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Three essays on the Internet: Network diffusion characteristics, Content pricing strategies, and new Regulation framework in IoT era

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Abstract

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Internet has changed the individual's life style and social aspect. And the Internet is the result of innovative activity since its development. This dissertation revisits the Internet on the view on innovation diffusion.

The usage and diffusion of the Internet vary greatly by country and by income level. Chapter 2 investigates through empirical analysis the factors that make Internet diffusion faster, and the results show that the various and abundant content has played a crucial role for fast diffusion of the Internet. Another result is that, in the early stage of Internet

diffusion, network externality seems to be the most important factor for fast Internet diffusion, but as diffusion progresses to a matured stage, the amount of available content is the crucial factor for fast Internet diffusion. And it can be inferred that the two industries are in an indivisible relationship for the diffusion of Internet.

Chapter 3 compares the efficiency of digital contents firms which have different pricing strategies and the result shows that the zero pricing with additional revenue from online advertisement is the most efficient strategy by meta-frontier analysis. On the view of diffusion of innovation, this new business or operational strategy have helped diffusion of Internet or diffusion of innovation. It could be also inferred that this innovative strategy has helped and supported the diffusion of Internet rather than their innovation activity itself.

Chapter 4 proposes new regulation framework in the IoT era. IoT service is new and innovative service based on the Internet and recently starts to launch. The new regulation framework, named as Isotropic dynamics regulation framework, is conceptual framework rather than a practical or legal regulation tool. And it considers three points of view. First, data and information should be delivered to targeted destinations precisely and on time, implying that the need for a vertical regulation framework has arisen. Second, appropriate regulations should be imposed on the three layers of the full IoT service, similar to the horizontal regulation framework associated with the traditional Internet era. Finally, innovations should be promoted isotropically in all three layers.

The above describes the diffusion of Internet as diffusion of innovation. However, the integration of information will be another main issue as Internet network and its related

services and contents, which came from integrated technologies, advance. And two policy directions are inferred: One is that integrated information should be managed very carefully because misused information may harm to users, and the other is that worldwide ICT policy is needed to deploy these integrated information and technologies in the developing countries because reduced transaction cost can spread more dividends of ICT in these countries.

Keywords: Internet, diffusion of Internet, pricing of content providers, Internet regulation framework
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Chapter 1. Overall Introduction

1.1 Research Backgrounds

The Internet has changed many aspects of our daily lives and society, and this change will continue as new and innovative Internet-based services such as IoT emerge. The Internet consists of a physical network and content or service delivered over it. In other words, the proliferation of the Internet can only be achieved if the diffusion of physical networks, the abundant contents, and the spread of new emerging services are intertwined. This dissertation explores the factors to proliferate the Internet: the first is for the fast Internet network diffusion, the second is for enriching the Internet content, and the third is for new regulation framework to prepare the emerging new Internet based service; IoT.

The first essay analyzes the diffusion factors in the physical Internet network.

Bass (1969) and Rogers (2010) have studied the diffusion characteristics of new products and new technologies. The Bass model is that adopters of innovations consist of innovators who introduce new products or new technologies directly and imitators that embrace new technologies by mimicking the actions of innovators. The Rogers model distinguishes these innovation adopters as innovators, early adopters, early majority, late majority, and late ladders. The innovation diffusion model has evolved into various and detailed expression, and the three stylized facts of innovation diffusion, summarized by Hall and Rosenberg (2010) are (1) the diffusion of innovation is the S-type curve shape, (2) the diffusion of innovation is time consuming process, (3) the innovation diffusion speed is very different by technology and country. This dissertation analysis the factors to influence the Internet network diffusion, starting from the previous results: Internet network diffusion has also followed S-type curve and the diffusion speed varies by country.

This dissertation sets the Internet content as the main explanatory factor of the diffusion of the Internet network, according to the network externality or network effect theory. Karz and Shapiro (1985) explain the network externality, in which the utility of using a product or service increases as the use of this product or service by other consumers increases. Network externality is categorized into two types: direct network externality where the utility increases as others use the same product or services (e.g. telephone, facsimile, and so on) and indirect network externality, which is the hardware and software paradigm, where the PC user's utility increase as usage of the software compatible to that PC by other PC users grows. And the Internet network and contents have a typical indirect network externality.

Therefore, the first essay examines whether the various and available Internet contents have a positive effect on the diffusion speed of the Internet network. The previous studies show that the diffusion of the Internet network is diversified by the income level, the usage price, the competition level of network providers, the existence of competition policy, the effect of direct network externality, and so on. And the previous studies analyze the factors to influence the level of diffusion measured by the number of subscribers which is the dependent variable. Although Viard and Economides (2014) present Internet content as an important factor in the diffusion of Internet networks, this study also uses the degree of diffusion measured by Internet network subscribers as a dependent variable, however, this dissertation analyzes the factor to influence the speed of diffusion. In addition, Lee and Brown (2008) use the speed of diffusion as a dependent variable, however, it is also different from the analysis framework of this dissertation because Lee and Brown (2008) investigate the effect of competition policy (LLU policy) as the explanatory variable.

The second essay examines the driving factor to provide diverse and innovative Internet content. The analysis of the first essay shows that a wide variety of rich Internet content is a factor in speeding up the diffusion of Internet networks. So, examining the driving factor to provide diverse and innovative content on the Internet can also provide important results in investigating the proliferation of the whole Internet; network, content and service.

There are researches that Internet contents have developed variously and innovatively in the situation that there is no regulation unlike traditional broadcasting, communication, and cable TV. Shin (2006) argues that VoIP service has been flourished in the no regulation or hand-off approach although VoIP service is very similar with traditional telephone service. And many research results (e.g., Reggiani & Valletti, 2016; Lessig, 2002; Lee & Wu, 2009; Guo et al., 2012) argue that innovation in content providers, which is called as innovation at the edge, is more important for innovation in the whole Internet.

However, the absence of regulation can help to launch a variety of innovative Internet content, but the reason that Internet content can be provided to users widely is that the price of Internet content is very cheap or free of charge comparing the content or service provided via other media. What make Internet content cheap or free of charge result from the fact that information goods including Internet contents have a high initial production cost but the very low cost of reproduction or distribution. In particular, the distribution cost of digital content distributed through the Internet network is close to zero. Shapiro and Varian (2013) have analyzed the strategies available to companies that produce and sell information goods based on these characteristics.

Nonetheless, even though the reproduction or distribution cost is very low, companies could make profit difference of the revenue and cost. However, many Internet contents is provided free of charge to users. The reason why Internet contents can be provided free of charge is that Internet content providers can add an online advertisement to Internet contents so that they can earn additional revenue from online advertisement and take an appropriate pricing strategy between advertisers and content users. In other words, Internet content providers can serve as a platform for the two-sided market composed of advertisers and content users. Rochet and Tirole (2004) describe the two-sided market as a market where there is a platform for appropriate pricing strategies while interacting with users at both ends. Parker and Van Alstyne (2005) show that information goods traded in the double-sided market can be offered to users at a very low price or free of charge.

Online advertising added to Internet contents can be located freely on the contents, displayed in a variety of forms such as text, pictures, and animations or moving pictures, and targeted in accordance with the characteristics of users. Therefore, online advertisement is mentioned as an innovative advertising strategy. From these result, the Internet advertising market has grown significantly (Evans, 2008; Evans, 2009).

Also, there are many studies on the pricing strategies of Internet content providers as the influence of online advertising has grown (e.g., Fan et al, 2007; Prasad et al., 2003; Lin et al., 2012). However, these studies result in optimal pricing strategy through economic analysis with assumptions of market status, there is no research that analyze whether the strategy of zero pricing with online advertisement revenue is effective for firms' operation to my knowledge.

This dissertation compares the technical efficiency of Internet content companies having paid, free, or mixed pricing strategies through meta-frontier methodology, shows that the efficiency of Internet contents providing companies with zero pricing and online advertisement revenue is relatively higher, and confirms that the contents on the Internet have been developed and spread more diversely and innovatively because of free of charge to users.

The third essay examines and proposes the conceptual regulation framework needed to better spread the new and innovative Internet-based IoT services.

IoT (Internet of Things) service is composed three layers: device which has computing capability sense and deliver surrounding information to analysis application via Internet network, analysis application analyzes collected information and give feedback of solution to user via Internet network, and network, which is a portion of the whole Internet, delivers raw information from device to analysis application and analyzed solution from analysis application to user. It acts as a part of the whole Internet in that the information and data are transmitted through the Internet network. However, since the non-human intelligence devices automatically sense and transmit the information, it is a very different service with traditional Internet service or content.

In order to spread and diffuse such IoT services, industry sectors including network operators, equipment manufacturers, information analysts, technology standardization organizations market analysis companies are actively researching and developing in each area.

In view of the fact that the existing Internet contents have been developed and flourished variously and innovatively under no regulation condition, it seems possible to argue that no regulation is appropriate way to spread and diffuse newly emerging IoT service, however, the IoT service is very different from existing Internet contents or services in that it has another layer of device which is an intelligent device with computing capability.

Although the initial Internet has transmitted contents through a telephone network or a cable TV network that existed before, the Internet contents are very different from those of traditional voice communication, broadcasting, or cable TV. So, the vertical regulation framework imposed on the traditional medial such as voice telecommunication, broadcasting, and cable, has not been available in the Internet era and another horizontal regulation framework is imposed on the Internet. IoT service is also similar to the birth of the early Internet in that it is provided on the basis of the existing Internet network. However, since the IoT service differs greatly from the contents or service provided by the

Internet nowadays, works for another regulation framework in the IoT era is essential at this point.

The regulatory framework required for the IoT era should consider following concerns: (1) Because the information should be delivered precisely and on-timely to the destination, a part of the vertical regulatory framework for broadcasting and communication should be applied in part; (2) Because IoT is a portion of existing Internet with additional device layer, the existing horizontal regulation framework of existing Internet are also required in part; (3) In that IoT service result from the innovation of all three layers, new regulation framework should promote or expand innovations at all three layers. In addition, IoT service is considered as the integration of device, networks, and information analysis technology and which is also important, analytical technology, however, this service eventually treats or handles raw information, more aggressive regulation should be imposed on information-handling analysis application.

1.2 Research Questions and Models

It has been said that the Internet has changed many aspects of individual life styles and social behaviors. It has also been said that Internet increases productivity in industrial sectors and increases national economic growth. The research in this area is too numerous to list. And it would be possible to argue that the Internet is the most outstanding innovation in the world.

On the view of innovation of Nelson and Winter (1982), they say innovation involve change in routine, the Internet is the innovative activity since its development. Academic researchers desired to change their routine of the way to feedback their research result: from via the printed papers to via the digitalized files. And further successive innovation has made Internet network from the local to the global network, from the dial-up modem connection to broadband, and from fixed lines to the mobile Internet, and also made Internet related services extremely various from simple text transport such as email, FTP, and USENET to searching, providing news, Internet shopping, financial services, multimedia streaming, governmental services, and others.

Every technologies and services or contents mentioned in above paragraph is the product of innovative activities, and above all is very accustomed to us all. So, it could be said that the Internet as both the network technology and services and contents has been diffused very well nowadays.

This dissertation makes three questions on the diffusion of the Internet on the view of the diffusion of innovation. Does the amount and variety of services and contents on the Internet, which is mentioned as innovation at the edge, have made the Internet diffusion fast?, Is the zero pricing strategy effective to the content providers?, and What is prepared to promote new and emerging IoT services?

The first question seems concerning the relation of two major industries composing the Internet: network and contents industry. Two Internet-related industries are the Internet network industry and the content and/or service industry, mated to the network layer and content layer in the horizontal regulation framework. Content or service firms create new and innovative products, and once individual users select their contents or services, they can make sales and enjoy earnings but their digital products are delivered by the Internet networks of network firms. Moreover, individual users contract with an Internet network service because they need a network in order to enjoy new and innovative digital products of content or service firms. This drives network firms' sales and earnings, indicating that without network firms', content or service firms could not exist, and vice versa. Figure 1 shows the relationship between fixed broadband subscribers[1] and the number of homepages[2] which is a proxy for the amount of Internet content and the number of services.

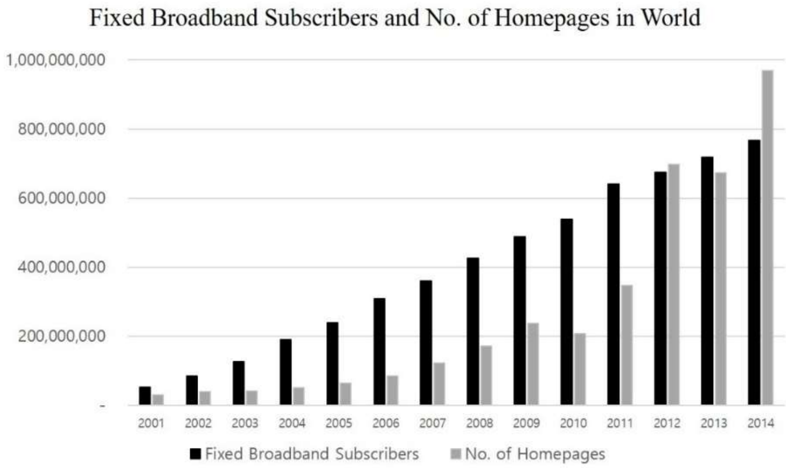

Figure 1.1 Fixed Broadband Subscribers and No. of Homepages in World

[1] Data from Worldbank

[2] Retrieved at http://www.internetlivestats.com/total-number-of-websites/#ref-1 on 12 Nov. 2016.

Hence, the two industries need to be in a cooperative relationship, but the real world shows that they are not. Especially with the network neutrality debate, they appear to be standing at opposite sides in this debate.

However, the result of this question has meaningful implication for the Internet less diffused countries. In chapter 2 of this dissertation, which is the first essay, it will be shown that the two industries are in an indivisible relationship with the investigation of the effect of contents on the diffusion speed of a fixed broadband network. So, in the countries where the Internet network is not well diffused, it is the important policy to promote abundant available contents as well as to gather initial Internet user, and as does in countries where the new type of Internet based contents or services: VR(Virtual Reality), AR(Augmented Reality), IoT(Internet of Things), and others, start to launch.

To answer the second question, this dissertation compares the efficiency of digital contents firms which have different pricing strategies. We are highly accustomed to free-of-charge Internet contents or services, including search engines such as Google, Internet newspapers, blog services, SNSs such as Facebook and Twitter, and others that occasionally it is thought that they were originally free of charge. Some free goods or services have existed, such as TV programs and magazines or newspapers distributed in subway stations, but they were rare cases before the Internet era. For nearly all goods or services before the Internet, an appropriate price was charged by firms to earn a profit. The difference between sales revenue and production costs becomes the profit of a firm.

In the Internet era, many firms offer their contents or services out of charge as they have other revenue sources from online advertisements. Others charge, and some offer both free and not free content and services. Many earlier studies investigated the effects of online advertisement and optimal pricing strategies of content firms. However, there is no research on the efficiency of firms with different pricing strategies to the best of my knowledge. So, in chapter 3, the efficiency of content firms is compared using a meta-frontier analysis. The results show that the traditional pricing strategy is not the most efficient strategy in the Internet era.

The result of the Ch.3 looks concerning the business strategies of contents providing firms. However, on the view of diffusion of innovation, their new business or operational strategy have helped diffusion of Internet or diffusion of innovation. It could be also insisted that the zero pricing strategy with additional revenue from online advertisement be an innovative activity. However, this dissertation emphasize that their innovative strategy has helped and supported the diffusion of Internet rather than their innovation activity itself.

To promote any new, emerging, and innovative services or goods, it is needed to analyze many considerations including market, users' demand, technology, relation between society and service, and so on. And the IoT service is the new, emerging, and innovative services among the Internet based technology. Hence, many academic research, technology standards, and market analysis firms have made the result relating the IoT service

However, on the view of innovation diffusion this dissertation has emphasis on the regulation, strictly speaking the conceptual regulation framework in the IoT era that could make the IoT services diffuse more well, and propose the isotropic dynamic regulation framework.

As we have seen the very confused situation imposing regulations on the emergence of the Internet, because the Internet and its related services are very different from traditional communications services such as telecommunication, broadcasting, and cable TV. So, it is anticipated that this new and different IoT service will need another type of regulation framework based on the Internet but different from that of the Internet.

The following three considerations are integrated into a new regulation framework in the IoT era. The first of these is that IoT services need more precise transport of information from sensing devices to IoT service firms and from IoT service firms to IoT service users. Hence, a vertical regulation framework for the innovative delivery of information is somewhat needed in the IoT era. The second consideration is that akin to the two layers, the network and content layers, of the traditional Internet service, IoT services are composed of three layers as well, which are the sensing device, Internet network and IoT application layers. Hence, a horizontal regulation framework of the Internet era is also needed in the IoT era, but the relationships between another new layer of sensing devices and the network and IoT applications should be considered. The third consideration is that innovations should expand at all three layers equally. Innovation of the network is more important in the traditional telecommunication era and innovations at the edge, meaning innovations of content or services, is more important in the traditional Internet era. However, in the IoT era, innovations at all three layers are required for better IoT services. Integrating the three considerations above, the isotropic dynamic regulation framework as proposed here is a conceptual framework for anticipative discussions and efforts.

This dissertation is composed as follows. Chapter 2, 3, and 4 have each result and give answers to above three questions respectively, and in chapter 5, the summary of each result is provided and the meaningful concept of integration after diffusion of the Internet is discussed.

Chapter 2. Content as a fast Internet diffusion factor

2.1 Introduction

The Internet has changed and continues to change individual's daily lifestyles and society's aspect. And the new emerging contents and services connected to Internet, such as VR (Virtual Reality) or the IoT (Internet of Things) are also anticipated to impact individuals and society.

Early Internet development occurred due to two main purposes: the military required a communication network that could withstand extreme communications situations in which the communication network is partially broken, and the academic community desired a more efficient method for sharing and feedback of digitalized research results.-However, as more Internet users take advantage of various Internet content and services on Internet, it has changed much of individual's lifestyles and society's aspect.

Together with the changes for individuals and society, the Internet has played an important role in the economic development of each country in the information economy era as the studies (Choi and Yi, 2009; Bojnec and Ferto, 2012; Meijers, 2014; Pradhan et al., 2013; Arvin and Pradhan, 2014) shows. The International Telecommunication Union (ITU) and the United Nations Educational, Scientific, and Cultural Organization (UNESCO) (2015) ascertains that broadband Internet is an important tool for sustainable development in countries – especially in the least developed countries – and states the importance of governmental policies for broadband diffusion.

Despite the efforts of companies, governments, and international organizations toward Internet diffusion, Internet users and fixed broadband subscribers vary greatly by country and income level. At the end of 2014, the number of Internet users per 100 people by the world aggregated level was 40.7; however, based on the World Bank's four income levels of high, upper middle, lower middle, and low, Internet users are 80.6, 47.7, 22.6, and 6.3, respectively. For the case of fixed broadband, world aggregated subscribers per 100 people is 10.6, but by the four income levels they are 28.3, 12.4, 2.4, and 0.2, respectively. The above two Internet-related records have huge gaps by countries' income level.

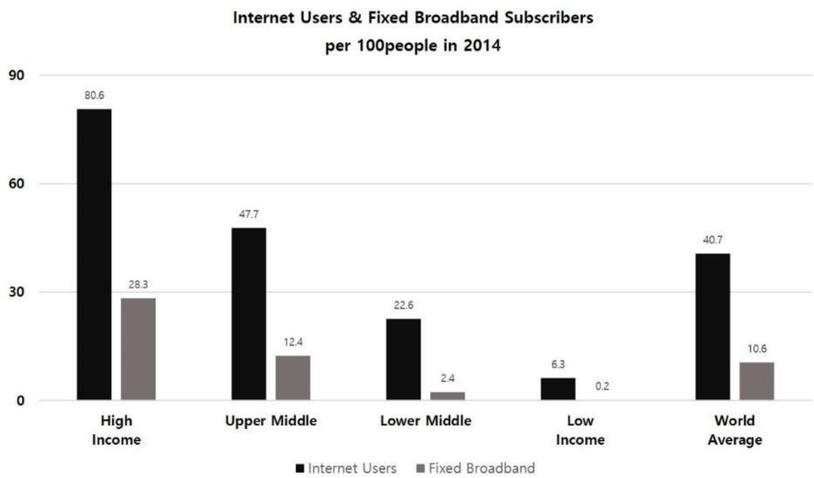

Figure 2.1 Internet Users and Fixed Broadband Subscribers by Income level

Another gap by income level is that higher income countries tend to support policies that promote higher Internet speed: Quality of Internet diffusion. For example, the United States' Federal Communications Commission (FCC) (2010) updated household broadband speed 4Mbps downstream and 1Mbps upstream, and after 5 years the FCC (2015) stated that 25Mbps downstream and 3Mbps upstream is required for household consumers. The European Commission (2010) targets 30Mbps for all European people and 100Mbps for more than 50% European people by the year 2020 in all European countries. In Korea, known as a country of a well-equipped Internet infrastructure, giga broadband service has been launched in 2014, whose maximum download speed reaches 1Gbps, and on June 2016, 1.7 million people use giga broadband service in the total of 20.3 million broadband subscribers.

However, for less developed countries where the Internet infrastructure is not well established and Internet usage is not well diffused, the high priorities of policies are deploying Internet infrastructure and diffusing Internet service to the people; Quantity of Internet.

In these situation, it is questioned what can make Internet diffusion faster for developing or less developed countries to catch up with developed countries' Internet diffusion and usage. This dissertation selects Internet content as the most important factor for fast Internet diffusion and verifies this through empirical analysis.

ITU and UNESCO (2015) explains the importance of content for Internet diffusion, and Viard and Economides (2014) shows that content is an important factor for more Internet subscribers and argue that promoting Internet content is an easier way than economic development: GDP and socio-demographic changes: Education level. However, this dissertation shows that the abundance of Internet content is the most important factor to speed up Internet diffusion.

Many research results show which factors have the effect on the Internet diffusion on the view point of number of subscribers, however, this dissertation has the question which factor make it faster on the view point of diffusion speed. And some results show the amount of available content has the effect, however, these results except Viard and Economides (2014) treat the content variable as one of independent or control variable. But this dissertation argue that the amount of available content is the main explanatory factor to make Internet diffusion faster.

To achieve this, the empirical analysis has conducted to determine which factors have effect on the maximum speed of Internet diffusion tracing an S-type curve of new technologies and innovations diffusion.

This chapter is constructed as follows. Ch. 2.2 includes the literature reviews for the type and diffusion of new technology or innovation and Internet diffusion factors. Ch. 2.3 explains methodologies. Ch. 2.4 describes data collections. Ch. 2.5 shows analysis results. Ch. 2.6 concludes this chapter with policy implications.

2.2 Literature Review

2.2.1 S-type curve diffusion of new technology

One of the three stylized factors of innovation diffusion summarized by Hall and Rosenberg (2010) is that the diffusion of new technology or innovation follows an S-type curve. Two others are those: (1) diffusion is time-consuming, and (2) diffusion speed varies across technologies and across countries.

Stoneman (1983) explains the diffusion of innovations or new products from an economic point of view. The innovative new products are diffused as consumers buy these goods. So in this situation two points must be considered: (1) gross sales quantity will reach saturation level and (2) all potential consumers do not buy new products immediately. Thus, the gross sales have sigmoid shape, that is S-type curve, from launch when product was emerged in market to saturation when all potential buyer bought it. Here are two well-known S-type curves: the logistic curve in eq. (2.1) and the Gompertz curve in eq. (2.2) with time-varying diffusion speed $g(t)$ and $h(t)$, where $N(t)$ is gross sales and K is a saturation level. In many cases, the above diffusion speed is assumed to be a constant: non-time-varying diffusion speed.

$$\frac{dN(t)}{dt} = g(t)N(t)\left(1 - \frac{N(t)}{K}\right), \qquad g(t)\text{: diffusion speed at time } t \tag{2.1}$$

$$\frac{dN(t)}{dt} = h(t)N(t)\big(logK - logN(t)\big), \qquad h(t)\text{: diffusion speed at time } t \tag{2.2}$$

The assumption of constant diffusion speed is related to the population growth model in biology. The intrinsic growth rate r of bacterial population growth explained in Tsoularis and Wallace(2002) has the same influence as the constant diffusion speed on the S-type diffusion curve. Bacterial population $N(t)$ at time t with intrinsic growth rate r has the exponentially increasing curve form shown in eq. (2.3). However, because an infinite increase is unreal, a generalized logistic curve of eq. (2.4) is formulated by conditioning the limitation of saturation level K. And setting the variables of α, β, and γ determines the detailed shape of the S-type curve. A logistic equation is set with $\alpha = \beta = \gamma = 1$, Richard's equation with $\alpha = \gamma = 1$, and Gompertz equation with $\gamma = 1$ after limiting of $\beta \rightarrow 0$.

$$\frac{dN(t)}{dt} = rN(t), \quad \text{with solution } N(t) = N_0 e^{rt} \tag{2.3}$$

$$\frac{dN(t)}{dt} = r \; N(t)^{\alpha} \left[1 - \left(\frac{N(t)}{K}\right)^{\beta}\right]^{\gamma} \tag{2.4}$$

Zwietering et al. (1990) states that the three deterministic factors explaining the S-type curve are maximum growth rate (μ), lag time (L), and saturation level (K) which are shown in Figure 2 and propose the modified equations from which the above three factors can be directly extracted. The maximum growth rate (μ) is the curve's largest increasing rate, which occurs at the inflection point[3]. Lag time L is the growth take-off time at which the tangential line from the inflection point and the time-axis intersect. Table 2.1 shows the differential equation form, the functional form, and the modified form by Zwietering et al. (1990) for three growth curves.

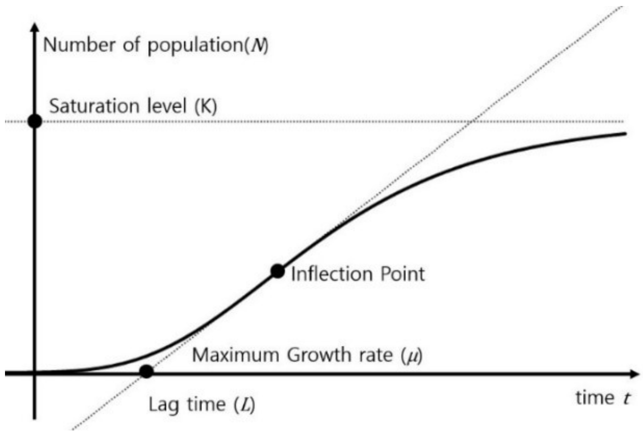

Figure 2.2 Three deterministic factors for the growth curve

Table 2.1 Equations of three S-type growth curves

Logistic Growth Curve	
Differential Eq.	$\frac{dN(t)}{dt} = rN(t)\left(1 - \frac{N(t)}{K}\right)$
Functional form	$N(t) = \frac{KN_0}{(K - N_0)\exp(-rt) + N_0}$

[3] in mathematical expression, $\frac{d^2N(t)}{dt^2} = 0$ at the inflection point.

Modified form	$N(t) = \dfrac{K}{\left\{1 + exp\left[\frac{4\mu}{K}(L-t)+2\right]\right\}}$
Gompertz Growth Curve	
Differential Eq.	$\dfrac{dN(t)}{dt} = rN\left(\ln\left(\dfrac{K}{N(t)}\right)\right)$
Functional form	$N(t) = K\ \ exp\left\{ln\left(\frac{N_0}{K}\right)exp(-rt)\right\}$
Modified form	$N(t) = K\, exp\left\{-exp\left[\frac{\mu e}{K}(L-t)+1\right]\right\}$
Richard's Growth Curve	
Differential Eq.	$\dfrac{dN(t)}{dt} = rN\left[1-\left(\dfrac{N(t)}{K}\right)^{\beta}\right]$
Functional form	$N(t) = \quad K\left\{1-\exp(-\beta t)\left[1-\left(\frac{N_0}{K}\right)^{-\beta}\right]\right\}^{-\frac{1}{\beta}}$
Modified form	$N(t) = K\ \ \left\{1+\beta\cdot exp(1+\beta)\cdot exp\left[\frac{\mu}{K}(1+\beta)^{\left(1+\frac{1}{\beta}\right)}\cdot(L-t)\right]\right\}^{\left(-1/_{\beta}\right)}$

Logistic and Gompertz curves consist of three variables, so by $K, L,$ and μ growth curves can be fitted. Logistic curves have two main characteristics: the inflection point occurs at the half level of saturation, in comparison with the Gompertz curve which makes its inflection point at 37% of the saturation level, and the other is that logistic curves are symmetrical by their inflection points (Stoneman, 1983; Tsoularis and Wallace, 2002; Gruber: 2001). Richard's curve has four variable function including β so they can fit the S-type curve in detailed shape.

2.2.2 Broadband diffusion driving factors

Many previous studies have investigated the driving factors of Internet diffusion and shows varying results.

Rai et al. (1998) argues that Internet promotion requires integrated consideration, including partnerships between the government and private enterprise, opening the Internet to commercial use, technological innovation, more ISPs, and heterogeneous adopters, and stated that the development of WWW (World Wide Web) and web browsers made the Internet easier to use in the early 1990s.

Hargittai(1999) and Kiiski and Pohjola(2002) measured the number of Internet hosts as the diffusion of Internet, and their results show that GDP per capita, education level, English proficiency, university education, Internet access cost, and monopoly status have the most significant effect on Internet diffusion.

Garcia-Murillo (2005) states that to launch the broadband service GDP per capita, competition in telecommunication market and unbundling policy are important, but after launching GDP per capita and unbundling policy have no significant effect on broadband diffusion.

Lee and Brown (2008) state that competition, broadband speed, ICT usage, content, LLU policy, etc., have significant effects, but GDP per capita has no effect.

Bouckaert et al. (2010) show that inter-platform regulation policy among telecommunications regulatory policies play a major role in Internet diffusion, and Andrés et al. (2010) argue that network externalities are the most important factor.

Ford et al. (2011) show GDP per capita, broadband price, economic inequality, percent of population over 65 years old, and wired phone subscription rate have the largest effects, and in Jakopin and Klein (2011) GDP per capita, percentage of employment in the service sector, PC penetration, and regulatory quality have the largest effects on the broadband diffusion.

Lee et al. (2011) analyze the factors affecting diffusion speed of fixed broadband subscribers on the point of regulatory policy and ascertain that LLU policy together with GDP per capita, population density, education level, and broadband prices have the most significant effects. Kyriakidou et al. (2013) analyze two periods before and after the inflection point on the S-type diffusion curve and argue that positive factors for broadband diffusion are E-government online availability, persons employed using computers connected to the Internet, population density, individual's level of Internet skills, and communication expenditure, and a negative factor is the inequality of income distribution.

Viard and Economides (2014) emphasize the available content for Internet diffusion factor among other significant factors, such as GDP per capita, available content, urban population ratio, an age ratio of 40 to 64 years, and telephone infrastructure.

Results of previous studies are summarized in Table 2.2, and in the last column of Table 2.2, the independent variables that are used in both this dissertation and previous studies are recorded.

The summary of previous studies is as follows: First, almost all studies consider income level measured by GDP per capita as an Internet diffusion factor, and except for the results by Garcia-Murillo (2005) and Lee and Brown (2008), it has been analyzed that GDP per capita has an effect on Internet diffusion.

Second, until the early 2000s, studies measure the number of Internet hosts as the proxy of broadband or Internet diffusion. However, studies after the mid-2000s measure broadband subscribers or penetration, and Garcia-Murillo (2005) and Lee and Brown (2008) measured the number of Internet hosts as the proxy of Internet content instead.

Third, studies (Garcia-Murillo, 2005; Lee and Brown, 2008; Viard and Economides, 2014) considering Internet content as an independent variable report the same result that content has the positive effect on Internet diffusion.

Fourth, studies (Hargittai, 1999; Jakopin and Klein, 2011) using English proficiency as an independent variable do not measure English proficiency itself, but treated it as the potential to read homepages in English since so many homepages have been created in English due to the Internet's development in United States.

Fifth, Andrés et al. (2010) and Bouckaert et al. (2010) use 1 year lagged broadband subscribers and penetration rate as an independent variable respectively, and these variables showed significantly positive effects. Andrés et al. (2010) also argue that the network effect measured by 1 year lagged number of subscribers is one of the most important factors.

Finally, competition status among broadband service firms or governmental competition policies including LLU, inter-platform competition, and so on had the effect on Internet diffusion (Hargittai, 1999; Garcia-Murillo, 2005; Bouckaert et al., 2010; Lee et al., 2011).

Table 2.2 Previous studies on Internet diffusion driving factors

Previous Studies	Methodology	Observations (year)	Dependent Variable	Variables related with this dissertation
Hargittai (1999)	OLS	OECD 18 countries (1998)	No. of Internet hosts	GDP per capita English proficiency
	Positive factors: GDP per capita, Human capital (education level and English proficiency) Negative factors: monopoly status			
Kiiski and Pohjola (2002)	Gompertz Curve	OECD 23 countries (1995–2000)	No. of Internet hosts	GDP per capita
	Positive factors: GDP per capita Negative factors: Access cost			
	Gompertz curve	141 countries (1995–2000)	No. of Internet hosts	GDP per capita
	Positive factors: GDP per capita, University education Negative factors: Telephone cost (proxy of Internet access cost)			
Garcia-Murillo (2005)	Logit Regression	61 to 92 countries (2001)	Broadband launched or not	GDP per capita
	Positive factors: GDP per capita, Competition, Unbundling policy			
	OLS	18 countries (2001)	No. of broadband subscribers	GDP per capita Population density No. of hosts
	Positive factors: Competition, Population density, Internet hosts (proxy of available contents), Price No effect: GDP per capita, Unbundling policy			
Lee and	OLS ANOVA	110 observations	Broadband penetration	GDP per capita Population density

Previous Studies	Methodology	Observations (year)	Dependent Variable	Variables related with this dissertation
Brown (2008)			rate	No. of hosts
	Positive factors: Competition, Broadband speed, ICT usage (measured by PC penetration ratio), Content(measured by No. of Internet host), LLU policy No effect: GDP per capita			
Bouckaert et al. (2010)	Panel OLS	20 OECD countries (2003–2008)	broadband penetration ratio	GDP Population density 1 year lagged penetration
	Positive factors: Inter-platform regulation, GDP, Population density, 1 year-lagged total penetration			
Andrés et al. (2010)	Logistic curve	214 countries (1990–2004)	Internet users	GDP per capita Lagged No. of Internet users
	Network externalities is the one of most important determinants of Internet diffusion driving factor Positive factors: GDP per capita, Lagged No. of Internet users (proxy variable to estimate network effect), No. of PC, Competition (in high-income countries)			
Ford et al. (2011)	Weighted LS SFA	30 OECD countries (2006–2007)	Broadband subscription rate	GDP per capita Population density
	Positive factors: GDP per capita, Wired Phone subscription, Education level Negative factors: broadband price, GINI index, over age 65 rate			
Jakopin and Klein (2011)	OLS	179 countries (2009)	Broadband penetration ratio	GDP per capita Urbanization English literacy
	Positive factors: GDP per capita, Service sector employment, PC penetration, Regulatory quality			
Lee et al. (2011)	Logistic curve OLS	30 OECD countries (2000–2008)	Broadband subscribers	GDP per capita Population density
	Positive factors: LLU policy, GDP per capita, Population density, Education level Negative factors: Broadband price			
Kyriakidou et al. (2013)	Non-parametric and parametric regression	26 Europe countries (2001–2009)	Broadband penetration	GDP per capita E-gov. availability Population density
	Positive factors: E-government online availability, Employments using PC, Population density			
Viard and Economides (2014)	Panel OLS GLS	207 countries (1998–2004)	Internet users	GDP per capita Urban population Liberty index Content
	Positive factors: GDP per capita, Contents, Urban population Rate, 40 to 64 age ratio Negative factors: Telephone infra. No effect: Internet price, Civil liberty index			

2.3 Methodology

2.3.1 Basic Framework

The main question of this dissertation is whether the amount of available content has an effect on the country level Internet diffusion speed. To analyze and investigate this question, empirical analysis was conducted. For the empirical analysis, after country i's fixed broadband subscribers were fitted into the appropriate S-type diffusion curve, then the maximum diffusion rate μ of each country was estimated. This μ of each country is used as a dependent variable:$speed_i$. The main explanatory independent variable is the amount of available content at the fixed broadband diffusion take-off time: $content_{i,T}$. With other independent variables eq. (2.5) gives the analysis model for each country i. Subscript T means "at diffusion take-off time".

$$speed_i = \beta \cdot content_{i,T} + \sum_j \gamma_j \cdot z_{j,T} + \varepsilon_i \tag{2.5}$$

$x_{i,T}$: Amount of available content measured at take-off time

$z_{j,T}$: other independent variables measured at take-off time

Eq. (2.6) is the regression model of this dissertation. For convenience, subscript T is omitted.

$$SPEED = CONTENT \cdot \beta + Z \cdot \gamma + \varepsilon \tag{2.6}$$

Lee et al. (2011) also use the growth rate of the logistic growth curve model[4] as a dependent variable and analyze the factors to affect broadband diffusion, and regression analysis[5] for 30 OECD countries from year of 2000 to 2008 was conducted to verify the effect of LLU regulatory policy on the broadband diffusion speed (b_{it})[6]. Two main differences between the this dissertation and Lee et al. (2011) are: (1) this dissertation analyzes all the countries in the world while Lee et al. (2011) analyzed 30 OECD countries and (2) Lee et al. (2011) fitted a diffusion curve into only the logistic model. This dissertation selected the most well-fitted curve among logistic, Gompertz, and Richard's curves.

2.3.2 S-type curve fitting and maximum diffusion rate

As Hall and Rosenberg (2010) have mentioned, diffusion speed varies across technologies and countries and each S-type curve has its own characteristics as stated in Ch. 2.1, so it is better to select the best fitted curve among different S-type curves country by country.

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4 $y_{it} = \frac{y^*_{it}}{1+exp(-a_{it}-b_{it}t)}$, where i: country, t: time, and y^*: saturation level.

5 $b_{it} = \beta_0 + \sum_{j=1}^{J} \beta^j D^j_{it} + X_{it}\beta$, D: explanatory variables, X: socio-economic characteristics.

6 $\frac{dy_{it}}{dt}\frac{1}{y_{it}} = b_{it}\frac{y^*_{it} - y_{it}}{y^*_{it}}$

S-type curve models used in previous studies were applied without any rule or criteria. Rai et al. (1998), anticipating Internet diffusion from 1981 to 1997's data, reported that the exponential growth model outperformed the logistic and Gompertz growth curve models. It is thought that because the period of 1981 to 1997 was early in the time of Internet diffusion, the exponentially increasing shape could be fitted well without the limitation of saturation. Kiiski and Pohjola (2002) used the Gompertz growth model, and Andrés et al. (2010) and Lee et al. (2011) used the logistic growth.

In this dissertation, the curve for each country's fixed broadband subscribers per 100 people is fitted into all three types of growth models explained in Table 1. The fitting performance of three models is compared by the Akaike information criterion(AIC) and the best fitted model for each country is selected.

After that, the maximum growth rate μ_i represented in Eq. (4) and Figure 2 is estimated for each country, which is the dependent variable $speed_i$

2.3.3 Explanatory variable: the amount of available content

Almost all Internet content is provided through websites represented by WWW (World Wide Web), and Internet users access websites via broadband networks and consume or use these contents. With the Internet globally connected, every user can access all the Internet content worldwide. However, as Viard and Economides (2014) explained, the content available to each Internet user is highly related to their own languages. In this dissertation, the amount of available content is measured in the view of available content considering languages, geographic locations, and other related studies' results.

In some studies (Garcia-Murillo, 2005; Lee and Brown, 2008; Viard and Economides, 2014) content is found to be the factor of broadband diffusion, which was measured by the number of Internet hosts. However, the Internet hosts contain all networked computer systems for either providing contents or not, so the number of hosts may count more than the actual content servers. In this dissertation, the number of TLD (Top Level Domain) servers is counted to measure the amount of available content, which is well matched with the amount of content because TLD servers with Internet address of URL provide Internet contents.

On the Internet, language seems to create barriers against the use of the Internet contents if accessed content is different from the languages spoken, read, or written by Internet users. However, in contrast even though contents are located geographically far away from Internet user, contents in user's own languages are available to user.

Barnett and Park (2014) using network analysis to analyze shared Internet web usage shows that countries on the Internet are grouped into seven clusters based on the language, geography, and historical circumstance and seven clusters are: (1) Chinese countries, (2) former Soviet republics, (3) Arab countries, (4) French-speaking African countries, (5) Spanish-speaking Latin American countries, (6) developed English-speaking countries, and (7) Asian countries historically tied to the United Kingdom and United States. Based on the work of Barnett and Park (2014), in this dissertation all countries are categorized into eight geographical regions[7], which are based on the World Bank's seven regional categories[8], and the number of TLD servers in the same language in each geographic region is counted as the available contents of each country. After that, the number of TLD servers in English in high income OECD countries is counted as the available content of English-speaking developed countries[9].

2.3.4 Other Independent Variables

2.3.4.1 Broadband subscribers at take-off time

The Internet has the characteristic of point-to-point communications, so the direct network effect is imposed on Internet usage. Previous studies have shown that 1 year lagged number of broadband subscribers had an effect on broadband diffusion, especially in the work of Andrés et al. (2010), who argue that network externality measured by 1 year lagged number of subscribers is one of the most important factors for Internet diffusion.

In this dissertation, the number of fixed broadband subscribers per 100 people at diffusion take-off time is used as another independent variable, and the effect of network externality is analyzed.

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7 East Asia, the Pacific, Europe and Central Asia, North America, Latin America and the Caribbean, South Asia, Middle East and North Africa, and Sub-Saharan Africa.

8 In World Bank's regional category, East Asia and the Pacific are added into one region, East Asia and Pacific.

9 These are six countries: Australia, Canada, Ireland, New Zealand, United Kingdom, and United States.

2.3.4.2 GDP per capita

As mentioned in Ch. 2.2, almost all previous studies analyzed the effect of income level measured by GDP per capita. In this dissertation, GDP per capita based on PPP in diffusion take-off year is also used as another independent variable.

2.3.4.3 Urbanization rate

A dependent variable of this dissertation is the number of “fixed” broadband subscribers per 100 people. For fixed broadband service, communication lines must be equipped for individuals or households. Thus, in countries or areas of higher population density, the deployment of fixed broadband infrastructure is easier.

In this dissertation, the urban population ratio is used as another independent variable to measure the ease of infrastructure deployment. Some researches (Garcia-Murillo, 2005; Lee and Brown, 2008; Bouckaert et al., 2010; and Ford et al., 2011) used population density, and Viard and Economides (2014) used urban population numbers.

2.3.4.4 Freedom of Press

One of the Internet's characteristics[10] mentioned by DiMaggio et al (2001) is the potential for broadcasting media, so liberal status or freedom of the press may affect Internet usage. Viard and Economides (2014) used an independent variable of liberty index. In this dissertation freedom of the press is used as another independent variable.

2.3.5 Regression Model and Variable Description

Eq. (2.7) shows the regression model. Table 2.3 summarizes the variables of this dissertation and their descriptions.

$$SPEED = \beta \cdot CONTENT + \gamma_1 \cdot FBS + \gamma_2 \cdot GDP + \gamma_3 \cdot URBAN + \gamma_4 \cdot FOP + \varepsilon \qquad (2.7)$$

Table 2.3 Variables description

Variables	Description
Dependent Variable	
SPEED	Maximum diffusion rate of fixed broadband subscription per 100 people
Independent Variables	
CONTENT	Number of available contents measured by TLD server numbers in 1,000,000 unit in diffusion take-off year
FBS	Number of fixed broadband subscribers per 100 people in diffusion take-off year
GDP	Gross domestic product, PPP in current US 10,000$ in diffusion take-off year

[10] Point to Point communication media, broadcast media, and digital media

URBAN	Number of population in urban area per 100 people in diffusion take-off year
FOP	Freedom of Press index in diffusion take-off year

2.4 Data Collection

2.4.1 Fixed Broadband Subscribers data and Growth curve fitting

Fixed broadband subscriptions per 100 people[11] provided by the World Bank were collected. This data contains the fixed broadband subscriptions of 214 countries from year of 1998 to 2014. With statistics package R, each country's subscription was fitted into the three types of growth curves, and the most outperforming and well fitted growth curve was selected by AIC. 39 countries, the data of which cannot be fitted into the S-type curve, were excluded from further analysis.

Table 2.4 shows growth curve fitting results by income level and by region. Total number of 161 is the number of countries analyzed in this dissertation with whole dataset. From Figure 2.3 to 2.8 shows the diffusion of fixed broadband subscribers per 100 people under different fixed broadband subscription diffusion characteristics.

[11] The World Bank. (2016). Fixed broadband subscriptions (per 100 people) downloaded at http://data.World Bank.org/indicator/IT.NET.BBND.P2, available at 18. Jul. 2016

Table 2.4 Growth curve fitting

	Gompertz	Logistic	Richards	total
All countries	110	36	15	161
By Income Level				
High: OECD	27	3	2	32
High: non-OECD	14	7	4	25
Upper Middle	37	6	3	46
Lower Middle	25	9	6	40
Low	7	11		18
By Region				
East Asia and the Pacific	19	6	1	26
Europe and Central Asia	35	6	6	47
North America	3			3
Latin America and Caribbean	23	5	3	31
South Asia	5	2	1	8
Middle East and North Africa	10	2	2	14
Sub-Saharan Africa	15	15	2	31

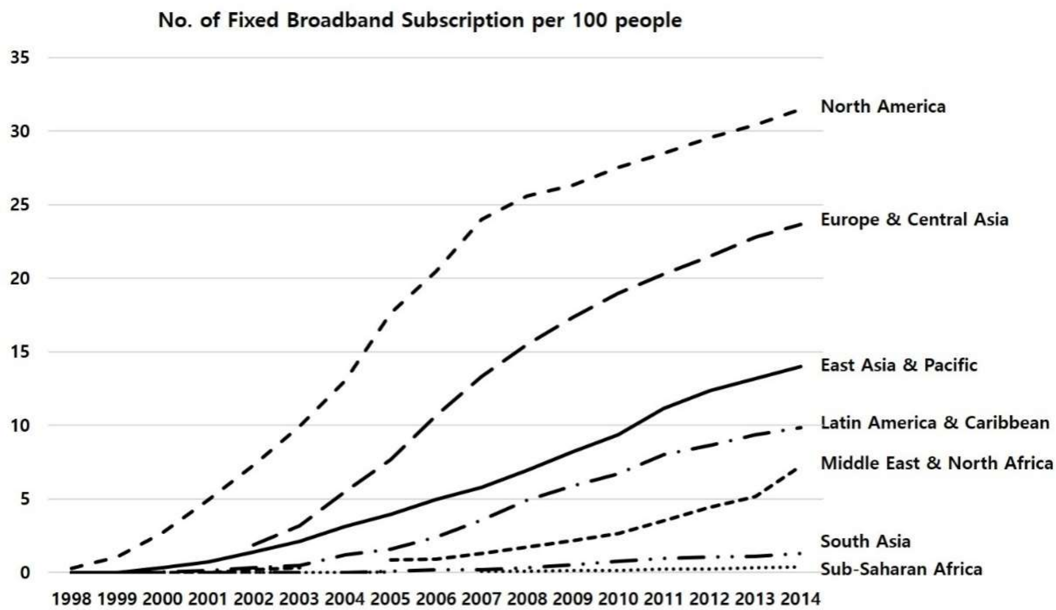

Figure 2.3 No. of Fixed Broadband Subscriptions per 100 people by Region

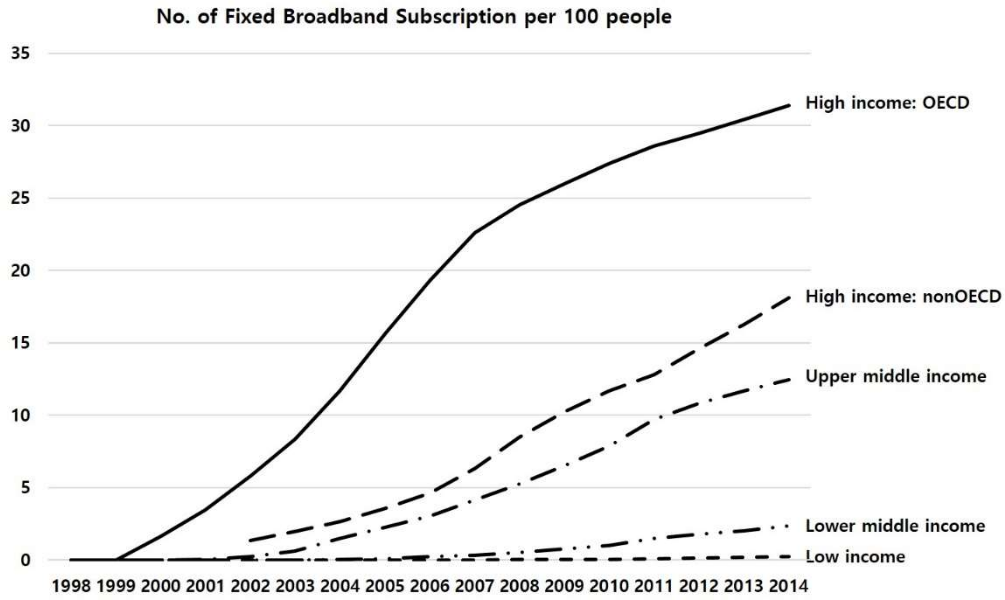

Figure 2.4 No. of Fixed Broadband Subscriptions per 100 people by Income level

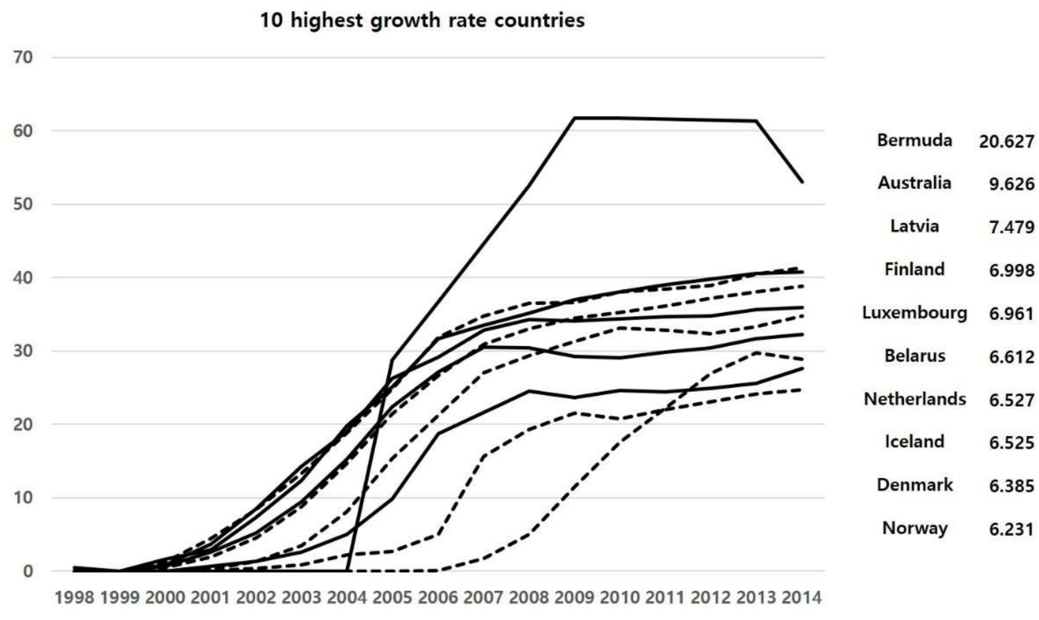

Figure 2.5 Growth Curve Fitting: Top 10 Fastest diffusion speed μ Countries

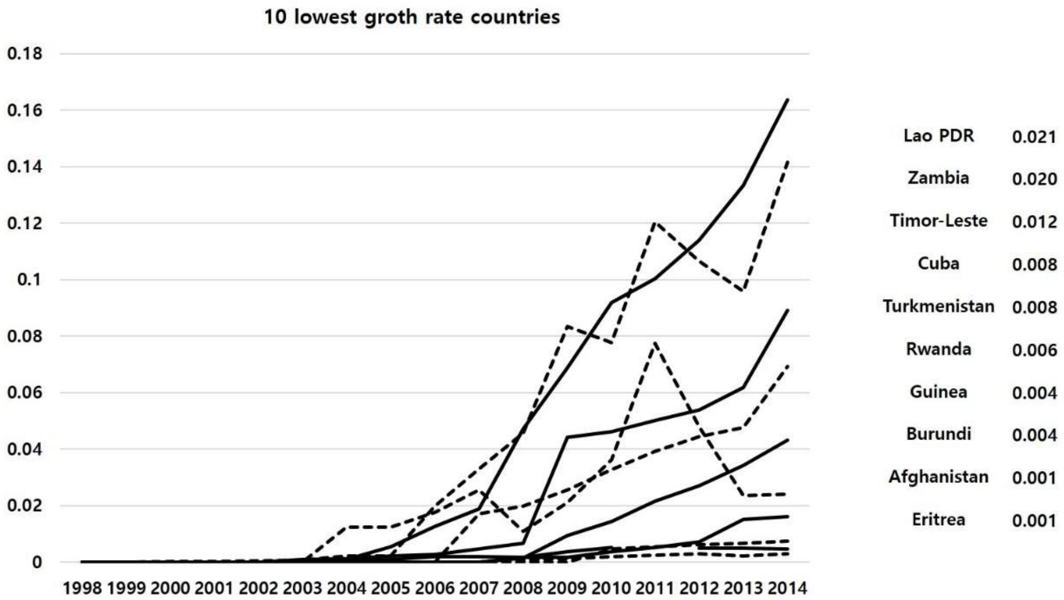

Figure 2.6 Growth Curve Fitting: Top 10 Slowest diffusion speed Countries

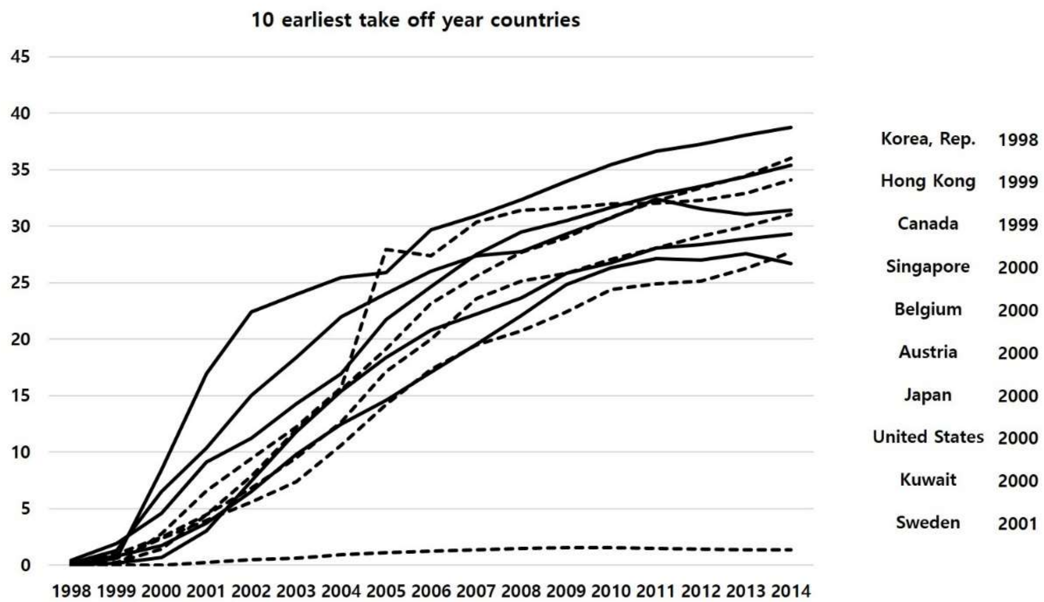

Figure 2.7 Growth Curve Fitting: Top 10 Earliest Take-off Year Countries

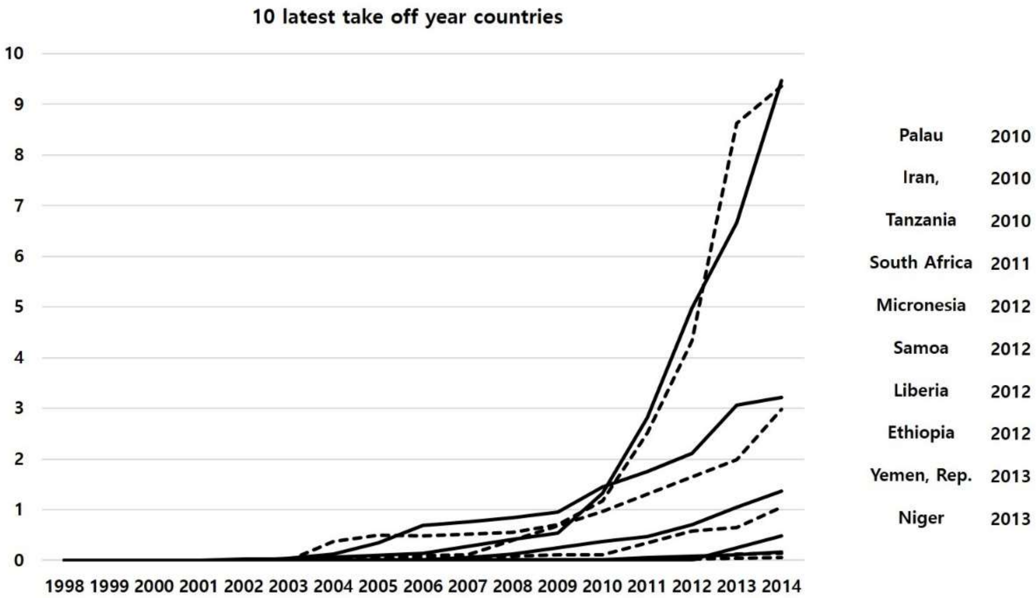

Figure 2.8 Growth Curve Fitting: Top 10 Latest Take-off Year Countries

2.4.2 GDP, URBAN, and FOP

GDP per capita based on purchasing power parity, PPP[12] is collected from the World Bank's data[13]. But 53 countries' data were not recorded so these countries are excluded from further analysis.

Urban population ratio data[14], or the percentage ratio of people living in urban areas was also collected from the World Bank.

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[12] The World Bank. (2016). GDP per Capita, PPP (current international $), downloaded at http://data.World Bank.org/indicator/NY.GDP.PCAP.PP.CD, available at 18. Jul. 2016.

[13] The World Bank. (2016). GDP per Capita, PPP (current international $), downloaded at http://data.World Bank.org/indicator/NY.GDP.PCAP.PP.CD, available at 18. Jul. 2016.

[14] The World Bank. (2016). Urban population (% of total), downloaded at http://data.World

Freedom of the press was measured by the Freedom of Press score[15], which has been reported annually by Freedomhouse. This score ranges from 0 to 100, and scores of 0 to 30 means free status of press, 31 to 60 means partly free, and 61 to 100 means not free, respectively. Freedomhouse also reports a Freedom on the Net score, but this started from 2011 with limited countries. Therefore, in this dissertation, the Freedom of Press score is used.

2.4.3 Amount of available content

The amount of available contents is measured by the following procedures.

Total number of TLD servers: The number of TLD servers reported by the Internet Systems Consortium, Inc. was collected. This data[16] has been reported biannually and contains the total number of TLD servers worldwide from year of 1995 to 2015.

Each country's TLD servers: Each country's annual number of TLD servers was counted by multiplying the total number of TLD servers by the server location ratio of country. The ratio was collected from W3techs[17] and ratio of 1. Jan. 2016 was used.

Bank.org/indicator/SP.URB.TOTL.IN.ZS, available at 18. Jul. 2016.

[15] Freedom House. (2016). FREEDOM OF THE PRESS Scores and Status 1980-2016, downloaded at https://freedomhouse.org/sites/default/files/Scores and Status 1980-2016.xlsx, available at 18. Jul. 2016.

[16] Internet Systems Consortium. (2016) ISC Domain Survey, downloaded at https://www.isc.org/network/survey/, available at 18. Jul. 2016.

[17] W3Techs. (2016). Usage of server locations for websites, downloaded at https://w3techs.com/technologies/overview/server_location/all, available at 18. Jul. 2016.

TLD servers by national language: Each country's national language was collected from the homepage of Ethnologue by Lewis et al. (2015). Out of the 161 analyzed countries, 121 countries have 1 national language, 34 have 2, 5 have 3, and South Africa has 11 national languages. The number of TLD servers by national language located in each country is calculated by dividing the number of TLD servers in a country by the number of national languages.

Shared Web usage by geographic region: Following Barnett and Park (2014), in the geographically close region contents in the TLD servers by certain language is also available by other countries Internet users who speak the same language with TLD server's language, even though users and TLD servers are not in the same country. In this dissertation all countries are grouped into eight regions, which are based on the World Bank's seven regions. The regions of East Asia and the Pacific of World Bank are grouped separately into East Asia and the Pacific region. In each of the eight regions, the total numbers of TLD servers of the same language are summed up respectively. For each country, the amount of available content is the number of TLD servers in its region by its national languages. So annual summing the total number of TLD servers by national languages within a region is the country's number of available contents in a certain year.

For highly developed English-speaking countries: The numbers of TLD servers calculated by the above procedures in six English-speaking OECD countries are summed because these countries have a strong shared web usage trend.

2.4.4 Basic Statistics

2.4.4.1 Basic Statistics of Whole Dataset

Table 2.5 Basic statistics of whole dataset (number of observations = 161)

Variable	Mean	Std. Dev.	Min	Max
SPEED	2.128	2.501	0.001	20.627
CONTENT	7.166	27.985	0.000	289.213
FBS	1.114	1.299	0.000	6.604
GDP	1.440	1.538	0.069	9.424
URBAN	56.221	23.447	9.735	100.000
FOP	43.646	24.173	8.000	96.000
YEAR	2005.242	3.132	1998.000	2013.000

2.4.4.2 Pearson's Correlations between variables

Table 2.6 Pearson′s correlations between variables

	CONTENT	FBS	GDP	URBAN	FOP
CONTENT	1				
FBS	0.067	1			
GDP	***0.281	***0.432	1		
URBAN	***0.236	***0.512	***0.621	1	
FOP	**-0.170	***-0.395	**-0.165	***-0.248	1

2.4.4.3 Basic Statistics by Income Level

Table 2.7 Basic statistics by income level

Variable	Mean	Std. Dev.	Min	Max
Income Level: HIGH (Number of observation = 57)				

Variable	Mean	Std. Dev.	Min	Max
SPEED	4.199	2.899	0.124	20.627
CONTENT	16.325	45.549	0.019	289.213
FBS	2.148	1.533	0.000	6.604
GDP	2.935	1.687	1.054	9.424
URBAN	74.322	19.400	9.735	100.000
FOP	29.491	22.779	8.000	90.000
YEAR	2002.632	2.304	1998.000	2010.000
Income Level: Upper Middle (Number of observation = 46)				
SPEED	1.647	1.254	0.008	6.612
CONTENT	3.034	5.413	0.000	26.540
FBS	0.857	0.657	0.000	2.293
GDP	1.005	0.405	0.416	2.675
URBAN	58.174	15.097	23.098	83.358
FOP	48.239	24.362	11.000	96.000
YEAR	2005.674	2.232	2001.000	2011.000
Income Level: Lower Middle (Number of observation = 40)				
SPEED	0.648	1.039	0.012	5.720
CONTENT	2.049	2.716	0.000	11.137
FBS	0.425	0.609	0.000	2.541
GDP	0.401	0.191	0.133	0.790
URBAN	41.802	16.824	13.073	76.853
FOP	52.200	18.187	21.000	83.000
YEAR	2007.025	2.370	2002.000	2013.000
Income Level: Low (Number of observation = 18)				
SPEED	0.089	0.141	0.001	0.493
CONTENT	0.095	0.168	0.000	0.553
FBS	0.027	0.053	0.000	0.224
GDP	0.128	0.045	0.069	0.219
URBAN	25.956	10.667	10.641	48.541
FOP	57.722	18.692	24.000	94.000
YEAR	2008.444	2.662	2004.000	2013.000

2.4.4.4 Basic statistics by 7 Regions

Table 2.8 Basic statistics by 7 Regions

Variable	Mean	Std. Dev.	Min	Max
East Asia & Pacific (Number of observation = 26)				
SPEED	2.036	2.394	0.012	9.626
CONTENT	18.727	58.501	0.000	289.213
FBS	1.007	1.235	0.000	5.005
GDP	1.378	1.546	0.133	6.322
URBAN	53.108	29.172	13.073	100.000
FOP	44.385	23.128	10.000	82.000
YEAR	2004.846	3.684	1998.000	2012.000
Europe & Central Asia (Number of observation = 47)				
SPEED	3.827	1.823	0.008	7.479
CONTENT	7.956	19.383	0.000	101.539
FBS	2.005	1.435	0.000	6.604
GDP	1.924	1.174	0.165	6.093
URBAN	66.417	14.474	26.450	97.128
FOP	33.340	24.736	8.000	96.000
YEAR	2003.809	2.473	2000.000	2009.000
North America (Number of observation = 3)				
SPEED	9.265	9.840	3.514	20.627
CONTENT	66.459	50.537	28.798	123.893
FBS	1.466	1.301	0.000	2.484
GDP	3.731	1.012	2.766	4.784
URBAN	86.053	12.078	79.057	100.000
FOP	15.667	2.082	14.000	18.000
YEAR	2001.000	2.646	1999.000	2004.000
Latin America & Caribbean (Number of observation = 31)				
SPEED	1.502	1.151	0.008	5.165
CONTENT	1.957	1.748	0.002	6.020
FBS	1.005	1.031	0.000	4.943
GDP	1.042	0.641	0.338	3.339
URBAN	58.596	21.406	9.735	94.112
FOP	36.290	20.029	11.000	96.000
YEAR	2004.839	2.238	2001.000	2010.000
South Asia (Number of observation = 8)				

Variable	Mean	Std. Dev.	Min	Max
SPEED	0.715	0.842	0.001	2.560
CONTENT	1.343	1.865	0.002	3.993
FBS	0.338	0.412	0.001	1.326
GDP	0.595	0.509	0.104	1.716
URBAN	32.476	16.953	16.822	70.626
FOP	64.000	15.390	35.000	91.000
YEAR	2007.250	2.188	2004.000	2010.000
Middle East & North Africa (Number of observation = 14)				
SPEED	1.450	1.419	0.263	5.261
CONTENT	0.796	0.472	0.195	2.084
FBS	0.769	1.018	0.000	4.062
GDP	3.008	3.049	0.379	9.424
URBAN	72.937	19.405	33.450	98.113
FOP	66.500	15.975	30.000	94.000
YEAR	2005.071	3.245	2000.000	2013.000
Sub-Saharan Africa (Number of observation = 32)				
SPEED	0.295	0.559	0.001	2.426
CONTENT	0.342	0.698	0.000	3.884
FBS	0.307	0.831	0.000	3.919
GDP	0.476	0.731	0.069	3.639
URBAN	37.303	16.308	10.641	76.853
FOP	52.844	20.151	24.000	94.000
YEAR	2008.031	2.362	2004.000	2013.000

2.5 Analysis Result

To analyze the factors that affect the maximum growth speed of fixed broadband diffusion, regression analysis–robust regression analysis to loosen the impact of outliers and heteroscedasticity – has been conducted, and the result is summarized in Table 2.9. Table 2.9 shows that all the explanatory variables including both CONTENT and other four independent variables have positive and statistically significant effects on the speed of fixed broadband diffusion.

However, some countries among the 161 analyzed countries did not reach a saturation state, so their growth curves do not have completed S-type curves. So, for the 122 countries, diffusion status of which reach in the saturation stage, another regression analysis has been conducted and the results are shown in Table 2.10. The main difference from Table 2.9 is that FBS which is the critical mass of network externalities at take-off time and GDP which represent the economic and developed state of each country do not have statistically significant effects.

From the above two results, it can be inferred that the amount of available content has an effect on the broadband diffusion speed, which is the main finding of this dissertation. Secondly, critical mass and economic state are important factors for fast broadband diffusion, but in the countries of which diffusion status is after saturation these are not. Finally, the country's liberal state represented by Freedom of Press has a statistically significant effect on the broadband diffusion speed.

The other variable, URBAN, also has a positive effect on the broadband diffusion speed. However, it is an explicit result because this dissertation analyzes “fixed” broadband diffusion speed so the ease of deploying fixed broadband infrastructure measured by the URBAN variable has the positive effect on broadband diffusion.

From the difference of the above two analyses, another four additional analyses were conducted to compare the different effect of variables in “broadband more diffused countries” versus “broadband less diffused countries”. The results are explained from section 2.5.1 to 2.5.5.

2.5.1 Comparison by income level

It would be reasonable to assume that higher income countries have more broadband subscribers and faster broadband diffusion speed. Table 2.11 shows the result for each of the above middle income countries including the high income and upper middle income countries by World Bank category and the below middle income countries including lower middle income and low income.

For both groups, the URBAN variable has a positive effect. But CONTENT and FOP have the positive effect for the above middle income groups and FBS has the positive effect for the below middle-income groups.

2.5.2 Comparison by diffusion take-off time

Table 2.12 shows the difference between early diffusion take-off countries and late take-off countries. The separation between early and late is year of 2005 which is the median value of take-off year in all 161 analyzed countries and also mean value of 2005.242.

For early take-off countries group CONTENT, URBAN, and FOP variables have the effect on diffusion speed and this is the same for the above middle income countries discussed in section 2. 5.1. For late take-off countries group only FBS has a positive effect.

2.5.3 Comparison by the number of fixed broadband subscribers

More subscribers may represent more diffused countries. By aggregated level of 10.558 subscribers per 100 people in year of 2014, 161 countries are separated into two groups: larger number of subscribers and smaller number of subscribers. Table 2.13 shows the result.

The URBAN variable has an effect on both groups. But the CONTENT variable affects the diffusion speed in the larger subscribers group and FBS affects in the smaller group.

2.5.4 Comparison by the diffusion speed

The countries with faster diffusion are those with more fixed broadband diffusion. By the aggregated level estimated diffusion speed of 0.994, 161 countries are separated into two group: the faster diffusion group and the slower diffusion group. The analysis result shown in Table 14 is the same with section 2. 5.1 by income level.

2.5.5 Highlights of comparisons

Table 2.15 shows the analysis results from section 2. 5.1 to 2. 5.4. In all four cases based on the income level, take-off time, number of subscribers, and diffusion speed, the CONTENT variable has positive and statistically significant effect on the “fixed broadband More Diffused countries”; however, FBS had an effect on the “fixed broadband Less Diffused countries”. This means that (1) in the “fixed broadband Less Diffused countries” where fixed broadband service starts to launch or diffusion is on the early progress FBS, the critical mass for network externalities, has the main role on the diffusion speed and (2) however, in the “fixed broadband More Diffused countries”, where broadband infrastructures are well equipped and many subscribers have the benefits from broadband Internet, CONTENT, the abundance of available content distributed and shared over the Internet, plays the main role.

Table 2.9 Robust OLS results for all 161 countries

Model 1				
Variable	**Coef.**	**S.E**	**t-value**	**Pr > |t|**
CONTENT	0.045***	0.017	2.61	0.010
Const.	1.804***	0.159	11.33	0.000
Model	**OBS**	**F(1, 159)**	**Pr>F**	**R-sq**
specification	161	6.8	0.010	0.257

Model 2				
Variable	**Coef.**	**S.E**	**t-value**	**Pr > |t|**
CONTENT	0.028*	0.016	1.76	0.080
FBS	0.486*	0.277	1.75	0.081
GDP	0.274*	0.155	1.76	0.080
URBAN	0.020***	0.008	2.62	0.010
FOP	-0.021***	0.006	-3.23	0.002
Const.	0.762**	0.349	2.18	0.031
Model	**OBS**	**F(5, 155)**	**Pr>F**	**R-sq**
specification	161	70.36	0.000	0.585

Table 2.10 Robust OLS results for 122 countries on the diffusion saturated stage

Model 1				
Variable	**Coef.**	**S.E**	**t-value**	**Pr > |t|**
CONTENT	0.043**	0.017	2.53	0.013
Const.	2.213***	0.192	11.53	0.000
Model	**OBS**	**F(1, 159)**	**Pr>F**	**R-sq**
specification	122	6.39	0.013	0.258

Model 2				
Variable	**Coef.**	**S.E**	**t-value**	**Pr > |t|**
CONTENT	0.027*	0.016	1.73	0.087
FBS	0.434	0.321	1.35	0.18
GDP	0.246	0.193	1.27	0.206
URBAN	0.026***	0.01	2.64	0.01
FOP	-0.021***	0.008	-2.72	0.008
Const.	0.771*	0.437	1.76	0.08
Model	**OBS**	**F(5, 116)**	**Pr>F**	**R-sq**
specification	122	59.79	0.000	0.572

Table 2.11 Robust OLS results by income level

Above Middle (High and Upper Middle income countries)				
Variable	**Coef.**	**S.E**	**t-value**	**Pr > |t|**
CONTENT	0.028*	0.015	1.85	0.067
FBS	0.327	0.303	1.08	0.284
GDP	0.22	0.154	1.43	0.156
URBAN	0.022*	0.012	1.81	0.074
FOP	-0.028***	0.009	-3.00	0.003
Const.	1.350**	0.541	2.5	0.014
Model specification	**OBS**	**F(5, 97)**	**Pr>F**	**R-sq**
	103	22.73	0.000	0.479
Below Middle (Lower Middle and Low income countries)				
Variable	**Coef.**	**S.E**	**t-value**	**Pr > |t|**
CONTENT	-0.005	0.037	-0.12	0.902
FBS	1.380***	0.417	3.31	0.002
GDP	-0.073	0.289	-0.25	0.803
URBAN	0.004**	0.001	2.65	0.011
FOP	0.003	0.002	1.36	0.179
Const.	-0.198**	0.102	-1.94	0.058
Model specification	**OBS**	**F(5, 52)**	**Pr>F**	**R-sq**
	58	9.80	0	0.528

Table 2.12 Robust OLS results by take-off year

Countries with take-off before 2005				
Variable	**Coef.**	**S.E**	**t-value**	**Pr > |t|**
CONTENT	0.027*	0.015	1.75	0.085
FBS	0.316	0.377	0.84	0.403
GDP	0.27	0.166	1.62	0.108
URBAN	0.025*	0.014	1.78	0.078
FOP	-0.037***	0.010	-3.65	0.000
Const.	1.357**	0.532	2.55	0.013
Model specification	**OBS**	**F(5, 83)**	**Pr>F**	**R-sq**
	89	37.34	0.000	0.555

Countries with take-off after 2005				
Variable	**Coef.**	**S.E**	**t-value**	**Pr > |t|**
CONTENT	0.068	0.053	1.26	0.211
FBS	0.821***	0.170	4.82	0
GDP	0.016	0.174	0.09	0.926
URBAN	0.007	0.006	1.18	0.242
FOP	0.005	0.006	0.81	0.419
Const.	-0.304	0.45	-0.68	0.502
Model specification	**OBS**	**F(5, 66)**	**Pr>F**	**R-sq**
	72	14.51	0.000	0.570

Table 2.13 Robust OLS results by present number of subscribers per 100 people

Larger than World level (10.558)				
Variable	**Coef.**	**S.E**	**t-value**	**Pr > |t|**
CONTENT	0.026**	0.013	2.05	0.045
FBS	-0.005	0.357	-0.02	0.988
GDP	0.327	0.333	0.98	0.328
URBAN	0.026**	0.015	1.81	0.074
FOP	-0.016	0.011	-1.46	0.149
Const.	1.720**	0.686	2.51	0.015
Model specification	**OBS**	**F(5, 65)**	**Pr>F**	**R-sq**
	71	7.06	0.000	0.392
Smaller than World level (10.558)				
Variable	**Coef.**	**S.E**	**t-value**	**Pr > |t|**
CONTENT	0.009	0.022	0.4	0.688
FBS	0.878***	0.120	7.33	0.000
GDP	0.036	0.059	0.6	0.549
URBAN	0.007***	0.003	2.75	0.007
FOP	0.001	0.002	0.41	0.685
Const.	-0.166	0.135	-1.23	0.224
Model specification	**OBS**	**F(5, 84)**	**Pr>F**	**R-sq**
	90	25.42	0.000	0.698

Table 2.14 Robust OLS results by Diffusion speed

Faster than World level (0.944)				
Variable	**Coef.**	**S.E**	**t-value**	**Pr > |t|**
CONTENT	0.027*	0.014	1.94	0.056
FBS	0.155	0.315	0.49	0.625
GDP	0.272	0.212	1.28	0.203
URBAN	0.023*	0.012	1.89	0.062
FOP	-0.023**	0.009	-2.5	0.014
Const.	1.638***	0.525	3.12	0.002
Model specification	**OBS**	**F(5, 86)**	**Pr>F**	**R-sq**
	92	12.51	0.000	0.429

Slower than World level (0.944)				
Variable	**Coef.**	**S.E**	**t-value**	**Pr > |t|**
CONTENT	0.004	0.012	0.31	0.76
FBS	0.551***	0.110	5.00	0.000
GDP	-0.012	0.013	-0.87	0.386
URBAN	0.003***	0.001	2.68	0.009
FOP	0.000	0.002	-0.08	0.939
Const.	0.045	0.105	0.43	0.668
Model specification	**OBS**	**F(5, 63)**	**Pr>F**	**R-sq**
	69	20.06	0.000	0.529

Table 2.15 Statistically significant variables in each analysis

fixed broadband More Diffused countries	**fixed broadband Less Diffused countries**
By Income level	
Above Middle-Income countries	**Below Middle-Income countries**
CONTENT*	CONTENT
FBS	**FBS*** **
GDP	GDP
URBAN*	**URBAN****
FOP***	FOP
By take-off year	
Early Take-off countries; before 2005	**Late Take-off countries; after 2005**
CONTENT*	CONTENT
FBS	**FBS*****
GDP	GDP
URBAN	URBAN
FOP***	FOP
By Subscribers in 2014	
More Subscribers than World level countries	**Less Subscribers than World level countries**
CONTENT**	CONTENT
FBS	**FBS*****
GDP**	GDP
URBAN**	**URBAN*****
FOP	FOP
By Diffusion Speed	
Faster Diffusion than World level countries	**Slower Diffusion than World level countries**
CONTENT*	CONTENT
FBS	**FBS*****
GDP	GDP
URBAN*	**URBAN*****
FOP**	FOP

2.6 Chapter Conclusion

Many previous studies analyzing the factors affecting Internet diffusion show that there are various Internet diffusion factors with respect to economic development, social aspects, demographics, regulatory policy, and so on. However, distinct gaps of Internet usage and diffusion status by countries' development status exist in the real world.

This dissertation began with the question "What makes Internet diffusion faster?" for developing or less developed countries to catch up with the usage and diffusion of the Internet in developed countries and assumed that the amount of contents would be another important Internet diffusion factor.

Therefore, the research hypothesis of this dissertation is that the various and abundant amount of content affects the Internet diffusion speed. The results of empirical analysis shows that the above hypothesis is correct, which is the main finding of this dissertation.

Another meaningful finding of this dissertation is that the factors affecting broadband diffusion speed vary according to the diffusion stages. At the early stage of diffusion, the number of subscribers at take-off time is important for faster broadband diffusion. However, in the matured or saturated stages the amount of available content at take-off time is important.

Interesting result is that the amount of contents at take-off time has an effect on the diffusion speed in the matured stage. This can be explained as follows: unlike other industrial goods, Internet content does not disappear but remains in the servers or storage after any usage of it, such as searching, accessing, reading, writing, downloading, sharing, feedback, and so on. So as time goes on, contents are accumulated and the number of contents becomes larger. Thus, more available contents at take-off time is equivalent with more contents both after take-off and in the saturation stage throughout all the diffusion stages.

Two policy implications are inferred from the above results. One is for the broadband less diffused countries and the other is for more diffused countries. For less diffused countries with less equipped broadband infrastructures and smaller numbers of broadband subscribers, policies are needed to promote the gathering of more subscribers for early take-off and fast diffusion. However, with the anticipation of fast diffusion after take-off, during the progress of diffusion, and finally in the saturation stage, it is necessary to implement policies to promote various and abundant Internet content from the early stage of diffusion.

The policies of broadband more diffused countries should include preparation for the future Internet: fast diffusion of different types of service and content from traditional Internet such as IoT (Internet of Things) or VR (Virtual Reality). Based on well-equipped broadband Internet infrastructures, the diffusion of these new services or contents will follow also an S-type diffusion curve. So gathering more users is important in the early diffusion period and promoting various and abundant available content immediately from its launching is also important for the fast diffusion after take-off period. This should be taken into account for both governmental policies and related firm’s business strategies.

This dissertation has two limitations. One is that no weight is given in measuring the number of TLD servers by national languages. In countries of more than one national language, the numbers of users of each national language are not evenly distributed, so if the language users' weight were applied, more precise counting would be obtained. But to the author's best knowledge, the ratio of national language users has not been reported.

Other limitation related to TLD servers is that the number of TLD servers is not able to reflect the content genre provided by each TLD server. If the genre of available contents can be categorized, e.g. information, news, search, multimedia, communication, and so on, and the effect of each content genre can be analyzed, the result of this dissertation would be greater and have more meaningful implications.

Another limitation is that this dissertation's analysis and results are obtained from "fixed" broadband related data. Nowadays mobile broadband Internet usage with smart phones are very popular, and in the developing countries, mobile Internet usage rate is greater than fixed Internet usage rate. It seems that Internet related concerns should also involve mobile Internet usage. However, some realistic limitations for the analysis of mobile Internet usage also exist. Mobile Internet usage diffused rapidly after the emergence of the smartphone, so sufficient data cannot be gathered. Another limitation is that separation of mobile Internet usage from mobile phone usage is very difficult because mobile phone subscribers use both voice calling and Internet connection. Nonetheless, the result of this dissertation seems to reflect mobile or overall Internet usage status, because of strong correlations between fixed broadband and overall Internet usage shown in Table 2.16 by world level and Table 2.x in low and lower middle income countries.

Table 2.16 Correlation of fixed broadband subscribers and Internet usage (World level)

	Fixed Broadband Subscribers		Internet User	
	Estimated Maximum Growth Rate	Estimated Saturation Level	Estimated Maximum Growth Rate	Estimated Saturation Level
Fixed Broadband Subscribers				
Estimated Maximum Growth Rate	-			
Estimated Saturation Level	0.432 (***)	-		
Internet Users				
Estimated Maximum Growth Rate	0.195 (**)	0.539 (***)	-	
Estimated Saturation Level	0.343 (***)	0.714 (***)	0.320 (***)	-

*** and ** denote statistically significant at significance 1% and 5% level
Number of observations: 146
(The countries whose estimated saturation level of Internet users exceed 100 are excluded)

Table 2.17 Correlation of fixed broadband subscribers and Internet usage (low and lower middle income countries)

	Fixed Broadband Subscribers		Internet User	
	Estimated Maximum	Estimated Saturation	Estimated Maximum	Estimated Saturation

	Growth Rate	Level	Growth Rate	Level
Fixed Broadband Subscribers				
Estimated Maximum Growth Rate	-			
Estimated Saturation Level	0.918 (***)	-		
Internet Users				
Estimated Maximum Growth Rate	0.607 (**)	0.585(***)	-	
Estimated Saturation Level	0.466 (***)	0.559 (***)	0.697 (***)	-

*** and ** denote statistically significant at significance 1% and 5% level
Number of observations: 48
(The countries whose estimated saturation level of Internet users exceed 100 are excluded)

Chapter 3. Efficiency comparison of digital content providers with different pricing strategies

3.1 Introduction

The price of a product is proportional to the cost of production. According to traditional economic theories, businesses pursue profit maximization, where the price of a product is proportional to marginal cost rather than fixed cost. However, the price of digital content products, unlike traditional products, is uniquely determined. A myriad of digital content, such as information available through search engine services and Internet newspaper articles, are offered free over the Internet.

As stated in a number of literatures, including Shapiro and Varian (1999), unlike traditional products, digital content can be offered free because the marginal cost required for additional production is close to zero. Yet, although the marginal cost for digital content is almost zero, a lot of fixed cost is incurred during early production. As shown in the studies of Shapiro and Varian (1999) and Lee et al. (2006), fixed cost is reflected in the price of a product, which deviates from the traditional economic theory.

Nevertheless, another reason that digital content can be offered free is due to advertising sales. Because content providers place advertisements on the homepage that offers digital content and are thus able to gain sales from advertisers, they can offer digital content at a price lower than the actual price or for free. Gallaugher et al. (2001) and Fan et al. (2007) explain that as traditional newspapers or media firms transform their business strategy to that of the Internet, homepage advertisements become a new revenue stream, thus allowing content to be offered free. In another study, Parker and Van Alstyne (2005) showed that information goods traded in a two-sided market can also be offered at a reduced price or free to the users.

Evans (2008) describes three innovative changes of online advertising that makes it distinct from traditional advertising: 1) the placement of targeted ads through collection of user information, 2) the creation of effective market parameters for advertising deals, and 3) the emergence of specialized advertising platform firms, such as Google and advertising.com. Furthermore, Lin et al. (2012) assert that the influence of advertising on Internet content providers is a critical factor in the success of online business. Since free digital content is offered at a lower price than that of the competitors, it is a strategy that can beat the competition. In addition, when a lot of consumers are secured through this strategy, advertising revenue also increases.

Online advertisement has been in the non-regulated area as Internet contents and services have been. Traditional advertisement via traditional media such as broadcast, cable TV, and press has been regulated very tightly; advertising content, time, and so on. However, non-regulated status of Internet contents have made online advertisement very free with very loose post ante regulation on adult material, medical related material, and so on.

However, despite such advantages, digital content firms in reality use various strategies, such as the advertising sales-based strategy, freemium strategy, and membership fee-based strategy. For example, in 2015, among Google's total sales of $74,989M, $67,390M was from advertising sales, constituting 89.9% of the total sales; among Facebook's sales of $17,928M, $17,079M was from advertising sales, constituting 95.3% of the total sales. On the other hand, Netflix's sales reached $613.4M solely from membership fees. According to Korea Mobile Internet Business Association (2015), the sales structure of the entire mobile content firms in Korea is as follows: paid-for sales of $2,068M (40.0%), advertising sales of $1,025M (19.8%), and in-app purchase sales of $2,079M (40.2%).

Table 3.1 Revenue structure of the mobile content firms in Korea

category	paid contents		advertisement		In-app purchase		total
	revenue	ratio	revenue	ratio	revenue	ratio	revenue
game	6,275	22.1%	5,753	20.3%	16,312	57.6%	28,340
multimedia	5,471	58.7%	3,113	33.4%	736	7.9%	9,320
communication	2,070	55.2%	424	11.3%	1,256	33.5%	3,750
e-book	4,061	85.5%	247	5.2%	442	9.3%	4,750
life style	3,325	40.3%	817	9.9%	4,109	49.8%	8,251
productivity	1,863	55.6%	821	24.5%	667	19.9%	3,351
e-learning	1,502	48.7%	537	17.4%	1,046	33.9%	3,085
etc	243	20.1%	587	48.5%	380	31.4%	1,210
total	24,810	40.0%	12,299	19.8%	24,948	40.2%	62,057

(unit: ten million KRW / year of 2015)

Such differing views regarding the optimal pricing strategy of digital content firms can be seen in existing studies. Fan et al. (2007) propose for media firms offering content over the Internet that paid-for sales is appropriate when the product quality is high and the user's network cost is low, whereas free strategy based on advertisement is suitable when the user's network cost is high. In another study, Prasad et al. (2003) suggest different optimal strategies for content firms depending on the context: pure pay-per-view strategy for high-income users, who are willing to pay the advertising avoidance fee, and free strategy based on advertisement for high advertising sales with low-quality content. Lin et al. (2012) assert that a mixed strategy of paid and free content is most favorable for content firms in a monopoly position, and in a duopoly state, only one firm is able to employ the mixed strategy.

As mentioned above, information product has different production scheme with industrial goods: high production cost but very low reproduction or distribution cost. However, this dissertation compare the efficiency of online digital content firms not by production but by sales or earning profit strategies with or without advertisement revenue. Researches expressed in above paragraph result from methodologies based on economics without empirical analysis. And other empirical analysis compare efficiency of online firms of digital product and physical product (Barua et al., 2004), efficiency between e-tailer and non e-tailer firms (Serrano-Cinca et al., 2005), and efficiency of different digital content firms group separated by production, distributors, and software provision (Choi & Oh, 2009), but there is none of research result to compare the efficiency of different sales or pricing strategies to my best knowledge.

To do this, this dissertation categorizes Korea's digital content firms into three groups based on the pricing strategy ('fee' group that offers content at a certain price, 'free' group that offers content for free, and 'mix' group that offers both paid and free content) and uses the stochastic frontier analysis (SFA) method to estimate the efficiency of each group. Although the SFA method provides the efficiency value within each group, it is unable to compare the efficiencies across different groups. Thus, the meta-frontier analysis (MFA) method is used to compare the efficiencies across different groups. In addition, Tobit regression is used to analyze whether the differences in the efficiency levels between groups are statistically significant. This dissertation provides implications regarding the optimal pricing strategy for digital content firms.

3.2 Methodology

To measure the efficiency value of online content firms with different pricing strategies, this dissertation first applies the SFA method to obtain the efficiencies of the three groups. Then the suggested MFA method is used to compare the efficiencies of the three groups of firms that engage in production activities under a different production function.

3.2.1 SFA (Stochastic Frontier Analysis)

SFA indicates the relationship between input and output with a production function. It uses the frontier production function, the maximum output from a given input, to estimate the technical efficiency. Technical efficiency (TE) of a firm refers to how the technology level of a given firm stands relative to the technical efficiency standard represented in the form of a frontier production function. Here, as the distance between a firm's technology level and the frontier production function increases, the given firm's efficiency level decreases.

To reflect the change in efficiency over time, the following eq. (3.1) based on the SFA model suggested by Battese and Coelli (1995) is used to estimate efficiency:

$$Y_{it} = f(x_{it}, \beta)e^{V_{it}-U_{it}}, \qquad i = 1,2,\dots,N, \qquad t = 1,2,\dots,T \tag{3.1}$$

where Y_{it} is the output of firm i in period t; x_{it} is an input vector of firm i in period t; $f(\cdot)$ is the production function; β is the parameter of the production function; V_{it} is independent from U_{it} and is a random error that follows a distribution of $N(0, \sigma_v^2)$; U_{it} is a non-negative random variable that represents the technical efficiency of firm i in period t. If V_{it} is a typical random error of a regression, U_{it} is the firm's inefficiency. To denote a fixed inefficiency, U_{it} is not negative, and it is assumed in the present paper that U_{it} follows a half-normal distribution.

From eq. (3.1), the technical efficiency of firm i in period t, TE_{it}, is given as follows:

$$TE_{it} = e^{-U_{it}} = \frac{Y_{it}}{f(X_{it}, \beta)e^{V_{it}}}, \qquad i = 1, 2, \dots, N, \qquad t = 1, 2, \dots, T \tag{3.2}$$

Generally, the Cobb-Douglas function or the translog function is most widely used as the production function of SFA. However, the Cobb-Douglas function has the tendency of oversimplification, as it considers output variables only as a log-linear combination of input variables. Therefore, the translog function, more specifically the random effects time-varying production model, is used in this dissertation. When assuming the use of the translog production function, eq. (3.1) can be expressed as eq. (3.3) shown below:

$$lnY_{it} = \beta_0 + \sum_{m=1}^{3} \beta_m lnx_{mit} + \sum_{m=1}^{3} \sum_{k\geq m}^{3} \beta_{mk} lnx_{mit} lnx_{kit} + V_{it} - U_{it} \tag{3.3}$$

where x_{1i} is the amount of capital (K) of an i_{th} firm in period t; x_{2it} is the amount of cost (M) of an ith firm in period t; and x_{3it} is the number of employees of an ith firm in period t that received a salary (L). This dissertation uses total asset as K, the cost of revenue as M, and the number of employees as L. Furthermore, the net sales value is used as output Y.

3.2.2 Meta-Frontier Analysis

The traditional SFA is unable to compare the technical efficiencies across different groups of firms with different technologies. Consequently, the meta-frontier production function that encompasses the production functions of the different groups is used (Battese & Rao, 2002). Initially, the meta-frontier analysis was largely applied to the agricultural sector. However, as of 2016, it has been applied to various areas, such as telecommunications, broadcasting, online content, as well as the information technology (IT) industry (e.g. see Hong et al. (2011), Yang et al. (2013), Lee et al. (2015), Kim et al. (2016), Lee et al. (2016)). The meta-frontier production function model proposed by Battese et al. (2004) is defined as follows:

$$
\begin{gathered}
Y_{it}^{*} = f(x_{it}, \beta^{*}) = e^{x_{it}\beta^{*}}, \\
i = 1,2,\dots,N, \qquad N = \sum_{i=1}^{R} N_j, \qquad t = 1,2,\dots,T, \\
s.t. \quad x_{it}\beta^{*} \geq x_{it}\beta_{(j)} \quad for \ \ all \ \ j = 1,2,\dots,T
\end{gathered}
\tag{3.4}
$$

where j denotes each group, and the different pricing groups are represented as follows: firm that offers paid content $(j = 1)$, firm that offers free content $(j = 2)$, and firm that offers both paid and free content $(j = 3)$. β^{*} is the unknown vector variable of the meta-frontier function that satisfies the eq. (3.4). From eq. (3.4), the meta-frontier production function graph is always located above each group's production frontier function graph during all periods. That is, the meta-frontier production function envelopes the frontier function of each group with identical technologies. For simplification, when function $f(\cdot)$ in eq. (3.1) is assumed to be in the form of $e^{X_{it}\beta_{(j)}}$, eq. (3.1) can be transformed as follows:

$$Y_{it} = e^{-U_{it(j)}} \times \frac{e^{x_{it}\beta_{(j)}}}{e^{x_{it}\beta^*}} \times e^{x_{it}\beta^* + V_{it(j)}} \tag{3.5}$$

When both sides of eq. (3.5) are divided by $e^{x_{it}\beta^* + V_{it(j)}}$, eq. (3.6) is derived as follows:

$$\frac{Y_{it}}{e^{x_{it}\beta^* + V_{it(j)}}} = e^{-U_{it(j)}} \times \frac{e^{x_{it}\beta_{(j)}}}{e^{x_{it}\beta^*}} \tag{3.6}$$

The first part of the right-hand side of eq. (3.6), $e^{-U_{it(j)}}$, refers to the technical efficiency (TE) of group j. The second part is the Technical Gap Ratio (TGR) or Meta-Technology Ratio (MTR), which denotes the ratio of group j's frontier function to the meta-frontier function. The meta-frontier technical efficiency, TE*, is the product of TE and TGR and can be expressed as follows:

$$TE_{it}^* = \frac{Y_{it}}{e^{x_{it}\beta^* + V_{it(j)}}} = TE_{it} \times TGR_{it} \tag{3.7}$$

There are two methods to calculate the parameters of the meta-frontier production function: linear programming (LP) and quadratic programming (QP). LP minimizes the sum of the absolute value of deviations, whereas QP minimizes the sum of squared deviations. According to Battese et al. (2004), LP and QP are defined as follows:

$$\text{LP:}\ \min_{\beta^*} \sum_{t=1}^{T} \sum_{i=1}^{N} |x_{it}\beta^* - x_{it}\hat{\beta}_{(j)}|, x_{it}\beta^* \geq x_{it}\hat{\beta}_{(j)} \tag{3.8}$$

$$\text{QP:}\ \min_{\beta^*} \sum_{t=1}^{T} \sum_{i=1}^{N} \left(x_{it}\beta^* - x_{it}\hat{\beta}_{(j)}\right)^2, x_{it}\beta^* \geq x_{it}\hat{\beta}_{(j)} \tag{3.9}$$

3.3 Analysis Result and Discussion

3.3.1 Data

Based on Koiso-Kanttila's (2004) conceptualization of digital content as "bit-based objects distributed through electronic channels" (p. 46), Rowley (2008) provides examples of digital content, such as "online news, electronic journals, e-books, virtual pets, online health advice, databases, online directories, mobile micro movies, games, music downloads, and software package updates" (p. 521-522). Among the abovementioned categories of digital content, this dissertation analyzes firms that offer digital content to general users over the Web. Accordingly, e-learning, multimedia (audio and video type), online news, information offering, and Internet portals are included in the digital content classification. This dissertation uses data collected from the KISVALUE database provided by Nice Investors Service. The KISVALUE database provides information, such as portfolio, financial statement, credit rate, and stock price, of firms in Korea that are listed or undergoing external audits. The sample consisted of 25 paid-content firms, 9 free content firms, and 16 freemium content firms, totaling 50 firms. Various information, such as the firm's net sales, total asset, cost of revenue, and number of employees, was collected during the period from 2000 to 2014. Table 3.2 and 3.3 show the basic statistics of the collected information.

Table 3.2 basic statistics

Variables (Unit)		Group of Content firms by pricing		
		Fee	Free	Mix
No. of Firms		25	9	16
No. of Observations		234	66	194
Y: Net Sales (KRW)	Min	1,457,313	1,604,909	1,071,630
	Max	220,464,782,000	162,261,056,000	1,637,164,959,000
	Average	20,014,570,609	27,022,824,672	97,302,057,241
	S.D.	28,542,722,303	47,049,722,323	260,463,125,044
K: Total Asset (KRW)	Min	676,317	1,141,466	1,056,246
	Max	158,886,722,000	203,444,588,000	2,755,830,752,000
	Average	21,124,367,704	23,780,083,525	142,426,395,443
	S.D.	27,368,203,040	42,881,962,850	430,618,000,703
M: Cost of Revenue	Min	193,797	562,735	574,538
	Max	198,297,943,000	25,840,945,000	925,265,388,000

(KRW)	Average	12,880,544,023	5,375,132,662	47,086,126,145
	S.D.	25,422,905,462	7,148,873,939	121,474,216,309
L: No. of Employees (Persons)	Min	2	3	1
	Max	1,285	818	3,259
	Average	111	249	327
	S.D.	161	268	554

Table 3.3 Number of firms in content genre

Content genre	No. of firms			
	Fee	Free	Mix	total
e-learning	4	-	-	4
Audio & Video	5	1	3	9
News	-	2	6	8
Information	16	5	3	24
Portal & Communication	-	1	4	5
total	25	9	16	50

3.3.2 Analysis Result

The production function for each firm was estimated through the *FRONTIER 4.1* program, and the meta-frontier production function was calculated using *MATLAB*. As mentioned in the introduction section, this dissertation categorized online content firms into three groups (fee, free, and mix) based on the pricing scheme. Table 3.4 below depicts the estimates of the production functions for all three groups using SFA. The coefficient of the meta-frontier production function calculated through the MFA based on the estimation results is displayed on the two far right columns.

Table 3.4 Estimation results of group and meta-frontier production functions

Variables	Fee Group		Free Group		Mix Group		Metafrontier	
	Estimated Coefficient	S.E.	Estimated Coefficient	S.E.	Estimated Coefficient	S.E.	LP	QP
Constant	0.006	1.421	10.238***	1.971	-0.951	2.171	10.238	10.238
lnx_1	1.024*	0.584	0.353	0.469	0.813	0.546	0.725	0.865
lnx_2	0.901	0.697	0.867**	0.439	0.644	0.482	-0.143	-0.391
lnx_3	0.073	0.691	-0.851*	0.449	0.271	0.351	0.130	0.361
$(lnx_1)^2$	-0.022	0.029	-0.022	0.052	-0.037*	0.021	-0.004	-0.009
$(lnx_2)^2$	-0.172***	0.043	-0.178**	0.091	0.026	0.037	0.056	0.032
$(lnx_3)^2$	-0.211***	0.047	-0.130	0.088	0.068*	0.035	0.044	0.009
$(lnx_1)(lnx_2)$	-0.275***	0.064	0.058	0.112	0.149***	0.053	-0.086	-0.062
$(lnx_2)(lnx_3)$	0.384***	0.081	0.334*	0.178	-0.088	0.067	-0.073	-0.012
$(lnx_3)(lnx_1)$	0.246***	0.063	-0.067	0.130	-0.168***	0.048	0.058	0.027

Note: *, **, and *** denotes $p < 0.1$, $p < 0.05$, and $p < 0.01$ respectively.

Based on the estimated production functions, the technical efficiency (TE) of each group, TGR, and TE* can be calculated, as depicted in Table 3. The results showed that the mix group had the highest TE value (0.669), followed by fee group (0.512) and free group (0.425). However, because the comparison of the technical efficiencies of groups with different production functions is meaningless, the meta-frontier analysis was conducted. As for TGR, which compares the efficiencies of groups by measuring the distance between meta-frontier and group frontier production function, the exact opposite result was found. The free group, which showed the lowest technical efficiency, had the highest TGR value of 0.886[18]. On the other hand, the mix group, which showed the highest technical efficiency, had the lowest TGR value of 0.459. This result indicates that the free group's production function is closer to the meta-frontier production function. Even though the average TE value of free group was the lowest, this result implies that it is not because most firms in the free group were inefficient, but because some firms in the free group tried to elevate their production frontier. When the production frontier of one group was moved toward the meta-frontier by some portion of firms in the group and if there was no change on other firms in the same group in terms of production, the average TE of that group decreases. Even regarding TE*, which is the product of TE and TGR, the free group had the highest TE* value of 0.718, followed by fee group (0.560) and mix group (0.331). The free group had the highest standard deviation value in the TE results. This is probably because firms in the free group raise sales through advertising and are thus able to freely engage in innovative activities compared to other groups. Although the free group had the highest standard deviation and the lowest average TE value due to the high degree of freedom, the firms' freedom of innovative activities shifted the free group's production function upwards.

[18] This paper mentions the LP estimates only because the LP and QP estimates are almost the same.

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

Estimated Value	Group	Mean		St. dev.		Minimum		Maximum	
TE	Fee	0.512		0.156		0.294		0.915	
	Free	0.425		0.233		0.205		0.848	
	Mix	0.669		0.104		0.473		0.854	
Estimated Value	Group	Mean		St. dev.		Minimum		Maximum	
		LP	QP	LP	QP	LP	QP	LP	QP
TGR	Fee	0.658	0.646	0.050	0.048	0.576	0.566	0.720	0.707
	Free	0.886	0.850	0.053	0.053	0.739	0.710	0.935	0.913
	Mix	0.459	0.453	0.038	0.041	0.394	0.370	0.533	0.529
Estimated Value	Group	Mean		St. dev.		Minimum		Maximum	
		LP	QP	LP	QP	LP	QP	LP	QP
TE*	Fee	0.560	0.550	0.042	0.041	0.490	0.482	0.612	0.601
	Free	0.718	0.688	0.043	0.043	0.598	0.575	0.757	0.739
	Mix	0.331	0.327	0.028	0.030	0.284	0.266	0.384	0.381

To more accurately analyze the cause of the differences in the TGR values, this dissertation additionally conducted Tobit regression using the STATA program. In model 1, lnK, lnL, lnM values were used as moderator variables in order to moderate the effect of firm size on the TGR value. To analyze the difference in TGR values across groups, mix group-based dummy variables D_fee and D_free were used. Table 3.6 below depicts the Tobit regression results. There was no significant effect of lnL on efficiency difference, whereas lnK had a positive effect and lnM had a negative effect significantly. The TGR values of both the free group and fee group were statistically significantly greater than that of the mix group.

In model 2, this dissertation puts content genre information as dummy variables in the Tobit model because the pricing strategy largely depends on the genre of the content as mentioned in the introduction section. Four variables, D_info, D_media, D_portal, and D_elearn, which indicate content group providing various information, online video streaming group, online portal group, and e-learning group respectively, were used as dummy variables, and newspaper group providing news through online website was used as the baseline group. The results of moderator variables (lnL, lnK, and lnM) and group dummy variables (D_fee and D_free) in model 2 were similar to those of model 1. For content genre dummy variables, only the TGR of media group providing online video streaming service was significantly smaller than that of newspaper group, and there was no significant difference among other groups.

Table 3.6 Estimation results of the Tobit model

	Model 1			*Model 2*		
Variables	Coef.	(S. E.)	t –Value	Coef.	(S. E.)	t –Value
lnK	0.042^{***}	0.007	6.07	0.073^{***}	0.008	9.41
lnL	0.004	0.007	0.56	-0.003	0.008	-0.38
lnM	-0.040^{***}	0.007	-5.93	-0.074^{***}	0.007	-10.05
D_fee	0.195^{***}	0.014	14.09	0.201^{***}	0.020	10.21
D_free	0.409^{***}	0.020	20.17	0.431^{***}	0.022	19.20
D_info				-0.028	0.023	-1.24
D_media				-0.088^{***}	0.027	-3.28

D_portal				-0.038	0.028	-1.36
D_elearn				0.004	0.034	0.13
Constant	0.351***	0.049	7.16	0.452***	0.070	6.49

Note: *** indicates statistically significant at the 1% level

D_fee and *D_free*: dummy variables indicating fee and free group respectively

D_info, D_media, D_portal, D_elearn: dummy variables indicating content group providing various information, online video streaming group, online portal group, and e-learning group respectively

3.3.3 Discussion

Based on the analysis results, it can be concluded that the traditional business strategy, which consists of content production cost, sales, and the collection of profit based on the difference between the two, is no longer effective in the digital content market. This is in the same vein as the research results of Gallaugher et al. (2001) and Fan et al. (2007), who describe a phenomenon that can emerge when traditional mass media such as newspapers and broadcast transform to a business conducted over the Internet.

Gallaugher et al. (2001) state that a greater number of online newspapers will adopt the free strategy supported by online advertisement with two reasonings: The first reasoning is that because online advertisements have fewer restrictions than printed newspapers, earning revenue from online advertisement and offering free online news are effective, and the second reasoning is that since users have become accustomed to free content, if similar content charges a fee, users will not select paid content. In another study, Fan et al.

(2007) explain that it has become easier for users to download or watch media programs over the Internet, so the perception of media firms is eventually changing from traditional broadcast businesses to content delivery firms.

Furthermore, based on the MFA analysis, the meta-frontier efficiency value of the mix group was lower than that of the fee group. According to Lin et al. (2012), the mixed strategy of paid and free content is optimal only when the content provider is in a monopoly position. Moreover, Sprenger et al. (2016) suggest that when the users' willingness to pay is different, where a business is targeting general customers in lieu of a specific audience, the mixed strategy is effective. However, in cases where the competitor's content or service is offered free, consumers will be unwilling to purchase paid content (Sprenger et al., 2016). As shown in Table 1, because firms that use the mixed strategy are in competition with other firms that offer similar content, they are unable to be in a monopoly position, where the mixed strategy is optimal. Furthermore, content offered by firms that adopt the mixed strategy is often similar to those provided by firms that use paid or free strategy. Hence, it can be analyzed that the meta-frontier efficiency value of the mix group was rather lower because it lacks a definite differentiating factor in competing against firms that offer similar content for free, as described by Sprenger et al. (2016).

In addition, from the fact that the strategy that generates sales through advertisements and offers free content has a high efficiency from a metafrontier perspective, it can be inferred that consumers have a favorable attitude toward online advertisements that lower the cost of content. As explained by Evans (2008), advertising over the Internet consists of an innovative factor that makes it different from traditional advertising, and there are many favorable results regarding user attitudes on Internet advertisements. In a 1996 survey, Schlosser et al. (1999) derived results that Internet users generally have a positive attitude toward online advertisements. More than half of the respondents stated that Internet advertisements are informative, and that they are confident in their purchasing decisions, indicating their trust in Internet advertisements (Schlosser et al., 1999). Calisir (2003) states that young consumers have a perception that website as an advertising media is excellent for precipitating for action, is the most reliable source, provides two-way communication and is not irritating. Furthermore, it can lead to more outstanding results than traditional advertising media, such as TV and radio (Calisir, 2003). In another study, Dehghani et al. (2016) conducted a 2015 survey on 378 university students and analyzed that the entertainment effect and customization of YouTube advertisements have a significant effect on the user's purchase intention, and especially customization plays an important role in advertisement value.

Accordingly, as online advertising that began with a simple banner advertisement (Briggs & Hollis, 1997; Bruner, 2005) improves continuously, it offers utility that exceeds the advertising avoidance cost of online content users. However, as can be seen in the results of studies on the negative effect of Internet advertisements and the reasons for avoiding them (Cho & Cheon, 2004) and factors of using advertising avoidance software (Gill et al., 2013), it is necessary to consistently ponder over an online advertising method that is not harmful to the users at an appropriate level.

3.4 Chapter Conclusion

Unlike the traditional offline products, digital content products can be offered free because the marginal cost is close to 0, and advertising revenue can be raised based on secured consumers. However, there is some dissent among researchers regarding the optimal pricing strategy for digital content providers. In fact, firms in reality use various pricing policies. This dissertation categorized the digital content firms into three groups based on the pricing strategy and estimated each group's efficiency value using SFA. The estimation results showed that the mix group that uses both free and fee strategies had the highest average efficiency value, whereas the group that uses free strategy had the lowest average efficiency value. The limitation of traditional efficiency measurement methods is that it is unable to compare the efficiencies of groups that use different production functions. Therefore, TGR and TE* values were estimated using MFA. The comparison of efficiency values of three groups based on the meta-frontier production function showed opposite results. The TGR and TE* values of the free group were the highest, whereas the TGR and TE* values of the mix group, which had the highest TE value, were the lowest. So, it can be inferred that the pricing strategy composed of free of charge pricing for consumer and revenue from online advertisement is the most efficient pricing strategy in the view of meta-frontier methodology.

Lowering the product's price to 0 will lead to price competitiveness among competitors, thus securing more consumers in the initial market. When more consumers are secured, it will be more advantageous regarding word-of-mouth effect and product diffusion. Especially because IT products, including digital content, have a higher network effect than other products, it is highly probable that the firm that secures more consumers will maintain its competitiveness. It is most likely for this reason that the firms using the zero pricing strategy had a higher meta-frontier efficiency compared to the other groups. An interesting point is that the meta-frontier efficiency value of the mix group was lower than that of the fee group.

There are two research result branches about Internet online advertisement; one for Internet users' preferable attitude on online advertisement (e.g. Schlosser & Kanfer, 1999; Calisir, 2003; Dehghani et al., 2016) and the other for willingness to avoid the advertisement (e.g. Cho & Cheon, 2004; Pujol & Feldmann, 2015; Gill et al., 2013). From these research results, it can be inferred that the Internet users feel the greater utility by zero or very low price than willingness to avoid the online advertisement which annoys Internet usage. And this relation has made online advertisement flourish in the Internet.

However, in the mobile Internet usage, above good relation may be deteriorated because the usage fee of mobile Internet, in general, is higher than fixed line Internet and small display of mobile device has more restrictions to advertisement showing than PC display. And these concerns have occurred in real; a member of the Korean National Assembly points out the free mobile multimedia streaming services contain advertisement but network fee caused by this advertisement is high and Three, the mobile operator in UK, has tried to deploy Ad blocking application to users insisting the necessity of the Internet uses protection from Internet usage fee and annoyance on mobile Internet usage.

New research challenges are inferred from the findings of this chapter. Zero pricing with additional advertisement revenue is proven as the most efficient strategy by Internet content providers and this strategy have helped the diffusion of Internet and edge innovation. However, is this strategy available for new Internet services such as VR, AR, big data analysis, and the IoT?

On the traditional Internet contents or services, users can separate online advertisements from the original contents or services. However, the VR (virtual reality) contents aim to mimic the real world at the highest level, hence, the advertisements attached to VR contents could degrade the reality of the contents. And IoT services handle user's raw information directly, implying that targeted advertisement by an IoT Agency means the IoT Agency manage user identification issues.

The discomfort level caused by online advertisements inserted into contents has been endurable for traditional Internet contents and services, but if it degrades quality of content or misuses user identifications or personal information, no one can answer at present whether it is endurable or not.

One of the limitations of this dissertation is that it only analyzed firms that are listed or undergoing external audits, which have grown beyond a certain size. Because many firms that offer new content and services over the Internet have started as small firms, analysis on the efficiency of such firms will also derive meaningful research results. Nevertheless, albeit the limitation, the fact that the efficiencies of digital content providers with different pricing strategies were compared using MFA has great implications for the digital content industry, which will become increasingly important in the future.

Chapter 4. New Regulation Framework in the IoT era: Isotropic Dynamics regulation

4.1 Introduction

The Internet has developed and advanced with innovations in many areas of technology and has produced various and innovative contents, services and applications. IoT services are new, innovative and emerging services based on the Internet.

Various IoT services have been launched and are now available to consumers, but consumers are not accustomed to IoT services or even the concept of IoT, despite the fact the ITU (2012) and the IEEE Internet Initiative (2015) recently defined the IoT, as described in the following section. However, IoT-related research expresses consistently, as noted by Atzori et al. (2010), that the IoT started with RFID (radio frequency identification) and operates on certain parts of the Internet overall and will eventually make dramatic changes as compared to the traditional Internet.

The Internet has an explicit and simple resolution as a "global information system[19]" according to the Federal Networking Council, who defined it as such in 1995. However,

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[19] The Federal Networking Council (FNC) agrees that the following language reflects our definition of the term "Internet."

> "Internet" refers to the global information system that --
> (i) is logically linked together by a globally unique address space based on the Internet Protocol (IP) or its subsequent extensions/follow-ons;
> (ii) is able to support communications using the Transmission Control Protocol/Internet Protocol (TCP/IP) suite or its subsequent extensions/follow-ons, and/or other IP-compatible protocols; and

information services over the Internet are very different from communications services such as voice telephony, broadcasting services, and cable TV, all of which were categorized before the Internet; moreover, it is impossible to classify whether these new information services are telecommunication or broadcasting services.

The earlier Internet the regulation framework, known as the vertical or silo regulation framework, was separately imposed on voice telecommunication services, broadcasting services, and cable TV services. New services over the Internet network are not classified into different services; hence, no regulation has been imposed on new Internet-based information services.

For example, the VoIP (Voice over Internet Protocol) service is very similar to the traditional voice telecommunication service, but it was not classified as a telecommunication service because it is based on the Internet. Voice signals are transported through the Internet network. Shin (2006) explains that VoIP service firms had free time in their business operations for open-access Internet networks in the hand-off approach period up to 2004, when FCC has not yet decided whether VoIP was a telecommunication service or an information service.

The lack of regulations made it very easy for new and various content, service, or application firms to enter and exit the market. Table 1 shows the changes of top five Internet

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> (iii) provides, uses or makes accessible, either publicly or privately, high level services layered on the communications and related infrastructure described herein."

(available at https://www.nitrd.gov/fnc/Internet_res.aspx on 1 Nov. 2016) search firms. Yahoo, which is frequently mentioned as an example of an Internet search engine firm in Varian & Shapiro (1999), has dropped from first to third in the ranking, with its market share shrinking from 34.3% to 14.5% in the United States in just 13 years.

Table 4.1 Market share comparison of search engine in United States

Ranking	Aug. 1997	Jan. 2004	4th Quarter 2010
1	Yahoo (34.3%)	Google (39.4%)	Google (71.0%)
2	Infoseek (18.3%)	Yahoo (30.4%)	Yahoo (14.5%)
3	Excite (47.6%)	MSN (29.6%)	Bing (9.8%)
4	Lycos (11.4%)	AOL (15.5%)	Others (4.7%)
5	Altavista (10.9%)	AskJeeves (8.5%)	
Source	Gandal. (2001)	Telang et al. (2004)	Haucap et al. (2014)

The regulation framework before the Internet is the vertical or silo regulation framework, which classifies communication services into telecommunications, broadcasting, or cable TV services and imposes separate regulations on each type (Frieden, 2002).

However, after the Internet emerged, telecommunications and broadcasting converged as new services over the Internet not classified into separate groups. The vertical regulation framework cannot be imposed on information services based on Internet. Therefore, it was only after a great deal of research and debate that the horizontal or layered regulation framework, obviously different from the vertical regulation framework, emerged (e.g., Frieden, 2002; Werbach, 2002; Wu; 2006).

The horizontal regulation framework classifies the entire Internet environment into two layers. The first is a network layer that transports digital data and the second is a content layer that produces content, services, or applications. Moreover, different regulations are imposed on each layer. Generally, economic regulations concerning competition statuses and discrimination issues against the content layer are imposed on the network layer while content regulations concerning socio-cultural issues are imposed on the content layer.

This dissertation investigates the difference between traditional communication services and Internet services, leading to a new regulation framework for the IoT services based on the Internet.

It may be the time to wait and see the emerging, launch to market, and advancement of the new and innovative IoT services, as it has been shown that no regulation approach made the traditional Internet based services flourishing, more innovative, and more competitive. And regulatory concerns on IoT services concentrate on the personal information and privacy protection both in the academic research area (e.g. Peppet; 2014, Weber; 2009, Weber, 2010) and in the legislation area (e.g. Weber, 2015; European Union, 2016). Accordingly, the Korean government proclaimed guidelines for non-identifying personal information on June, 2016.

IoT services will be provided as a part of the traditional Internet but with a dramatic change (Atzori et al., 2010). It is inferred that this difference will required another type of regulation framework different from the horizontal or layered regulation frameworks in the Internet era.

An IoT service is composed of three layers. These are the IoT things layer, which collects raw information; the IoT Agency layer, which analyzes raw information and gives feedback to users; and the network layer, which transports raw information and analyzes solutions. With regard to the targeted, precise, and timely delivery of information, the vertical regulation framework appears to be appropriate, and regarding the three-layer model, the horizontal regulation framework appears to be most appropriate.

Given the above two points of view, this dissertation investigates the basic values of each period, i.e., before and after the Internet and the IoT era, and examines the successive innovations at all three layers in the IoT era, finally proposing a new regulation framework for the IoT era. It is a conceptual framework rather than practical regulatory policy tools and legislative directions.

To do this, basic values and innovations are investigated in section 4.2 before and after the Internet while section 4.3 concentrates on the IoT era. In section 4.4, empirical analysis to investigate users' preference was conducted, resulting in some regulatory concerns on IoT service. Section 4.5 proposes the new regulation framework; isotropic dynamics regulation framework, and section 4.6 concludes this chapter.

4.2 Basic value and Regulation Framework Before IoT era

4.2.1 Electronic communications era

During the electronic communication era, the main communication services were voice telecommunications, broadcasting services, and cable TV services, and their main role was the transport of information from the sender (the caller for telecommunication services, broadcasting stations, and cable TV systems) to the recipient (telephone call recipients, TV viewers, and radio listeners). Thus, the basic value of electronic communication media is the innovative delivery of information.

For this purpose, the vertical regulation framework is appropriate, as it imposes different regulations on the separated services. Regulations differ depending on the service; however, each regulation is unitary through the overall service, handset – network – handset for telecommunications and contents – broadcasting system – network – TV or radio for broadcasting or cable TV.

The emergence of voice telecommunications and TV broadcasting was an innovation itself. Considering voice telecommunications, innovation has arisen from technological advances which now allow more persons to make phone calls simultaneously. Electronic communication systems convert and transport human voice signals into electronic signals within the human audible frequency range (20 to 20,000Hz). Hence, the maximum capacity at which phone calls with limited frequency ranges can be transported simultaneously is important. In fixed-line voice telephony, advances in the area of exchangers or switchboards from low to high capacity levels (manual exchanges – automatic exchanges

– digital switches) were the result of innovations while in mobile voice telephony, advances in multiple access (e.g., FDMA: Frequency Division Multiple Access, TDMA: Time Division Multiple Access, CDMA: Code Division Multiple Access, OFDMA: Orthogonal Frequency Division Multiple Access) were all the result of innovations.

Regarding broadcasting services, it is the main concern of innovators to deliver content precisely. For radio, technological advances changed AM (amplitude modulation) to FM (frequency modulation) while for TV, black and white displays became color displays.

Economic regulatory concerns mainly relate to interconnection issues, especially after the privatization of the telecommunications market. Economides (1996) explains that national or governmental telecommunication firms having a natural monopoly have no incentives to provide services to all potential users, and insist that incumbent firms should open their networks and interconnect new entrants for a larger network on which more potential users can be provided voice telephony service.

In the broadcasting area, content regulation is the main concern from a socio-cultural viewpoint, and phone tapping or monitoring are other social issues related to voice telecommunication services.

4.2.2 Traditional Internet era

The Internet was developed with mainly two purposes by two separate research groups. One was to share and provide feedback about digitalized research results with other researchers, and the other was to sustain communications in extreme situations with a partially broken network for military purposes (Leiner et al, 2009). However, the usage of the Internet increased explosively after general and free usage, beyond the limited purpose of both the military (ARPANET) and academia (NSFNET), became available (Rai & Samaddar, 1998).

As noted by DiMaggio et al. (2001), three aspects of the Internet are point to point media, broadcasting media, and digital media. The purpose of the Internet for users would be to share digitalized contents or services via the Internet as a form of media. Therefore, it can be inferred that the basic value of the Internet is the innovative sharing[20] of information.

In the Internet era, the vertical regulation framework for traditional communication services does not function properly because the contents and services based on the Internet are not classified into rigidly separate entities such as voice telecommunications, broadcasting, or cable TV. Instead, categorization covers it as a whole, via ICE (Internet-mediated information, communications, and entertainment) (Frieden, 2002).

Many researchers (e.g., Frieden, 2002, Wu, 2006) explain the confused situation in which the traditional vertical regulation framework does not operate, and much research and debate conclude that a horizontal or layered regulation framework is needed in the Internet era, which does not separate ICEs into specific telecommunication or broadcasting

[20] 'share' does not mean free of charge, but with widespread contents and opinions.

services but separate Internet tiers into two layers, i.e., the network layer which transports digital data and the content layer which generates digitalized contents, services, or applications. In detail, regulatory tools different depending on the country, e.g., whether a two-layer or three-layer model is used or whether ex ante or ex post regulations exist. However, it is agreed that the Internet should be separated into layers and that the same regulations should be imposed on each layer.

Considering the horizontal regulation framework, the main concern for economic regulations is discrimination. Over the Internet, discrimination can occur in many cases, as mentioned by Pasquale (2010). Examples include search result discrimination by search engines, reputation discrimination by attorney list services, and an Internet service provider's discrimination against content providers. In addition, thus far, network layer (by Internet service providers) discrimination against the content layer (content providers) has been a major issue. In particular, this case is strongly regulated, with ISPs prohibited from monitoring and managing data streams in a practice known as gate-keeping, or from highly prioritizing their own data streams or vertically integrated services. Regarding content layer content regulation, a socio-cultural viewpoint is imposed in most countries.

In the Internet environment, innovations have occurred on both the Internet network, known as the core, and at two end points of the network, collectively called the edge. Innovations at the edge have been followed by advances of computing technologies, including personal computers and server systems and have produced and launched new, various, and innovative contents, services, and applications. Moreover, many studies (e.g., Reggiani & Valletti, 2016; Lessig, 2002; Lee & Wu, 2009; Guo et al., 2012) insist that innovations at the edge are more important factor for advances of the entire Internet.

However, the innovations at the Internet network, i.e., innovations at the core, have occurred successively in two streams. Initially, IPv6 was standardized. A unique IP address (Internet Protocol) should be assigned to devices connected to the Internet network. IPv4 stated with RFC 791 issued in 1981 using 32-bit addressing, allowing a total of 2^{32} devices, approximately 4.3×10^{9}, to be connected to the Internet network. As time passed and the number of Internet devices, including PCs, servers, routers, and IoT sensing devices, increased, there were too few available IP addresses. However, the new standard IPv6 started with RFC 2460 issued in 1998 using 128-bit addressing, allowing 2^{128} devices, i.e., approximately 3.4×10^{38}, to be connected to the Internet network. This is practically an infinite number covering all electronic machines.

Another innovation of the Internet network is that it broadens the transport capacity, referring to the bandwidth of the Internet network. Voice telecommunications can only transport a limited range of the human audible frequency. For this reason, it is more important to accommodate more phone calls simultaneously than to broaden the bandwidth of the communication network. However, for the Internet, as the transported content grows in size, the bandwidth capacity of the network becomes more important. In the beginning of the Internet era, nearly all content was in the form of lists of text, whereas over time, many parts of homepages became filled with images. Currently, audio/video multimedia and streaming content are very popular. Hence, the Internet network bandwidth has broadened over time. The ITU in 1997 and the Media Fact Sheet in 2003 explained the term broadband as “qualifying a service or system requiring transmission channels capable of supporting rates greater than the primary rate,” and Recommendation I.113 of the ITU Standardization Sector defined broadband as having a “transmission capacity that is faster than primary rate Integrated Services Digital Network (ISDN) at 1.5 or 2.0 megabits per second (Mbps).” However, in the real world, the required broadband speed is higher than 1.5 to 2.0 Mbps. For example, the European Commission (2010) targets all European speeds at 30 Mbps, and more than 50% at 100Mbps by 2020, while the Federal Communications Commission (2015) stated that the required broadband speed for household Internet is 25Mbps for downstream and 3Mbps for upstream.

As shown above, innovations pertaining to the Internet have occurred at both edges, at the content layer and the core, and at the network layer.

4.3 Basic value and Innovation of IoT

4.3.1 What is IoT ?

Aston (2009) noted that the term IoT was used for the first time by Procter & Gamble (P&G) in a presentation in 1999 which presented the results of studies of how RFID (radio frequency identification) would be better under the Internet environment from the viewpoint of the supply chain. Hence, many studies state that the IoT started from RFID technology (e.g., Atzori et al., 2010; Gubby et al., 2013).

There is no consensus on a definition of the IoT, and the IEEE Internet Initiative (2015) states that researchers, research institutes, and standardization groups have defined IoT differently.

Atzori (2010) explain IoT as the convergence of three visions: things-oriented, Internet-oriented, and semantic-oriented visions, while Miorandi et al. (2012) states that the term IoT is broadly used from three standpoints: (1) as a global network interconnecting smart objects, (2) as a set of supporting technologies, and (3) as an ensemble of applications and services.

ITU (2012) defines the IoT as "a global infrastructure for the information society enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving, interoperable information and communication technologies," and the IEEE Internet Initiative (2015) states the following: "An IoT is a network that connects uniquely identifiable 'Things' to the Internet. The 'Things' have sensing/actuation and potential programmability capabilities. Through the exploitation of unique identification and sensing, information about the 'Thing' can be collected and the state of the 'Thing' can be changed from anywhere, anytime, by anything."

The IoT application area can be expanded to anything that can be connected to the Internet, which is the new dimension[21] of the IoT: Any THING can have a connection, as

[21] A new dimension has been added to the world of information and communication technologies (ICTs): from anytime, anyplace connectivity for anyone, we will now have connectivity for anything.

explained by the ITU (2005). Atzori et al. (2010) classifies IoT services as transportation and logistics, healthcare, smart environments, and personal and social applications.

4.3.1.1 A definition and Three Layer model approach of the IoT

Following above definitions of the IoT, this dissertation proposes another definition and three layered model of the IoT service. The definition of the IoT is that IoT is a service composed of automated information sensing, collecting the information through the Internet network, analyzing the collected information and feedback the solution; analyzed information to user.

Sensing devices have capability of computation, so can sensor information automatically and transport it to the Internet network.

The Internet network of the IoT service include two interfaces of one for sensing devices and the other for application for information analysis. An interface for sensing devices is usually wireless network, however it varies with the type of services; if a sensing devices are not in motion, NFC technologies such as WiFi and Bluetooth are more appreciate and if in motion, mobile network technologies are more appreciate. Another interface for IoT application is usually fixed line network and it would vary with the type of services. If the IoT service deal with the critical information such as human being's life, public securities, or disaster monitoring, a dedicated line or private network would be more appreciate.

Sensing devices with capability of computation and networking is also important and another innovative advancement, however, analyzing the collected information is the most important composition of the IoT service, because end users' post actions are followed by this feedbacked analysis.

End user can be either human being or other devices or machineries. If the solution is feedbacked to human being user, he or she will decide post action following by feedbacked solution. And if the end user is another device or machinery, it operates by the direction of feedbacked solution.

Horizontal or layered regulation framework divides traditional Internet service into two layers: network layer and content layer. This dissertation proposes to IoT service divided into three layers similarly with traditional Internet regulation framework.

Atzori (2010) divides IoT service into two group in the view of enabling technologies: Middleware which perform analysis of collected raw data and tasks related with securities and management, and sensing and communication technologies which performs sensing raw data and transportation it to middleware. IEEE Internet initiative (2015) suggests three tier architecture, which looks like three layer model in this dissertation. Three tier architecture of IEEE Internet initiative (2015) divides IoT service into three technological architecture, however three layer model of this dissertation divide IoT service into three layer in the view of service. Three layers in this research, which provides one IoT service, are IoT Things, Network, and IoT Agency layer respectively.

IoT Things layer is a set of devices which are capable of sensing raw information, computing, and sending raw information to network. IoT Things layer is very similar concept with definition of sensing by IEEE Internet Initiative (2015) and device by ITU (2012). Network layer is the Internet network including both IoT Things to IoT Agency and from IoT Agency to users.

IoT Agency layer is computing system that analyzed raw information from IoT Things, make a better solution, and feedback to user. The 'Agency' is from the fact that IoT Agency analyze raw information from IoT users and make solution for IoT users on behalf of IoT service users. IoT Agency is similar with middleware by Atzori (2010) and Application by IEEE Internet Initiate (2015).

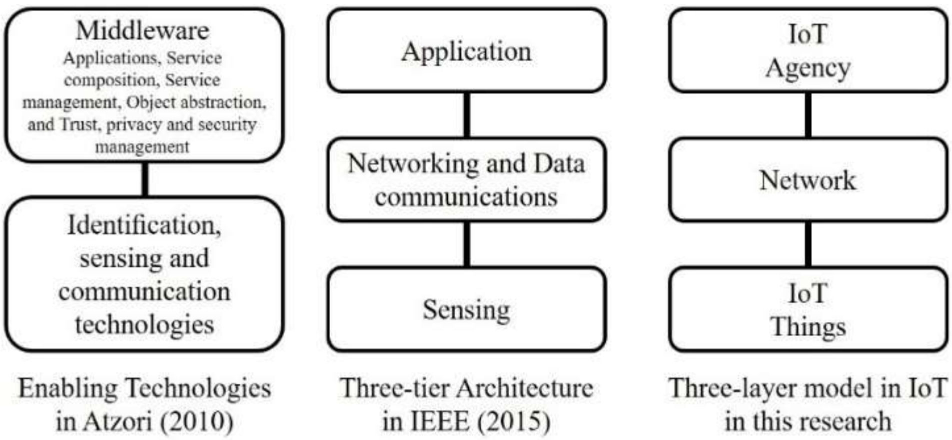

Figure 4.1 Three-layer model in IoT

4.3.2 Characteristics of IoT

4.3.2.1 Bidirectional stream of information

An IoT service is composed of a two-directional stream of information: one stream is raw information from IoT Things to IoT Agency and the other is solution feedback information from IoT Agency to IoT service users.

With regard to bidirectional streams, the IoT service's bidirectional stream appears similar to voice telecommunications. In voice telecommunications, callers and recipients engage in bidirectional exchanges of information, provide feedback to each other, and reach solutions. However, this differs from the IoT case in two ways. First, in voice telecommunications, a caller can select a recipient, but in the IoT, IoT Things should send raw information to a pre-fixed IoT Agency. Second, in voice telecommunications, callers and recipients provide feedback to each other and reach solutions, but in the IoT, IoT Things only send and IoT Agency only analyzes without feedback to each other.

In communications via the Internet, data streams between users and content providers appear bidirectional, but they also differ from the IoT case. In the traditional Internet, upstream data from users to content providers is mostly search-related data such as homepage urls, search queries and mouse clicks after a selection. Therefore, upstream data for searches is not important once desired information or content begins to move downstream. However, in the IoT case, the upstream raw information from the IoT Things to IoT Agency is very important to analyze by IoT Agency. Hence, in these two cases, the traditional Internet and IoT services, bidirectional data or information streams differ from each other.

4.3.2.2 Automated sensing and networking of IoT Things

The second characteristic of IoT services is that IoT Things are capable of computing and networking. The computing capabilities of IoT Things include the sensing of raw information automatically, and via networking they can send raw information to the IoT Agency also automatically.

Voice telecommunication or broadcasting also requires devices such as a handset or a TV, but such devices have no computing capabilities and are operated in passive mode by the user, who makes and receives phone calls or selects a TV channel.

Likewise, PC or computing machines for Internet communications are capable of computing but also operate in passive mode, in contrast to IoT Things, which automatically operate via sensing and networking.

4.3.3 Basic value of IoT

An IoT service uses the following sequential procedure. IoT Things sensor raw information and send it to an IoT Agency via the Internet and the IoT Agency analyzes this information; some IoT services may analyze big data while mixing information from other sources, creating solutions for users, and providing feedback about the solution to IoT users via the Internet.

Above procedure contains two basic values of forms of telecommunication: the innovative delivery of information and the Internet, and the innovative sharing of innovations. The targeted, precise, and timely delivery raw information from IoT Things to the IoT Agency and solution feedback from the IoT Agency to the user is important in IoT services, as is the sharing of raw information to be analyzed regardless of whether big data is involved or not. This refers to the integration of two basic values.

Another form of integration occurs with information. Raw information sensed by IoT Things is integrated information which is used to improve the data analysis process. It includes information sensed from objects, such as the geographical location, temperature, and/or electricity usage as well as user-specific information such as the owner, time, and/or position. The IoT Agency analyzes integrated information which is either that of a single IoT user, mixed information from users of the same IoT service, or big data information with additional information from other sources. Thus, the basic value of an IoT service is the innovative integration of information.

4.3.4 Innovation occurs at all three layers

In the telecommunication era, innovations have occurred mainly in relation to networks while in the Internet era, it has occurred at both the edges and the core, as explained above. In the IoT era, innovations must occur at all three layers, and they should be advanced.

Innovation in the IoT era started with the IoT Things layer. Devices, also known as IoT Things in this dissertation, of a small size and capable of computing and networking, enabled the launch of IoT services. Innovations at the IoT Things layer should target smaller, low-power, high-performance devices for more accurate sensing and networking. The capability of IoT Things to compute infers intelligence.

However, another and more critical innovation is anticipated, guaranteeing the targeted, precise, and timely transport of information. Specifically, information related to emergencies, life and death issues, or public disasters have become more important and critical in IoT networks based on the Internet to guarantee the targeted, precise, and timely transport of information. Public Internet networks are also known as a best-effort network, meaning they are first-input, first-output networks, with no guarantee of QoS (Quality of Service). The priority or private Internet network has not flourished in the traditional Internet era not due to technological issues but owing to the lack of gate-keeping and non-discrimination regulation issues. In the IoT era, private networks that guarantee the targeted, precise, and timely transport of critical information are needed, and innovative activities at the network layer should advance in this direction. In a word, Internet networks to support IoT services need intelligence.

Innovations in the IoT Agency layer are as important as IoT features and those in the network layer because they provide solutions for user. Advances in analysis and synthesis methods and the adoption of big data analysis for better solutions are innovations in the IoT Agency layer. This is also where innovations should target the best solutions – beyond better. It also means that the IoT Agency will become more intelligent than it is at present.

4.4 Empirical Analysis

4.4.1 Introduction of Empirical Analysis

Because the IoT is a new and emerging service, there is insufficient data and statistics for an empirical analysis. Accordingly, this dissertation investigates consumer preferences for imaginary IoT services reflecting the regulation and innovation conditions. To do this, a mixed logit methodology and a conjoint survey were utilized.

The application area of IoT service is very divergent with sensing, network, and analysis technologies. Miorandi et al. (2012) categorizes IoT application area into smart home and smart building, smart city, environmental monitoring, smart business by inventory and product management, and security and surveillance. Gubbi et al. (2013) categorizes IoT services into personal and home, enterprize, utilities, and mobile.

However, to investigate consumers' preference on IoT service, two separation guidance is needed: consumers' status and IoT Thing's status. Consumer's status is divided into three group: individual, enterprize or business, and government or public area. And IoT Thing's status is divided into two group: mobile Things and fixed Things.

A household environmental (temperature, moisture, and indoor air quality) monitoring service was assumed as an imaginary IoT service. A consumer of imaginary household environmental monitoring IoT service is individual and sensing device is attached to house, which means 'fixed'. To use or subscribe to this IoT service, consumers have to purchase IoT Things capable of sensing environmental conditions and sending information to the IoT Agency. Accordingly, a survey questionnaire focusing on the relationship between IoT Things and the network and between IoT Things and the IoT Agency.

Related to innovations, a private network was considered as an example of innovation of the network layer in the IoT era along with big data analysis for the IoT Agency layer. Private networks were developed and used before the IoT service, but they are not widely used in households or for personal Internet connection. Therefore, private networks were selected as an attribute of an IoT service, which could be interpreted as a consumer preference for a private or prioritized network with a more innovative IoT service in the future.

Big data analysis has been also developed separately from IoT services, but more detailed solution big data analyses will be widely adopted through innovations in the IoT Agency. However, because big data requires a mixture of data from other sources, the protection of personal information will become more of a concern. The questionnaire explains this situation fully.

To reflect economic concerns in the IoT era, consumer preferences for vertical integration both between IoT Things and the network and between IoT Things and the IoT Agency are considered. It is thought that in the absence of integration that consumers can select a network or an IoT Agency after purchasing IoT Things.

Hence, four attributes, (1) private networks, (2) selecting a network, (3) selecting an IoT Agency, and (4) big data analysis for an imaginary IoT service were selected to estimate consumer preferences, and a monthly usage fee was also included as another attribute to calculate consumers' willingness to pay for each attribute.

After conducting a mixed logit analysis, the consumer preference or utility was estimated for each attribute of the IoT service. With these estimated preferences, the median marginal willingness to pay and the relative importance of each attribute were calculated.

4.4.2 Methodology: mixed logit

To investigate consumer preferences for IoT services, this dissertation uses a mixed logit model with a conjoint survey. Compared to other discrete-choice models based on a random utility model such as a logit or probit model, the mixed logit model has several advantages; it can reflect consumers' heterogeneity with regard to their preferences for goods or services, select different distributions for each attribute, and relax the strong assumption of IIA (independence from irrelevant alternatives) imposed on the logit model

(Train, 2009). In the random utility model, consumer n can have utility U_{ni} while selecting alternative i expressed in eq.(4.1).

$$U_{ni} = V_{ni} + \varepsilon_{ni} = \beta_n' X_{ni} + \varepsilon_{ni}, \qquad \beta_n \sim N(b, W) \tag{4.1}$$

Consumer utility is composed of a deterministic term V_{ni} and a stochastic term ε_{ni}. The deterministic term is the product of attribute vector X_{ni} of alternative i and coefficient vector β_n representing the consumer's preference. This dissertation assumes that β_n has a normal distribution with a mean of b and variance W while ε_{ni} has an i.i.d. type Ⅰ extreme value distribution. The probability P_{ni} for consumer n to select alternative i from among the J choice set is expressed by Eq. (4.2).

$$P_{ni} = \int \frac{exp(\beta_n' x_{ni})}{\sum_j exp(\beta_n' x_{ni})} \; f(\beta) d\beta \tag{4.2}$$

It is impossible to estimate β_n analytically with a likelihood function containing Eq. (4.2); consequently, a simulation is necessary.

4.4.2.1 Marginal Willingness to Pay (MWTP)

Marginal willingness to pay refers to the monetary unit that the consumer will pay additionally to maintain an identical level of utility with one unit change of another attribute of a good or service. The MWTP for attribute k is calculated by Eq. (5.3) with estimated coefficients of β_n.

$$\text{Median } MWTP_k = \text{ Median } \left[-\frac{\partial U_{ni}/\partial x_{nk}}{\partial U_{ni}/\partial x_{n,price}}\right] = \text{ Median}\left[-\ \frac{\beta_{nk}}{\beta_{n,price}}\right] \quad (4.3)$$

4.4.2.2 Relative Importance of attribute

Each attribute affects the decision-making or choice process differently depending on the relative importance for consumers to feel for each attribute, as calculated by Eq. (5.4).

$$\text{Average Relative Importance for attribute } k = \frac{1}{N}\sum_{n=1}^{N}\frac{part\_worth_{nk}}{\sum_k part\_worth_{nk}} \quad (4.4)$$

$$part\_worth_{nk} = (interval\ \ of\ \ attribute\ \ k's\ \ level) \times \beta_k$$

4.4.2.3 Attributes and level

Table 4.2 shows the attributes and their levels for the conjoint survey. Eight choice alternatives are selected through an orthogonal test with the statistics package SPSS. The attribute of price is assumed to have a log-normal distribution while the four other attributes have a normal distribution. Table 4.3 shows eight alternatives.

Table 4.2 Attributes and levels

Attribute	Description	Level
Price	Monthly charge for IoT service including network charge, IoT service fee, and IoT Thing purchase price	(1) 1,000 [KRW] (2) 2,000 [KRW] (3) 3,000 [KRW]
Private network	Connecting to a dedicated private Internet network	(0) public Internet with best effort (1) private network for IoT services
Network select	Selecting a network company for use with the IoT Thing	Consumers can (0) not select a network company (1) select a network company
Agency select	Selecting an IoT agency for an IoT service	Consumers can (0) not select an IoT agency (1) select an IoT agency
Big data	Big data analysis with data collected from both IoT Things and other data sources	IoT Agency analysis (0) only data collected data from IoT Things (1) big data including other data sources

Table 4.3 Eight alternatives

Alternative	Monthly Charge	Private Network	Network Selectable	Agency Selectable	Bigdata Analysis
1	(1)	(1)	(0)	(0)	(1)
2	(2)	(0)	(0)	(1)	(1)

3	(1)	(1)	(0)	(1)	(0)
4	(1)	(0)	(1)	(0)	(1)
5	(1)	(0)	(1)	(1)	(0)
6	(3)	(1)	(1)	(1)	(1)
7	(3)	(0)	(0)	(0)	(1)
8	(2)	(1)	(1)	(0)	(0)

4.4.3 Analysis Result

4.4.3.1 Conjoint Survey

An online conjoint survey was conducted with 923 respondents from 27 Oct. 2016 to 31 Oct. Each respondent was asked to choose their preferred IoT service among two alternatives in one choice set. The four section processes led to total eight orthogonal alternatives. In addition, as the survey respondents were not used to emerging IoT services, the above procedure was repeated one more time with a different choice set. Table 4.4 shows the basic statistics of the survey respondents.

Table 4.4 Basic statistics of survey respondents

		No.	Ratio (%)
Sex			
	Male	465	50.38%
	Female	458	49.62%
Age			

20 to 29	176	19.07%
30 to 39	216	23.40%
40 to 49	260	28.17%
50 to 51	271	29.36%
Region		
Seoul	181	19.61%
Gyeonggi & Gangwon	321	34.78%
Chungcheong	90	9.75%
Jeolla & Jeju	99	10.73%
Gyeongbuk	95	10.29%
Gyeongnam	137	14.84%

4.4.3.2 Estimated coefficients: IoT service users' preference

Table 4.5 shows the estimated coefficient β_n with its mean and standard deviation. The result is summarized as all attributes of an IoT service except for a private network, which may affect consumers' preferences for utility from an IoT service. Thus, if an IoT service user can select a network (ISP) and an IoT Agency and if the IoT Agency can provide big data analysis, the preference for an IoT service and utility for users will likely increase.

The non-significance of the private network attribute can be interpreted as follows: The household environmental monitoring IoT service assumed in the conjoint survey does not deal with emergencies, human life, or public disasters. Therefore, users of this service may not be concerned about the precise transport of information without delay, jitter, or distortion.

Table 4.5 Estimated coefficients

	Distribution	Estimated value		S. E	z	P>z
b **(Mean)**						
private network	normal	0.071		0.067	1.060	0.288
network select	normal	0.907	(***)	0.061	14.890	0.000
agency select	normal	0.879	(***)	0.057	15.550	0.000
Bigdata	normal	0.656	(***)	0.073	9.020	0.000
price	log-normal	-6.739	(***)	0.071	-94.530	0.000
W**(S.D.)**						
private network	normal	1.598	(***)	0.094	17.090	0.000
network select	normal	0.912	(***)	0.088	10.420	0.000
agency select	normal	0.452	(***)	0.100	4.530	0.000
bigdata	normal	1.755	(***)	0.105	16.780	0.000
price	log-normal	1.439	(***)	0.142	10.160	0.000

***: statistically significant in 1% confidence level

4.4.3.3 Median Marginal Willingness to Pay

Table 4.6 shows calculated median marginal willingness to pay for each attribute. This result shows that IoT service users have the highest WTP when they can select an IoT agency. The next highest are in the following order: when they can select an Internet network company, when the IoT agency provides solutions through big data analysis, and when the WTP is lowest for using the private Internet network.

Table 4.6 Median marginal willingness to pay for each attribute

attribute	private network	netwotk select	agency select	bigdata
Median MWTP	22	440	640	179
S.D	1,524	1,060	703	1,838
Min.	-8,592	-822	43	-7,244
Max.	8,538	5,075	4,283	7,443
No. of respondents of the largest MWTP	134	195	247	347

Unit: KRW

4.4.3.4 Relative Importance

Table 4.7 shows the relative importance levels of the attributes of an IoT service. Relative importance refers to a consumer who chooses a certain service or good of which the attribute is considered to be important compared to other attributes. Apart from the price attribute, the relative importance levels for the other four attributes do not differ distinctly, though the relative importance of big data analysis is somewhat higher.

Table 4.7 Relative importance for each attribute

attribute	private network	netwotk select	agency select	bigdata	price
Relative	12.52%	12.11%	11.20%	14.98%	49.20%

Importance					
S.D	11.42%	10.06%	6.41%	13.79%	26.78%
Min.	0.03%	0.02%	1.87%	0.05%	11.74%
Max.	55.58%	47.81%	42.19%	51.39%	91.92%
No. of respondents of the largest RI	231	170	105	417	

4.4.4 Discussion of empirical analysis

The imaginary IoT service assumed in the survey, i.e., the household environmental monitoring service, is not able to represent all IoT services in the market or those waiting to go to market. However, some very interesting findings are inferred from the results.

First, IoT service users consider all four attributes as important factors in an IoT service. The four attributes are, as noted above, a private network, selection of a network company, selection of an IoT Agency company, and big data analysis by the IoT Agency. Private network and big data analysis represent innovations at the network layer and IoT Agency layer, respectively, and the selections of the network company and the IoT Agency explain whether or not the IoT Things layer is vertically integrated with the network and the IoT Agency layer. And also private network represents the vertical regulation concern for an IoT service to transport information data precisely, on timely and to the targeted destination. This finding means that innovations at all three layers, vertical regulation concern, and non-vertical integration are equally important in an IoT service.

Second, the relative importance of big data analysis seems slightly higher than those of the other three attributes except price attribute and the t-test result also shows that the relative importance of bigdata attribute is greater than other three attributes' with 1% significance level. And the relative importance of 417 respondents out of 923 is the largest on bigdata attribute.

This indicates that IoT service users hope for a better solution from an IoT Agency. However, more detailed analysis result and feedbacked solution needs more amount of information as well as IoT Agency's innovations such as analyzing method and techniques. So appreciate regulations on IoT Agency which treats great amount of information is also required.

Finally, the median marginal willingness to pay for selecting an IoT Agency is highest, and all respondents' MWTP for this attribute is greater than zero, which can be confirmed that the minimum value of MWTP for this attribute is 43 KRW and greater than zero.

With an additional layer in the IoT service, i.e., the IoT Things layer, a new type of vertical integration is possible: vertical integration with an IoT Things layer and an IoT Agency layer. In that these two layers do not interface directly, this case of integration differs from others, i.e., the integration of IoT Things and the network and the integration of the network and the IoT Agency. Therefore, regulatory policy tools to ensure that users select an integrated or non-integrated service according to their choice are needed, and no discrimination against IoT Things should be imposed on the IoT Agency layer.

Following above discussions, regulatory issues in the IoT era is summarized as follows: new regulation framework need (1) vertical regulation concerns for exact transport of information, (2) horizontal regulation concerns on each three layers for IoT service, (3) expansion of innovation, and (4) regulations on IoT Agency layer.

4.5 New Regulation Framework in IoT era

4.5.1 Regulatory Concerns in IoT era

4.5.1.1 Technological concern

In the traditional Internet era, Internet networks have complied with international standards or recommendations for all sub-networks to connect to global networks, and contents or applications do not have standards but instead offer competitive innovations to overcome their competitors. The IoT era appears to follow this condition; IoT Agencies advance their analysis capabilities given their own innovations and IoT networks follow international standards or recommendations. IoT Things should adhere to these two conditions as well, i.e., competitive innovations for sensing and international standards for networking.

Therefore, technological concerns in the IoT era will come from network and communication technologies for the targeted, precise, and timely transport of information. There should also be an absence of data signal interference in wireless networking regions.

4.5.1.2 Economic concern

In the traditional Internet era, discrimination has been the main economic concern to those who create regulations, as is also true in general in the IoT era. The connection between the network layer and the IoT Agency layer is very similar to that between the network and the content; thus, non-discrimination regulation against the IoT agency should be imposed on the network layer, with the exception of private or prioritized networks.

Compared to the traditional Internet, IoT services have one additional layer. IoT Things and discrimination at the interface the IoT Things layer and the network layer are linked to economic regulation in the IoT era. Similar to the Internet case, non-discrimination against IoT Things should be imposed on the network layer. However, another case of discrimination arises in that discrimination may occur between the IoT Things layer and the IoT Agency layer. These two layers are indispensable components of an IoT service, but they do not interface directly. In emerging IoT services, many or nearly all IoT services to IoT Things and IoT Agency are vertically integrated, meaning that if a consumer purchases IoT Things, the IoT agency is set and decided without consumer choice. However, over time and with IoT related innovation advances, a greater variety of innovative IoT Things or IoT Agencies will become available to consumers, along with more utilities for consumers. Hence, regulatory policies are needed such that anyone who wants to select IoT Things and an IoT Agency can do so.

4.5.1.3 Social concern

In the IoT era, regulations on information tapping or monitoring, similar to those related to phone tapping in the telecommunication era and on sensed information, similar to content regulation at the broadcasting or Internet content layer, should still be imposed on IoT services; the protection of privacy and personal information may be more of a concern than in the telecommunication and Internet era.

The protection of privacy and personal information has been a concern since the start of the telecommunication and Internet era, and appropriate regulatory tools are operated in each country. However, these issues may cause more concerns in the IoT era because information is sensed automatically by IoT Things and IoT Agencies deal with very large amounts. This information may be private or personal information.

4.5.2 What to be considered

4.5.2.1 Vertical regulation

With regard to the delivery of information from IoT Things to the IoT Agency and from the IoT agency to users, it is analogous to the basic value of telecommunication, i.e., the innovative delivery of information, and the vertical regulation framework appears proper for delivering information in this case. However, it does not mean consistent vertical regulation from IoT Things via the network to the IoT Agency, but it contains technological standards which affect new interfaces between IoT Things and the network which induce no interference, with low power consumption and wide-area communication and considering relationship between private and public Internet network. Therefore, vertical regulation in the IoT era should be imposed on each interface: one between IoT Things and the network and the other between the network and the IoT Agency.

4.5.2.2 Horizontal regulation

For a greater variety of innovative IoT services, as shown in the Internet era, a horizontal or layered regulation framework should be imposed onto the three layers of IoT services. For the IoT Things layer, the main concern is what information can be sensed and what cannot be sensed, while for the IoT Agency layer, the concerns are related to how information should be treated, i.e., how long it will be stored, whether is it possible to exchange information with other firms or authorities, and other such concerns. Network-layer regulations on the Internet network should still be imposed. Figure 2 shows a conceptual diagram of the vertical and horizontal framework explained in the two sections above.

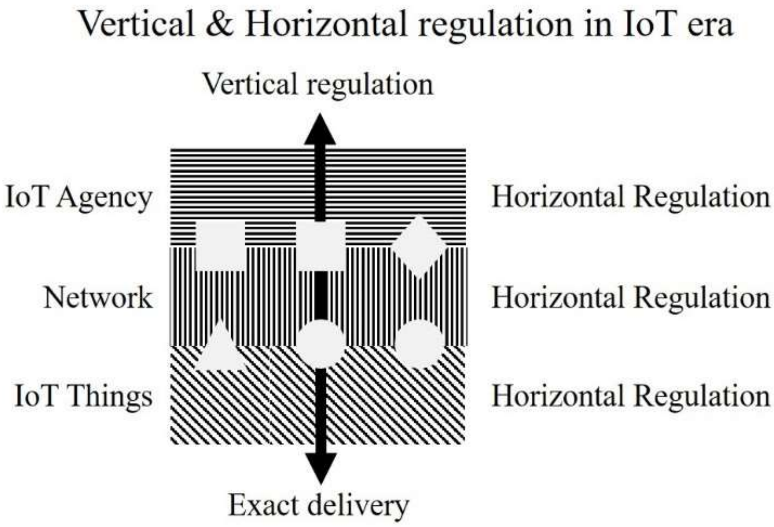

Figure 4.2 Vertical and Horizontal Regulation

4.5.2.3 Expansion of Innovation

As explained in section 4.3.4, in IoT-era innovations should occur at all three layers composing an IoT service. In addition, regulatory or policy tools should make the innovations at each layer increase equally via the isotropic expansion of innovations at these layers. Figure 4.3 shows a conceptual diagram of the isotropic expansion of innovation.

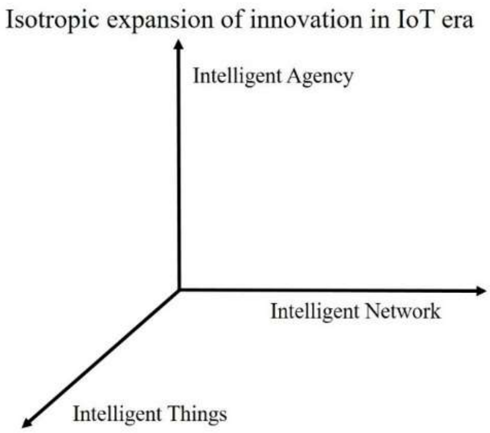

Figure 4.3 Isotropic Expansion of Innovation

4.5.2.4 Regulation on IoT agency layer

Regulations banning gate-keeping and discrimination by the network layer in the Internet era should be maintained in the IoT era. Assuming that these regulations on the network layer is maintained, Internet services, consisting of content providers, networks and users, appear to be equal to IoT services, consisting of the IoT Things, IoT Agencies, and users, as shown in Figure 4.4. Subsequently, similar regulations should be imposed on the IoT Agency, in this case no information-keeping and no discrimination against IoT Things.

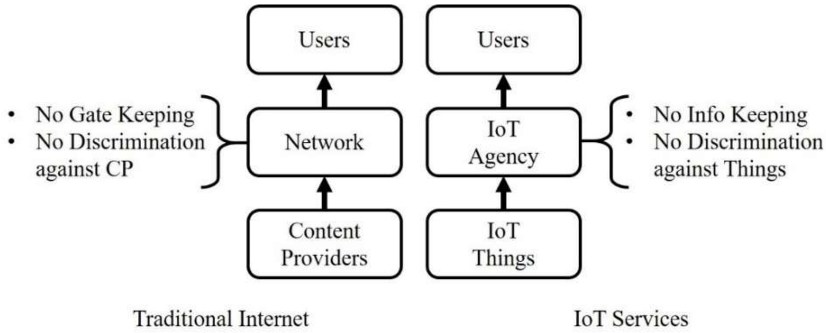

Figure 4.4 Role of IoT Agency in IoT era

IoT Agency should collect indispensable information from IoT Things and notify to users what kind of information would be collected and how the information is managed. In addition, information-keeping activities such as collecting additional information and the arbitrary treatment of information beyond the contract with the user should be prohibited.

Information keeping may be more serious in case that when IoT Things and IoT Agency are vertically integrated in a single firm, IoT Agency may can control arbitrarily IoT Things via Internet without notice to users. Hence, regulatory tools are needed, under which users can select IoT Things and IoT Agency respectively and IoT Agency cannot discriminate IoT Things.

4.5.3 New Regulation Framework: Isotropic Dynamics Regulation

Telecommunication is basically point-to-point vertical communication and is therefore thought to have one dimension. Internet communication is separated into the two areas of the network and the content with a horizontal boundary line and is thus considered to have two dimensions. Similarly, an IoT is interpreted to have three dimensions because it has three layers, and there are IoT Things everywhere in the three-dimensional space. The vertical and horizontal regulation in Figure 4.2 appears two-dimensional but considering the overlapped image of Figure 4.2 due to IoT Things existing everywhere and the isotropic expansion of innovation as shown in Figure 4.3, it is a good introduction to the Isotropic Dynamics Regulation Framework, which is shown in Figure 4.5. If only observing the shape, it can be called a Cubic Regulation Framework, but this cubic structure is not static and does not have a fixed position.

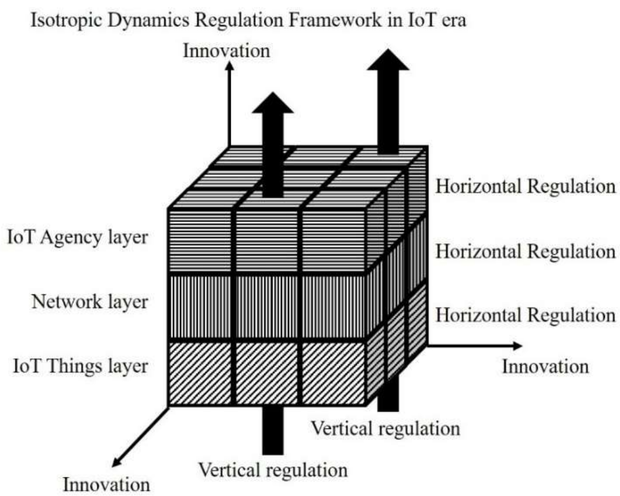

Figure 4.5 Isotropic Dynamics Regulation Framework

The word 'Isotropic' assumes the isotropic expansion of innovations at all three layers, and 'Dynamics' means that as technologies advance, the tools of vertical and horizontal regulation may change to adopt innovative technologies and services.

4.6 Chapter Conclusion

An isotropic dynamics regulation framework in the emerging IoT era is proposed in this dissertation. It synthesizes vertical regulation concerns in the telecommunication era, horizontal regulation concerns, and concerns over the expansion of innovations.

An empirical analysis using a mixed logit analysis with a conjoint survey was conducted to investigate users' preference on the IoT service. Empirical analysis result shows that IoT users consider innovations, the exact delivery of information, an absence of vertical integration, and detailed solutions as equally important. Moreover, the analysis result showed that IoT users are most concerned about big data analysis, and highest WTP was for the absence of a vertically integrated status for IoT Things and the IoT Agency layer. Hence, regulations which mandate the absence of information keeping as well as the absence of discrimination against IoT Things should be imposed on the IoT Agency layer.

Following the basic value of IoT; innovative integration of information and empirical analysis result, this dissertation proposes an isotropic dynamics regulation framework. For the precise delivery of information, standardization for new NFC technologies and mobile technologies is needed, as is rule-setting related to public and private Internet networks.

These are vertical regulation concerns. Considering the horizontal regulation framework, regulations should be identical for each of the three layers in an IoT service. However, on the IoT Agency layer, no information keeping and no discrimination against IoT Things should be imposed. In addition, the regulation framework should enable innovations to expand at all three layers isotropically. Hence, the isotropic dynamics regulation framework for IoT services proposed in this dissertation located in three-dimensional space.

It may appeal that the IoT is an emerging and premature service and market, implying that it is too early or not the proper time to discuss such regulations. And some research results and policy directions argue that the personal information and privacy protection is the main concern and issue in the IoT era. However, the change from telecommunications to the Internet led to much confusion regrading communications regulations. Hence, anticipative discussions or efforts to prepare mature IoT services without regulatory confusion are needed at this time.

Chapter 5. Overall conclusion

5.1 Summary of results

The three research results of chapters 2 to 4 describe, respectively, (1) the main factor of fast Internet network diffusion factor is the abundant available content, (2) the most efficient pricing strategy of Internet content providers is free-of-charge pricing with other advertisement revenue streams (very different from traditional industrial goods and services), and (3) for new Internet-based IoT services, the isotropic dynamics regulation framework should be imposed on IoT services.

The main finding of chapter 2 is that the various and abundant amounts of content affect the Internet diffusion speed and can increase the speed. Another meaningful finding of this dissertation is that the factors affecting the broadband diffusion speed vary according to the diffusion stage, i.e., whether it is in the early stage, which is the diffusion take-off stage, or the mature stage, which is the saturated stage of diffusion.

At the early stage of diffusion, the number of subscribers at the take-off time is important for faster broadband diffusion, which means a direct network effect. However, in the mature or saturated stages, the amount of available content at the take-off time is important, which infers an indirect network effect.

Policy implication for countries in the early stage of broadband diffusion is as follows: Gathering more subscribers for early take-off and rapid diffusion is important, but with the anticipation of fast diffusion after take-off and finally in the saturation stage, it is also important to promote various and abundant forms of Internet content from the time of the early stage of diffusion.

In a word, it can be inferred that the two industries surrounding the Internet, which are networks industry and contents industry, have indivisible relation for the Internet diffusion. So, they should try to make the Internet more innovative altogether.

The result of chapter 3 shows that free-of-charge pricing with additional online advertisement revenue is the most efficient strategy for Internet content providers through meta-frontier analysis. This strategy is very different from that of traditional industrial goods or service firms and can be called a new business model in the Internet era.

On the view of innovation diffusion, this business model has help very much to the diffusion of the Internet. On the demand side of Internet users, because they can consume digital contents with zero or very low price, more and more services and contents are available on the Internet. And on the supply side of content providers, additional revenue source by online advertisement have made entry and exit to market easier even though they are just start-ups with new ideas.

The new regulation framework in the IoT era is proposed in chapter 4, which is a conceptual framework rather than a practical framework. This new regulation framework synthesizes vertical regulation concerns in the telecommunication era for the precise delivery of information, horizontal regulation concerns in the Internet era owing to the three layers of IoT services, and concerns over the isotropic expansion of innovations in all three layers.

The IoT Things layer is a new layer of IoT services but other regulations similar to those of the network layer in the traditional Internet service should be imposed on the IoT Agency layer, specifically no information keeping and no discrimination against the IoT Things layer.

Empirical analysis by a mixed logit method and a conjoint survey support the isotropic dynamics regulation framework and additional regulations on the IoT Agency layer.

It may appear that the IoT is an emerging and premature service and market such that it is too early or not the correct time to mention regulation. However, anticipative discussions or efforts to prepare for mature IoT services without regulatory confusion are needed at this time.

5.2 Further Research Challenges: Integration of Information

This dissertation focuses on and emphasize the diffusion of the Internet and its innovation. However, nowadays new types of contents and services based on the Internet have emerged, which are the integrated contents and services.

A VR (Virtual Reality) content is new and emerging content, the material of which is very close to the real world. At now, the beginning of VR, it is not distributed via the Internet, because it has tremendous data volume not like traditional Internet content.

However, it will be distributed via the Internet network as Internet network will also advance to support transport VR contents seamlessly. Hence, in the near future the VR content, Internet network, and device to display VR content will be integrated and become a just VR service.

IoT service is also another case of technology integration. The sensing device, Internet network, and analysis of raw information comprises one IoT service. And it started to launch at the market.

In above two paragraph, it could be concluded that the Internet related integration comes from technological integration: hardware (VR displaying device or IoT sensing device), Internetwork, and software (VR contents or analysis algorithm). Integration of technologies is very important, however, another integration has occurred in the Internet based new contents and services: integration of information.

VR content user feel as he or she is surrounded by the circumstance provided by VR content, because VR content provides the information close to the real world. And technology advance with time, the VR content's information exceeds audio and video information and information of touch, smell, and taste could be provided by VR content. It's the integration of information.

Sensing devices, which is called as IoT Things in this dissertation, can collect more precise information beyond human being's capability. They can sense location, altitude, moving speed, quality of environment, any difference in the space, and so on. IoT service application, which is called IoT Agency layer in this dissertation, analyze this integrated information with integrated method and algorithm such as bigdata analysis. And this dissertation argues that the basic value of the IoT is the innovative integration of information.

At the corner of information integration supported by technology integration, it should be considered: For what information and technology is integrated? Here are two main concerns.

The first is that the integrated information may influence individual users. Misused information in the VR content can make users misunderstand whether it is 'virtual' or 'reality'. IoT service users offer their raw information to the IoT application, so misused information by IoT application may give birth to great harm to users. Hence, anyone who deal with integrated information should be very careful not to harm their user, and further Internet related policy should have two direction that the content composed of integrated information should be distinct between 'virtual' and 'reality' and services collecting raw information notify the kind of collected information to the users.

The other is that the integrated information and technology is more effective in the developing countries especially in the area of public services. Network or communication technologies can reduce transaction cost, and this reduced cost can evoke innovative activities. The integrated information and technology can reduce more transaction cost, which developing countries could endure. Public services, such as environment monitoring, disaster monitoring, education systems, and etc., are more important in the developing countries. So, worldwide ICT policy should target the innovative Internet based services and contents with integrated information and technology should be deployed in the developing countries as well as developed countries, which means the digital dividends should be spread worldwide (World Bank, 2016).

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Appendix 2-1: Analyzed countries in Ch. 2

(1) By Region

East Asia and the Pacific (36 countries)

Eastern Asia (7 countries)

China, Hong Kong SAR China, Japan, Korea Dem. People′s Rep. [1), 2)], Korea Rep., Macao SAR China, Mongolia,

South-Eastern Asia (11countries)

Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar[2)], Philippines, Singapore, Thailand, Timor-Leste, Vietnam

Pacific (18 countries)

American Samoa[1), 2)], Australia, Fiji, French Polynesia[2)], Guam[2)], Kiribati, Marshall Islands[1), 2)], Micronesia Fed. Sts., New Caledonia[2)], New Zealand, Northern Mariana Islands[1), 2)], Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu[1), 2)], Vanuatu[1), 2)]

Europe and Central Asia (58 countries)

Eastern Europe (10 countries)

Belarus, Bulgaria, Czech Republic, Hungary, Moldova, Poland, Romania, Russian Federation, Slovak Republic, Ukraine

Northern Europe (13 countries)

Denmark, Estonia, Faroe Islands[2)], Finland, Greenland[2)], Iceland, Ireland, Isle of Man[1), 2)], Latvia, Lithuania, Norway, Sweden, United Kingdom

Southern Europe (15 countries)

Albania, Andorra[2)], Bosnia and Herzegovina, Croatia, Greece, Italy, Kosovo[1), 2)], Macedonia FYR, Malta, Montenegro, Portugal, San Marino[2)], Serbia, Slovenia, Spain

Western Europe (10 countries)

Austria, Belgium, Channel Islands[1), 2)], France, Germany, Liechtenstein[2)], Luxembourg, Monaco[2)], Netherlands, Switzerland

Central Asia (5 countries)

Kazakhstan, Kyrgyz Republic[1), 2)], Tajikistan, Turkmenistan, Uzbekistan[1), 2)]

Western Asia (5 countries)

Armenia, Azerbaijan, Cyprus, Georgia, Turkey

Latin America and the Caribbean (41 countries)

Caribbean (21 countries)

Antigua and Barbuda, Aruba[2)], Bahamas[1), 2)], Barbados, Cayman Islands[2)], Cuba, Curacao[2)], Dominica, Dominican Republic, Grenada, Haiti[1), 2)], Jamaica, Puerto Rico, Sint Maarten (Dutch part) [1), 2)], St. Kitts and Nevis, St. Lucia, St. Martin (French part) [1)], St. Vincent and the Grenadines, Trinidad and Tobago, Turks and Caicos Islands[1), 2)], Virgin Islands (U.S.) [2)]

Central America (8 countries)

Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama

South America (12 countries)

Argentina[2)], Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela

Middle East and North Africa (19 countries)

Western Asia (13 countries)

Bahrain, Iraq[1), 2)], Israel, Jordan, Kuwait, Lebanon[1), 2)], Oman, Qatar, Saudi Arabia[1), 2)], Syrian Arab Republic[2)], United Arab Emirates, West Bank and Gaza, Yemen Rep.

Northern Africa (6 countries)

Algeria, Egypt Arab Rep., Libya, Morocco, Sudan[1), 2)], Tunisia

North America (3 countries)

Bermuda, Canada, United States

South Asia (9 countries)

Afghanistan, Bangladesh[1), 2)], Bhutan, India, Iran Islamic Rep., Maldives, Nepal, Pakistan, Sri Lanka

Sub-Saharan Africa (48 countries)

Eastern Africa (18 countries)

Burundi, Comoros, Djibouti, Eritrea, Ethiopia, Kenya, Madagascar[1), 2)], Malawi[1), 2)], Mauritius, Mozambique, Rwanda, Seychelles, Somalia[2)], South Sudan[1), 2)], Tanzania, Uganda, Zambia, Zimbabwe[1), 2)]

Middle Africa (9 countries)

Angola[1), 2)], Cameroon, Central African Republic[1), 2)], Chad[1), 2)], Congo Dem. Rep. [1), 2)], Congo Rep. [1), 2)], Equatorial Guinea, Gabon[1), 2)], Sao Tome and Principe

Southern Africa (5 countries)

Botswana, Lesotho, Namibia, South Africa, Swaziland

Western Africa (16 countries)

Benin, Burkina Faso, Cabo Verde, Cote d'Ivoire[1), 2)], Gambia[1), 2)], Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria[1), 2)], Senegal, Sierra Leone[1), 2)], Togo[1), 2)]

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(2) By Income Level

High income: OECD (32 countries)

Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea Rep., Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, United States

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High income: non-OECD (47 countries)

Andorra[2)], Antigua and Barbuda, Argentina[2)], Aruba[2)], Bahamas[1), 2)], Bahrain, Barbados, Bermuda, Brunei Darussalam, Cayman Islands[2)], Channel Islands[1)], Croatia, Curacao[2)], Cyprus, Equatorial, Guinea, Faroe Islands[2)], French Polynesia[2)], Greenland[2)], Guam[2)], Hong Kong SAR China, Isle of Man[1), 2)], Kuwait, Latvia, Liechtenstein[2)], Lithuania, Macao SAR China, Malta, Monaco[2)], New Caledonia[2)], Northern Mariana Islands[1), 2)], Oman, Puerto Rico, Qatar, Russian Federation, San Marino[2)], Saudi Arabia[1), 2)], Seychelles, Singapore, Sint Maarten (Dutch part) [1), 2)], St. Kitts and Nevis, St. Martin (French part) [1), 2)], Trinidad and Tobago, Turks and Caicos Islands[1), 2)], United Arab Emirates, Uruguay, Venezuela RB, Virgin Islands (U.S.) [2)]

Upper middle income (53 countries)

Albania, Algeria, American Samoa[1), 2)], Angola[1), 2)], Azerbaijan, Belarus, Belize, Bosnia and Herzegovina, Botswana, Brazil, Bulgaria, China, Colombia, Costa Rica, Cuba, Dominica, Dominican Republic, Ecuador, Fiji, Gabon[1), 2)], Grenada, Iran Islamic Rep.,

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Iraq[1), 2)], Jamaica, Jordan, Kazakhstan, Lebanon[1), 2)], Libya, Macedonia FYR, Malaysia, Maldives, Marshall Islands[1), 2)], Mauritius, Mexico, Mongolia, Montenegro, Namibia, Palau, Panama, Paraguay, Peru, Romania, Serbia, South Africa, St. Lucia, St. Vincent and the Grenadines, Suriname, Thailand, Tonga, Tunisia, Turkey, Turkmenistan, Tuvalu[1), 2)]

Lower middle income (51 countries)

Armenia, Bangladesh[1), 2)], Bhutan, Bolivia, Cabo Verde, Cameroon, Congo Rep. [1), 2)], Cote d'Ivoire[1), 2)], Djibouti, Egypt Arab Rep., El Salvador, Georgia, Ghana, Guatemala, Guyana, Honduras, India, Indonesia, Kenya, Kiribati, Kosovo[1), 2)], Kyrgyz Republic[1), 2)], Lao PDR, Lesotho, Mauritania, Micronesia Fed. Sts., Moldova, Morocco, Myanmar[2)], Nicaragua, Nigeria[1), 2)], Pakistan, Papua New Guinea, Philippines, Samoa, Sao Tome and Principe, Senegal, Solomon Islands, Sri Lanka, Sudan[1), 2)], Swaziland, Syrian Arab Republic[2)], Tajikistan, Timor-Leste, Ukraine, Uzbekistan[1), 2)], Vanuatu[1), 2)], Vietnam, West Bank and Gaza, Yemen Rep., Zambia

Low income (31 countries)

Afghanistan, Benin, Burkina Faso, Burundi, Cambodia, Central African Republic[1), 2)], Chad[1), 2)], Comoros, Congo Dem. Rep. [1), 2)], Eritrea, Ethiopia, Gambia[1), 2)], Guinea, Guinea-Bissau, Haiti[1), 2)], Korea Dem. People′s Rep. [1), 2)], Liberia, Madagascar[1), 2)], Malawi[1)], Mali, Mozambique, Nepal, Niger, Rwanda, Sierra Leone[1), 2)], Somalia[2)], South Sudan[1), 2)], Tanzania, Togo[1), 2)], Uganda, Zimbabwe[1), 2)]

Remark 1) Thirty six countries were excluded from analysis because of SPEED; the maximum diffusion speed cannot be estimated.

Remark 2) Fifty three countries were excluded from analysis because GDP per capita based on PPP is not reported.

Appendix 2-2: Analyzed data in Ch. 2

No.	Country	Region	Income Level	SPEED	YEAR take-off	FBS
		URBAN	**FOP**	**CONTENT**	**GDP**	**YEAR saturation**
1	Afghanistan	South Asia	Low income	0.001	2005	0.001
		22.895	69	0.005	0.104	2011
2	Albania	Europe & Central Asia	Upper middle income	0.943	2006	0.162
		47.815	50	0.016	0.707	2015
3	Algeria	Middle East & North Africa	Upper middle income	0.472	2005	0.398
		63.830	61	0.739	1.098	2010
4	Antigua and Barbuda	Latin America & Caribbean	High income: nonOECD	2.009	2004	2.034
		29.837	40	0.085	1.759	2013
5	Armenia	Europe & Central Asia	Lower middle income	2.160	2009	1.344
		63.789	66	0.053	0.616	2011
6	Australia	East Asia & Pacific	High income: OECD	9.626	2004	5.005
		87.849	18	289.212	3.131	2007
7	Austria	Europe & Central Asia	High income: OECD	2.889	2000	2.375
		65.800	14	8.895	2.957	2010
8	Azerbaijan	Europe & Central Asia	Upper middle income	5.322	2009	1.113
		53.190	79	0.133	1.490	2013
9	Bahrain	Middle East & North Africa	High income: nonOECD	3.595	2006	4.062
		88.419	71	0.919	4.022	2016
10	Barbados	Latin America & Caribbean	High income: nonOECD	2.870	2001	0.000
		33.651	16	0.037	1.139	2009
11	Belarus	Europe & Central Asia	Upper middle income	6.612	2007	1.772
		73.273	91	23.098	1.235	2011
12	Belgium	Europe & Central Asia	High income: OECD	3.930	2000	1.404
		97.128	9	7.837	2.828	2008
13	Belize	Latin America & Caribbean	Upper middle income	0.857	2003	0.364
		46.851	22	0.060	0.647	2011
14	Benin	Sub-Saharan Africa	Low income	0.123	2007	0.008
		40.703	31	0.032	0.165	2012
15	Bermuda	North America	High income: nonOECD	20.627	2004	0.000
		100.000	18	123.893	4.784	2012
16	Bhutan	South Asia	Lower middle income	0.610	2008	0.298
		33.236	61	0.011	0.542	2012
17	Bolivia	Latin America & Caribbean	Lower middle income	0.165	2005	0.139
		64.194	33	2.766	0.418	2006
18	Bosnia and Herzegovina	Europe & Central Asia	Upper middle income	2.623	2006	1.032
		39.181	37	0.626	0.733	2007

No.	Country	Region	Income Level	SPEED	YEAR take-off	FBS
		URBAN	FOP	CONTENT	GDP	YEAR saturation
19	Botswana	Sub-Saharan Africa	Upper middle income	0.218	2007	0.185
		55.539	36	0.494	1.231	2019
20	Brazil	Latin America & Caribbean	Upper middle income	1.213	2004	1.716
		82.521	40	3.564	1.032	2018
21	Brunei Darussalam	East Asia & Pacific	High income: nonOECD	0.624	2002	0.796
		72.136	76	1.070	6.322	2010
22	Bulgaria	Europe & Central Asia	Upper middle income	3.076	2004	0.086
		70.233	35	0.770	0.916	2015
23	Burkina Faso	Sub-Saharan Africa	Low income	0.041	2006	0.012
		22.339	39	0.029	0.117	2015
24	Burundi	Sub-Saharan Africa	Low income	0.004	2010	0.004
		10.641	74	0.000	0.069	2024
25	Cabo Verde	Sub-Saharan Africa	Lower middle income	1.284	2007	0.792
		59.363	28	0.013	0.537	2009
26	Cambodia	East Asia & Pacific	Low income	0.047	2007	0.061
		19.413	60	0.018	0.219	2009
27	Cameroon	Sub-Saharan Africa	Lower middle income	0.027	2009	0.004
		50.928	66	0.459	0.248	2013
28	Canada	North America	High income: OECD	3.654	1999	1.913
		79.103	14	28.798	2.766	2018
29	Chile	Latin America & Caribbean	High income: OECD	1.396	2002	1.191
		86.648	22	1.269	1.054	2012
30	China	East Asia & Pacific	Upper middle income	1.519	2004	1.903
		41.144	82	9.471	0.442	2017
31	Colombia	Latin America & Caribbean	Upper middle income	1.226	2005	0.738
		73.581	61	2.766	0.825	2013
32	Comoros	Sub-Saharan Africa	Low income	0.067	2010	0.048
		27.918	48	0.062	0.132	2010
33	Costa Rica	Latin America & Caribbean	Upper middle income	1.965	2006	1.897
		66.932	20	3.439	1.064	2012
34	Croatia	Europe & Central Asia	High income: nonOECD	3.955	2005	2.648
		56.406	39	0.293	1.554	2020
35	Cuba	Latin America & Caribbean	Upper middle income	0.008	2006	0.000
		76.227	96	3.439	1.463	2010
36	Cyprus	Europe & Central Asia	High income: nonOECD	3.733	2004	1.680
		68.410	22	0.607	2.560	2011
37	Czech Republic	Europe & Central Asia	High income: OECD	3.743	2003	0.340
		73.740	23	1.720	1.961	2009
38	Denmark	Europe & Central Asia	High income: OECD	6.385	2001	4.445
		85.150	9	0.629	3.025	2015
39	Djibouti	Sub-Saharan Africa	Lower middle income	0.383	2007	0.137
		76.853	72	1.025	0.230	2017

No.	Country	Region	Income Level	SPEED	YEAR take-off	FBS
		URBAN	FOP	CONTENT	GDP	YEAR saturation
40	Dominica	Latin America & Caribbean	Upper middle income	1.257	2001	0.251
		65.382	16	0.037	0.665	2007
41	Dominican Republic	Latin America & Caribbean	Upper middle income	0.672	2004	0.405
		65.995	38	2.232	0.711	2014
42	Ecuador	Latin America & Caribbean	Upper middle income	1.621	2009	1.635
		62.495	47	5.332	0.889	2015
43	Egypt, Arab Rep.	Middle East & North Africa	Lower middle income	0.486	2006	0.354
		43.073	62	0.919	0.790	2015
44	El Salvador	Latin America & Caribbean	Lower middle income	0.530	2005	0.697
		61.648	43	2.766	0.628	2018
45	Equatorial Guinea	Sub-Saharan Africa	High income: nonOECD	0.124	2010	0.170
		39.223	90	0.050	3.639	2011
46	Eritrea	Sub-Saharan Africa	Low income	0.001	2007	0.000
		19.518	94	0.007	0.139	2010
47	Estonia	Europe & Central Asia	High income: OECD	3.862	2001	1.288
		69.242	18	0.283	1.055	2009
48	Ethiopia	Sub-Saharan Africa	Low income	0.493	2012	0.009
		18.160	82	0.009	0.126	2013
49	Fiji	East Asia & Pacific	Upper middle income	0.549	2004	0.000
		49.479	30	3.495	0.677	2006
50	Finland	Europe & Central Asia	High income: OECD	6.998	2002	5.259
		82.503	10	1.184	2.842	2007
51	France	Europe & Central Asia	High income: OECD	4.969	2002	2.756
		76.380	17	7.909	2.850	2010
52	Georgia	Europe & Central Asia	Lower middle income	2.382	2008	2.541
		52.625	60	0.148	0.616	2022
53	Germany	Europe & Central Asia	High income: OECD	5.105	2002	3.830
		73.174	15	15.498	2.844	2009
54	Ghana	Sub-Saharan Africa	Lower middle income	0.088	2008	0.099
		49.351	26	0.347	0.275	2014
55	Greece	Europe & Central Asia	High income: OECD	4.284	2005	1.450
		74.452	28	0.752	2.540	2011
56	Grenada	Latin America & Caribbean	Upper middle income	2.229	2004	0.593
		35.963	20	0.085	0.908	2011
57	Guatemala	Latin America & Caribbean	Lower middle income	0.345	2006	0.300
		47.593	59	3.439	0.589	2011
58	Guinea	Sub-Saharan Africa	Low income	0.004	2009	0.000
		34.426	71	0.045	0.114	2017
59	Guinea-Bissau	Sub-Saharan Africa	Low income	0.045	2009	0.000
		44.342	54	0.018	0.126	2012
60	Guyana	Latin America & Caribbean	Lower middle income	1.138	2009	0.874

No.	Country	Region	Income Level	SPEED	YEAR take-off	FBS
		URBAN	FOP	CONTENT	GDP	YEAR saturation
		28.221	30	0.202	0.538	2013
61	Honduras	Latin America & Caribbean	Lower middle income	0.332	2010	0.013
		51.696	61	6.020	0.425	2016
62	Hong Kong SAR, China	East Asia & Pacific	High income: nonOECD	4.318	1999	1.284
		100.000	28	2.197	2.470	2015
63	Hungary	Europe & Central Asia	High income: OECD	3.377	2003	2.606
		65.489	20	0.668	1.564	2006
64	Iceland	Europe & Central Asia	High income: OECD	6.525	2001	3.670
		92.532	8	0.050	3.126	2014
65	India	South Asia	Lower middle income	0.253	2006	0.201
		29.569	35	3.993	0.317	2011
66	Indonesia	East Asia & Pacific	Lower middle income	0.269	2006	0.085
		46.732	54	1.867	0.653	2011
67	Iran, Islamic Rep.	South Asia	Upper middle income	2.560	2010	1.326
		70.626	91	3.960	1.716	2011
68	Ireland	Europe & Central Asia	High income: OECD	4.867	2003	1.042
		59.925	16	101.539	3.602	2011
69	Israel	Middle East & North Africa	High income: OECD	5.261	2001	0.716
		91.267	30	0.359	2.496	2009
70	Italy	Europe & Central Asia	High income: OECD	3.584	2002	1.478
		67.382	28	3.105	2.790	2021
71	Jamaica	Latin America & Caribbean	Upper middle income	0.706	2003	0.340
		52.437	17	0.060	0.722	2006
72	Japan	East Asia & Pacific	High income: OECD	3.833	2000	0.680
		78.649	23	4.513	2.594	2006
73	Jordan	Middle East & North Africa	Upper middle income	1.450	2006	0.896
		81.442	61	0.919	0.902	2008
74	Kazakhstan	Europe & Central Asia	Upper middle income	2.320	2008	2.167
		54.111	78	26.840	1.930	2010
75	Kenya	Sub-Saharan Africa	Lower middle income	0.034	2008	0.008
		22.800	60	0.394	0.230	2009
76	Kiribati	East Asia & Pacific	Lower middle income	0.157	2003	0.000
		43.512	27	2.481	0.149	2008
77	Korea, Rep.	East Asia & Pacific	High income: OECD	4.825	1998	0.031
		79.145	28	0.386	1.470	2014
78	Kuwait	Middle East & North Africa	High income: nonOECD	0.269	2000	0.000
		98.113	48	0.195	5.890	2017
79	Lao PDR	East Asia & Pacific	Lower middle income	0.021	2006	0.013
		28.537	81	0.005	0.290	2028
80	Latvia	Europe & Central Asia	High income: nonOECD	7.479	2005	2.728
		68.000	19	0.371	1.412	2011
81	Lesotho	Sub-Saharan Africa	Lower middle income	0.035	2009	0.020

No.	Country	Region	Income Level	SPEED	YEAR take-off	FBS
		URBAN	FOP	CONTENT	GDP	YEAR saturation
		24.259	48	0.684	0.202	2007
82	Liberia	Sub-Saharan Africa	Low income	0.142	2012	0.013
		48.541	56	0.553	0.078	2006
83	Libya	Middle East & North Africa	Upper middle income	1.141	2007	0.000
		77.175	94	1.025	2.675	2006
84	Lithuania	Europe & Central Asia	High income: nonOECD	3.965	2003	1.977
		66.737	18	0.344	1.232	2016
85	Luxembourg	Europe & Central Asia	High income: OECD	6.961	2003	3.434
		85.743	12	29.217	6.093	2013
86	Macao SAR, China	East Asia & Pacific	High income: nonOECD	4.525	2002	3.817
		100.000	80	5.385	3.754	2008
87	Macedonia, FYR	Europe & Central Asia	Upper middle income	3.054	2005	0.595
		57.527	49	0.029	0.821	2013
88	Malaysia	East Asia & Pacific	Upper middle income	1.374	2004	0.995
		65.694	69	11.353	1.541	2020
89	Maldives	South Asia	Upper middle income	1.307	2004	0.245
		32.490	68	0.002	0.775	2012
90	Mali	Sub-Saharan Africa	Low income	0.022	2005	0.000
		32.060	24	0.023	0.113	2010
91	Malta	Europe & Central Asia	High income: nonOECD	4.086	2002	4.307
		92.905	13	0.019	1.933	2008
92	Mauritania	Sub-Saharan Africa	Lower middle income	0.104	2006	0.030
		53.866	55	0.006	0.315	2008
93	Mauritius	Sub-Saharan Africa	Upper middle income	1.834	2006	2.293
		41.412	26	0.267	1.210	2008
94	Mexico	Latin America & Caribbean	Upper middle income	1.932	2005	1.736
		76.308	48	2.766	1.207	2015
95	Micronesia, Fed. Sts.	East Asia & Pacific	Lower middle income	1.131	2012	1.649
		22.317	21	11.137	0.349	2014
96	Moldova	Europe & Central Asia	Lower middle income	2.432	2007	1.438
		45.110	66	2.290	0.339	2009
97	Mongolia	East Asia & Pacific	Upper middle income	1.172	2008	1.235
		65.581	41	0.085	0.727	2010
98	Montenegro	Europe & Central Asia	Upper middle income	2.205	2005	1.245
		62.200	37	0.200	0.841	2011
99	Morocco	Middle East & North Africa	Lower middle income	0.263	2002	0.007
		53.990	57	0.352	0.399	2007
100	Mozambique	Sub-Saharan Africa	Low income	0.022	2006	0.000
		30.182	40	0.012	0.072	2011
101	Namibia	Sub-Saharan Africa	Upper middle income	0.415	2009	0.022
		40.601	34	0.414	0.780	2014
102	Nepal	South Asia	Low income	0.424	2010	0.224

No.	Country	Region	Income Level	SPEED	YEAR take-off	FBS
		URBAN	FOP	CONTENT	GDP	YEAR saturation
		16.822	59	0.043	0.196	2025
103	Netherlands	Europe & Central Asia	High income: OECD	6.527	2001	2.923
		77.830	15	4.463	3.280	2010
104	New Zealand	East Asia & Pacific	High income: OECD	4.554	2003	2.064
		86.000	10	101.539	2.396	2008
105	Nicaragua	Latin America & Caribbean	Lower middle income	0.284	2005	0.193
		55.933	44	2.766	0.338	2018
106	Niger	Sub-Saharan Africa	Low income	0.036	2013	0.036
		18.220	52	0.065	0.091	2012
107	Norway	Europe & Central Asia	High income: OECD	6.231	2002	4.526
		76.999	9	0.357	3.773	2015
108	Oman	Middle East & North Africa	High income: nonOECD	0.679	2007	0.785
		73.527	71	1.025	4.162	2022
109	Pakistan	South Asia	Lower middle income	0.208	2008	0.101
		35.816	62	2.672	0.412	2022
110	Palau	East Asia & Pacific	Upper middle income	2.938	2010	1.168
		83.358	14	9.425	1.216	2007
111	Panama	Latin America & Caribbean	Upper middle income	1.658	2004	0.507
		63.377	44	2.232	0.949	2008
112	Papua New Guinea	East Asia & Pacific	Lower middle income	0.027	2007	0.000
		13.073	28	6.004	0.180	2012
113	Paraguay	Latin America & Caribbean	Upper middle income	0.548	2007	0.140
		57.806	60	3.847	0.619	2010
114	Peru	Latin America & Caribbean	Upper middle income	0.571	2004	0.831
		74.644	40	2.232	0.619	2027
115	Philippines	East Asia & Pacific	Lower middle income	5.720	2010	1.843
		45.255	46	4.621	0.552	2014
116	Poland	Europe & Central Asia	High income: OECD	3.073	2004	2.291
		61.564	20	3.992	1.305	2009
117	Portugal	Europe & Central Asia	High income: OECD	2.475	2001	0.960
		55.044	15	0.290	1.859	2023
118	Puerto Rico	Latin America & Caribbean	High income: nonOECD	3.528	2005	3.144
		94.112	16	2.871	3.339	2015
119	Qatar	Middle East & North Africa	High income: nonOECD	2.085	2003	0.453
		96.868	61	0.423	9.424	2014
120	Romania	Europe & Central Asia	Upper middle income	2.947	2004	0.471
		53.043	47	1.333	0.891	2015
121	Russian Federation	Europe & Central Asia	High income: nonOECD	2.380	2005	1.104
		73.463	72	16.396	1.182	2010
122	Rwanda	Sub-Saharan Africa	Low income	0.006	2004	0.012
		18.426	84	0.194	0.084	2010

No.	Country	Region	Income Level	SPEED	YEAR take-off	FBS
		URBAN	FOP	CONTENT	GDP	YEAR saturation
123	Samoa	East Asia & Pacific	Lower middle income	0.441	2012	0.574
		19.639	29	11.137	0.576	2012
124	Sao Tome and Principe	Sub-Saharan Africa	Lower middle income	0.068	2005	0.000
		58.010	29	0.010	0.208	2012
125	Senegal	Sub-Saharan Africa	Lower middle income	0.098	2004	0.070
		40.943	37	0.019	0.177	2008
126	Serbia	Europe & Central Asia	Upper middle income	2.445	2006	1.493
		54.793	39	0.249	0.989	2010
127	Seychelles	Sub-Saharan Africa	High income: nonOECD	2.426	2007	3.919
		51.522	59	0.335	1.976	2014
128	Singapore	East Asia & Pacific	High income: nonOECD	3.079	2000	1.761
		100.000	68	1.011	4.093	2010
129	Slovak Republic	Europe & Central Asia	High income: OECD	2.839	2004	1.462
		55.713	21	0.570	1.499	2012
130	Slovenia	Europe & Central Asia	High income: OECD	3.909	2002	2.851
		50.777	19	0.149	2.013	2010
131	Solomon Islands	East Asia & Pacific	Lower middle income	0.122	2005	0.096
		17.832	30	4.330	0.143	2009
132	South Africa	Sub-Saharan Africa	Upper middle income	0.894	2011	1.746
		62.746	34	3.884	1.229	2022
133	Spain	Europe & Central Asia	High income: OECD	3.310	2001	1.145
		76.343	17	1.762	2.322	2013
134	Sri Lanka	South Asia	Lower middle income	0.360	2007	0.312
		18.357	67	0.059	0.696	2015
135	St. Kitts and Nevis	Latin America & Caribbean	High income: nonOECD	5.165	2002	1.065
		32.427	18	0.048	1.630	2018
136	St. Lucia	Latin America & Caribbean	Upper middle income	1.750	2003	0.865
		25.216	11	0.060	0.828	2012
137	St. Vincent and the Grenadines	Latin America & Caribbean	Upper middle income	1.825	2003	1.058
		46.272	14	0.060	0.736	2009
138	Suriname	Latin America & Caribbean	Upper middle income	1.492	2008	1.117
		66.479	23	0.002	1.316	2006
139	Swaziland	Sub-Saharan Africa	Lower middle income	0.255	2009	0.128
		21.574	76	0.685	0.740	2010
140	Sweden	Europe & Central Asia	High income: OECD	5.727	2001	6.604
		84.071	8	0.774	2.982	2012
141	Switzerland	Europe & Central Asia	High income: OECD	5.567	2001	1.944
		73.322	8	20.586	3.538	2017
142	Tajikistan	Europe & Central Asia	Lower middle income	0.057	2006	0.000
		26.450	76	0.010	0.165	2007
143	Tanzania	Sub-Saharan Africa	Low income	0.045	2010	0.017

No.	Country	Region	Income Level	SPEED	YEAR take-off	FBS
		URBAN	FOP	CONTENT	GDP	YEAR saturation
		28.114	48	0.063	0.207	2017
144	Thailand	East Asia & Pacific	Upper middle income	1.008	2005	0.847
		37.520	50	1.448	1.019	2015
145	Timor-Leste	East Asia & Pacific	Lower middle income	0.012	2007	0.005
		27.564	38	0.000	0.133	2019
146	Tonga	East Asia & Pacific	Upper middle income	0.155	2003	0.022
		23.098	44	2.481	0.416	2012
147	Trinidad and Tobago	Latin America & Caribbean	High income: nonOECD	2.946	2006	1.581
		9.735	24	0.130	2.704	2010
148	Tunisia	Middle East & North Africa	Upper middle income	1.638	2007	0.934
		65.433	81	1.025	0.925	2010
149	Turkey	Europe & Central Asia	Upper middle income	2.021	2004	0.865
		67.180	48	3.564	1.028	2017
150	Turkmenistan	Europe & Central Asia	Upper middle income	0.008	2008	0.002
		47.826	96	0.000	0.853	2015
151	Uganda	Sub-Saharan Africa	Low income	0.084	2010	0.041
		14.492	54	0.531	0.152	2013
152	Ukraine	Europe & Central Asia	Lower middle income	1.409	2006	1.109
		67.969	53	2.987	0.720	2026
153	United Arab Emirates	Middle East & North Africa	High income: nonOECD	1.624	2003	0.900
		81.472	75	0.423	8.556	2009
154	United Kingdom	Europe & Central Asia	High income: OECD	5.126	2002	2.282
		79.047	18	81.348	3.009	2012
155	United States	North America	High income: OECD	3.514	2000	2.484
		79.057	15	46.687	3.645	2013
156	Uruguay	Latin America & Caribbean	High income: nonOECD	3.378	2007	4.943
		93.779	30	3.834	1.350	2013
157	Venezuela, RB	Latin America & Caribbean	High income: nonOECD	0.933	2004	0.800
		88.522	72	2.232	1.190	2015
158	Vietnam	East Asia & Pacific	Lower middle income	0.886	2005	0.247
		27.281	79	2.226	0.310	2020
159	West Bank and Gaza	Middle East & North Africa	Lower middle income	0.694	2005	0.210
		73.061	83	0.739	0.401	2037
160	Yemen, Rep.	Middle East & North Africa	Lower middle income	0.649	2013	1.052
		33.450	76	2.084	0.379	2045
161	Zambia	Sub-Saharan Africa	Lower middle income	0.020	2005	0.002
		36.612	64	0.215	0.222	2012

Appendix 3-1: Analyzed data in Ch. 3

Total Asset (unit: 1,000,000 KRW)

year	Fee_01	Fee_02	Fee_03	Fee_04	Fee_05	Fee_06	Fee_07	Fee_08	Fee_09	Fee_10
2000	10,068	8,456	1,526	8,455	5,325	3,215	6,053	646	101	
2001	11,003	8,451	1,400	10,863	7,289	3,831	4,028	871	553	
2002	8,501	8,492	2,704	12,113	8,769	2,935	3,913	1,774	3,593	
2003	9,947	16,400	3,847	10,293	4,834	3,090	3,199	2,330	5,389	
2004	10,689	16,066	4,462	9,957	4,901	3,624	2,770	4,531	7,743	4,938
2005	8,648	37,807	6,489	6,079	5,460	4,529	2,976	5,675	9,153	5,894
2006	10,412	32,402	7,697	36,367	8,897	5,445	3,706	8,697	8,660	6,632
2007	12,312	35,723	10,151	58,313	10,759	6,813	4,778	7,996	11,846	7,582
2008	12,445	29,614	11,306	26,234	17,449	8,328	5,561	9,754	11,685	8,858
2009	16,021	33,901	12,732	20,590	18,061	10,188	6,023	10,856	12,331	9,570
2010	18,245	32,546	14,615	25,256	19,565	11,187	8,061	8,314	15,514	12,745
2011	20,174	27,824	17,339	27,036	20,549	10,762	9,976	7,923	16,134	16,134
2012	18,779	73,050	23,399	35,358	19,064	14,013	12,063	10,561	19,197	19,078
2013	14,726	82,997	24,574	31,338	17,806	17,495	12,294	12,618	20,360	21,602
2014	12,661	83,386	27,815	21,166	11,856	18,256	12,478	8,761	16,178	24,989

year	Fee_11	Fee_12	Fee_13	Fee_14	Fee_15	Fee_16	Fee_17	Fee_18	Fee_19	Fee_20
2000								82	55,336	
2001								96	65,029	
2002				800				163	64,828	
2003	2,145		1,058	3,001				224	79,698	
2004	2,818		1,547	3,513				801	80,269	
2005	3,838		3,035				4,053	1,518	94,681	
2006	5,929		3,571		4,918			1,747	95,627	
2007	11,592		5,966	37,311	10,543	9,172		2,018	105,463	
2008	11,716		7,634	35,100	13,792	13,759		11,851	116,797	
2009	13,992	14,954	22,447	50,462	17,182	20,536		10,915	152,880	
2010	14,038	19,200	22,531	71,795	25,391	24,203	9,502	11,048	105,390	
2011	12,790	25,450	26,264	67,184	24,982	29,271	8,566	14,964	115,642	5,630
2012	12,468	37,653	26,480	53,665	21,872	31,974	16,930	15,351	131,790	8,431
2013	12,610	54,824	29,860	61,178	20,340	30,564	17,350	15,402	140,688	10,834
2014	14,740	68,421	31,973	70,401	24,012	33,018	17,495	16,240	158,887	13,753

year	Fee_21	Fee_22	Fee_23	Fee_24	Fee_25	Free_01	Free_02	Free_03	Free_04	Free_05
2000					1	931	56,751			
2001					1	1,904	47,204			
2002				4	1	4,803	45,871			
2003				4		7,726	43,197			
2004				3	2	9,815	43,137			
2005					2	13,589	51,408			
2006				4	3	15,872	62,500			
2007				7	4	17,235	68,831	163		

2008				10	6	15,746	71,443	196		
2009	5,052			16	6	18,459	78,401	591		
2010	8,266			17	9	20,717	90,008	1,089		
2011	11,735			23		23,025	116,217	8,913		
2012	6,893	14,270		23	12	23,357	130,219	18,580		
2013	19,780	22,691		17	16	25,570	203,445	16,670		10,951
2014	16,655	20,956	11,774	16	16	29,178	200,491	13,953		15,486

year	Free_06	Free_07	Free_08	Free_09	Mix_01	Mix_02	Mix_03	Mix_04	Mix_05	Mix_06
2000		2			91,971	3,897		89,821	36,402	15,423
2001		1			141,607	4,232	495	88,245	46,007	20,762
2002		1	1		158,635	4,583	932	78,426	125,208	16,342
2003		1	1		212,189	5,128	1,423	62,956	200,687	17,142
2004		2	2	5	313,083	6,455	1,637	59,371	313,307	13,136
2005		2	3	8	348,142	5,098		52,968	373,727	20,162
2006		2	6	11	225,194	5,832		56,164	549,391	28,928
2007		9	11	13	220,875	6,520	1,699	52,450	811,052	34,131
2008		7	14	14	283,193	6,446	1,865	52,103	1,002,359	37,199
2009		4	20	16	297,485	10,671	1,831	50,038	1,304,885	44,085
2010		4	24	16	442,597	17,221	2,872	51,861	1,720,282	35,360
2011		4	47	19	515,332	16,041	4,888	58,590	1,984,793	34,091
2012		8	53	22	133,627	18,002	6,682	57,672	2,641,451	31,400
2013	22,698	18	59	22	218,293	18,111	6,067	61,006	2,260,147	26,809
2014	31,860	14	61	35	2,755,831	16,826	8,270	63,969	2,728,444	25,197

year	Mix_07	Mix_08	Mix_09	Mix_10	Mix_11	Mix_12	Mix_13	Mix_14	Mix_15	Mix_16
2000	1,880	9,705	3,498	10,734			12,808		2	1
2001	835	8,728	4,475	11,442			12,185		2	6
2002	1,173	5,542	4,684	11,770			19,873		15	7
2003	2,007		5,865	12,332			76,388		21	13
2004	5,281		4,981	11,870			59,730		20	12
2005	15,976		6,561	10,998	236		51,313		21	17
2006	17,952	4,982	7,271	13,345	6,740		312,658		33	21
2007	16,619	6,223	9,185	14,342	7,863		306,539		28	63
2008	17,411	7,104	17,979	14,483	17,094		288,550		24	64
2009	18,782	8,022	19,647	15,708	23,475	1,954	296,980		19	71
2010	17,667	10,290	22,733	16,692	29,976	1,567	310,513		21	88
2011	12,278	14,562	41,063	22,087	24,155	640	319,949		25	56
2012	13,310	15,890	42,263	23,698	20,332		265,819		25	57
2013	11,218	19,428	38,842	24,454	33,834		205,792	173,569	19	57
2014	11,936	15,777	38,968	25,665	37,854		176,168	210,785	18	63

Cost of Revenue (unit: 1,000,000 KRW)

year	Fee_01	Fee_02	Fee_03	Fee_04	Fee_05	Fee_06	Fee_07	Fee_08	Fee_09	Fee_10
2000	1,510	1,626	1,017	1,797	688	929	1,156	938	411	
2001	1,544	2,311	876	2,965	1,419	1,928	1,348	1,753	951	
2002	1,079	1,678	2,250	5,394	1,749	3,380	1,313	2,937	1,535	
2003	884	1,840	3,974	3,777	2,070	3,285	1,162	3,295	4,785	

2004	1,090	2,323	5,268	3,563	1,802	4,785	1,068	3,630	6,594	1,638
2005	1,050	4,616	6,854	1,190	2,059	5,123	1,264	3,882	7,029	1,758
2006	1,037	8,983	11,052	4,986	1,456	6,060	1,862	5,107	4,929	2,688
2007	1,197	6,985	11,862	10,656	2,443	8,095	2,048	6,004	6,549	2,901
2008	1,208	7,587	10,545	14,047	3,631	9,585	2,383	7,833	8,353	3,406
2009	1,299	14,937	12,452	9,709	8,135	10,582	3,086	5,384	8,632	4,035
2010	1,605	13,642	14,142	8,980	5,961	12,440	3,584	5,366	8,597	4,980
2011	1,628	13,130	16,334	22,309	6,033	11,195	3,766	6,490	7,886	6,317
2012	1,903	13,314	18,712	22,981	5,605	11,962	4,123	16,183	8,319	7,576
2013	1,788	19,671	22,410	21,263	3,984	11,367	4,308	21,330	7,201	9,769
2014	2,032	25,211	28,262	23,989	3,626	11,680	4,065	27,627	9,650	11,048

year	Fee_11	Fee_12	Fee_13	Fee_14	Fee_15	Fee_16	Fee_17	Fee_18	Fee_19	Fee_20
2000								31	29,734	
2001								157	42,204	
2002				196				451	44,459	
2003	2,238		637	990				743	65,731	
2004	2,768		860	997				926	85,008	
2005	4,168		1,336				1,029	1,346	95,823	
2006	4,875		1,483		601			1,498	119,808	
2007	6,756		1,982	2,537	9,363	2,835		1,605	117,402	
2008	7,755		2,288	5,366	22,740	20,495		2,647	122,134	
2009	8,966	1,710	7,848	5,828	26,968	19,991		3,313	112,883	
2010	9,223	2,202	9,155	10,133	34,426	22,089	3,295	2,622	16,282	
2011	8,972	3,253	10,426	17,420	33,381	23,119	2,964	3,054	97,191	4,002
2012	9,036	3,555	2,213	18,782	29,711	24,235	2,711	3,088	115,133	4,992
2013	10,988	3,030	10,276	19,224	29,981	23,943	2,851	3,150	150,138	5,320
2014	11,987	3,213	10,713	12,393	35,721	24,696	2,771	3,415	198,298	5,570

year	Fee_21	Fee_22	Fee_23	Fee_24	Fee_25	Free_01	Free_02	Free_03	Free_04	Free_05
2000					-	1,075	9,673			
2001					-	854	10,208			
2002				1	-	2,583	10,080			
2003				2		4,396	11,709			
2004				1	-	6,536	14,029			
2005				1	1	7,516	13,906			
2006					1	7,288	14,663			
2007				2	1	8,158	15,697	501		
2008				3	1	8,781	16,326	689		
2009	2,928			4	1	8,207	16,428	1,057		
2010	4,662			5	1	7,830	20,339	2,258		
2011	6,559			6		6,524	21,858	4,173		
2012	9,481	20,600		7	1	4,330	23,496	7,119		
2013	9,641	17,129		7	2	3,747	25,841	10,831		2,418
2014	9,600	14,124	18	18	2	5,383	22,240	12,456		2,662

year	Free_06	Free_07	Free_08	Free_09	Mix_01	Mix_02	Mix_03	Mix_04	Mix_05	Mix_06
2000		2			12,315	1,528		5,497	8,172	12,261
2001		1			8,832	4,045	299	4,768	7,707	11,285
2002		1	-		22,059	4,256	1,619	3,141	14,098	13,360
2003		2	1		44,768	5,113	5,382	1,117	40,476	16,692
2004		1	2	1	65,248	3,445	3,948	3,708	73,684	26,072

2005		1	4	2	64,746	2,173		3,499	101,455	32,037
2006		3	5	2	73,571	2,372		3,155	137,274	28,028
2007		3	7	3	163,010	2,078	5,378	7,066	197,050	31,234
2008		3	9	2	187,952	6,704	6,727	4,244	196,810	33,164
2009		2	11	2	200,015	8,745	5,759	8,478	180,142	38,792
2010		1	13	3	247,602	17,805	7,366	4,425	156,260	33,094
2011		2	17	4	300,650	14,203	5,936	4,949	781,103	36,620
2012		3	19	3	37,066	16,111	6,891	4,613	612,498	34,827
2013	1,451	3	19	4	144,538	3,119	7,051	4,892	633,108	20,853
2014	5,178	4	20	4	300,685	13,381	6,250	4,237	925,265	15,468

year	Mix_07	Mix_08	Mix_09	Mix_10	Mix_11	Mix_12	Mix_13	Mix_14	Mix_15	Mix_16
2000	695	5,903	2,336	666			5,721		2	1
2001	1,351	6,860	3,586	663			4,255		1	2
2002	2,533	6,389	4,420	822			2,518		1	2
2003	3,645		5,161	778			6,885		2	3
2004	6,859		6,563	821			15,299		2	3
2005	10,597		8,120	1,548	135		16,909		2	4
2006	11,420	5,133	9,974	1,403	1,670		152,070		7	5
2007	9,982	6,080	10,952	1,636	7,885		184,401		2	7
2008	6,953	6,028	17,665	2,149	9,253		196,059		3	39
2009	8,665	7,239	22,821	2,818	9,046	2,530	203,603		3	46
2010	9,403	9,695	27,665	3,209	10,673	2,134	224,285		4	53
2011	4,166	17,529	25,352	3,696	13,133	1,908	256,207		4	42
2012	1,723	21,452	24,786	4,012	14,023		244,067		4	45
2013	1,688	30,332	23,362	5,408	12,487		172,207	273,919	5	31
2014	1,427	20,192	21,259	6,073	12,635		109,883	375,809	4	43

Number of Employees

year	Fee_01	Fee_02	Fee_03	Fee_04	Fee_05	Fee_06	Fee_07	Fee_08	Fee_09	Fee_10
2000	23	39	18	54	48	21	35	20	12	
2001	21	36	29	74	27	38	40	34		
2002	15	30	55	59		40	38	53	31	
2003	15	28	70	42	20	43	33	95	70	
2004	15	40	90	36		46	33	76	92	
2005	15	102	133	47		54	34	82	93	
2006	14	69	140	105	25	68	44	103	90	55
2007	17	78	195	110	20	90	49	137	120	51
2008	17	123	192	69	52	116	49	98	130	59
2009	17	99	250	70	55	116	53	83	141	
2010	18	117	242	72	66	147	54	101	143	
2011	19	129	197	73	80	119	56	105	149	60
2012	14	131	265	92	56	108	65		154	122
2013	19	163	310	102	28	111	64	131	167	142
2014	2	190	372	131	28	108	68	89	143	143

year	Fee_11	Fee_12	Fee_13	Fee_14	Fee_15	Fee_16	Fee_17	Fee_18	Fee_19	Fee_20
2000										

2001									146	
2002									158	
2003	45								178	
2004	57			24					183	
2005	65						60		187	
2006	78				65			25	1,250	
2007	100		56		110			26	1,200	
2008	108		87	62	110	108			1,285	
2009	113	24		68	125	107		35	998	
2010	120	24	131	135	128	121	102	44	348	
2011	118	24	128	206	113	109	102	44	406	
2012	127	36	119	174	109	109		44	425	
2013	132	26	120	82	115	120	47	44	442	
2014	133	27	113	118	115		40	44	484	94

year	Fee_21	Fee_22	Fee_23	Fee_24	Fee_25	Free_01	Free_02	Free_03	Free_04	Free_05
2000					9	58	644			
2001					14	58	644			
2002				33	20		636			
2003				34			647			
2004				28		101	700			
2005						108	746			
2006				34		120	735			
2007				66		166	733			
2008				73		171	749			
2009				146		104	745			
2010				73		83	755			
2011				161		61	818	60		
2012	57	71		213		50	814	85		
2013		60		213	75	50	796	123		
2014	41	55		207	66		800	116		96

year	Free_06	Free_07	Free_08	Free_09	Mix_01	Mix_02	Mix_03	Mix_04	Mix_05	Mix_06
2000					178	34		227	115	75
2001		20			217	34		186	175	57
2002		32			344	33		159	283	56
2003		37	20		497	37	80	137	709	81
2004		33	35	90	653	40	50	133	751	85
2005			35	113	618	35		139	965	99
2006		3	40	114	587	40		199	1,569	104
2007			125	121	681	60		225	2,298	123
2008			164	121	831	100		236	3,259	130
2009		90	170	170	921	100	123	231	2,657	154
2010		90	173	172	1,123	150	140	254	2,549	151
2011		90	208	158	1,307	55	16	235	2,686	158
2012		90	217	173	1,402	44	16	241	2,495	158
2013		90	195	173		34	160		1,595	128
2014	30	75	214	196	2,255	21	167	229	2,346	71

year	Mix_07	Mix_08	Mix_09	Mix_10	Mix_11	Mix_12	Mix_13	Mix_14	Mix_15	Mix_16
2000	12	61	52	30			40		46	45
2001	27	59	64	35			62		45	36

2002	28	36	75	42			98		69	45
2003	38		90	38			252		150	45
2004	60		107	44			357		130	50
2005	170		114	46			260		150	61
2006	201		120	62			273		175	81
2007	168		139	76	155		1,133		128	248
2008	178	78	245	80	200		985		130	262
2009	225	78	267	87	210	1	969		140	320
2010	153	81	324	95	320	1	1,075		164	336
2011	109	98	324	103	320	1	1,321		166	211
2012	82	114	291	107	213		796		179	283
2013	51	111	263	135	229		304		184	
2014	47	105	262	137	231		285	681	111	291

Net Sales (unit: 1,000,000 KRW)

year	Fee_01	Fee_02	Fee_03	Fee_04	Fee_05	Fee_06	Fee_07	Fee_08	Fee_09	Fee_10
2000	7,658	8,932	1,248	5,958	216		69	916	84	
2001	7,473	4,525	1,467	6,039	4,601	1,151	1,892	2,062	1,975	
2002	7,855	10,220	4,144	5,383	2,562	2,534	3,675	3,420	4,890	
2003	5,583	9,062	4,389	6,657	1,771	3,375	2,665	5,559	13,327	
2004	7,015	9,117	5,660	8,021	3,622	5,247	2,397	7,088	16,888	6,362
2005	8,486	10,445	7,101	6,099	3,031	5,727	3,150	10,240	12,845	6,991
2006	10,020	25,819	12,142	9,336	3,148	6,877	4,348	14,298	10,744	8,234
2007	11,693	26,800	12,787	27,563	10,002	9,025	5,079	15,290	16,699	8,735
2008	14,314	33,786	11,192	27,267	13,948	10,832	5,956	16,884	17,928	10,150
2009	19,468	38,493	13,839	30,872	19,751	12,124	6,336	14,776	17,936	11,260
2010	19,529	40,112	15,636	28,901	23,122	14,371	7,084	12,922	17,694	13,203
2011	20,976	31,279	18,125	26,273	24,144	13,172	8,383	12,841	18,844	15,527
2012	22,940	31,393	20,848	23,657	21,915	15,187	10,305	16,744	20,100	18,461
2013	22,246	50,828	23,064	20,442	11,501	14,780	9,565	21,567	17,230	20,114
2014	20,090	86,340	29,374	18,490	2,167	14,838	8,974	21,006	22,043	23,598

year	Fee_11	Fee_12	Fee_13	Fee_14	Fee_15	Fee_16	Fee_17	Fee_18	Fee_19	Fee_20
2000								7	32,368	
2001								165	46,610	
2002				80				501	48,738	
2003	6,024		2,582	1,028				860	75,801	
2004	8,029		3,635	4,015				1,263	95,168	
2005	11,242		5,098				2,627	1,650	104,305	
2006	14,851		6,428		4,005			1,812	127,717	
2007	21,068		8,029	11,546	19,261	3,695		2,128	126,246	
2008	21,932		7,138	25,348	24,051	25,559		2,996	132,703	
2009	22,880	4,517	12,220	31,729	30,460	29,011		3,621	123,876	
2010	26,213	5,952	13,943	44,313	36,759	30,875	3,893	3,571	18,096	
2011	25,576	10,076	16,891	47,435	31,198	32,584	3,885	3,884	117,397	9,091
2012	24,639	12,603	2,341	50,378	27,091	35,490	3,879	4,473	132,677	11,519
2013	29,381	9,345	16,565	57,793	30,372	31,615	4,260	4,771	170,695	13,885

2014	30,368	9,392	17,466	54,859	37,677	30,905	4,646	4,830	220,465	16,350

year	Fee_21	Fee_22	Fee_23	Fee_24	Fee_25	Free_01	Free_02	Free_03	Free_04	Free_05
2000					2	800	54,966			
2001					2	2,520	54,461			
2002				3	1	5,059	56,010			
2003				5		8,861	62,560			
2004				3	3	11,543	71,475			
2005				4	4	12,239	88,407			
2006					5	12,956	100,936			
2007				8	6	13,598	116,092	342		
2008				12	6	14,256	122,099	676		
2009	6,338			14	8	13,864	126,050	1,234		
2010	7,016			20	7	14,546	134,994	2,546		
2011	8,611			24		12,511	143,081	4,959		
2012	13,129	17,135		28	9	8,805	150,725	9,645		
2013	12,555	14,444		36	9	7,262	154,226	13,276		12,397
2014	10,835	13,836		43	10	11,022	162,261	17,347		14,638

year	Free_06	Free_07	Free_08	Free_09	Mix_01	Mix_02	Mix_03	Mix_04	Mix_05	Mix_06
2000		1			28,465	2,058		36,442	8,837	10,085
2001		3			90,962	5,676	193	36,078	24,260	10,918
2002		6	1		225,227	4,835	1,280	31,498	74,614	11,987
2003		2	2		141,428	5,160	2,892	7,115	166,311	17,621
2004		2	3	5	183,392	4,308	2,800	27,548	229,383	26,659
2005		1	5	7	202,501	2,396		25,840	357,494	36,430
2006		3	7	9	197,091	4,178		28,107	573,398	31,320
2007		9	10	11	214,508	4,028	4,568	30,534	920,209	33,893
2008		7	14	12	233,963	12,026	5,853	31,270	1,208,127	34,743
2009		7	17	15	244,556	14,365	5,078	32,823	1,237,111	41,741
2010		8	21	17	345,510	23,998	8,424	35,931	1,312,506	30,769
2011		10	21	17	418,718	19,828	10,941	39,540	1,435,148	32,986
2012		10	25	18	45,828	25,311	13,433	40,627	1,131,383	34,237
2013		11	25	19	210,776	21,345	15,151	35,136	1,223,506	21,938
2014		12	26	19	487,805	14,696	14,578	33,084	1,637,165	19,265

year	Mix_07	Mix_08	Mix_09	Mix_10	Mix_11	Mix_12	Mix_13	Mix_14	Mix_15	Mix_16
2000	10	4,652	641	2,109			2,150		2	1
2001	691	4,293	2,874	4,502			3,378		2	5
2002	1,867	4,997	4,781	4,908			13,334		13	7
2003	4,901		5,788	5,926			25,999		20	9
2004	9,590		6,915	6,062			31,422		18	9
2005	11,983		8,841	5,799	523		34,225		13	12
2006	28,871	5,740	10,403	7,230	4,192		184,719		16	17
2007	37,281	6,751	11,653	8,909	16,585		197,273		15	22
2008	33,869	6,681	19,825	9,197	22,923		193,985		15	61
2009	39,214	7,935	29,442	11,145	24,634	1,751	200,096		14	70
2010	37,509	10,560	38,354	12,275	26,778	1,785	242,321		22	79
2011	15,484	18,828	48,936	16,140	28,931	1,630	260,573		27	46
2012	8,516	23,148	57,277	18,065	30,782		197,153		23	46
2013	8,807	31,131	48,438	19,042	31,079		128,272	127,886	21	36
2014	7,394	21,071	45,874	22,961	32,652		93,910	290,157	18	50

Abstract (Korean)

인터넷은 개인 이용자의 삶의 방식과 사회상에 많은 변화를 주고 있다. 그리고 인터넷은 개발될 당시부터 혁신적인 노력의 결과물이었다. 본 논문에서는 혁신의 확산이라는 관점에서 인터넷을 고찰해 보고자 한다.

인터넷의 사용과 확산은 국가별로 그리고 소득 수준 별로 매우 커다란 차이를 보이고 있다. 본 논문의 2 장에서는 실증분석을 통해 인터넷의 확산을 빠르게 하는 요인을 분석한다. 그리고 실증 분석은 다양하고 풍부한 인터넷 콘텐츠가 인터넷 네트워크의 확산 속도를 빠르게 하는 중요한 요인이라는 결과를 제시하고 있다. 하지만 확산의 단계에 따라 확산 속도에 영향을 주는 요인은 다른데, 인터넷이 막 확산되기 시작한 국가들은 인터넷 네트워크 가입자 수가 인터넷 확산의 중요한 요인이고 – 이는 직접 네트워크 효과가 더 중요하다는 의미 – 인터넷 확산이 포화 상태에 도달한 국가 들에서는 가용 콘텐츠가 인터넷 확산 속도에 영향을 주는 요인으로 분석되었다. 이러한 결과 들로부터 인터넷 확산을 위해서는 네트워크 산업과 콘텐츠 산업이 불가분의 관계라는 사실을 유추할 수 있다.

3 장은 서로 다른 가격 전략을 갖고 있는 콘텐츠 기업들의 경영 효율을 meta-frontier 방법론으로 비교하고, 그 결과는 이용자에게는 콘텐츠를 무료로 제공하고 온라인 광고를 통해 또 다른 매출을 발생시키는 전략이 가장

효율적인 전략으로 분석되었다. 광고 매출을 통해 이용자에게 콘텐츠를 무료로 제공하는 사업 모델은 그 자체로도 혁신적인 전략이지만, 이러한 전략은 이용자 들이 무료로 제공되는 콘텐츠를 더 많이 소비할 수 있도록 하여, 결국 인터넷의 확산에 긍정적인 영향을 주었다.

본 논문의 4 장은 IoT(사물인터넷) 시대에 필요한 새로운 규제 정책을 제안한다. IoT 는 인터넷 기술에 기반한 서비스로, 최근 시장에 출현한 새롭고 혁신적인 서비스이다. IoT 시대의 새로운 규제 정책은 isotropic dynamics 규제 정책으로 명명되었고, 이는 실제적인 규제 수단 또는 법률 수단이기보다는 개념적인 규제 정책이다. 이 규제 정책은 세 가지 요소를 포함하고 있는데, 먼저 데이터와 정보가 정해진 목적지로 정확히 전달되기 위해 수직 규제의 요소를 고려하였고, 두 번째로는 IoT 서비스도 기존의 인터넷 서비스와 유사하게 3 개의 계층으로 분리할 수 있으므로 기존 인터넷의 규제체계인 수평 규제의 요소를 고려하였으며, 마지막으로 새로운 혁신이 세 개의 모든 계층에서 등방향으로 발생하여야 한다는 점을 고려하였다.

이상의 본 논문의 내용은 혁신의 확산, 즉 인터넷의 확산과 관계된 내용들이다. 하지만 앞으로의 인터넷 세상에서는 기술의 통합과 함께 정보의 통합(integration)이 더욱 중요한 이슈가 될 것이다.

본논문에서는 과거의 인터넷 - 인터넷의 확산, 현재의 인터넷 - 콘텐츠 회사의 가격 전략, 그리고 미래의 인터넷 - 새로운 IoT 서비스에 대한 규제 정책에 대해 논한다. 그리고 통합된 기술과 통합된 정보의 인터넷 시대에 필요한 두 가지 정책 방향을 제시해 본다. 먼저 통합된 정보가 오남용되면

이용자에게 커다란 피해를 줄 수 있으므로, 통합된 정보는 매우 신중하게 다루어 져야 한다는 것이고, 두 번째로는 통합된 기술과 통합된 정보는 거래 비용을 계속 낮추게 되므로 이러한 기술과 서비스 들이 저개발 국가에도 확산되어 ICT 기술에 따른 사회적 후생이 증가하도록 하는 범국가적인 정책이 필요하다는 것이다.

주요어 : 인터넷, 인터넷의 확산, 콘텐츠 회사의 가격전략, IoT 서비스의 규제 정책

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