for their content that were selected by consumers and gain recognition. On the other hand, CPs that are rejected by consumers or refused by platforms benchmark the content selected by most of the consumers, produce new content, and re-enter it to the platform (back to the first step). As this process continues its cycle, CPs, platforms, and consumers evolve together.

4.2.1 The Entry of Content Providers

In the process when a CP tries to get its content onto a platform, the initial step of this process is just trying to enter in order to make a contract with the platform. For durable goods, market demand can be forecasted. However, market demand for content is difficult to forecast before they are launched into the market. Furthermore, consumers have no knowledge regarding their hidden needs for content, new information goods, before consuming the content. Therefore, this initial step is executed through trial and error to

explore the hidden needs of the consumers. This step helps to promote more diversity of the content, and for this reason, platforms should be more open to the idea of trial and errors.

4.2.2 Making a Contract

Even with great content, CPs may lose the opportunity to have their content be viewed by consumers if the CPs fail to contract with the platform[6]. Thus, making a contract is an essential step for CPs to reach consumers. It is the first selection step of creating variety of content that forces a reduction in diversity. If a platform chooses a particular content, the other unchosen content are taken out of the system, and then the preserving genes in the system will be reduced. The loss of diversity is not recovered only with combination among the genes in the system, but with new genes from the external systems. However, selection steps are important to challenge the population that has motivation for adopting and innovating themselves in order to be selected next time. Finally, how to manage the selective pressure is a key criterion of balancing between efficiency and diversity in the system.

[6] A platform might be a mobile OS provider such as iOS or Android, a social network service provider such as Facebook or Twitter, a network provider, or a smart-phone supplier. This thesis focuses on the platforms that mediate between content and information or content such as search engine and portal site providers.

4.2.3 Measurement of Performance

Once the contracting process has been finalized, CPs will then be able to expose parts of their content to the consumers. The CPs then generate revenue through the consumers' click activity of those content linked with advertisements. The second selection step is measuring the CP's performance which could be through the collection of sales data or the number of clicks. To be selected by consumers, a content should contain some aspects of consumers' needs. As mentioned before, since consumers' needs are complex and categorized into various dimensions, the content retaining uniqueness and being universal at the same time would attract attention from the consumers. In addition, once a content becomes a success and generates revenue, the CP gains reputation and the process of contracting with the PP will become more streamlined.

4.2.4 Benchmark or Imitate the Best Performed Content (Recombination)

Most content on a platform try to meet the consumers' needs, but usually only a few of them are successful at being selected. CPs that are little known or not contracted with a platform could learn from one of the popular content or benchmark it for future success. In the competitive content market, CPs may engage in imitating other successful content in order to reduce their risk. CPs that imitate content are divided into two types: Fast imitator, a CP that creates content based on the best performing content. These could be

in the form of a parody or a generic version of a popular content. The other type is the slow imitator, a CP that creates content based on original ideas and try to combine the ideas of other popular content[7].

[7] March (1991) introduced the concept of the fast and slow learners when he explained the organizational learning mechanism in the seminal paper; Exploration and exploitation in organizational learning. *Organization science*, *2*(1), 71-87.

4.3 Model

4.3.1 Genetic Algorithm and the Advantage of Modeling the Platform Ecosystem

This chapter uses a simulation model based on genetic algorithm to examine the effects of content diversity under a giant platform environment and how to recover from a decreased level of content diversity. In this dissertation, growth of platform ecosystem is considered as evolution, and the model applying genetic algorithm is an effective research tool for modeling biological evolution. March (1991) introduced genetic algorithm in order to study the process of evolution of organizational knowledge. The concepts from this model are applied to the platform ecosystem. CPs are considered to be organizational populations, and the evolution of platform ecosystem was molded from the evolution of organizational learning. According to Bauer (2014), when it comes to the system competition and innovation between platform and content providers, since previous theories have no dynamics, policy implications through those theories would be applied only into short-term problems, but it might cause side-effects in the long-run. Therefore, the systemic approach is more applicable to predict and give more realistic implications in the future. Furthermore, there are three reasons why the model used in Chapter 4 is fitted to reflect the concept and dynamics of platform ecosystem. Firstly, the process of producing content is like evolving an idea or thought, and this concept fits adequately with the mechanism of genetic algorithm. Secondly, in the way an organization mediates firms and individuals, a platform mediates content providers and users. Lastly, the models

are able to introduce a slow imitator to content providers, which is applied by the slow learner in the organization which March (1991) introduced.

In a traditional method of finding equilibrium, one single rational individual, who is a representative consumer with full information about the market, directly finds the optimal point. The optimum is not always a global peak, but once he reaches a peak, he may stop searching. In contrast, GA starts with multiple individuals called the population that do not behave rationally. The population starts exploring to achieve the global peak under a given problematic space. At every period, all individuals take a fitness test. Those who have a higher fitness value have a higher chance of survival, which is called selection, and try to get a much higher fitness value through recombination. The population that survived reproduces offspring which becomes the next generation. Until the population shares the same genetic code, the population keeps traveling. If some reach a local peak, they can escape it by the selection and reproduction mechanism. Once the population reaches equilibrium, they cannot evolve except through mutation. Therefore, genetic diversity is a serious issue for GA. Through the process of selection and reproduction, individual codes get similar, and finally, they converge. If genetic diversity remains in the system for a long time, the population can migrate far enough to find the global peak. In contrast, if diversity within the system diminishes quickly, the population will be stuck in the local peak and lose the chance to improve further.

The evolutionary path of content on the platform ecosystem has a high degree of similarity with the general GA. The evolutionary path consists of two steps comparable to

GA: making a variety and selection. In the first step, a variety of digital content, considered a group of multiple individuals, try to find the preference of the majority of the consumers through various trials. However, they have no way of determining which content will be successful or not, much like the multiple individuals in GA not having rationality. There is a significant philosophical difference between GA and traditional economic methods which have some hypothetical limitations of rationality. The next step is selection, which is slightly different when compared to the general GA. In general GA, the whole population can be measured, however in the platform ecosystem, a PP chooses some content which are likely to meet the consumer's needs and contracts with the CPs. The reproduction scheme is similar to the convergence of the content. When the best performer of the content, which meets the hidden consumer's preference is chosen, imitations will take place. Other CPs start to combine the best performers' ideas with theirs. The last similar point is the matter of diversity in the system. In this kind of evolutionary system, the potential of growth is measured by how much diversity remains. If all of the content are similar and the system has a low diversity, the population is likely stuck in some local peak, and there is no chance to improve. Table 4.1 shows the matching points between GA and dynamics in a platform ecosystem.

Table 4.1 Dynamics in a platform ecosystem model based on genetic algorithm

Genetic Algorithm	**Dynamics in a Platform Ecosystem**
Make Variety	Entry of new comers Creation of a new content or a new combination of content
Selection	Measurement or scoring system of the contents - Scoring made by consumer's click (profit and score made by consumer's preference) - Content innovation which meet consumer's complex needs and expands niche market
	Contraction between platform and content providers (selection) - New comer has to pass the entry barrier (Pnew=0.1)
	Exit of non-contracted contents In the case of incumbent, score and the reputation of the content determine the probability of contract with platform
Mating (Imitation)	Many content imitate the best performer among the content which won the contract or converge the bits of the best performer with their own - Pslow(Slow content): content provider that is likely to keep their original bits - Pfast(Fast content): content provider that is likely to imitate the best performer's bits - Rs(Ratio of Slow content): the ratio of the slow imitator to the content providers in the ecosystem
Environmental Change (Change in Consumers' Taste)	The consumer preference changes gradually The probability of changing the consumer preference is low like changing fashion

4.3.2 The Model of Relationship Between CP-PP-Users (Dynamic Rules)

Selection is a primary aspect of evolutionary mechanism. According to Holland (1992), selection is defined as the members of a population that survived to reproduce the next generation. In this chapter, the role of selection is only played by a giant platform. It decides which CPs to contracts with by regarding previous fitness values and the CPs' reputation. In general GA, selection is a simple mechanism; if an individual fails a test of the fitness, he perishes. If he passes the fitness test, he survives and reproduces offspring and passes his genes to the next generation. More fitted individuals are generally given a higher chance to participate in the reproduction process, and not every individual can join the intermediate population. As a result, information encoded in the current population is not entirely transferred into the next population. Likewise, if a content secures a contract with a platform and gains notoriety from the users, the content's gene gets passed down to the next generation. In addition, other CPs may try to imitate its gene or converge their gene to the successful content's gene.

Content is selected through two steps. The first one is sampling. The sampling process allows the PP to sample the contents of the CPs before being consumed by the users. When new entrants initiate deals with PPs to enter the content market, an entry barrier exists due to the platform's market power. A new entrant with no prior contract with the platform will have a difficult time overcoming the entry barrier. However, if a new entrant crosses the entry barrier once, the CPs would gain a reputation which enables it to

contract with the platform again. The second step is selection. This step is carried out by consumers who click on the content in the platform. Finally, the best consumed content emerges, and other CPs want to know its strategy and imitate it. In GA terms, this process is called recombination. Two different types of CPs exist during this process: fast imitator and slow imitator. A fast imitator recombines the best performer's idea with its content rapidly, while a slow imitator recombines the best performer's idea in their content slowly. The next process involves measuring the score, the number of dimensions that the content meets the consumers' needs, including their hidden needs. This process can be considered the first cycle of evolutionary dynamics. The second cycle also starts with sampling, but it is slightly different from the first cycle because there are not only new entries but incumbents with contracting experience. Therefore, starting from the second cycle, sampling by the platform considers the incumbents' reputation as well as their scores. New entrants still need to overcome the entry barrier, which becomes more difficult to penetrate while the platform grows in size. After the sampling process, consumers select the best performer, and these two cycles repeat continuously (see Figure 4.1).

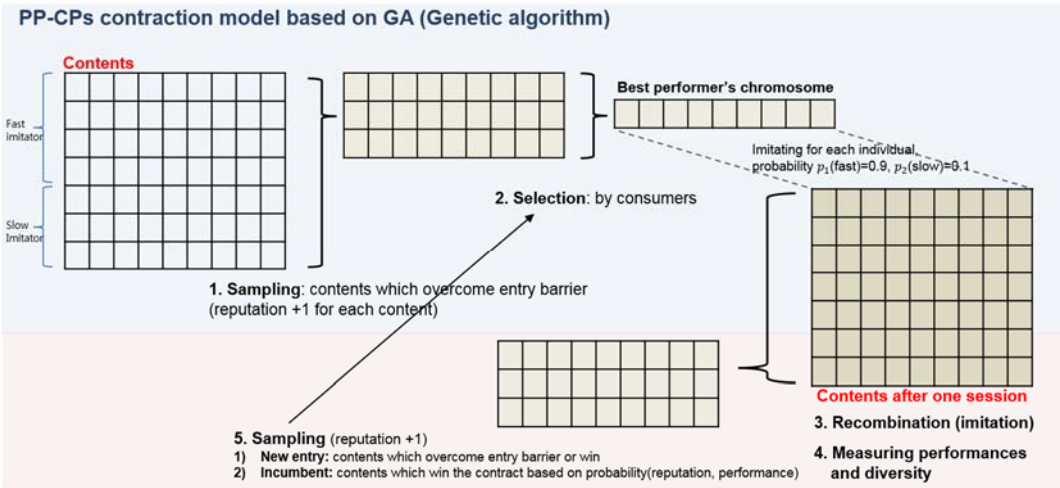


Figure 4.1 Dynamics of the platform and content providers

In the process of selection scheme, loss of diversity is unavoidable. However, to mitigate this loss, balancing or overcoming the conflict of exploration and exploitation is required in the selection. In a system, when all the individuals share the same gene, the chance to evolve diminishes completely. A system could become stuck in the low knowledge level if it converges too rapidly; this is called premature convergence, which also means that the system stops evolving at the local peak. Selection methods, the tests used to examine the survivability of individuals, deals with the level of diversity. In the platform ecosystem, if only one giant platform existed and had complete control of selecting content, what are the effects on the degree of diversity? What are the chances of keeping the rare and useful genes in the system? These are the questions that are answered in the remainder of this chapter.

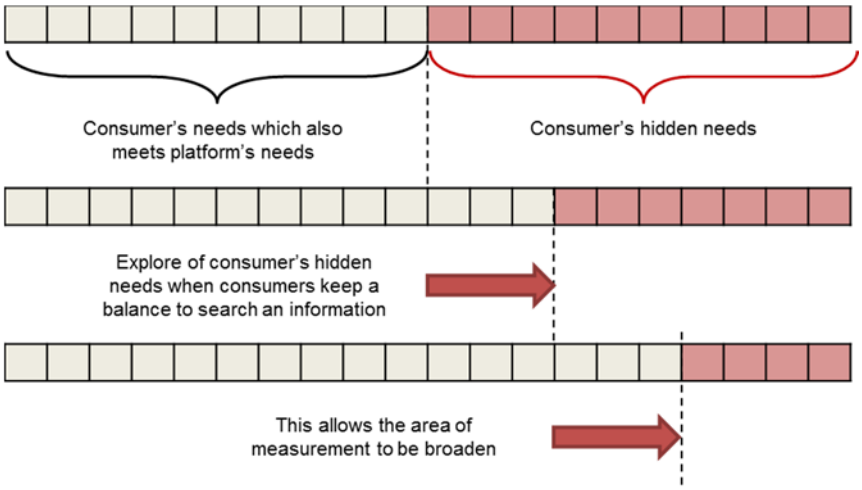


Figure 4.2 Expansion of consumers' hidden needs

In the dynamics of a platform ecosystem, consumers' needs consist of two parts. One is the part which contains the needs of the consumers and the platform, and the other part is consumers' hidden needs which have not been explored yet. The former part is usually met by content that gives an appropriate level of information that consumers are likely to like. If the consumer spends a large amount of time consuming the content, the consumer is satisfied to some degree and the platform is also satisfied. However, in this situation, the consumers' hidden needs have no way of being discovered by the CPs. Figure 4.2 shows the expansion of consumers' hidden needs. The more consumers search for specific information, the more CPs will try to create new methods to meet the consumers' hidden needs. In other words, the active will of exploring consumers' hidden needs promotes content diversity in the system and the new combination and creativity of content increases, thus giving vitality in the platform ecosystem.

4.3.3 Variables

This sections introduces the variables used in the simulation model. Average performance is the average of fitness value of contracted content in a period. There are two types of diversity: phenotype and genotype diversity. Phenotype diversity is the number of content that are under a contract in a given period. In the previous studies, diversity comprised of only the superficial aspects like the number of a population and the number of genres. However, the need to measure genuine diversity arises in a variety of contexts. Therefore, in this chapter, genotype diversity is now applied when measuring diversity in the platform ecosystem. Genotype diversity is the degree of content being different from each other in the view of the content's intrinsic characteristics. When two items of content are similar to the degree that the original is indistinguishable, the value of genotype diversity is almost zero, while the value of phenotype diversity is two. Much like the way that every human being has his/her unique DNA, every content also has its own genotype. Therefore, in the same way twins are identifiable by their DNA, we can also identify two similar sets of content by measuring their genotype diversity. Figure 4.3 shows the difference between a content's phenotype and genotype. In this case, phenotype diversity is three for both the left and right side of Figure 4.3 because there are three items of content. However, when we look at the second and third content on the left side, we can see that the genotypes of the two content are the same. Calculating genotype diversity of the left and right sides using an equation (from Table 4.3) gives a genotype of 4.59 and 6.31, respectively. The right side of Figure 4.3 has a high genotype diversity,

although phenotype diversity is the same as the left side.

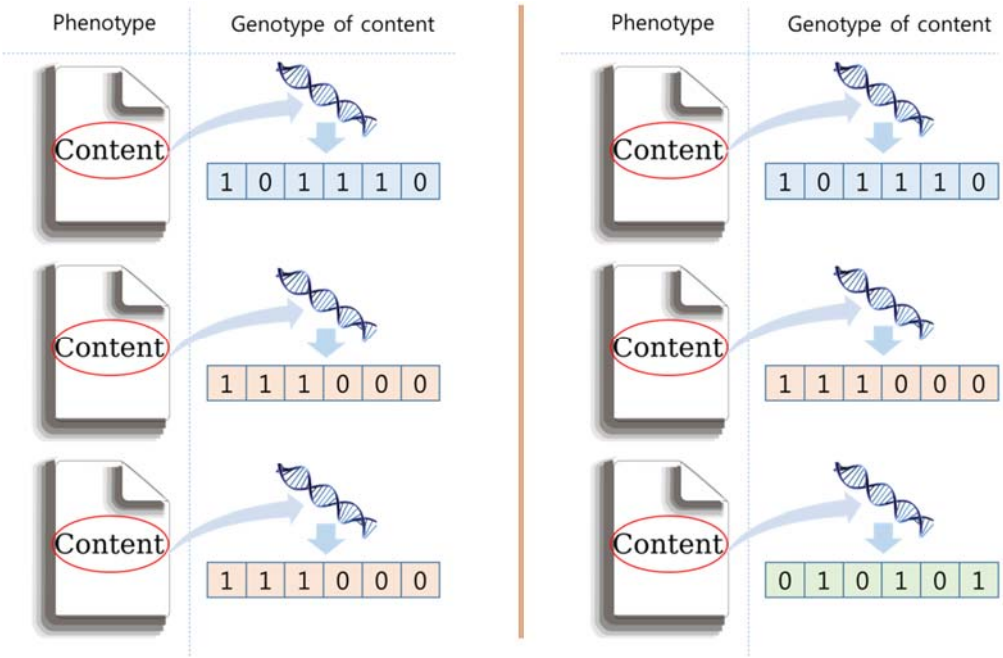


Figure 4.3 The difference of pheno/geno-type of content

Genotype diversity is the genuine diversity of contracted content. In evolutionary algorithm, including GA, genotype diversity is often measured using pair-wise Hamming distance, but comparing all the distances in the population is not an efficient method to measure genotype diversity. Therefore, this chapter introduces a method by Morrison and De Jong (2002) for calculating genotype diversity using the new moment of inertia method.

Experimental variables are twofold: Pnew and Rs. Pnew is the degree of difficulty to overcome an entry barrier of a platform. Since this variable is expressed as a probability, it ranges from 0 to 1. Rs is the ratio of slow imitator to contracted content and also ranges from 0 to 1. Control variables include population size (popSize), the number of dimensions of the consumer preference (bits), probability of slow imitators to imitate the best performer (Pslow), probability of fast imitators to imitate the best performer (Pfast), and the change in the rate of consumer preference (Penv), also described as change in the trend of technological opportunity and environment. Table 4.2 summarizes the list of variables and their detailed information.

Figure 4.4 shows an example of calculating variables when the population size is 7 and the number of dimensions of the consumer preference is 9. When there are three items of content under contract: fast imitator (1,1,0,0,0,1,1,1,0), fast imitator (1,1,1,1,1,0,0,1,0), slow imitator (1,1,1,0,0,0,0,0,1) and the consumers' needs are (1,1,1,1,1,1,1,1), each content's performance is measured by the number bits of consumers' needs met by each content. In this case, the performance of each content is: 5, 6, and 4. The ratio of the slow imitator to contracted content is 1 to 3 because there is only one slow imitator out of the three contracted content. Table 4.3 shows an example of calculating phenotype diversity, genotype diversity, and average performance. When calculating average performance, the sum of all contracted content is divided by the number of contracted content; (5+6+4)/3 = 5. Phenotype diversity is just the number of contracted content, so in this case, it is 3. Lastly, to calculate genotype diversity, we need

to calculate the coordinates of the centroid of each bit and the moment of inertia about the centroid. The details of the equation are in Table 4.3

Table 4.2 The list of variables and their details

Dependent Variables	Phenotype diversity	The number of contracted contents in a period
	Genotype diversity	The genuine diversity of contracted contents: degree of not overlapping between each bits
	Average performance	The average of fitness value of contracted contents in a period
Experimental Variables	Pnew	The height of an entry barrier of the platform (range 0~1)
	Rs	The ratio of slow imitator to contracted content (range 0~1)
Control Variable	popSize	Population size (Initial setting = 1000)
	bits	The number of dimensions of the consumer preference (Initial setting = 300)
	Pslow	Probability of slow imitator (Initial setting = 0.1)
	Pfast	Probability of fast imitator (Initial setting = 0.9)
	Penv	Changing rate of consumer preference (taste) (Initial setting = 0.005)

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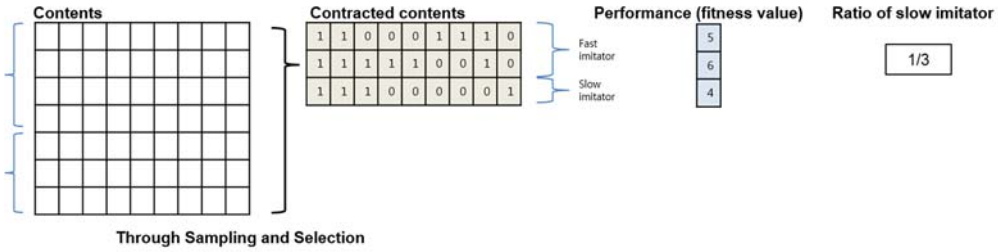


Figure 4.4 Example of calculating performance and ratio of slow imitator to contracted content

Table 4.3 Example of calculating phenotype diversity, genotype diversity, and average performance

Phenotype Diversity	The number of contracted content in a period = 3
Genotype Diversity	The genuine diversity of contracted content: degree of not overlapping between all bits 1) The coordinates of the centroid of each bit is $C_i = \frac{\sum_{j=1}^{j=P} x_{ij}}{p}$,where bit=i (1:L), id of population=j (1:P) C_i = *(3/3, 3/3, 2/3, 1/3, 1/3, 1/3, 1/3, 2/3, 1/3)* 2) The moment of inertia about the centroid is $\mathrm{I} = \sum_{i=1}^{i=L}\sum_{j=1}^{j=P}(x_{ij} - C_i)^2$,where bit=i (1:L), id of population=j (1:P) $= (1-\frac{3}{3})^2 + (1-\frac{3}{3})^2 + (0-\frac{1}{3})^2 + (0-\frac{1}{3})^2 \cdots + (1-\frac{1}{3})^2$
Average Performance	The average of fitness value of contracted content in a period (5+6+4)/3 = 5

4.3.4 Experiments

This chapter designs the four experiments. Each experiment is carried out ten thousand times, and the average values are calculated in order to show the trend.

Experiment 1

The first experiment aims to find how the giant platform influences content diversity and average performance of the system. Parameters are set at neutral[8]. In this chapter, neutral setting is as follows. Population size is one thousand, bits is five hundred, Rs is 0.5, Penv is 0.005, and Pnew is 0.1 which decreases as the platform size increases. Also, as the platform size increases, the market power of the platform will also increase gradually.

Experiment 2

The second experiment aims to identify the role of CPs that are trying to keep their true characteristics. As Rs changes from 0.1 to 0.9, while other parameters stay constant with the neutral setting, the change in the three dependent variables is observed.

Experiment 3

The third experiment models a situation where consumers, unsatisfied with the content from a giant platform, are trying to diversify the source from which they obtain

[8] To confirm the sensitivity of the neutral setting, this chapter contains sensitivity analysis of variables as a change in Pnew and Penv, and results are in Appendix 2.

information and content. This willingness of the users would enable them to explore the consumers' hidden needs, and CPs will try to meet the consumers' needs by creating other methods of acquiring content. Other parameters are the same as the neutral setting (as in Experiment 1), while one setting is added to factor in the consumers' hidden needs being explored. The change in the trends of the three dependent variables is observed.

Experiment 4

The fourth experiment aims to observe the change of content diversity and average performance when the giant platform is prevented from abusing its market power. The experiment supposes that a non-profit platform is introduced to the market. The non-profit platform, which is perfectly open to all users and CPs, does not rely on advertisement profit. As a result, CPs which could not make a contract with PP have the option to publish their content through a non-profit platform to meet users. Parameter setting is the same with Experiment 3 except that Pnew is 0.1 and stays constant. This experiment assumes the non-profit platform as the alternative to the giant platform.

Table 4.4 Experimental designs

Experiments		**Parameter Setting**
1	Trend of pheno/geno type diversity	Neutral - popSize = 1000, bits = 500 - Rs = 0.5 (Pslow = 0.1, Pfast = 0.9) - Penv = 0.005 - Pnew = 0.1 (decreasing on)
	Trend of average performance	
2	Trend of pheno/geno type diversity under a different ratio of slow learner	Rs changes (0.1,0.3,0.5,0.7.0.9) Other parameters are the same with a neutral setting
	Trend of average performance under a different ratio of slow learner	
3	Trend of pheno/geno diversity under a different environment of consumers and content providers	Consumers' hidden needs are found by any means (creative activity on) Other parameters are the same with a neutral setting
	Trend of average performance under a different environment of consumers and content providers	
4	Trend of pheno/geno diversity under an existing non-profit platform	Consumers' hidden needs are found by any means (creative activity on). Pnew = 0.1 (decreasing off)
	Trend of average performance under an existing non-profit platform	

4.4 Simulation Results and Analysis

Experiment 1

Figure 4.5 shows the result of Experiment 1. Average performance increases with time up to a certain point and then decreases gradually after that point. This trend is similar to that of phenotype diversity. Genotype diversity increases rapidly at the initial phase, but after it peaks, it declines and converges to zero. As it declines, phenotype diversity and average performance lose the capacity to grow. This result supports the hypothesis that the driving force to sustain growth in an ecosystem is genotype diversity, not phenotype diversity. The area under the trend of genotype diversity is the stimulus to grow a sustainable system. After genotype diversity declines, it does not recover. Firstly, this effect is due to the system being closed, so external diversity cannot be provided. Secondly, two selection pressure exists in the internal system: (1) sampling by platform and (2) selection by consumers. If external diversity is not provided, recovery of the diversity in the system would be difficult. By all appearances, the average performance and phenotype diversity look like they are maintaining proper levels, but it is already a dead system with regard to genotype diversity.

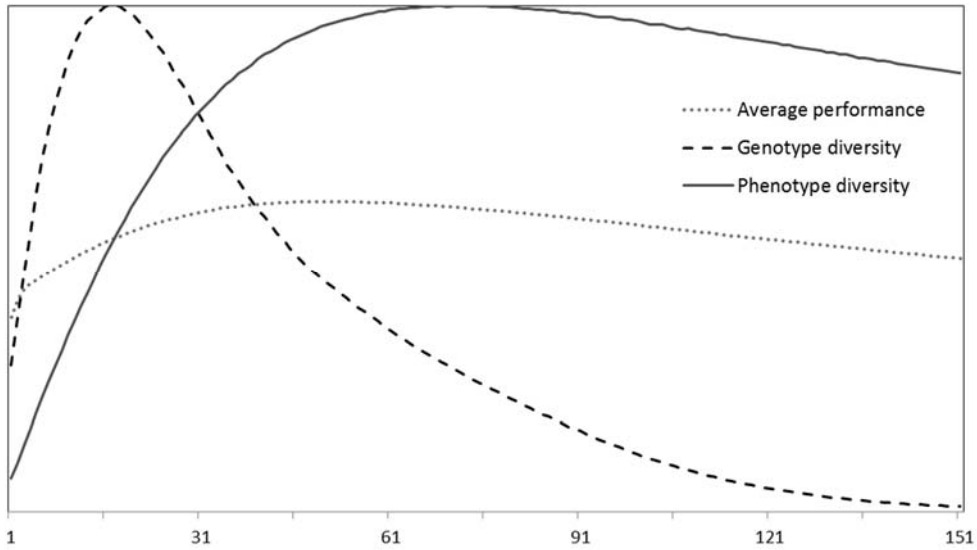


Figure 4.5 Results of Experiment 1 (Trends of three dependent variables)

Experiment 2

Figure 4.6 shows the trend of average performances for each change in the ratio of slow learner to contracted content. Average performance has a higher initial increase but a lower peak and converging point as the ratio of slow imitator is lower. In other words, if there are more CPs producing their unique content and not imitating the best performer, the rate at which the ecosystem degrades would be slow due to the unique and useful bits being more reserved in the ecosystem. This finding can also be proven by the trend of content diversity (see Figure 4.7). Suppose the area under the trend of genotype diversity is the energy potential to grow a sustainable system, the increase in the ratio of slow learner to contracted contents also increases the energy potential. In addition, phenotype diversity also increases as the ratio of slow learner increases.

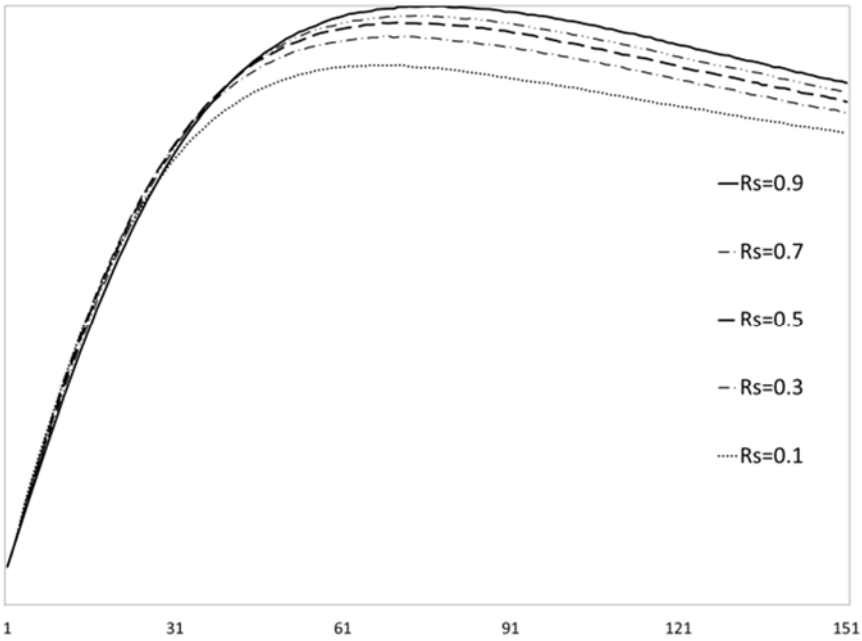
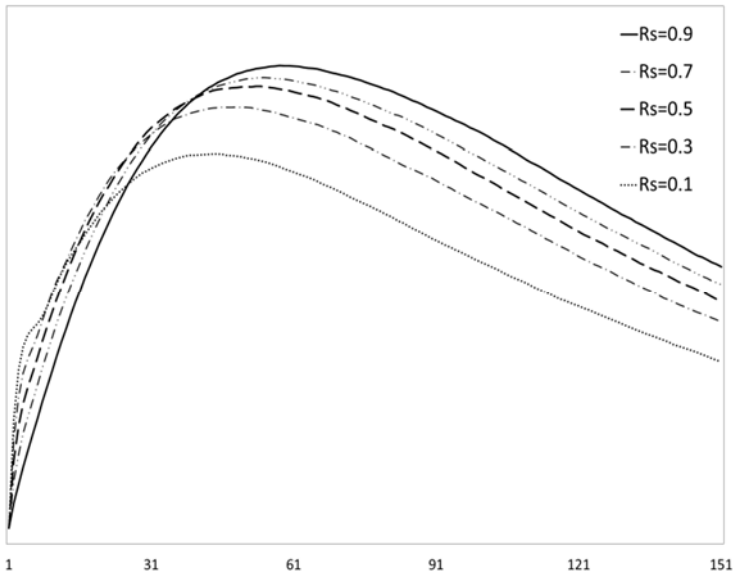
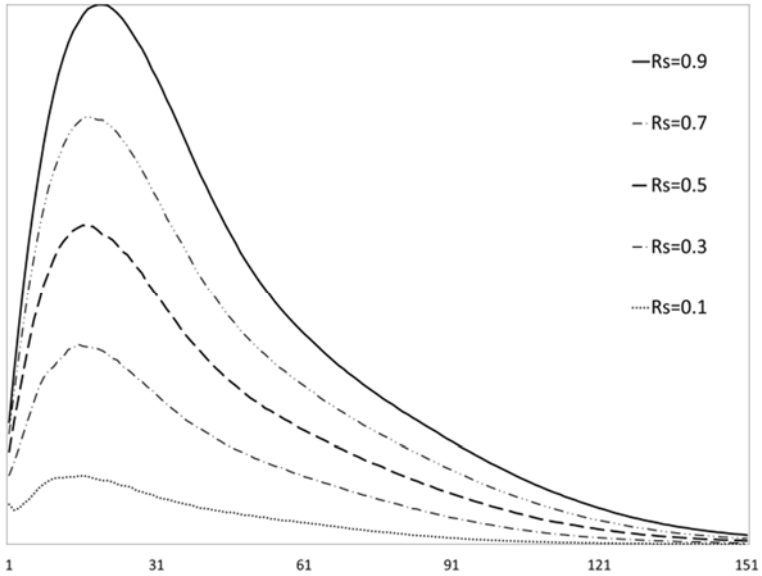


Figure 4.6 Results of Experiment 2 (Trends of average performances)



Phenotype diversity as changing ratio of slow imitators



Genotype diversity as changing ratio of slow imitators

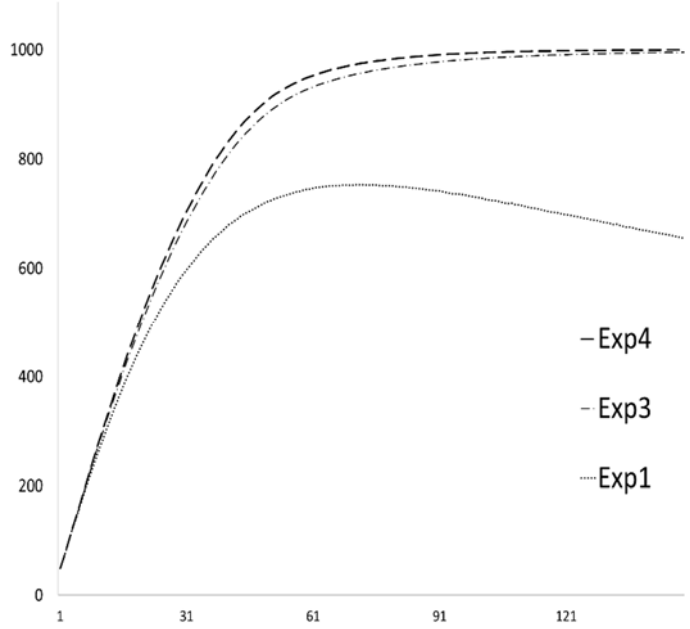
Figure 4.7 Results of Experiment 2 (Trends of content diversity)

Experiment 3

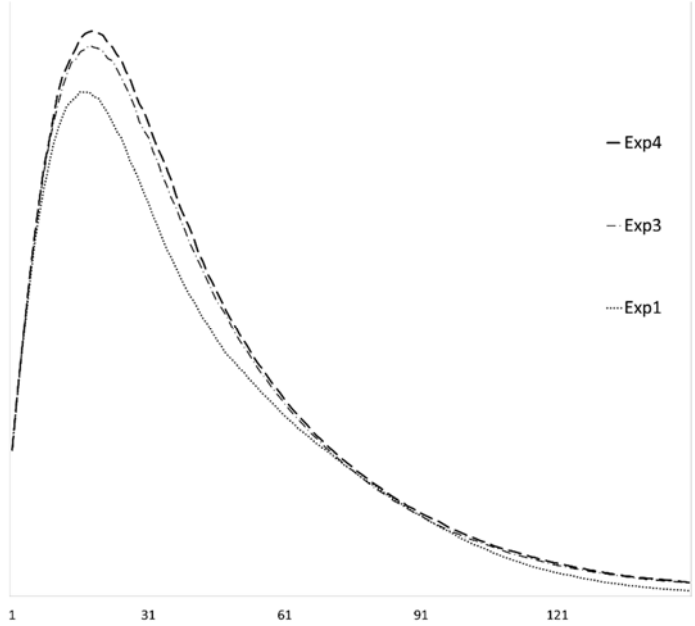
Experiment 3 simulates a situation where the previous users of a giant platform have altered their searching methods. Figure 4.8 (right side) shows that the level of genotype diversity in Experiment 3 is higher than in Experiment 1. In addition, Figure 4.8 (left side) shows that phenotype diversity in Experiment 3 is also higher than in Experiment 1. However, the most noticeable change is in the average performance. It is not only higher in Experiment 3 than in Experiment 1, but average performance also keeps growing which did not occur in a closed system (see Figure 4.9, left side). This implies that the will to diversify one's search creates external diversity in the system. Increase of diversity leads to more trial and error activity of productizing content, and this increase in creativity leads CPs to explore the consumers' hidden needs consistently, thus enabling the system to grow sustainably.

Experiment 4

Experiment 4 supposes there is a public or non-profit platform, thus the entry barrier does not get stronger for the giant platform due to the existence of alternative platforms for CPs and users to choose. In this experiment, the peak points of genotype diversity and phenotype diversity move up slightly compared to those of Experiment 3 (see Figure 4.8). Although the change from Experiment 1 to Experiment 3 is minimal, the content diversity still increases when a non-profit platform is introduced to the platform ecosystem.

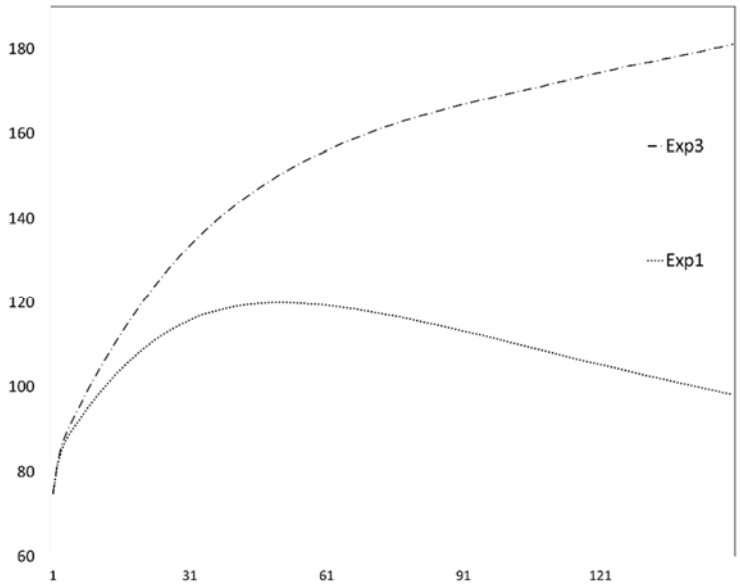


Phenotype diversity
(comparison among Exp1, Exp3, and Exp4)

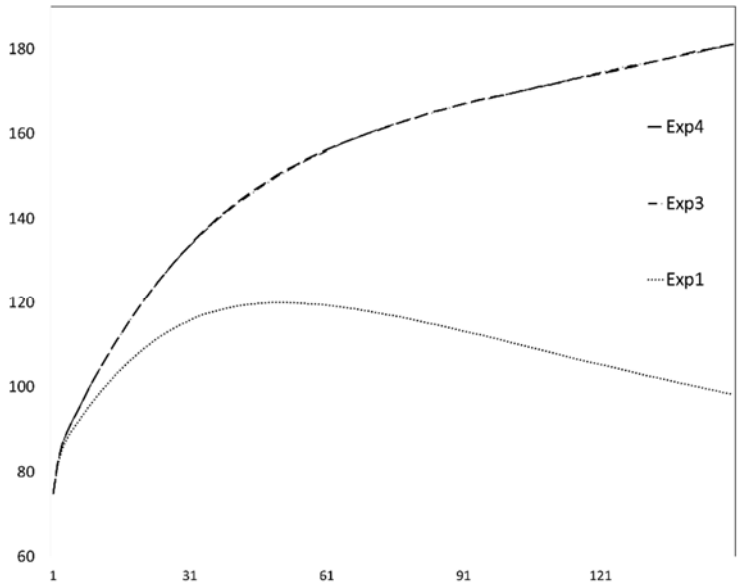


Genotype diversity
(comparison among Exp1, Exp3, and Exp4)

Figure 4.8 Comparison of the results of Experiment 1, 3, and 4 (Trends of content diversity)



Average performance (comparison between Exp1 and Exp3)



Average performance (comparison among Exp1, Exp3, and Exp4)

Figure 4.9 Comparison of the results of Experiment 1, 3, and 4 (Trends of average performances)

4.5 Discussion

How far a system can evolve is a matter of diversity. Diversity provides new knowledge to an organization. This is because if the expressive character of a gene is unique, it is able to influence the whole ecosystem[9]. However, recent giant platforms stopped taking chances on new and distinctive content because they are not provocative or sensational enough to generate revenue. This chapter verified the problem of declining content diversity through the results of a simulation. As long as CPs are under the environment of giant platforms, the selection mechanism of a content will stay distorted[10]. Even though content may look to be diverse (phenotype diversity does not seem to be decreasing much), actual diversity of the content's true characters decrease rapidly, having no chance to recover in the long run (genotype diversity decreases rapidly, converging to zero). The simulation model is not able to reflect reality perfectly. However, this chapter proposes that the direction of content diversity will keep decreasing if this system of giant platforms is not regulated.

This chapter focused on methods to relieve the speed of decreasing content diversity and methods to recover decreased content diversity because, in the system, diversity decreases no matter which selection mechanism it has. The result of the second experiment helped to determine the implications for the view of CPs. The higher the ratio of CP to the best performed content (slow imitator in the model), the higher the content

[9] http://www.nature.com/nrg/journal/v7/n7/abs/nrg1877.html

[10] According to Anderson and Gabzewicz (2006), advertiser preference could lead to a distortion of editorial content of a newspaper that is further from the readers preference

diversity is raised. Many giant platforms use articles or content with sensational titles to attract consumers to click on their sites. Many in the journalism industry know how this fishing strategy works and use the same strategy. When it comes to breaking news, we can see that many of the articles from various sources are becoming similar. These phenomena can lead to adverse selection problems in the market of information goods such as articles, content, music, etc. This can lead to misinformation of content and a loss of credibility of platform ecosystem. If this problem persists, consumers will no longer value the information or trust the articles from these platforms. However, what if the number of CPs that want to provide the truth and not imitate thoughtlessly increases? The adverse selection problem will then be solved gradually and content diversity will also be secured.

The third experiment provides an important implication to the consumers. The result shows that recovery of decreased content diversity is able to come from consumers' act of will, trying to find their hidden needs. This is a way of expanding the ecosystem by making new combinations through numerous new trials. For example, consumers may become a one-person media provider or try to diversify their source of content. To sum up, consumers should cognize that the content on the giant platform do not completely reflect their hidden needs but only reflect a part of their needs enough to guarantee the platforms' advertising revenue.

The fourth experiment supposes that a hypothetical non-profit portal is introduced to the ecosystem. To lower the commercial element of the giant platform and consistently

provide high-quality information with public value, aiding methods for non-profit platform financially and supporting policy is needed. In the way a public broadcast complements commercial broadcast in the media, public platforms could complement giant platforms and provide benefits to society via the web.

Giant platforms have been big contributors to new innovations in the Internet ecosystem that also created new markets. Moreover, there is efficiency and usability of the platform. However, considering the giant platform's social influence, alternatives are needed to avoid homogenization of information and reducing diversity and creativity of content. Also, in this system, the ecosystem is vulnerable to being diffused of false or low-quality information[11]. Pursuit of profit is an inherent trait of most firms, but if a firm's social influence becomes too powerful, the firm should care about their social responsibility like keeping diversity. In addition, users should also care about the firm's responsibility and not just enjoy the information that they can easily reach. Thus, not only the PPs, CPs, and governments but also consumers should cognize the importance of keeping proper diversity and cooperate with all stake holders which will help future platform ecosystems stay healthy and achieve sustainable growth.

According to March (1991), the balance between exploration and exploitation is important to maintain a healthy ecosystem. Furthermore, the main role of this balance is to lower the decreasing speed of diversity. As many different systems evolve toward reducing diversity in an effort to select the most innovative content among the diverse

[11] In an era of a fully connected network, viral and sensational messages are diffusing and parodying content through any means. Since the issue could evolve badly, media users should be aware and be cautious when dealing with these type of issues (Vista, 2014).

population, a serious problem arises where the diversity is too low in the ecosystem. For this reason, it is imperative that all kinds of systems maintain an appropriate level of diversity. The diversity of CPs is more important in the platform ecosystem than any other industrial ecosystem. The power of innovation in the new ICT ecosystem has moved from the infrastructure layer, like the network and device, to the content layer. The content layer needs creativity, and content diversity is a reservoir of creativity. Diversity is the source of providing the system with high flexibility and adaptability, and it is a valuable factor to a firm's survival, especially under rapidly changing environmental conditions (Korhonen, 2001).

Chapter 5. The Coevolution of Platform, Content Providers, and Users in the Platform Ecosystem

5.1 Introduction

This dissertation aims at finding the growth mechanism of a platform ecosystem in order to point the right direction to evolution. Chapter 3 considered platform openness and growth of an ecosystem, and Chapter 4 considered content diversity and growth of an ecosystem, but it is still unknown which actor drives the evolution of platform ecosystem and from where the growth of platform ecosystem started. These unknowns have also considered when there was an argument for network neutrality. The proponents for network neutrality insist that the innovation of ASP was the origin of growth of an Internet ecosystem. In contrast, the opponents for network neutrality claim that the innovation of ISP is more important than ASP. Likewise, in a platform ecosystem, questions could arise such as, which is more important? or which has to be the first among platform openness and retain CPs' uniqueness?

However, each actor cannot be the only player that innovates the ICT ecosystem. As the industry becomes more complex, cooperating with complementary actors is one of the most important strategies for the whole ecosystem to evolve (Moore, 1998). Moore (1993) indicates that several species live together and influence each other in an ecosystem. Also,

interdependency among the species help them to evolve. Therefore, in order to create value in the platform ecosystem, PPs, CPs, and even users come together to access complementary resources and cooperate with each other even when the situation may not be profitable for the actor in the short-term (Iyer, LaPlaca, & Sharma, 2006). Due to successful studies of the business ecosystem, scholars have started to apply the concept of an ecosystem into other various studies. However, there is still a lack of the studies that prove the hypothesis related to co-evolution of business ecosystem because showing the interdependency and representing dynamics are difficult to study.

To fill the research gap and in the flow of this dissertation, Chapter 5 aims at proving the hypothesis of co-evolution of platform ecosystems. Network analysis was used to analyze relationships among the actors in a platform ecosystem. Nowadays, a content is delivered to users via platform, network, and device. Content, platform, and other types of media can be connected to one another by creating a number of pathways, allowing consumers to have more choices for obtaining content. While each consumer's choice is collected, the frequent combination becomes general phenomena and creates a new trend.

Chapter 5 uses network analysis of users' media repertoire based on three theoretical foundations: network of platform ecosystem, users' media repertoire, and complex network theory. Users choose the platform providers, network providers, content providers, content genre, and applications, then combine them as a repertoire. Node is the users' media choices and edge is the relation between the users' choices. Network analysis enables to analyze various characteristics of a platform ecosystem by using

several index such as degree distribution, centralities, and modularity. In addition, chapter 5 will figure out how the network has evolved since the data structure is panel

5.2 Theoretical Foundation

5.2.1 Network of Platform Ecosystem

The first theoretical foundation of this chapter is the study of Basole and Karla (2011), which considers a mobile platform as an ecosystem and visualizes the structure and evolution of the mobile platform ecosystem (see Figure 5.1). Even if the importance of an ecosystem perspective was strongly emphasized, scholars had little knowledge on how to explain many of relationships between multiple actors in a complex system until the network analysis method was introduced. Basole and Karla (2011) was the first trial to visualize the mobile platform ecosystem which previously existed only in concept. They drew the platform ecosystem based on models and theories of complex systems, innovations, and network analyses, and they also analyzed the evolving structure of interfirm relations in the mobile device platform ecosystem.

However, the study has limitations when trying to find the real relationship between firms within an ecosystem. Firm-level data such as Thomsons's SDC database can only catch the relationships that are published, and it includes the data of small and medium-sized content providers. However, to better understand an overall platform ecosystem, the data of content providers are needed more so than those of big networks or device providers. Moreover, the emerging trends of application, genre of content, and SNS cannot be forecasted.

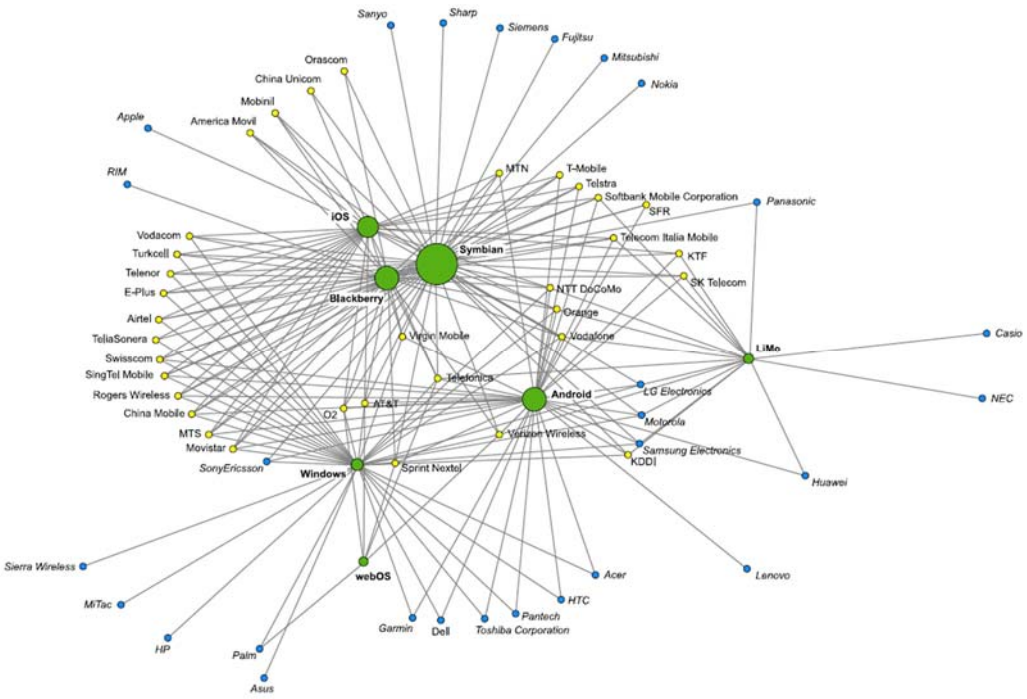


Figure 5.1 Visualizing platform ecosystem (Basole and Karla, 2011)

5.2.2 Media Repertoire in Trans-Media

The second theoretical foundation of this chapter is the study of media repertoire such as Taneja, Webster, Malthouse, and Ksiazek (2012); (Yuan, 2011) and the study of Internet traffic based on users' preference (Ibrahim, Omar, Habbal, & Zaini, 2013). Each user has his or her own media repertoire which combines a lot of options the user has. Users might have their favorite combination. By using the combination, researchers can figure out an effective way of advertising or marketing to them. Moreover, the media repertoire allows researchers to analyze the business ecosystem beyond the firm or industry-level. In addition, market share and the relationship among the firms of platform ecosystems are caught more accurately from the demand side by using the bottom-up method.

In the trans-media age, the user preference may be readily found in our daily lives. If we take a look into our daily lives, we can see that we are consuming various amounts of content with a number of platforms and networks. For instance, suppose there are three media giants (MBC, SBS, and KBS) that provide news as a form of content and networks such as wired cable TV, wired Internet, LTE, Wi-Fi, and platforms used in iOS and Android. For device, we can assume that there are desktops, TVs, laptops, tablet PCs, and smart phones. In the end, with the given information, there are 120 combinations (3*4*2*5) that can get the information of 'news'..Among these combinations, we can define the media repertoire as user preferred combinations. If a group of users show similar combinations in the whole trans-media system, we can say that the optimized

combinations of media repertoire have emerged[12].

'Media repertoire' became a widely used term once the media environment changed, which made it easier for passive users to become active users. Studies of media repertoire started by Ferguson (1992) illustrated it as a combination of multiple channels among the VCR and cable TVs. Through the change and diversification in the kinds of media, repertoire analyses of the web, genre, and programs have been developed. Nowadays, as users can make almost an infinite amount of combinations of media, the need for repertoire analysis or media network analysis is growing. In this area, mainly cluster analysis is exercised, which is a type of data mining methodology that clusters the users with similar amounts of media usage. However, cluster analysis has underlying limitations on handling panel data and difficulties with analyzing groups that have ambiguous identities from other groups. Therefore, in order to overcome the limitations and difficulties, this research adopts the network analysis method to draw a platform ecosystem map, represented by media combinations based on user preference.

[12] According to Kauffmann (1995), emergence is a phenomenon that arises where there are no features or actions from sub-level constituent, but happens at the higher level (system level) spontaneously. Emergence is a basic topic of the complex network study. Generally, complex network science tends to study human brain or a social phenomenon like the ecosystem, however this research adopts this term to be used for media and contents. Given that constituents spontaneously repeat self-organizing and adaptation, it shares the basic philosophy of a system in a complex network science.

5.2.3 Big Data and Complex Network Theory

The third theoretical foundation is the complex network theory. In a complex system such as an ecosystem, there are a lot of actors and relationships. If a researcher only focuses on the micro relationships between several actors, the researcher may not be able to see the whole picture of the ecosystem because there is a large gap between the micro phenomenon and macro emergence gathered from the small events. A platform ecosystem is also a complex system consisting of many actors and relationships. Therefore, there needs to be a focus not only on each user's preference and each firm's behavior, but also on the overall picture of platform ecosystem.

Big data is data that cannot be easily delivered through existing software, but it contains an enormous amount information in it (Snijders, Matzat, & Reips, 2012). Therefore, big data becomes useful when the limitless data finds a meaningful insight. A large data set such as a user preference data is a good example of an enormous data set that contains each individual level responses collected into one big set. In the past, researchers had difficulty analyzing the data to obtain meaningful information from the large data set because of the limited computing power. In addition, in the classical economics, the problem of users is only solved by assuming representative users[13] with omniscient rationality, mentioned in Chapter 2, which prevented economists from analyzing large data collections of user preference. However, much effort was used to overcome the number of assumptions that hitherto economics had, and such efforts are

[13] The perspective of one representative consumer could represent the average preference even though, in reality, many consumers have diverse propensity and preference.

applied to big data analysis, which have become a new trend in understanding socio-economic phenomena by exploring the merging patterns holistically.

The term ‘network’ has been popularized through the penetration of social network services to the masses. However, the network has existed almost everywhere since every material or phenomenon has its element (node) and relationship (edge) (Dorogovtsev & Mendes, 2013). In society, relationships among organizations and individuals take the form of networks called friendship, business-relationship, cooperation, etc. In the case of information, networks presence had been in the form of citation, connections between words, website links, etc. Biologically, there are networks of food chains and interactions of proteins (Dorogovstev & Mendes, 2013). However, even though we have quality data in large quantities, if there is no communication or connections between them, the data would be meaningless. This would also hold true for media and content. This is because the sum of the individuals does not equal to the whole, and it is also the reason for classical economic theory having limitations when dealing with the issue of media and content based on representative users. However, in the past, it was even difficult to collect and process large sets of data. Through the development of the Internet and computer processing speeds increasing exponentially, large sets of data are now able to be analyzed by researchers.

This chapter started by viewing the media and content as forms of living organisms. In this framework, the industry that comprises the media and content becomes the ecosystem, and certain kinds of patterns by the interrelation at the macro level is shown

by the perspective of the ecosystem. The research focuses not only on how such patterns are inspected at a micro level, but more on the relationships inside the ecosystem.

5.3 Methodology

5.3.1 Data and Variables

This research uses Korea information society development institute (KISDI) Media Panel data from 2010 to 2013. Firstly, data on combinations of contents, platforms, and other media is required to form a platform ecosystem network. Therefore, as illustrated in Table 5.1, this chapter uses individual data which depict the preference on media and content types. Furthermore, this chapter also includes genre and channel information data to provide diversity of analysis and further research. User preference data include applications in smart devices, genres and channels of TV broadcast programs, newspaper companies, e-mail accounts, blogs and SNS accounts, cloud service accounts, broadcasting programs, music, and N-screen[14] platforms and devices for books, newspapers, magazines, photos, and documents.

[14] N-screen is a user-based content provision service through advanced smart systems that can share and run multi contents anytime and anywhere.

Table 5.1 User preference data in forming the network

	2010	2011	2012	2013
Current using mobile device	0	x	0	0
Current using mobile device brand	0	x	0	0
Current using mobile OS platform	0	x	0	0
Current using mobile network provider	0	0	0	0
The most used applications in smart device	0	0	0	0
The most preferred TV show genre	0	0	0	0
The most preferred broadcasting channel	0	x	0	0
The most preferred newspaper company	x	x	0	0
The most used e-mail account	0	0	0	0
The most used Blog/SNS account	0	x	x	x
The most used blog account	x	0	0	0
The most used SNS account	x	0	0	0
The most used cloud service	x	x	0	0
N-screen – the most used broadcasting program services	x	x	0	0
N-screen – the most used video streaming service	x	x	0	0
N-screen – the most used music streaming service	x	x	0	0
N-screen – the most used books/newspaper/magazine service	x	x	0	0
N-screen – the most used photo services	x	x	0	0
N-screen – the most used document services	x	x	0	0
N-screen – the most used devices for broadcasting service	x	x	0	0
N-screen – the most used devices for video streaming service	x	x	0	0
N-screen – the most used devices for music streaming service	x	x	0	0
N-screen – the most used devices for book/newspaper/magazine service	x	x	0	0
N-screen – the most used devices for photo service	x	x	0	0
N-screen – the most used device for document service	x	x	0	0

5.3.2 Formation of Platform Ecosystem Network

Network analysis can be useful in catching the relationship from the link between platform and CPs by user preference. This research adopts service information data including user preference and actual user-used information provided by KISDI Media Panel (2010~2013). In order to visualize the collected information, this chapter proposes a hypothetical situation using media repertoire of User 1, which corresponds to Figure 5.2. User 1 prefers a genre in drama, Facebook for SNS, OCN channel for movies, uploads data to iCloud, and mainly uses Gmail for exchanging e-mail.

The next step for forming a network is to define the node and link. In other words, constituents and its relationships are needed to form a network. In this study, nodes consist of user preferred content, genre of content, TV channel, and media. As depicted in Figure 5.2, a user preference toward a genre in drama, Facebook, OCN channel, iCloud, Gmail become the nodes, and links between the platform-media and content are formed by the user.

Another user is assumed in Figure 5.2, User 2, who prefers comedy shows, uses Facebook, mainly watches KBS1, uploads his file onto Dropbox, and sends e-mail with Naver mail. With similar method for User 1, Facebook, KBS1, Dropbox, Naver mail are also connected to one another by User 2.

User 1 and User 2 share similarities in using Facebook as their SNS. Two media repertories are connected by Facebook. Therefore, convergence of user preference network is defined as Figure 5.2, which links every media, content, genre of the two users.

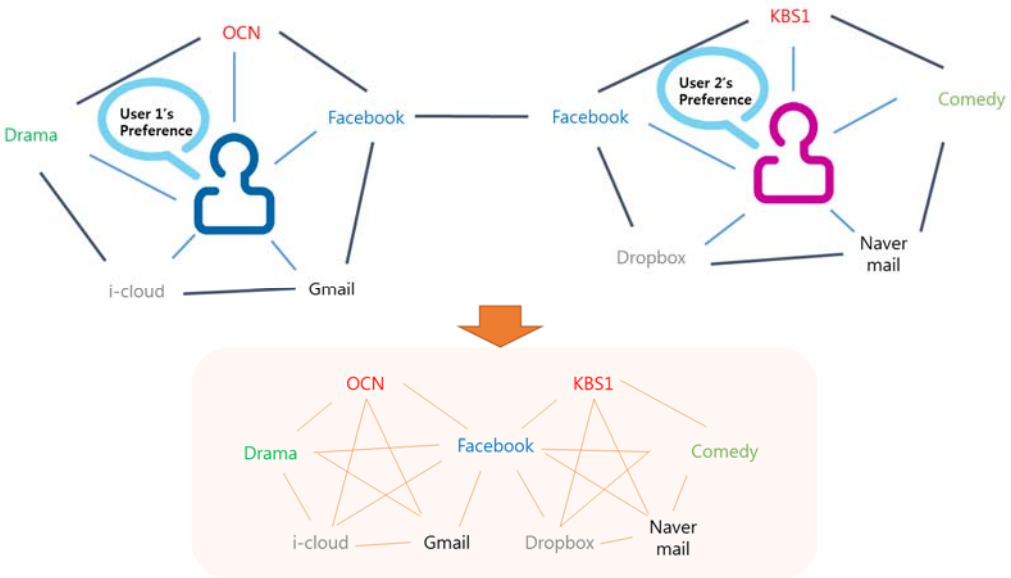


Figure 5.2 Media network formed with user preference of two users

5.3.3 Visualization Analysis

There are a number of methods to analyze a network, but the importance of visualizing and examining sample networks cannot be overlooked. Since the ground of network theory is originated from graph theory, drawing a sample to gain new insights can be helpful to researchers. The visualization method can be accomplished by identifying the nodes and linking them together, as done in Figure 5.2.

5.3.4 Analysis of the Physical Characteristics of the Network

Simply visualizing networks is helpful for gaining intuition, but it is difficult to follow every node and link physically with the human eye. However, statistics of network enable an understanding of the physical characteristics of the network.

The number of nodes represents the amount of first preferences of more than 10,000 people that are diverse. The number of links represents the amount of links between the collected samples. Therefore, if the number of nodes stays the same but the number of links increases, the connectivity between the nodes also increases. In this research, the increase in the number of links shows the path of convergence between the media as an increasing trend.

Graph density is estimated as the actual number of links in the network over every possible combination of links (Coleman & Moré, 1983). In formula, it is expressed as follows:

$$\mathrm{D} = \frac{2|E|}{|V|(|V|-1)}$$

(D=Density, E=number of edges (links), V=number of vertexes (nodes))

This indicator also represents the degree of connectivity. High density has two meanings for this research. Firstly, the platform-media and the contents are supplied in a number of methods on the supply side. Secondly, the users are attempting to combine a number of methods in consuming the content on the demand side.

Modularity is an indicator that shows how many modules[15] are formed inside the network (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008). It is possible for a large network to contain small groups of networks. Modularity is the probability indicator used for determining the quantities of groups of networks that can be found in the large network. Forming groups inside the network is a natural phenomenon, but extreme grouping prevents interactions between the nodes, and rare grouping makes it difficult for each piece of information to be protected.

Average path length is an indicator that shows the mean of the minimum distances between every pair of nodes (Watts & Strogatz, 1998). Having a low value of this indicator means high efficiency of diffusing information. For example, in the World Wide Web (WWW), a decrease in average path length indicates a lower cost of diffusion of information on the web. In a grid network, a decrease in this indicator shows a higher electricity efficiency due to low loss rate. In this research, decrease in average path length of a platform ecosystem network shows there is a high probability of the existence of

[15] It is also called a group, cluster, or community.

intermediary platform-media that link between user preferences.

The degree of a node in a network is the number of connections or edges the node has. The degree distribution is the probability distribution of these degrees over the whole network. The degree distribution is important in studying real networks because we can find the characteristics of connectivity in the network. The degree distribution P(k) of a network is then defined to be the fraction of nodes in the network with degree k. The same information is also sometimes presented in the form of a cumulative degree distribution, the fraction of nodes with a degree greater than or equal to k. In Chapter 5, both are used in the analysis, but cumulative degree distribution shows the characteristics of the network with a better resolution.

5.3.5 Centrality Analysis

Centrality analysis is the most representative statistical indicator in network analysis methodologies. In this research, degree centrality and between centrality have been measured in order to see how the top 10 nodes with high centrality change with time. With centrality analysis, the change in centrality of each node can be calculated, which shows which media has taken the role of an intermediary or a hub platform in a user preference based network.

Degree centrality, the number of links a node has, is measured by each node. If the direction of links by nodes has different implications between in-coming links and out-going links, in-degree and out-degree centrality should be measured separately. However this research does not consider the in-or-out-degree centrality because there is no meaning in the direction of the links. If a node clearly has high centrality compared to other nodes, it is defined as a hub or platform-media or platform-content.

$C_D(v) = \frac{\deg(v)}{n-1}$, where n is the number of node in network

Degree centrality depends only on the number of connections, but what if these connections are isolated? A central node should be one connected to powerful nodes. In this case, eigenvector centrality could be an alternative. Eigenvector centrality is defined as the influence of a node in a network. It assigns relative scores to all nodes in the network and then gives high scores when the nodes are connected to high score nodes. In

other words, it measures how many powerful directly-linked nodes the node has.

$$C_i = \frac{1}{\lambda}\sum_{j=1}^{n} a_{ij}\, C_j,$$

where C_i=node i's centrality, a_{ij} is the degree of strength of the relationship between i and j (0 to 1), λ is the eigenvalue of eigenvector which has a maximum value in the relationship between i and j

Between centrality indicates how corresponding nodes are well linked to other nodes. It is also measured by each node. A node with the highest between centrality is the most effective node in transferring information that also influences other nodes. Between centrality is measured by the number of the shortest paths that pass through each node. In a platform ecosystem network, Facebook is considered a representative node with high between centrality that links a number of user preferences.

$$C_B(v) = \sum_{\substack{s \neq v \neq t \in V \\ \mathrm{s} \neq \mathrm{t}}} \frac{\sigma_{st}(v)}{\sigma_{st}}$$

where σ_{st} is the number of shortest paths from s to t, and $\sigma_{st}(v)$ is the number of shortest paths from s to t that passes through node v.

Closeness centrality is defined as the reciprocal of the sum of geodesic distances (d_G: shortest path) between node v and all other reachable nodes from it. In other words,

closeness centrality measures the distance that information travels from a given node to other reachable nodes in the network.

$$C_C(v) = \frac{1}{\sum_{t \in V/v} d_G(v,t)}$$

5.3.6 Trend Analysis Based on Positioning of Each Node

In order to figure out the trend of positions of each node, this chapter introduces the weighted degree – betweenness degree centrality ($C_{W.D} - C_{Btw}$) matrix. The weighted degree centrality is used rather than degree centrality because it reflects market power more. Since the more overlapping linkages a node has, the more the node is selected by users, therefore, weighted degree centrality is better fitted to detect hubs in a platform ecosystem network. As mentioned before, high betweenness centrality means a higher possibility of connecting two random nodes. Therefore, if a node has both high weighted centrality and high betweenness centrality, the node is likely to be the global hub of the whole ecosystem because the platform or content has a high market share and even a higher possibility of overlapping with each user's repertoire. However, if a node has a high weighted centrality but low betweenness centrality, the node is likely to be the local hub of a community or a module because it has a high market share but only in a specific community that shares a similar repertoire. In addition, if a node has low weighted centrality but high betweenness centrality, the node is likely to be the bridge linking between communities. This means that the node does not have much market share, but

many users from different communities are starting to include the node in their repertoire.

Figure 5.3 illustrates the matrix of $C_{W.D} - C_{Btw}$ and the meaning of each dimension.

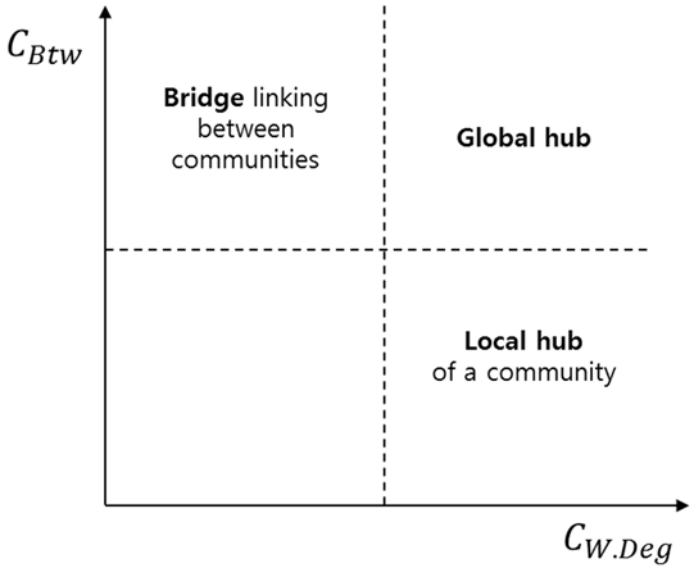


Figure 5.3 Network positioning matrix ($C_{W.D} - C_{Btw}$)

5.4 Results and Analysis

5.4.1 Visualization Analysis

The year 2010 was the start of the smart media era. At that time, the fixed Internet had not been integrated with wireless Internet to provide any type of service. Existing content and services of traditional media was moved to wireless Internet. Users did not utilize their own smart devices but focused on checking e-mail and sending messages through 2G and 3G networks. Few early adopters have attempted to use various types of applications. The adoption of various applications then diffused to other users, expanding the smart media platform ecosystem. Figure 5.4 illustrates how the majority of contemporary users were using 3G phones as their main device and Cyworld as the main SNS, which had a dominating market power in Korea. Additionally, e-mail service providers such as Hanmail by DAUM and Naver mail had maintained dominance in 2010. Lastly, from the genre perspective, users mainly used their devices consuming news content and very little for consuming entertainment or communication.

According to Figure 5.5, communication has expanded with wireless SNS in 2011. Based on the result of user preference analysis, well convergent media and content using both wired and wireless networks have taken over the market. Two examples are Twitter and Facebook. In contrast, Cyworld, a former SNS incumbent that had managed a vast network of existing users, had failed to maintain its central position at the platform ecosystem. Furthermore, during this time, the way people communicated had shifted from

a closed method (e.g. IMS or Cyworld[16]) to an open method with multiple channels. Expansion of communicational ranges have ignited the users to start using smart phones.

Many firms tried to start new businesses to gain compatibility with large platform and network providers during the trans-media era in 2012. However, since users became accustomed to the new trans-media environment, few groups that were noticeably too weak or too strong existed in the platform ecosystem network. In Figure 5.6, there doesn't seem to be a distinct center group nor a peripheral group, and it seems that various contents, genres, applications, media, and platforms are mixed. One case of remarkable growth that can be found in the platform ecosystem is Kakao Story, a social network service in Korea. Kakao, a company that caught the needs of users quickly by introducing an instant messaging service (IMS) called KakaoTalk grew to be one of the most popular service providers in Korea by 2012. While Kakao had the biggest market share in the mobile messaging market, users in Korea were less interested in the open style SNS like Twitter and Facebook. After the successful launch of Kakao Talk, Kakao introduced Kakao Story, a new service of mini-homepages which became a big success as shown in Figure 5.6. Kakao Story provided a private space for users to share their daily life experiences with authorized users. In addition, as N-screen services started to expand, many users began blending their own preferred N-screen services to their individual media repertoire. The year 2012 can be concluded as a period when platform ecosystems

[16] Cyworld services were mainly allowed only to those who had direct relations called 1-chon (similar to having friend on Facebook), so it is regarded as a closed communication system compared to the classic media.

have assured diversity and users have attempted a number of new combinations in them.

In 2013, Naver (NHN), an Internet portal site in Korea, had moved to the center of the media network, depicted in Figure 5.7. At that time, users had more options in the platform ecosystem and better understanding of the media. However, because large firms introduced their platforms with integrating number of services, users' choices had become simplified since 2011. Naver Mail, Naver Blog, and Naver N-Drive have repositioned to the center of the platform ecosystem, and in the music field, Melon, which is a giant platform that provides music streaming service, has been one of the most popular media repertories. However, the applications for communication and news are the most consumed among media. User preference on the game genre, entertainment, and navigation have shifted and diversified to dramas, shows, animation, movies, and sports. Furthermore, with the introduction of limitless LTE data plans on cell phones, video content like drama has moved to the center of the platform ecosystem.

2010. The beginning of smart media

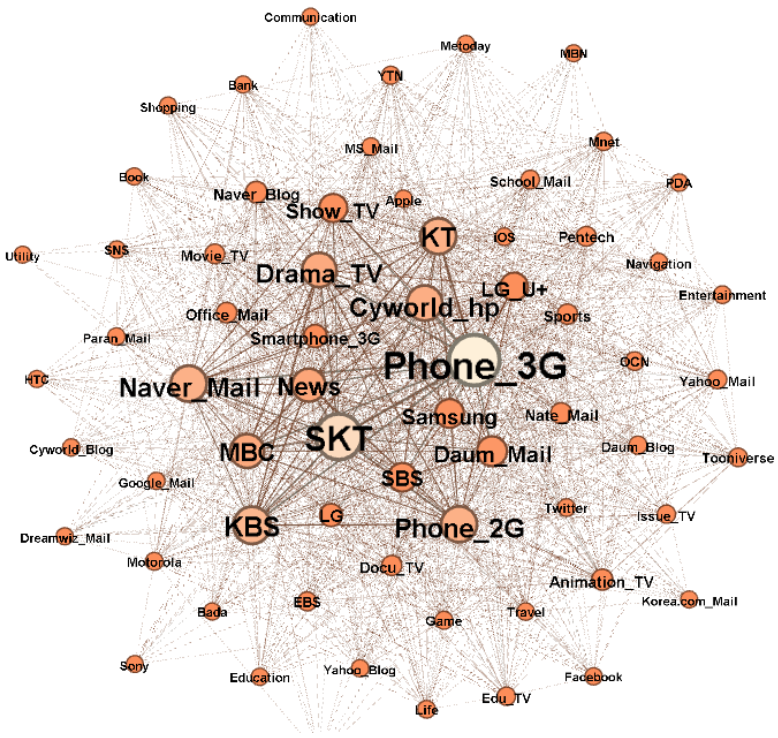


Figure 5.4 Platform ecosystem network (2010) – the beginning of smart media

2011. The era of mobile online social network

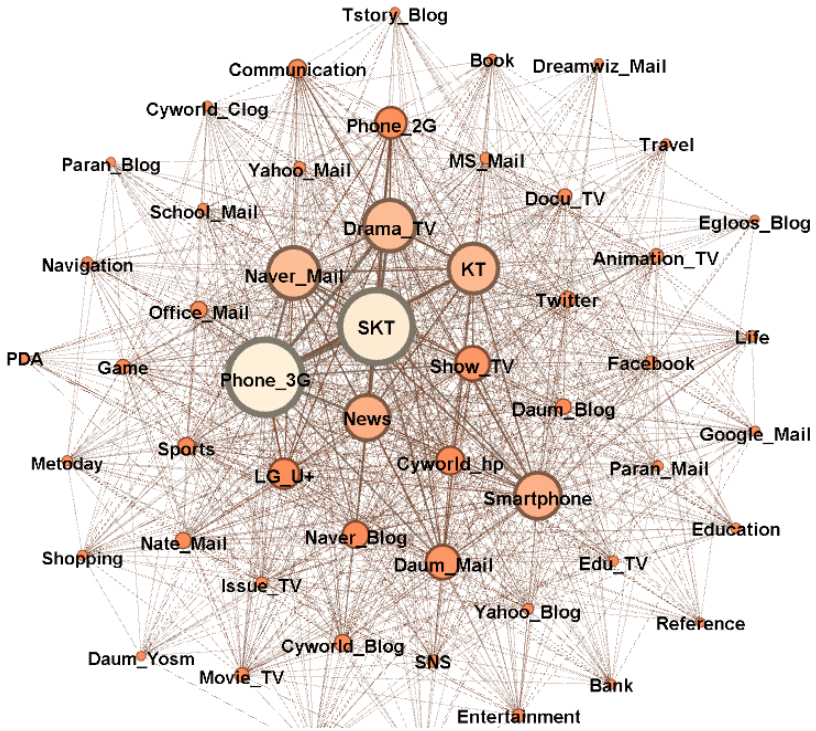


Figure 5.5 Platform ecosystem network (2011) – the era of mobile social network

2012. The era of trans-media

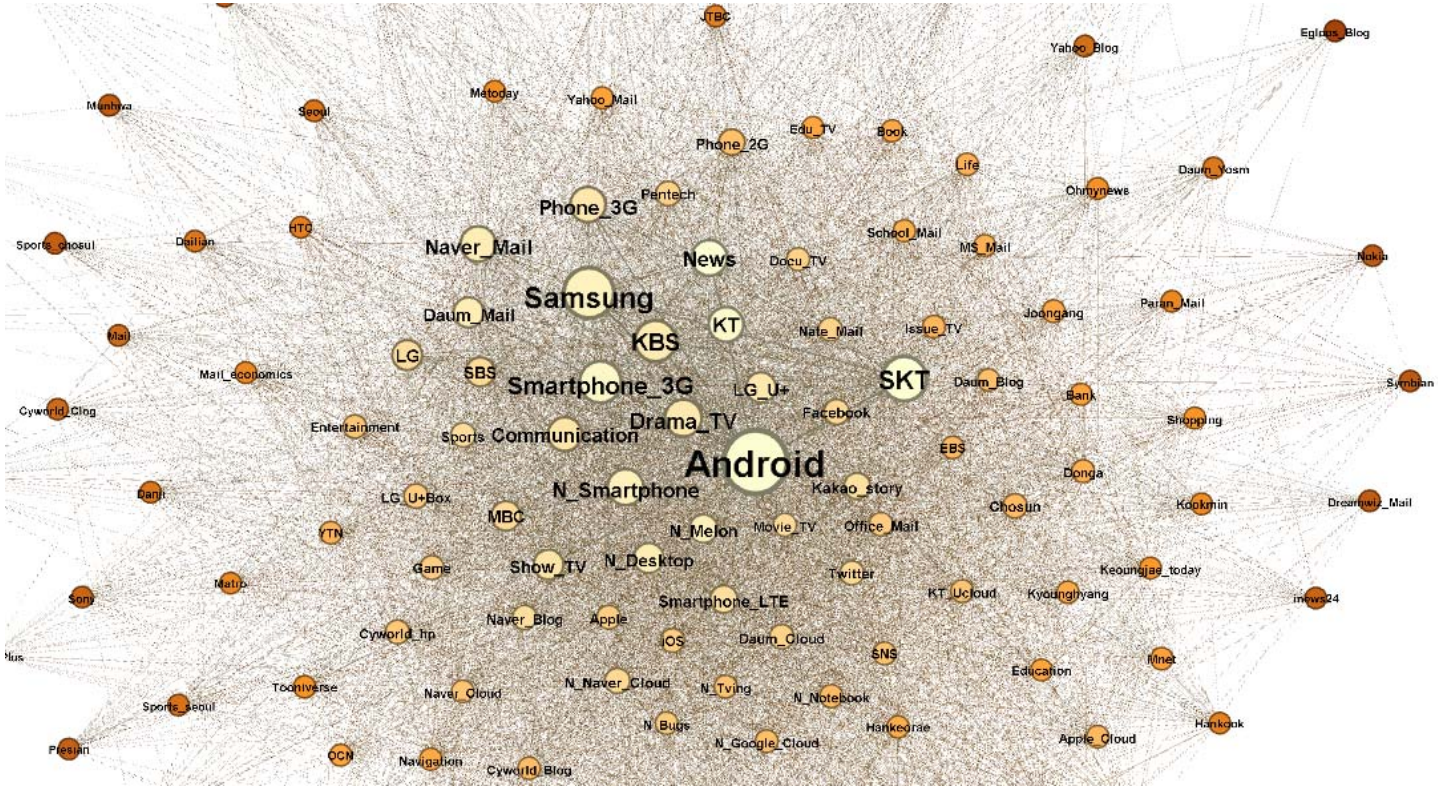


Figure 5.6 Platform ecosystem network (2012) – the era of trans-media

2013. The era of convergence and divergence

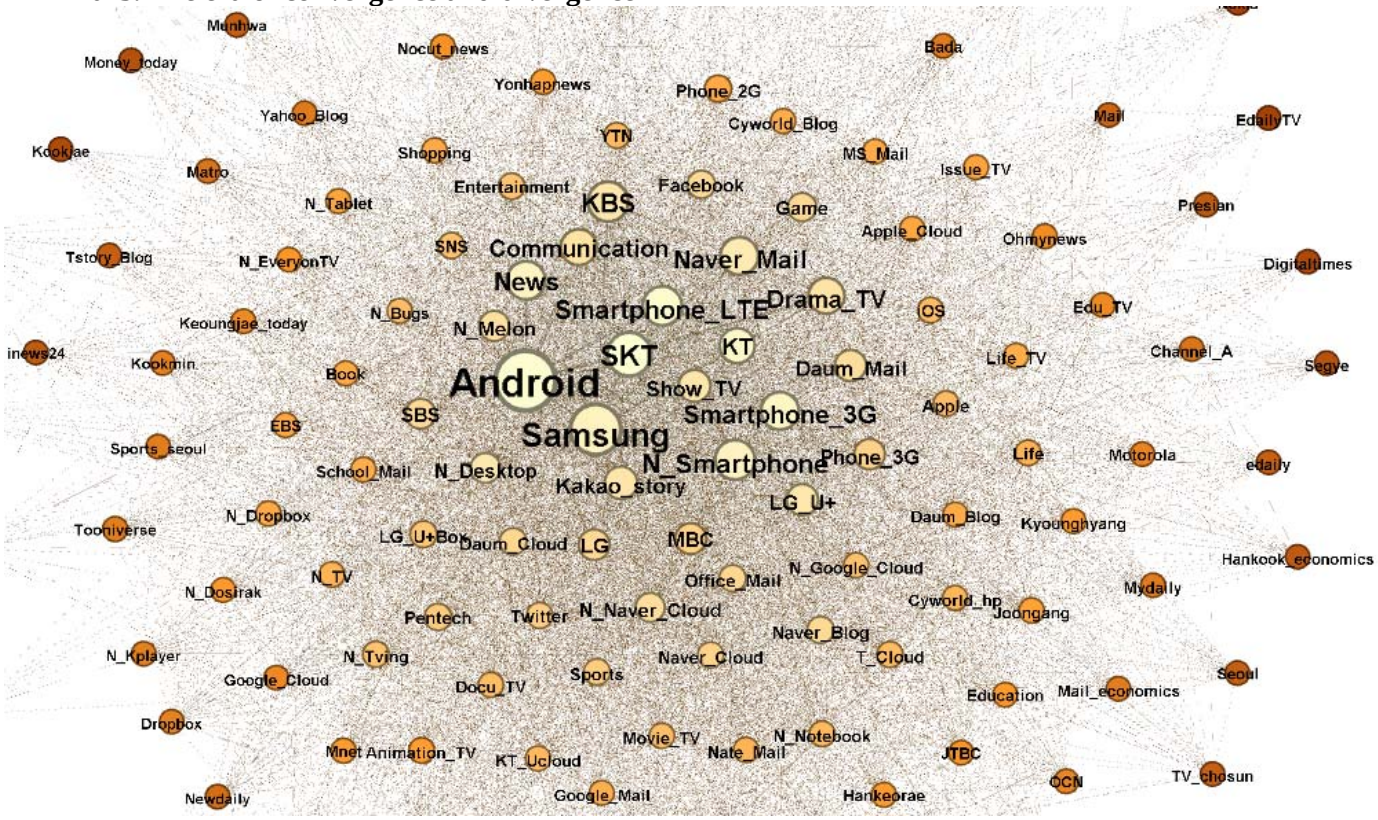


Figure 5.7 Platform ecosystem network (2013) – the era of convergence and divergence

5.4.2 Analysis of the Physical Characteristics of the Network

The changes in the physical characteristics of a network over time is summarized in Table 5.2 The years 2012 and 2013 had similar sample sizes with the same measured variables; a comparison of the two years can be accomplished. When comparing the number of nodes in 2012 and 2013, the number of services increased from 149 to 153, and the number of edges in 2012 and 2013 decreased from 5,909 to 5,824. It shows that the decrease of links is responsible for the simplification of the media repertoire of users, which indicates that content diversity in platform ecosystem had decreased.

Table 5.2 Changes in physical characteristics of platform ecosystem network (2010~2013)

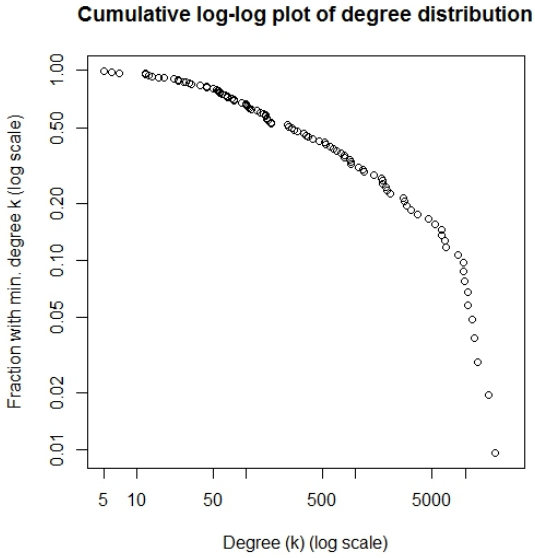
Network Topology	**2010**	**2011**	**2012**	**2013**
Number of Nodes	67	53	149	153
Number of Edges	1,376	930	5,909	5,824
Graph Density	0.622	0.675	0.536	0.501
Modularity	0.045	0.075	0.102	0.084
Ave. Path Length	1.378	1.325	1.464	1.499

Graph density shows that every possible combination of links in current nodes allows us to compare how the network has much connectivity between the nodes regardless of the number of samples in the network. In 2010, which is the beginning of the smart media era, diverse media and content started to be supplied via various sources, and more CPs had entered the ecosystem in 2011. This can be shown as the highest graph density of 0.675 in 2011. However, a decreasing trend can be found in 2013 (0.501). This result

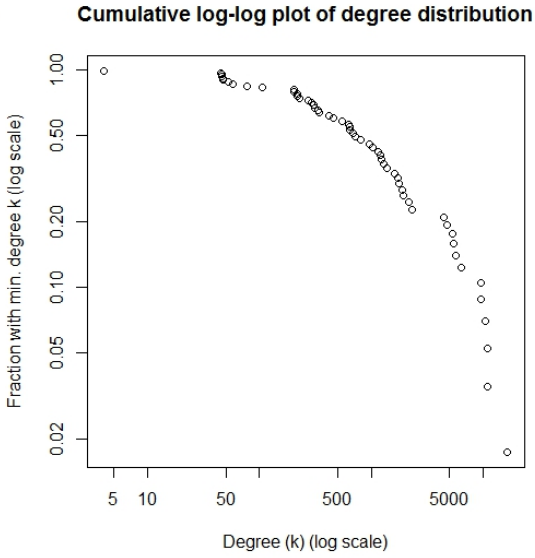
shows that the supply of the media and content became simplified, and users also had not attempted to combine new repertories.

Modularity indicator shows that the force of dividing into number of modules has changed drastically as time progressed. From 2010 to 2012, it increased from 0.045 to 0.102, but it falls to 0.084 in 2013. The average path length is an indicator that shows the average of the minimum distance between every pair of nodes. From 2011 to 2013, it increased from 1.325 to 1.499. This trend casts doubts that the trans-media phenomenon has truly enhanced the efficiency of communication.

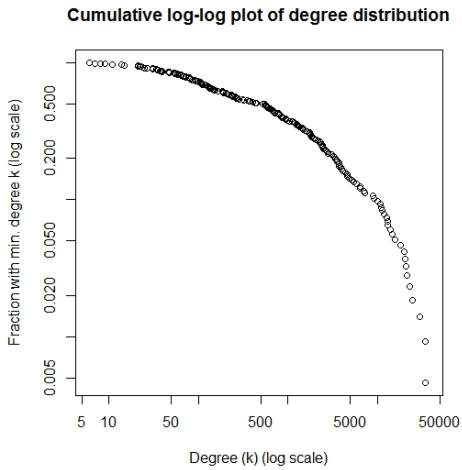
The results of the degree distribution show how the connectivity of the platform ecosystem has changed (see Figure 5.8). Since the node sizes of 2010 and 2011 are smaller than 2012 and 2013, the period has dis-connectivity in their degree distribution. On the log-log grid, degree distribution is not matched exactly with power-law distribution, but the graph is fan-shaped, which indicates that hubs are not as powerful as an Internet network, but many powerful middle hubs exist. From 2010 to 2012, there is not much difference in the shape of the graph, but the size of the ecosystem gets larger because the number of options of platforms and content increases.



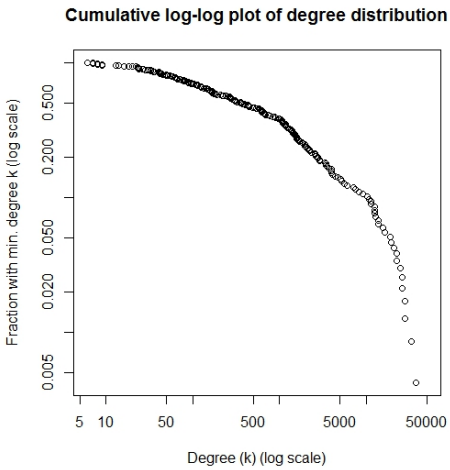
Degree distribution (2010)



Degree distribution (2011)



Degree distribution (2012)



Degree distribution (2013)

Figure 5.8 Degree distribution of platform ecosystem in Korea (2010~2013)

5.4.3 Network Centrality Analysis

Table 5.3 shows the top 20 weighted degree centralities, and Table 5.4 shows the top 20 betweenness centralities. From 2010 to 2011, using a feature phone with a 3G network was the most popular option of organizing a user's repertoire. But from 2012, since the smartphone was diffused deeply in Korea (see Table 5.4, dark shadowed with red), the Android mobile OS platform became the most popular repertoire option, which indicates that the leadership of ICT ecosystem changed from the network layer to the platform layer. This phenomenon is shown in Figure 5.9, which illustrates the change of network position of network providers (SKT, KT, LG) and platform provider (Android). While the network providers moved from the global hub position to the bridge or trivial position, the platform provider, especially the mobile OS platform shown in the graph, moved to the global hub.

In 2011, a new trend of communication emerged with the smartphone. Twitter, which was the leader of mobile SNS, had become a popular platform (weighted degree is 1711 in 2011). The year 2012 marked the beginning of the trans-media era, which was started by emerging N-screen services such as Melon (weighted degree is 10063 in 2012), a new mobile streaming service that provides a variety of music through smart devices. LTE-smartphones (weighted degree is 28293 in 2013) and Kakao Story (weighted degree is 15622) emerged as the leading device and SNS, respectively, in 2013. Construction of LTE infrastructure to cover the whole domestic land was completed in 2013, which made it possible to create new opportunities for content providers to design new services such

as the mobile video streaming service.

The top 20 nodes of betweenness centrality do not appear to be different from the top 20 of degree centrality, which indicates that a node with high market share likely plays the role of a bridge also. As the change of network topology is shown in Table 5.2, there are not many modules in the global network. Only a few services or genres are the pure bridges linking communities. In 2012, the bridge was SNS such as Twitter and Facebook. In 2012, it was N-screen services and the communication genre. Lastly, Kakao Story, a new SNS of Kakao-Talk, emerged in the top 20 of betweenness centrality.

Table 5.5 shows the results of calculating each node's closeness centrality, sorted by top 20. Different from other centralities, news has the top closeness centrality from 2010 to 2012. Platform and network providers have ranked in the top for four years. Interestingly, Cyworld homepage service and several TV shows have vanished from the top-ranked in 2012. On the other hand, N-screen services have emerged since 2012. Table 5.6 shows the result of calculating each node's eigenvector centrality, sorted by top 20. Ranking order is quite similar with the result of closeness centrality, but interestingly, smartphone for N-screen has moved up in rank from 2012 to the top of the rank in 2013. This is a good indication that users are using their smartphones for N-screens more frequently than before.

Table 5.3 Yearly changes in top-20 weighted degree centrality

2010	W.deg	2011	W.deg	2012	W.deg	2013	W.deg
Phone_3G	15280	Phone_3G	16831	Android	59919	Android	65237
SKT	13092	SKT	16274	Samsung	41642	Samsung	47705
Android	9552	Naver_Mail	10831	SKT	33279	SKT	35718
KBS	9197	Drama_TV	10797	Smartphone_3G	29392	KBS	29189
Naver_Mail	8631	KT	10370	KBS	28321	N_Smartphone	28287
Phone_2G	8566	Smartphone	9499	Drama_TV	22427	Smartphone_LTE	27282
KT	8563	News	9221	N_Smartphone	21212	News	26035
Cyworld_hp	8296	Show_TV	6465	News	20648	Smartphone_3G	24787
Drama_TV	7880	Daum_Mail	6349	Naver_Mail	20312	Naver_Mail	24683
MBC	7708	Phone_2G	5664	Phone_3G	20046	Communication	21650
News	7361	LG_U+	5433	KT	19447	Drama_TV	21584
Daum_Mail	5828	Cyworld_hp	4791	Communication	17895	KT	19857
Samsung	5362	Naver_Blog	4444	Daum_Mail	12769	Kakao_story	15622
SBS	5282	Communication	2298	LG	12535	Show_TV	14366
Show_TV	5111	Sports	2106	LG_U+	12521	Daum_Mail	13129
LG_U+	4892	Cyworld_Blog	1935	N_Desktop	12412	LG_U+	13097
LG	2639	Office_Mail	1894	Show_TV	12179	MBC	12542
Smartphone_3G	2625	Nate_Mail	1754	MBC	11925	LG	12231
Naver_Blog	2012	Twitter	1711	SBS	11113	Phone_3G	11905
Animation_TV	1865	Daum_Blog	1597	N_Melon	10063	N_Melon	11309

Table 5.4 Yearly changes in top-20 betweenness centrality

2010	Btw	2011	Btw	2012	Btw	2013	Btw
Smartphone_3G	43.61	News	24.45	SKT	232.38	SKT	263.97
KT	41.92	SKT	24.20	Android	228.15	Android	255.99
Naver_Mail	41.22	KT	24.20	News	201.89	Smartphone_LTE	243.47
SKT	40.55	Drama_TV	21.28	Samsung	171.72	Samsung	207.74
News	39.06	Show_TV	21.28	KT	169.46	KT	196.08
MBC	38.72	Smartphone	20.93	Naver_Mail	162.76	News	195.62
Android	36.83	Cyworld_hp	17.59	Smartphone_3G	161.70	Smartphone_3G	192.31
Show_TV	35.53	LG_U+	17.08	KBS	160.25	Naver_Mail	166.38
Phone_3G	28.80	Twitter	15.57	Daum_Mail	151.00	KBS	163.59
KBS	28.58	Docu_TV	14.91	Phone_3G	144.85	N_Smartphone	161.47
Cyworld_hp	28.35	Naver_Mail	14.54	N_Smartphone	109.90	Show_TV	149.24
Drama_TV	27.55	Phone_3G	14.06	Communication	108.90	Communication	145.84
SBS	24.76	Office_Mail	12.48	Drama_TV	108.15	Drama_TV	135.86
Samsung	23.38	Daum_Mail	12.33	N_Melon	102.77	LG_U+	129.67
Nate_Mail	21.85	Sports	12.24	N_Desktop	100.05	N_Desktop	129.07
LG_U+	20.61	Naver_Blog	11.96	LG_U+	99.88	Daum_Mail	123.50
Docu_TV	20.23	Facebook	11.52	Show_TV	98.12	Kakao_story	122.70
Office_Mail	19.51	Issue_TV	10.81	LG	96.77	SBS	118.86
Phone_2G	19.14	MS_Mail	10.76	Movie_TV	94.21	N_Melon	107.85
Movie_TV	17.87	Daum_Blog	10.03	SBS	88.31	Office_Mail	105.68

Table 5.5 Yearly changes in top-20 closeness centrality

2010	C.C	2011	Close.C	2012	Close.C	2013	Close.C
News	1.045	News	1.000	News	1.027	SKT	1.026
SKT	1.045	SKT	1.038	SKT	1.027	Android	1.033
Android	1.061	KT	1.038	Android	1.034	Smartphone_LTE	1.039
KT	1.076	Smartphone	1.058	KT	1.047	KT	1.059
Smartphone_3G	1.076	LG_U+	1.096	Smartphone_3G	1.061	Smartphone_3G	1.066
Phone_3G	1.121	Cyworld_hp	1.115	Samsung	1.081	News	1.072
Cyworld_hp	1.136	Show_TV	1.115	N_Smartphone	1.088	N_Smartphone	1.079
Show_TV	1.136	Drama_TV	1.115	N_Melon	1.101	Samsung	1.079
MBC	1.136	Sports	1.135	N_Desktop	1.108	Naver_Mail	1.112
Samsung	1.152	Twitter	1.135	Daum_Mail	1.108	N_Desktop	1.125
KBS	1.152	Naver_Blog	1.154	Naver_Mail	1.108	LG_U+	1.132
Drama_TV	1.152	Daum_Blog	1.173	KBS	1.115	Show_TV	1.132
Naver_Mail	1.152	Facebook	1.173	Drama_TV	1.122	KBS	1.132
LG_U+	1.167	Phone_3G	1.173	LG_U+	1.128	Kakao_story	1.138
SBS	1.167	Cyworld_Blog	1.192	Phone_3G	1.128	Drama_TV	1.145
LG	1.197	Naver_Mail	1.192	Communication	1.142	Communication	1.151
Nate_Mail	1.197	Docu_TV	1.192	Show_TV	1.149	N_Melon	1.158
Naver_Blog	1.212	Issue_TV	1.212	Kakao_story	1.162	N_Naver_Cloud	1.171
Phone_2G	1.212	Daum_Mail	1.212	LG	1.169	Daum_Mail	1.171
Daum_Mail	1.212	Office_Mail	1.231	Naver_Blog	1.176	Naver_Blog	1.191

Table 5.6 Yearly changes in top-20 eigenvector centrality

2010	Eig.C	2011	Eig.C	2012	Eig.C	2013	Eig.C
News	1.000	News	1.000	News	1.000	N_Smartphone	1.000
SKT	0.990	SKT	0.951	SKT	0.986	SKT	0.999
Android	0.989	KT	0.951	N_Smartphone	0.986	Android	0.997
KT	0.970	Smartphone	0.948	KT	0.986	Smartphone_LTE	0.991
Smartphone_3G	0.967	LG_U+	0.918	Android	0.981	KT	0.990
Phone_3G	0.937	Sports	0.908	N_Melon	0.978	News	0.988
Cyworld_hp	0.921	Cyworld_hp	0.895	N_Desktop	0.975	Smartphone_3G	0.984
Samsung	0.919	Twitter	0.885	Smartphone_3G	0.974	N_Desktop	0.973
Show_TV	0.915	Naver_Blog	0.882	LG_U+	0.949	Samsung	0.966
LG_U+	0.907	Show_TV	0.878	Samsung	0.949	LG_U+	0.958
MBC	0.905	Drama_TV	0.878	Drama_TV	0.936	N_Melon	0.956
KBS	0.901	Daum_Blog	0.871	Daum_Mail	0.929	N_Naver_Cloud	0.954
Drama_TV	0.900	Facebook	0.863	Naver_Blog	0.927	Kakao_story	0.951
SBS	0.894	Phone_3G	0.854	KBS	0.926	Naver_Mail	0.943
LG	0.890	Cyworld_Blog	0.854	Naver_Mail	0.925	Show_TV	0.937
Naver_Mail	0.887	Naver_Mail	0.827	Show_TV	0.925	Naver_Blog	0.933
Naver_Blog	0.877	Issue_TV	0.823	Phone_3G	0.924	Drama_TV	0.929
Nate_Mail	0.871	Docu_TV	0.822	Kakao_story	0.921	KBS	0.929
Phone_2G	0.867	Daum_Mail	0.817	N_Naver_Cloud	0.920	Daum_Cloud	0.927
Daum_Mail	0.866	Movie_TV	0.796	Communication	0.913	Daum_Mail	0.914

5.4.4 Trend Analysis of Network Position by Each Node

Replacement of leadership from the network layer to the platform layer

Chapter 4 introduced the change of leadership from the network layer to the platform layer during the trans-media era. Figure 5.9 shows the process of leadership changing. Network providers shifted from a global hub position to the bridge or trivial position, and the platform provider has moved to the global hub which represents the leadership of platform ecosystem. The biggest network provider in Korea, SKT, has maintained their betweenness but lost their weighted degree centrality due to the emergence of the giant platforms.

Trend of mobile devices and network technology

From 2010 to 2013, network technology has evolved rapidly in Korea: from 2G to 3G to 4G (LTE). The progress of technological advancement has promoted smartphone manufacturers to adopt advanced network technology, and network providers have also supported the smartphone manufacturers. Figure 5.10 shows how a 2G feature-phone, which was a global hub in 2010, has been decreasing as well as the 3G feature-phone. The 3G-smartphone, which was a bridge position in 2010, lost its weighted degree centrality but managed to maintain the bridge position. However, the LTE-smartphone has been moving to the global hub position rapidly.

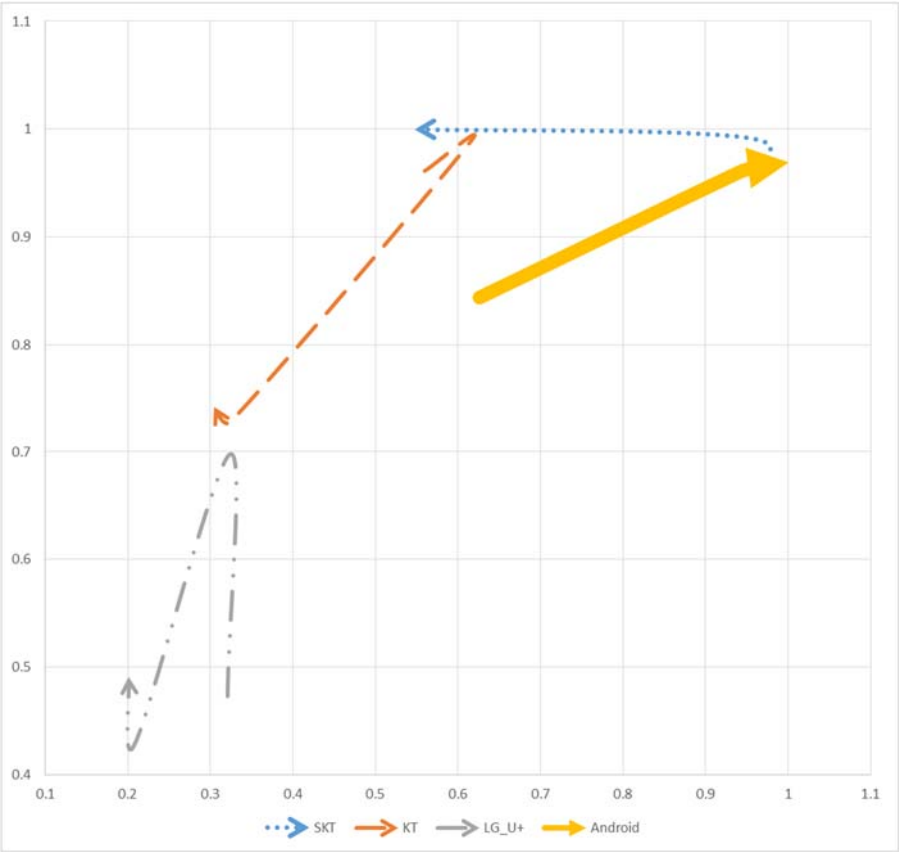


Figure 5.9 Replacement of leadership from network layer to platform layer

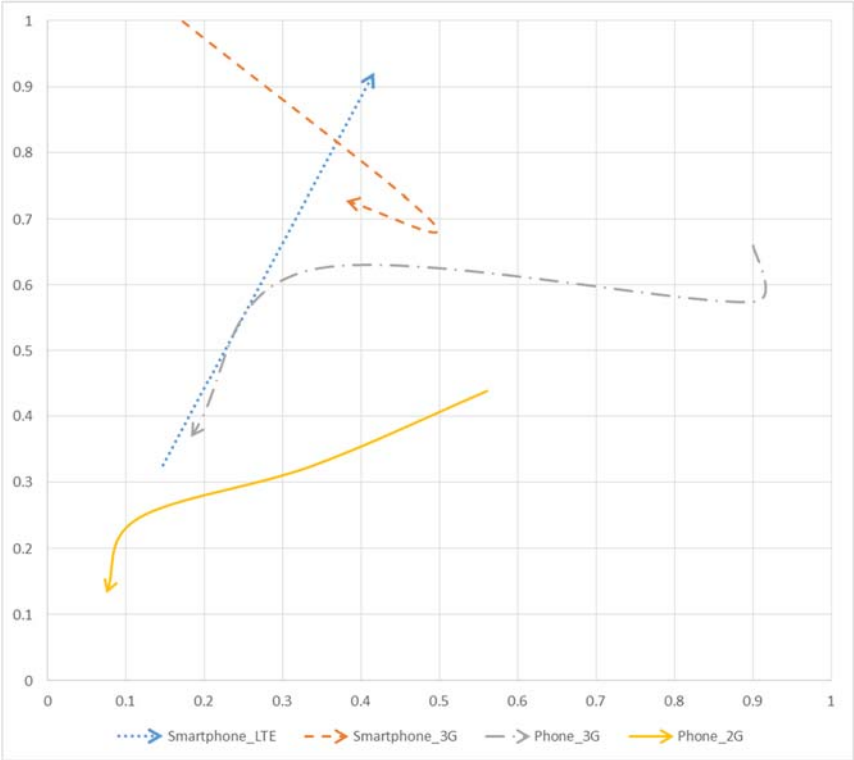


Figure 5.10 Trend of device and network technology

Trend of changing position of the preferred genre

In Chapter 2, this thesis mentioned that a new trend of ICT is changing the users' lifestyles. How does the emerging trans-media phenomenon change the users' media behavior? Figure 5.11 shows that news, dramas, and TV shows which were the global hub positions in 2010 have moved to a weaker hub position by losing weighted and betweenness centrality. However, users have started gaming, shopping, social networking, and communicating with other users through their smart-mobile devices since 2010. These genres of content have moved toward the hub position; this can be seen especially in the 'communication' genre.

Trend of changing position of SNS

SNS is not only a service or content provider but a new platform that has become more intimate with users nowadays. Figure 5.12 shows that Cyworld held the position as a global hub in the platform ecosystem in 2010 but has since been declining. Twitter was also moved to the bridge position in 2011 but fell again in 2013. However, Facebook and Kakao Story, two new entries in 2013, have moved toward a global hub position.

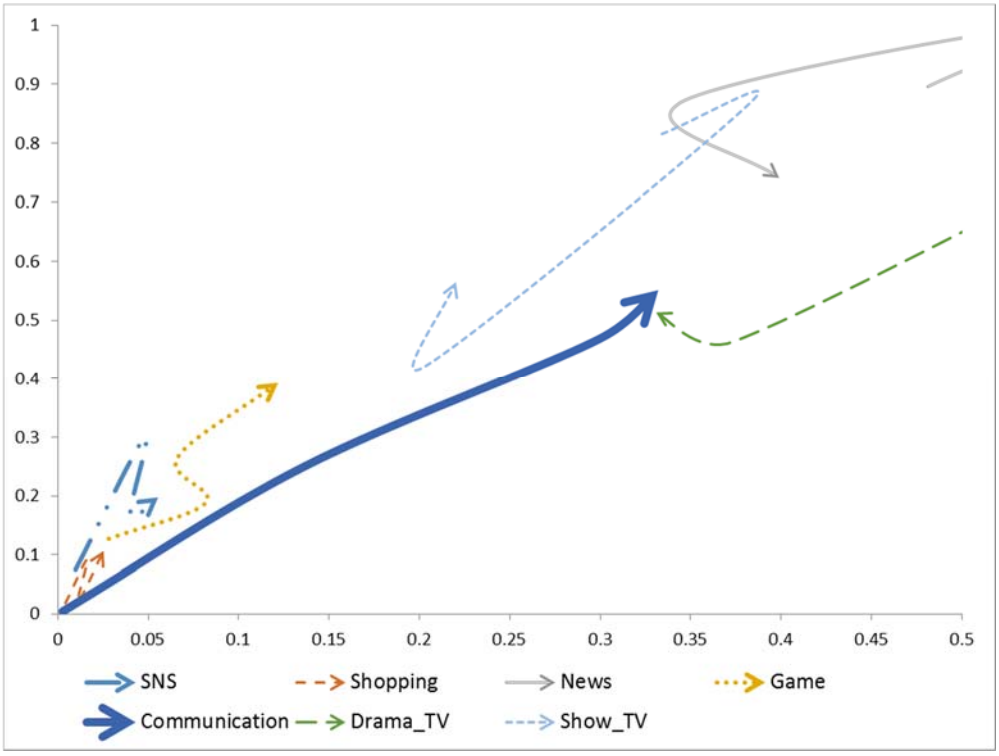


Figure 5.11 Trend of changing position of preferred genre

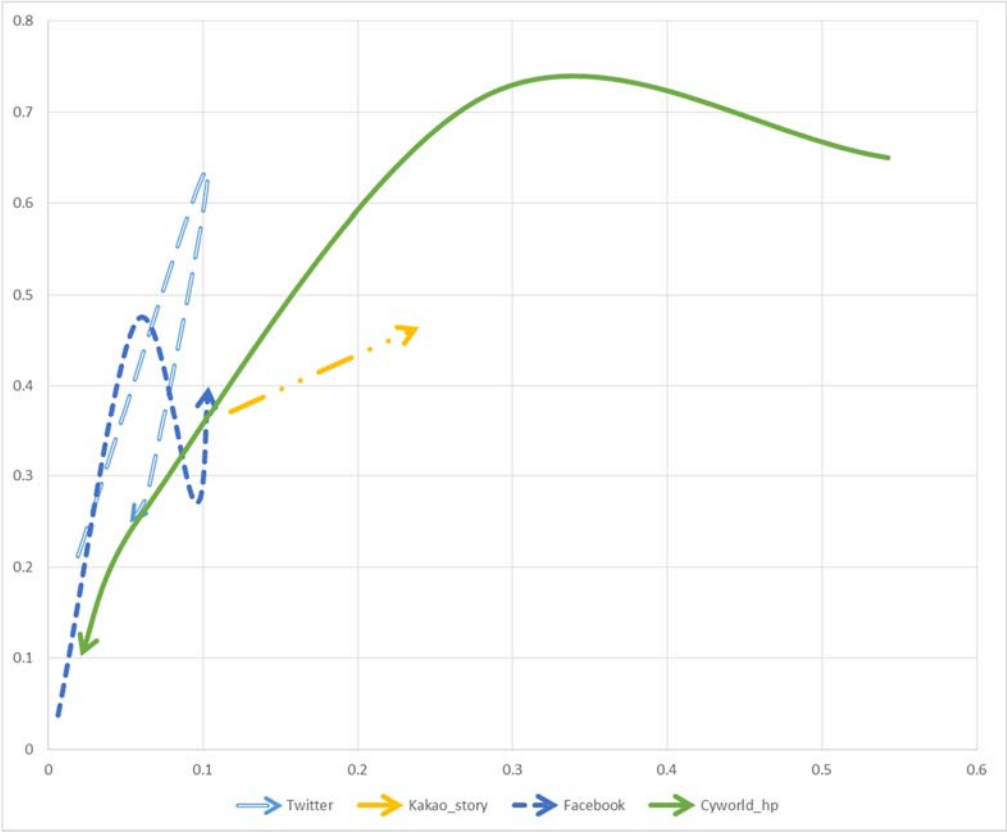


Figure 5.12 Trend of changing position of SNS

5.5 Discussion

The dynamics of individual behavior are difficult to define as a clear law or theory. In addition, as society's interests and desires become diversified, user preference naturally follows the rapidly shifting phase unprecedentedly. Therefore, deriving a single theory with a single formula is almost impossible. A complex theory is used in attempting to explain the macro social phenomenon by analyzing micro social interactions between actors. The platform ecosystem during the trans-media era, which was proposed and defined in this research, was a complex system. From the supplier's perspective, the barriers of the multi-level layers of C-P-N-D will be lowered by active interactions among the four layers to create new value. On the other hand, users value the service that is recognized as something new and innovative, and users also compose their media repertoire based on their preferences. In this process, the physical characteristics of the network in the platform ecosystem have changed, which can be explained as a non-linear amplification and self-reinforcing phenomenon. This coevolution of network will make the platform ecosystem grow because the users and suppliers will continuously form a feedback loop by interoperations (Buldyrev, Parshani, Paul, Stanley, & Havlin, 2010).

Based on the result, this study was able to analyze what has happened in the platform ecosystem during the last four years. The result showed that the platform ecosystem has experienced a tumultuous period to adapt to the trans-media environment from the starting point of smart age (2010) to the matured period of trans-media (2013) in Korea.

This chapter contributes to proposing the way of drawing 'platform ecosystem

network map' based on the preferred content and service providers by users, which is a bottom-up style methodology. In addition, it allows policy makers to understand the evolutionary trajectory of platform ecosystem and find an appropriate route for diffusing advertisement policy under the rapidly changing trans-media environment. It also gives managerial implication by suggesting a way to create new value and diffuse their information or services effectively under the rapidly changing market.

Chapter 6. Discussion and Policy Implications

6.1 Result Summary and Discussion

Chapter 3 defined platform openness as the degree of strictness in content selection when CPs want to enter the platform ecosystem. It also found that the different degrees of openness make the CP's productivity different by comparing the two different platform ecosystems, which are representatives of open and closed platforms. The results indicated that the closed platform ecosystem achieves a higher average efficiency within the ecosystem than the open platform (0.891 > 0.804). However, in terms of meta-frontier analysis, the open platform achieves a higher efficiency than the closed platform (0.391 < 0.339). This means that an open ecosystem has a higher efficiency in the long run. Therefore, this dissertation verifies that Hypothesis 1 holds true. In addition, this hypothesis is also verified by the result of Experiment 4 in Chapter 4, which supposes a situation where a non-profit platform with a low entry barrier for CPs is introduced to market. It shows that there is a slight increase in geno-type and pheno-type diversity of content and a significantly large increase in average performance of the overall platform ecosystem under the given condition. This means that openness of platforms such as public portals makes CP more diverse and even makes the content's internal gene more heterogeneous.

Hypothesis 1. *Openness of platform is helpful for maintaining content diversity and the content providers' long-term efficiency.* ***(Accepted)***

Thereafter, this dissertation discussed what the exact role of openness in the evolution of an ecosystem is and how the open system achieves long-run efficiency. Chapter 3 concluded that the role of openness is to produce a greater diversity in the ecosystem, allowing third parties to enter freely, and as a result, creative content is likely to be promoted under this condition.

By creating a model of a platform ecosystem using genetic algorithm, Chapter 4 focused on solving problems regarding how to relieve the speed of decreasing content diversity, how to recover from a decreased content diversity, and what actors should do to sustain the growth of a platform ecosystem. First of all, Experiment 3 proposed an important implication to the users. The result showed that recovery of decreased content diversity is able to come from the users' active will. When users start actively trying to find their hidden needs by diversifying the source from where they obtain information, the performance of the platform ecosystem would increase. By making new combinations through numerous new trials, the ecosystem can be expanded. Therefore, this dissertation concludes that Hypothesis 2-1 could be accepted.

Hypothesis 2-1. *The will of the users to diversify their source of information is important for revitalizing content diversity in the platform ecosystem.* ***(Accepted)***

Chapter 4 also found the implications for the view of CPs through the result of Experiment 2. The result showed that the higher the ratio of CPs that retain uniqueness to all CPs increases, the more pheno-type and geno-type diversity are raised to a higher level. Thus, this dissertation accepts Hypothesis 2-2.

Hypothesis 2-2. *The will of the content providers to retain their uniqueness and not imitate indiscriminately also influences content diversity.* ***(Accepted)***

In Chapter 4, creativity is shown as the key to meet users' needs. Experiment 2 showed that high content diversity influences the increasing peak point of average performance. In other words, content diversity is the source of creativity, which enables a platform ecosystem to grow sustainably. In addition, Experiment 1, which tested the role of genotype diversity of CPs compared with their phenotype diversity, showed that average performance of the platform ecosystem can no longer increase when genotype diversity converges to zero. This means that internal diversity of content is more essential than external diversity when providing energy for the growth of the platform ecosystem. Thus, this dissertation admits that Hypothesis 2-3 is accepted.

Hypothesis 2-3. *Content internal diversity is the source of creativity, and this provides sustainable energy to the whole platform ecosystem.* ***(Accepted)***

Chapter 5 was meaningful in the point of showing the complex dynamics of a platform ecosystem under the trans-media environment. From the supplier's perspective, it showed that the barriers between the C-P-N-D layers were getting lower, creating new values and opportunities through convergence and divergence. On the other hand, the users' repertories have co-evolved with the platform ecosystems by participating in the evolution of the platform ecosystem. In addition, Chapter 5 analyzed the media network of Korea's platform ecosystem and how the ICT industry evolved.

Chapter 5 gave two meaningful findings. Firstly, the distinction between hub-media and intermediary(bridge)-media was unclear, and secondly, platform ecosystem based on media repertoire consisted of several modules, which meant that famous media repertories in Korea can be narrowed down to a few. Chapter 5 also indicated that a few giant platforms became both a hub and an intermediary-media that integrates with other small media. In addition, visualizing the platform ecosystem based on user preference in 2013 showed that even if users are used to using transmedia freely, vertical integration or M&As by giant PPs make users' repertoire less diverse than before. Furthermore, graph density has decreased since 2010. This shows that the users' repertoire is unintentionally becoming simple, as the sizes of the main platform-medias are becoming larger. In sum, this dissertation accepts Hypothesis 3: *Platform ecosystem co-evolves with PP, CP, and User altogether.* ***(Accepted)***

6.2 Managerial Implications

This thesis gives several managerial implications in the view of the framework of platform ecosystem. First, PPs need to open their platforms. Apple opens their platform technologically but keeps their compatibility closed (Tiwana et al., 2010). Technological openness of the platform is a good strategy from the perspective of fostering content diversity, which is verified by several cases (Both Apple and Android open their platform technologically). However, compatible openness is executed carefully because it depends on the degree of market share owned by the PP. If a PP has a certain number of loyal users, keeping a closed platform could also be an effective strategy[17]. Nevertheless, as the result indicated in Chapter 3, openness not only technologically but also compatibly can make the overall ecosystem achieve long-term efficiency, which also can foster internal (genotype) diversity of a content. Through the openness, PPs can continuously provide new value to users by maintaining intimate relationships with them.

Second, to maintain long-term productivity, content or application service providers (CP or ASP) should publish their content to a platform that is perceived more open than other platforms by a manager. Chapter 3 found the long-term productivity of CPs that provide their content to open platform is higher than others. In addition, CPs need to try to satisfy a diverse demand of users in order to create new value, which could be recognized as a creative content by users. Chapter 4 shows that internal diversity of content is more important to give energy into the growth of the platform ecosystem. The

[17] Apple Inc. is the case.

source of the energy is from CPs' exploration of the users' diverse and complex hidden needs. The CP that catches the quality of demand would succeed in the long run.

6.3 Policy Implications

Based on results and analysis of the above studies, this dissertation proposes several policy implications. First of all, governments should encourage CPs to make new content which are different from existing content in the view of genotype diversity. For instance, governments could share public data with the public by allowing CPs to create a new service which is not for commercial but educational and informative purposes. They could make at least one non-profit public platform that would guarantee CPs' content to be published. Even though CPs make great content, they will have difficulty continuing to create new content if contracts with platforms are seldom made or made unfairly. To promote the creation of new content, governments should regulate copyrights of content and make the copyrights of contents belong to CPs that create them even if they are being outsourced. In England, after the reform of broadcast rights system in the 1990s, new investments poured into the content market to make outsourcing productions, and creative content is continuously being produced.

Second, government should create a failure-friendly atmosphere. It is important to develop platforms for promoting creative content, but it requires more cultural creative capabilities to produce quality content for each genre. Chapter 5 showed that the platform ecosystem has been coevolving with PPs, CPs, and users. So, policy makers should have a holistic view of growing the platform ecosystem. Making a diverse pool of CPs is the first step for making creative content. If a platform hinders this process, regulators should be ready to step in.

Lastly, policy makers need to create a policy to enable users to participate voluntarily to grow the platform ecosystem. Chapter 4 showed that the most important actor for maintaining the internal content diversity on platforms is users. When users start diversifying the source of information or content, the health of platform ecosystems would dramatically improve.

6.4 Limitations and Future Research

This study sheds light on the new structure of platform ecosystem. Combining the literature from economics, business, and engineering in ICT industry, the study provides an overview of the current problems of the platform ecosystem, and suggests its growth mechanism. Furthermore, the study finds managerial and policy implications for significant factors in the process of sustaining platform ecosystem.

However, this dissertation still has limitations in the process of verifying hypotheses and applying new methodologies. Limitations to this dissertation might give rise to future extensions. In Chapter 3, a survey was conducted in only one country and with a small sample size, and implications for CPs in each phase have not been identified. Therefore, further study might allow for the formulation of a strategy for CPs to choose a platform ecosystem in each phase.

In Chapter 4, the model assumed a simplest possible setting. For example, there is only one platform market with one kind of performance measuring function and there is no destructive innovation. In addition, system in the model is closed and there is no way to recover diversity when the whole population is converging to be the same as each other. Therefore, further study might expand the model with two competitive platforms with various performance measuring functions.

In Chapter 5, even with regard to which the methodology that draws platform ecosystem based on user preference is at an early stage of providing a new framework for research, complementary measures are needed in order to procure universality of the

methodology. Therefore, further study is possible to supplement the methodology and literatures to provide higher explanatory powers with evidences and cases. For instance, this dissertation mainly focused on the most preferred network, but focusing on second and third most preferred networks may provide more abundant implications to managers and policy makers.

Chapter 7. Conclusion

In the ICT industry, value does not flow in one direction, but circulates through the four layers of C-P-N-D. Digital innovation has completely changed the boundaries of the ICT industry, converging technology from all types of businesses, such as music, books, games, social media, and broadcasting, into one “smart” device. For the continuous innovation and development of the ICT industry, it is important to create a positive circulation of value among all of the layers combined. In the ICT industry, there is no field for one firm to act alone. Telecom-operators, Internet portal service providers, software developers, etc. and many stake-holders should run their business in the view of platform ecosystem to meet the users’ hidden needs. This is possible when policy makers and managerial executives understand the growth mechanism of a platform ecosystem. To conclude, this dissertation suggests three factors for sustainable growth.

First, a platform has to be a place where good content and services are selected by user preferences and choices naturally and evolve by the positive feedbacks. Healthy ecosystems are created by well-constructed platforms, especially in the smart ecosystem based on openness. Therefore, an important point to consider for PPs is giving users the right of select freely. A good idea or content should have the right to enter the platform easily with little to no entry barrier.

Second, platform ecosystems need to care about maintaining the genuine diversity of content. How far a system can evolve is a matter of diversity. Diversity provides new and

fresh knowledge to the organization. Even though it may look as if the content are diverse superficially, the diversity of the content's true characters could be decreasing. This dissertation insists that diversity, which is a reservoir of creativity and the power of sustainable growth in the platform ecosystem, must be kept properly, and this maintains vitality in the platform ecosystem.

Third, the direction of technological evolution should be toward human beings. In addition, firms which satisfy this condition could eventually survive and grow because human centric thinking is an effective way of exploring and meeting users' hidden needs. So, when all the actors in an ecosystem understand their roles properly, sustainable growth of a platform ecosystem would be possible. All organizations in the platform ecosystem should break from the techno-centric view which sees humans as tools for seeking a firm's profit or objective of technology, but move toward human-centric view which regards humans as the core competency of management. Policy makers can make users participate in the activity of growing the platform ecosystem by using appropriate motivations and policy advertising to cause users to diversify the source of information and their repertoire.

Appendix 1. Verification of the Model in Chapter 4

- Sensitivity Analysis of Simulation Results

The model in Chapter 4 has six parameters, which consist of two experimental variables and five control variables (see Table A1.1). Population size (popSize) and the number of dimensions of the consumer preference are set to 1000 and 300, respectively. These do not need to be verified because the bigger the size of population and the number of dimension are the better and more realistic the model is. The only limited condition for these variables is the computer's performance. I suggest that moderate levels of complexity reflect real-world problems well (Kauffman, 1996; Rivkin, 2000). Probability of slow and fast imitator (Pslow / Pfast) is set to 0.1 and 0.9, respectively. These variables also do not need to be verified because changing Pslow from 0.1 to 0.5 and Pfast from 0.5 to 0.9 is meaningless. It is meaningful when Pslow is lower than 0.5 and Pfast is higher than 0.5. Nevertheless, the results were examined for different Pslow and Pfast, ranging from 0 to 1. Over this range, I find that the results are not sensitive to the rate of Pslow and Pfast as long as Pslow is lower than 0.5 and Pfast is higher than 0.5. Therefore, the researcher has to verify the remaining variables: Pnew, Rs, Penv. However, the test for Rs was omitted because Experiment 2 already showed the trend of dependent variables by changing the ratio of slow learner (Rs from 0.1 to 0.9).

Table A1.1 Six parameters in the model (Chapter 4)

Experimental variables	Pnew	The height of entry barrier of the platform (range 0~1)
	Rs	The ratio of slow imitator (range 0~1)
Control variable	popSize	Population size (Initial setting = 1000)
	bits	The number of dimensions of the consumer preference (Initial setting = 300)
	Pslow	Probability of slow imitator (Initial setting = 0.1)
	Pfast	Probability of fast imitator (Initial setting = 0.9)
	Penv	Changing rate of consumer preference(taste) (Initial setting = 0.005)

I examined the sensitivity of five parameters: (1) the height of the entry barrier of the platform provider, (2) population size, (3) the number of dimensions of the consumer preference, (4) probability of slow imitator, (5) probability of fast imitator, (6) the rate of changing environment.

First, I verified the model for sensitivity of variable Pnew. By changing Pnew from 0.001 to 0.9, this dissertation confirms the initial setting is neutral and represents current platform ecosystem. Results in Appendix 2 show that as the height of the entry barrier of the platform provider gets higher the number of content on the platform (phenotype diversity) becomes reduced significantly (see Figure A1.1). In the case of genotype diversity, the problem is more serious. The entry barrier of a platform provider has significant influence on the genotype diversity of content on the platform ecosystem (see Figure A1.2). Moreover, average performance such as productivity or creativity in the

ecosystem decreases as the entry barrier increases (see Figure A1.3).

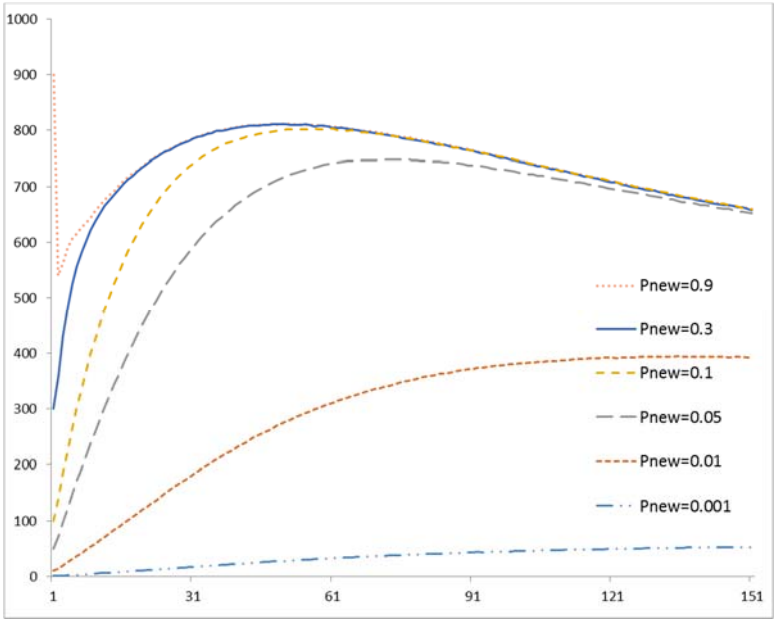


Figure A1.1 Sensitivity analysis of Pnew on phenotype diversity

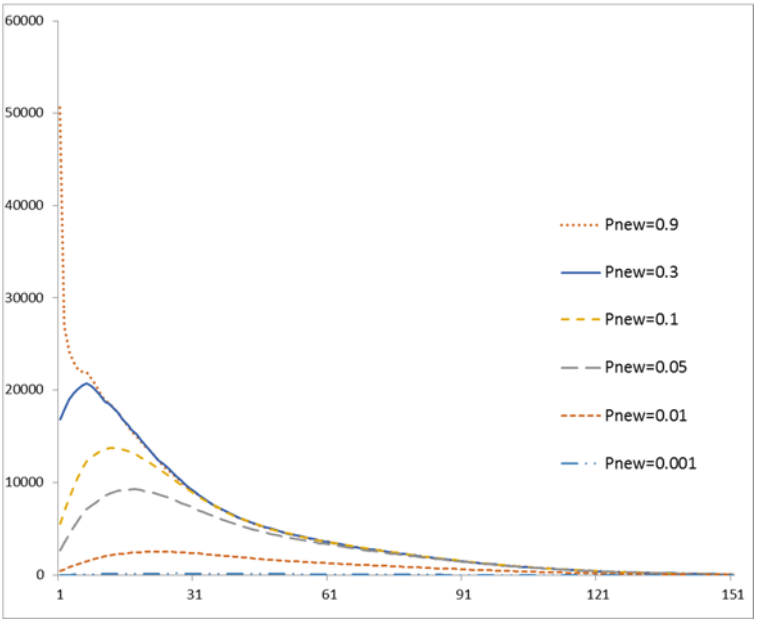


Figure A1.2. Sensitivity analysis of Pnew on genotype diversity

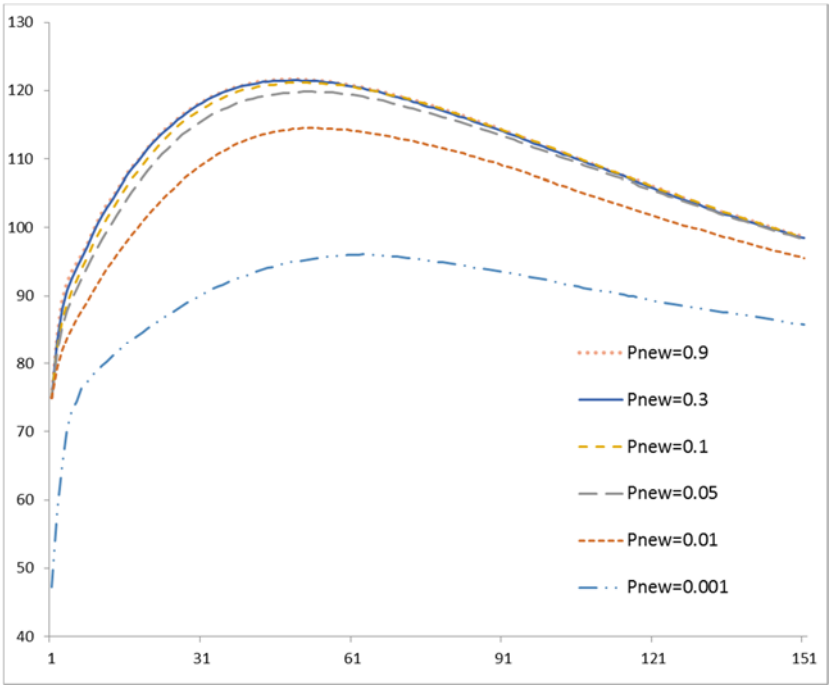


Figure A1.3 Sensitivity analysis of Pnew on average performance

Second, I verified the model for sensitivity of variable Penv. Results in Appendix 2 show that as the rate of environment changes more rapidly, the number of content on the platform (phenotype diversity) is reduced (see Figure A1.4). In the case of genotype diversity, however, rapidly changing environment which is higher than 0.5 gives a higher genotype diversity in the ecosystem. Much like the slow imitator effect, the change in an environment has the same effect as giving genotype diversity on the ecosystem because content providers cannot learn fast when the landscape changes frequently (see Figure A1.5). Average performance such as productivity or creativity in the ecosystem decreases as the environment changes more rapidly (see Figure A1.6).

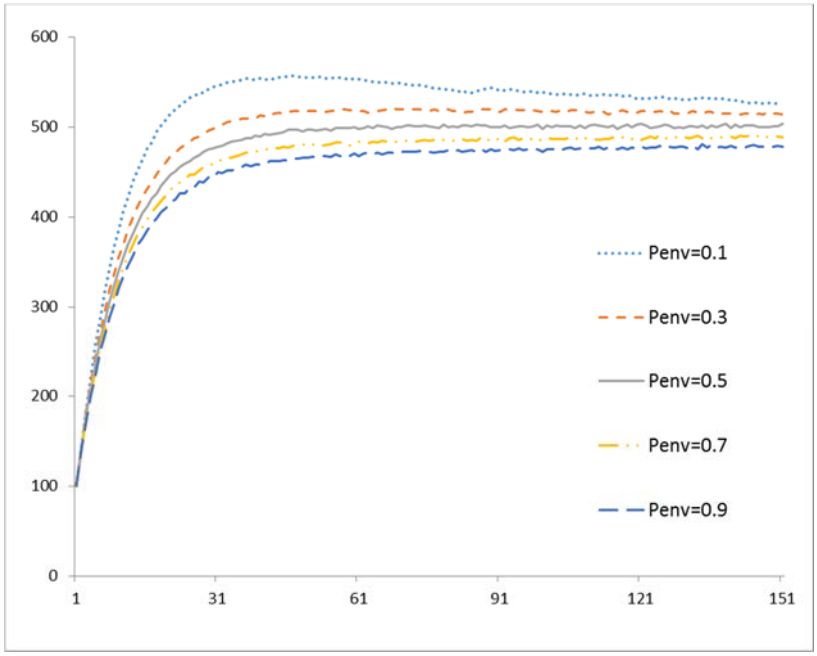


Figure A1.4 Sensitivity analysis of Penv on phenotype diversity

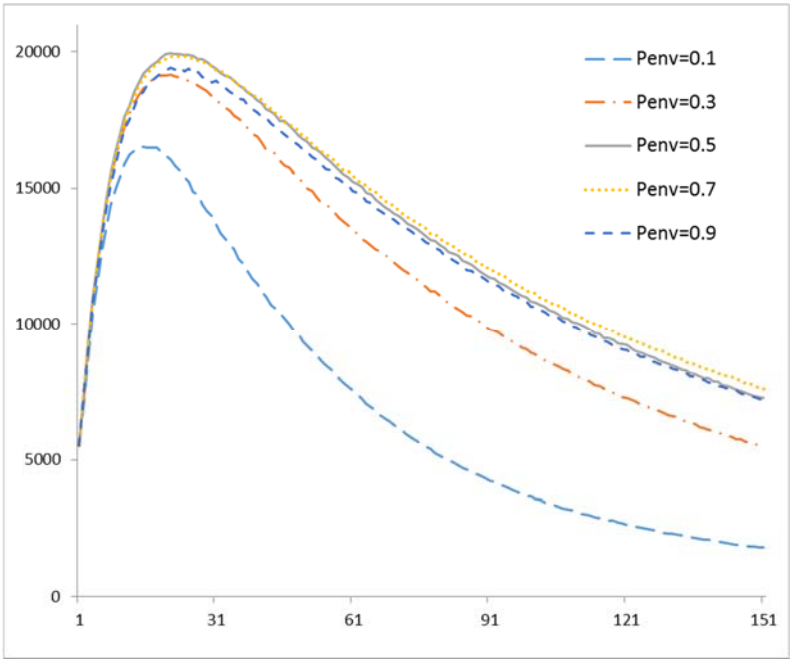


Figure A1.5 Sensitivity analysis of Penv on genotype diversity

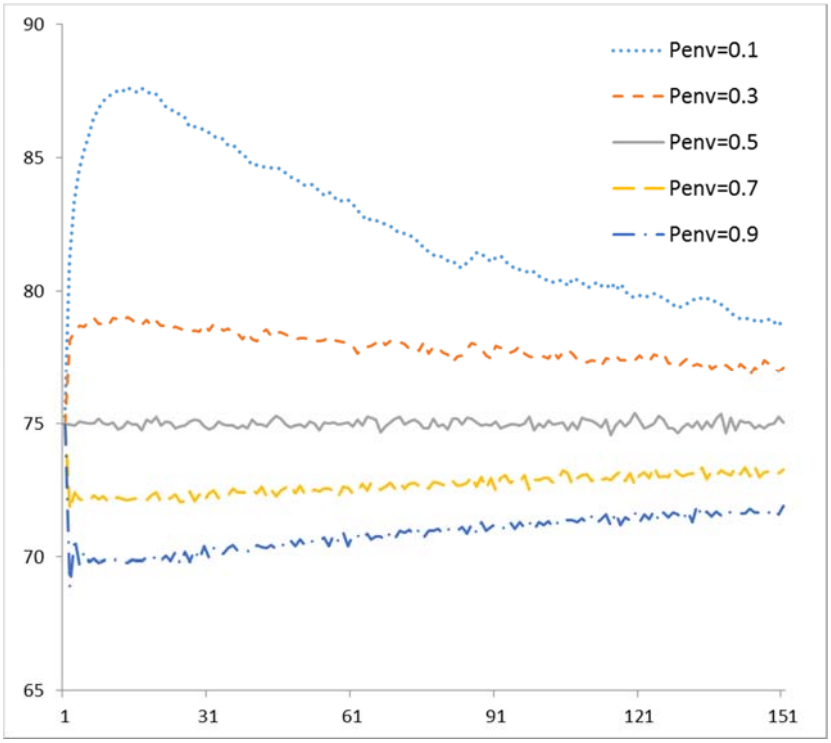


Figure A1.6. Sensitivity analysis of Penv on average performance

In addition, I improved the model to make the environmental change more realistic. The previous model considered the environmental change as just an incremental change (changing rate of consumer preference (taste), initial setting = 0.005). However, as Professor Hwang mentioned, there are many uncertainties in the real world such as disasters: wars, earthquakes, financial crisis, etc. In the case of a platform ecosystem, the uncertainty which has to be considered is the period of technological innovation. There are two types of innovations: radical and incremental innovation (Ettlie, 1983). While

incremental innovation occurs every period of an evolving technology, radical innovation seldom occurs. According to Schumpeter (1934), creative disruption that completely changes the previous technological landscape exists. Nowadays, scholars predict that the frequency of the radical innovation occurs about once every five years. Therefore, I added the idea in the model. When I compared the result with the original version, the result is not significantly different with the original version of the model. The exact value is changed but the trend is not changed. The following figures show the results.

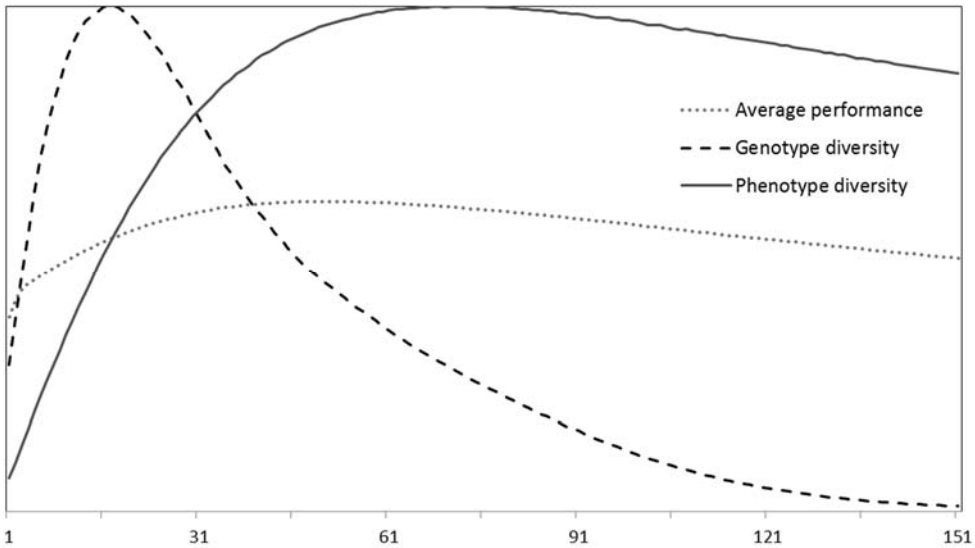


Figure A1.7 The result of Experiment 1 (original version)

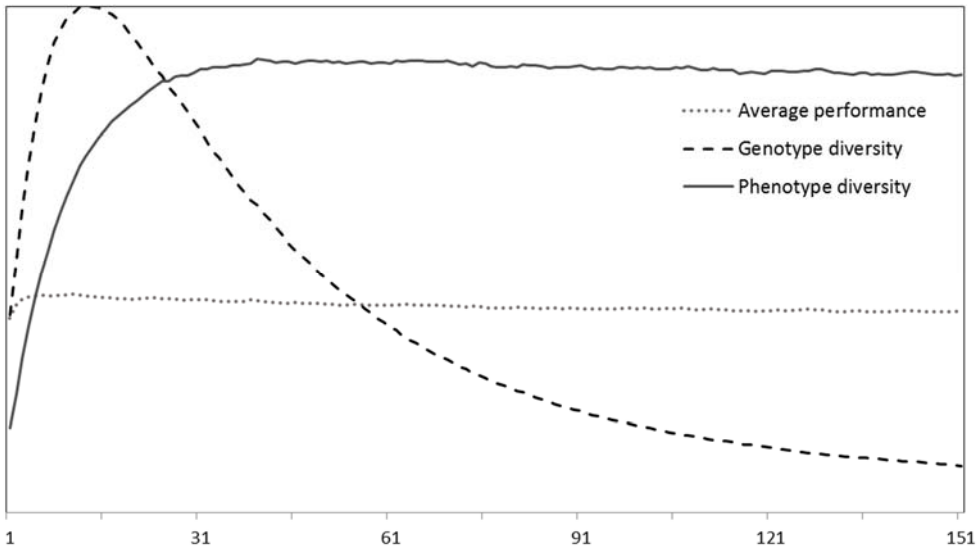


Figure A1.8 The result of Experiment 1 (considering radical/incremental innovation period)

Appendix 2. Validation of the Model in Chapter 4

Conceptualized simple models are impossible to validate with real data. One example is March's organizational learning model. In this case, according to Rand and Wilensky (2006), the case study is helpful for validating that kind of simple model. So, I added two case studies to show how giant platforms reduce content diversity. The first case is crisis of journalism due to redundancy of information and the second case is European Commission's (EC) regulation against reducing content diversity.

Case 1: *Crisis of journalism*

The International Colloquium 'information pluralism and new issues' was held on September 2012, in Paris, France. It was a part of a project 'Internet, pluralism, information redundancy' in the national research institute of France, ANR (Agence Nationale de la Recherche). Internet has two sides: fast diffusion of information and information redundancy. Media pluralism can be the number of media that exist but also the number of expressions that are melted in the media. However, as media starts to duplicate information more than creating information, diversity would be reduced. In the case of the United States and France, it seems to increase the surface area of media diversity and emerge new types of editors. When looking at the Internet media in detail, they realize 'network newsroom' which hires diverse journalists creates reporter union. However, this network newsroom rather reduces information diversity. As a result, the

opinions of experts on specific subjects disappeared, and instead, general journalists started to deal with many types of subjects. Also, as secondly processed articles of news and social media increased, the number of revealed subjects seemed to increase. However, as vast amounts of similar content were created by many types of media, redundancy of information became more serious.

Case 1 shows the crisis of Internet journalism. The characteristics of Internet makes journalism more of a giant networked union, but it could be a serious problem of reducing information diversity. Under the convergence environment, a giant platform emerges, and this reduces internal content diversity, even though the number of content increases. This matches well with Experiment 1. Moreover, Case 1 shows the reasons why content diversity is reduced. Firstly, there is no specialist but lots of generalists dealing with lots of subjects, and secondly, high secondary manipulation of information reduces content diversity. This matches well with Experiment 2. Due to the high rate of fast imitators, genotype diversity is reduced. Thirdly, it looks like the increase in the number of news and this matches high phenotype diversity at the initial phase.

Case 2: *EC regulation on how to keep reducing content diversity*

European Commission (EC) adopted a report 'preparing for a fully convergent audiovisual world' as a response to warning about reducing content diversity. The report includes the following agendas: 1) change of market competition under the convergence era, 2) content access and findability, 3) safeguarding diversity and funding model, 4)

securement of infra and frequency capacity for content transmitting traffic, 5) values in convergence era, and 6) improvement of regulation. The most important agenda is the access and findability and safeguarding diversity and funding model. They know the most important value of this convergence era they have to keep is diversity.

EC emphasized the content findability. End-users are able to access the content or service they want and also find the content in any particular content gateway. But, in reality, that scenario is not possible because of the platforms' economic incentives. The report said platforms could select the content or keep the content which they think suits their profit. Therefore, the report suggests the policy implications as follows:

- *Guarantee of non-discriminatory transfer of all content and keep expression and cultural pluralism*
- *In order to keep product and expression diversity, content findability cannot be decided by economic stake-holders*
- *Regulative action when platform providers abuse their gate-keeping power on discriminating specific content*
- *EC will monitor the content gate-keepers that abuse their power in order to give priority to specific companies*

The next important agenda is safeguarding diversity and funding model. EC considers content diversity should be guarded by any means. They suggest the policy implications as follows:

- *EC will decide how to raise funds for creating content.*
- *EC will monitor whether or not the new business model which provides unauthorized*

audiovisual content funded by advertisement threaten premium broadcast and media.

- *In order to keep independence, public media or platform has to be apart from limitation of only being funded by advertisement, and EU members should support the public parts.*

Case 2 also validates the model. Under the convergence era, platforms could abuse their gate-keeping role and this inevitably reduces content diversity. In order to recover the diversity, EC suggests several policy remedies which also match with the implications in Chapter 4. For example, EC states content access and findability and content uniqueness have to be kept for users. It means that CPs have to keep their uniqueness and PPs have to open their platforms, which are the implications of Chapter 4. In addition, EC also suggests that non-profit platforms are needed, which is also the result of Experiment 4. Therefore, I could say that two case studies validate the model appropriately.

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Abstract (Korean)

스마트 혁명은 기존의 산업 조직을 와해 시키고 콘텐츠(C), 플랫폼(P), 네트워크(N), 단말(D)의 네 가지 층(C-P-N-D)으로 이루어진 새로운 정보통신산업 생태계를 조성하였다. 최근, 플랫폼 제공자들이 콘텐츠 제공자들과 사용자들간의 관계를 이어주면서 자신의 가치를 확장시키고 있는 가운데, 플랫폼의 거대화가 이슈가 되고 있다. 플랫폼의 크기가 확장되면서 플랫폼의 시장 지배력의 증가와 함께 콘텐츠 제공자들을 상대로 불공정 거래 가능성이 커졌고, 이런 환경에서 콘텐츠 제공자들은 단기 이익 극대화를 목표로 새로운 것을 창조하기 보다 무분별하게 클릭 수를 늘리는 전략을 취하기 시작했으며, 사용자들은 정확하게 자신들이 원하는 콘텐츠와 정보를 찾는 것을 포기하고 플랫폼이 제공하는 편이에 고착화 되고 있다. 이러한 악순환은 결국 플랫폼 생태계 내의 콘텐츠 다양성을 줄이고, 사용자들의 콘텐츠 선택을 제한하게 되고, 플랫폼 생태계의 성장 동력인 콘텐츠 창의성 역시 발현되기 어렵게 한다. 하지만, 대부분의 기존 연구는 플랫폼 생태계 내 각 층의 기업 전략에만 초점을 맞추고 있어, 플랫폼 생태계의 성장 메커니즘 이해에 대한 노력이 부족한 실정이다. 또한 특별히 콘텐츠 제공자들의 다양성과 창조성과 관련한 플랫폼 개방성의 역할, 콘텐츠 제공자와 사용자의 역할에 대한 연구가 부족하다. 따라서 본 논문은 지속 가능한 플랫폼 생태계의 성장 메커니즘에 대한 가설들을 제시하고, 세 가지 이론과 실증 연구를 통해 가설을 검증함으로써, 플랫폼 생태계의 성장 메커니즘 역학에 대한 틀을 제공하는 것을 목표로 한다.

첫 번째 연구에서는 확률프론티어 분석과 메타프론티어 분석을 사용하여, 플랫폼 개방성과 콘텐츠 제공자의 생산성의 관계를 실증하였다. 개방과 폐쇄 플랫폼을 대표하는 두 개의 플랫폼 생태계를 비교함으로써, 콘텐츠 선택의 개입 정도로 나타나는 플랫폼 개방성이 어떻게 콘텐츠 제공자들의 생산성에 영향을 끼치는지를 보였다. 폐쇄적인 플랫폼은 생태계 내에서 높은 평균 효율성을 보이지만, 개방적인 플랫폼은 메타프론티어 관점에서 폐쇄적인 플랫폼보다 높은 효율성을 보였다. 이 결과를 통해 플랫폼 개방성이 콘텐츠 제공자들로 하여금 장기적인 관점에서 높은 생산성을 가지도록 도와주는 역할을 한다는 것을 알 수 있다.

두 번째 연구에서는 거대 플랫폼이 콘텐츠 다양성에 끼치는 영향을 밝히기 위해 유전알고리즘 기반 시뮬레이션을 통해 다양성 감소 메커니즘을 보였다. 주요한 발견으로는 첫째, 줄어든 다양성의 복원을 위해서는 소비자의 의지가 필요하다는 것이고, 둘째, 콘텐츠 제공자들 중 그들의 독특함을 유지하려고 노력하는 제공자들이 많아질수록 콘텐츠의 내적 다양성이 증가한다는 것이다. 소비자들이 자신의 숨은 니즈를 찾기 위해 노력하고 정보와 콘텐츠를 얻는 플랫폼을 다양화 시키기 시작하면, 콘텐츠 제공자들도 그 니즈를 만족시키기 위해서 자신의 독특함을 유지하면서 새로운 것을 만들어 내려고 노력하게 된다. 이것은 플랫폼과 콘텐츠 제공자들로 하여금 완전히 다른 새로운 가치를 만들기 위해 여러 가지 시도를 조장하는 것으로 생태계의 총 가치를 확장시키는 방법이다. 세번째 발견은 높은 콘텐츠 다양성이 플랫폼 생태계 전체의 평균 성과를 향상시키는데 영향을 준다는 것이다. 이것은 콘텐츠 다양성이 결국 플랫폼 생태계를 지속가능하게 성장시키는 콘텐츠 창의성의 원천이 된다는 것을 의미한다.

세 번째 연구에서는 한국의 2010년에서 2013년까지의 미디어 사용자의 선호를 기반으로 한 플랫폼 생태계 네트워크 지도를 그려봄으로써 플랫폼 생태계의 공진화 과정과 진화 궤적에 대해 알아보았다. 해당 년도의 네트워크 위상의 특징과 여러 중심도의 변화 궤적을 분석하여 네트워크가 어떻게 진화해 왔는지를 보였다. 결과로부터 플랫폼 생태계는 변화하는 기술 환경에 적응해 나가는 플랫폼, 콘텐츠 제공자들의 노력과 그렇게 창출된 새로운 가치를 선택하는 사용자가 맞물려 공진화 해왔다는 것을 알 수 있었다. 또한 사용자들은 모두 다른 미디어 레퍼토리를 가지지만 거시적으로는 상당한 유사점 역시 공유하고 있다는 점과 이로 인해 미디어 커뮤니티가 형성되는 것을 볼 수 있었다. 따라서, 플랫폼 생태계의 가치 창출과 지속적 성장은 당장의 수익 창출이 힘들어도 플랫폼 제공자, 콘텐츠 제공자, 사용자들이 협력할 때 이루어진다는 것을 알 수 있다.

세 가지 연구를 통해, 본 논문은 지속가능한 플랫폼 생태계의 성장 메커니즘을 다음과 같이 제안한다. 플랫폼이 콘텐츠 선택 과정을 개방하면, 이것이 콘텐츠의 내적 다양성을 높이고, 이것은 콘텐츠 제공자들로 하여금 장기 효율성을 유지할 수 있게 도움을 준다. 콘텐츠의 내적 다양성은 소비자의 숨은 니즈를 충족시킬 수 있는 새로운 콘텐츠를 창조할 수 있는 확률을 높이게 되고 궁극적으로 생태계 전체에 에너지를 공급한다. 플랫폼 개방은 콘텐츠 공급자

들이 그들의 콘텐츠 독자성을 유지하는 의지에 간접적으로 영향을 주며, 그러한 의지들은 콘텐츠 다양성이 증가하는 데 다시 영향을 준다. 사용자가 정보와 콘텐츠를 공급받는 원천을 다양화하는 의지 역시 콘텐츠 다양성을 높이는 데 있어 중요한 역할을 담당하고, 이러한 모든 프로세스는 플랫폼, 콘텐츠 제공자, 사용자 모두가 상호 의존적으로 연결되어 있다. 따라서, 플랫폼 생태계의 지속가능한 성장을 위해서는 플랫폼, 콘텐츠 제공자, 사용자의 의지를 증진시키고, 콘텐츠의 창조적 가치가 인정받는 분위기를 조성하는 전체적인 관점이 필요하다.

본 논문은 몇 가지 경영적, 정책적 시사점을 제공한다. 먼저, 플랫폼 제공자의 관점에서 플랫폼은 개방하는 것이 좋다. 플랫폼의 기술적인 개방뿐만 아니라 호환적인 개방, 나아가서 콘텐츠 제공자의 선택 과정조차 개방하는 것이 그들의 생태계의 장기 효율성을 증진시키는 방법이기 때문이다. 두 번째로, 콘텐츠 제공자들은 각자가 지닌 콘텐츠의 독특성을 지켜나가려는 노력이 필요하다. 정부는 이 모든 과정을 돕기 위해 실패를 용인하고 창조성이 인정받는 분위기가 조성되도록 힘써야 할 것이다. 본 논문은 플랫폼 생태계 성장 역학에 대한 새로운 이론을 학문적으로 제안하고, 이를 통해 기업 전략과 공공 정책에 필요한 필수 가치에 대한 이해를 돕고, 철학적 기반을 제공한다는 것에 그 의의가 있다.

주요어 : 플랫폼 생태계, 지속가능한 성장, 플랫폼 개방성, 콘텐츠 다양성, 콘텐츠 창조성, 플랫폼 제공자, 콘텐츠 제공자, 사용자, 공진화, 메타프론티어, 유전알고리즘, 네트워크분석

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