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Fixed Broadband and Wibro (Wireless Broadband): Are They Substitutes or Complements?*

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Abstract

This paper investigates whether fixed and mobile broadband services are substitutes or complements using firm-level panel data obtained from three major telecommunications operators in South Korea. We employ a multi-level demand model based on Hausman et al. (1994), which allows for the possibility of complementarity between differentiated services. The estimated price elasticities of demand indicate that mobile broadband is a (weak) substitute for fixed broadband while fixed broadband is complementary to mobile broadband. This is in contrast with the previous studies based on logit models which essentially assume substitution between different technologies. This result implies that fixed and mobile internet services constitute distinctive antitrust markets at least in the early stage of mobile broadband development.

KRF Classification : B030906
Keywords : Mobile Broadband, Fixed Broadband, Substitution, Complementarity, Multi-level Demand Model

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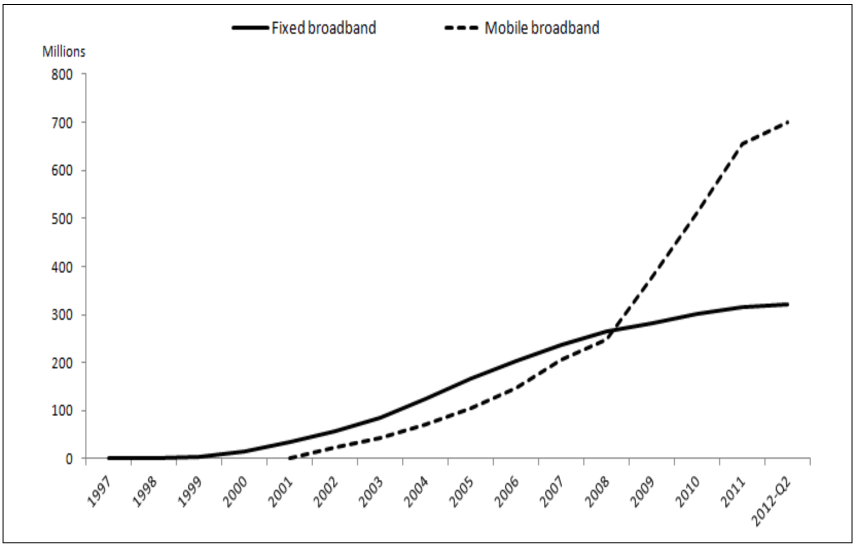
Ⅰ. Introduction

Technology advances in mobile internet technologies have narrowed the gap between mobile and fixed internet services in terms of speed and stability. Also, the advent of the age of smartphones is making mobile broadband an integral part of our everyday life and business in many developed countries. The number of mobile broadband access surpassed the number of fixed broadband in 2008 and since then is growing rapidly in OECD countries (See figure1). The fast growing usage of mobile broadband will have strong impact on firm strategy as well as regulation in the broadband business.

【Figure 1】 Mobile and fixed broadband subscriptions in OECD countries1)



Source: OECD Communications Outlook 2013.

In this regard, the initial reactions of some telecommunications companies to the diffusion of mobile broadband are noteworthy. AT&T and Verizon abolished their unlimited data plan. Also, many

1) Data for mobile broadband from 2001 to 2007 are estimates.

mobile operators are trying to prohibit tethering service which they once have allowed for monthly fees. These observations seem to reflect telecommunications companies' concern about the possibility that mobile broadband cannibalizes the market for fixed broadband. That is, the firms seem to see mobile broadband threatening fixed internet businesses. However, it is too hasty to conclude that mobile and fixed internet services are substitutes. Cardona et al. (2009), based on descriptive statistics on customer switching behavior in the Austrian broadband market, find that the majority of households do not see mobile broadband as a substitute for fixed broadband services and furthermore some business users use both fixed and mobile services simultaneously. This means that the question of whether mobile and fixed internet services are substitutes is non-trivial and requires thorough empirical investigation.

The competitive relationship between fixed and mobile broadband services is also important in designing regulatory policies in the telecommunications market, in relation to market definition, mergers, network investments, etc. If fixed and mobile broadband services are close substitutes, then two services are likely to be in the same market, and the policy maker may consider horizontal separation of currently integrated service providers. For example, Pereira and Ribeiro (2011) estimate cross-price elasticities of demand for fixed broadband services in Portugal, and show that structural separation of telecommunication operators who offer both DSL and cable modem services would increase social welfare. On the other hand, if complementarities exist then integrated structure would be more desirable in inducing socially optimal R&D and network investments.

This paper employs a multi-level demand model following Hausman et al. (1994) to estimate own and cross-price elasticities of broadband internet services. We use 4-year firm-level panel data obtained from several government organizations and three major telecommunications operators in Korea. Korea is ranked 6th in fixed broadband penetration and ranked 3rd in mobile broadband supply per population among OECD countries in 2013 (OECD Broadband portal 2014). We believe that Korea, one of the leading countries for developing broadband, is a good testing ground for studying the competitive effect between fixed and mobile broadband.

Our results indicate that in general fixed and mobile internet services are (weakly) complementary goods rather than substitutes under the Slutsky symmetry. Without the Slutsky symmetry, the result shows some asymmetries; mobile internet services are (weak) substitutes for fixed internet services while fixed broadband services are complementary to mobile internet service.[2] These results indicate that mobile and fixed broadband substitution would not happen in the near future.

There is a sizable body of literature on the demand relationship between fixed and mobile voice telephony. The recent paper by Vogelsang (2010) provides a comprehensive survey on the issue of fixed to mobile substitution. Most of these studies, based on empirical analyses using various sources of aggregate and disaggregate data, find that fixed and mobile telephone services are substitutes (Ahn and Lee, 1999; Grajek and Kretshmer, 2009; Gruber and Verboven, 2001; Grzybowski and Verboven, 2013; Jang et al., 2005; Suarez and Marinoso, 2013; Narayana, 2010; Rodini et al., 2003; Sung and Lee, 2002; Ward and Woroch, 2010; Ward and Zheng, 2012). A few exceptions are found in the stream of research analyzing the diffusion pattern of fixed and mobile voice access. Gruber (2001)

2) The failure of the Slutsky symmetry seems to reflect the heterogeneity in consumers' perception of mobile and fixed broadband services. For instance, Grzybowski and Verboven (2013) find substantial heterogeneity across households with different age, education, professional activity, etc., which implies that some individuals may perceive fixed and mobile voice telephony as complements even though the two services are substitutes on average.

finds that mobile diffusion tends to be higher in countries with a higher penetration rate of fixed network in the Central and Eastern European region. On the other hand, Banerjee and Ros (2004) look at the effect of mobile penetration on fixed line diffusion. They argue that the competitive relation between fixed and mobile services changes over time, in particular mobile and fixed networks are complements in the early phase of mobile voice diffusion and later they become substitutes.

In contrast to voice telephony, research on the competitive relation among internet data services is rather scarce. There have been some discussions about the substitution between narrowband and broadband internet services (Flamm and Chauhuri, 2007; Ida and Kuroda, 2006; Yanelis et al., 2009) Also, there exist several studies examining the substitutability within different fixed broadband technologies such as Sidak et al. (2002), Pereira and Ribeiro (2011) and Ida and Sakahari (2008), all of which identify substitution effects.

Only very few papers, up to now, have examined substitution or complementarity between fixed and mobile broadband services. Using household survey data in Austria, Cardona et al. (2009) estimate the nested logit models and find that different broadband access technologies including DSL, cable, and mobile broadband are substitutes. Since the penetration rate of mobile broadband was still very low at the time of the survey, they do not investigate whether DSL and cable taken together would be constrained by mobile broadband. Srinuan et al. (2012) analyze fixed and mobile broadband substitution using a survey data in Sweden. Also relying on nested logic models, they estimate own-price and cross-price elasticities for various broadband technologies such as DSL, cable, LAN/Fiber, and mobile broadband and find that different broadband technologies are close substitutes in areas in which multiple broadband technologies are available. Similarly, Grzybowski et al. (2014) estimate a mixed logit model using survey data in Slovakia and show that fixed and mobile broadband are competing in the same relevant market for broadband Internet access.[3)]

All these works, however, employ logit models which essentially assume substitution between different technologies and, therefore, are not suitable for examining the possibility of substitution or complementarity between fixed and mobile broadband services. Note that in logit models a consumer basically chooses only one commodity that provides her the highest utility. A few recent studies try to explicitly consider the possibility of complementarity in voice telephony employing the model developed by Gentzkow (2007) which allows for the use of both fixed and mobile services at the same time. For instance, Macher et al. (2013) and Grzybowski and Verboven (2013), using survey data in the US and EU respectively, analyze whether fixed-line and mobile voice telephony are substitutes or complements. They both find that connections to mobile and fixed-line telephone services are substitutes.

This paper is, to our knowledge, is the first attempt to investigate whether fixed and mobile broadband services are substitutes or complements, taking into account the possibility of complementarity between the two. Using firm-level panel data obtained from three major Korean telecommunications operators, we estimate a multi-level demand model following Hausman et al. (1994).[4)] Specifically, we match the top level to Internet service, the middle level to fixed and mobile broadband, and finally the bottom level to individual brands and technologies providing Internet services.

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3) Another related work is Grzybowski and Verboven (2013) which relates Internet access to the demand of fixed or mobile connections in voice telephone services.

4) Unfortunately, we cannot employ the Gentzkow model since our firm level data do not specify the number of consumers who use both fixed and mobile internet services.

Our main focus is the result of the middle level analysis. The estimated price elasticities of demands at the middle level indicate that mobile broadband is a (weak) substitute for fixed broadband while fixed broadband is complementary to mobile broadband. This is in contrast with previous works which suggest substitutability based on logit models that essentially rule out the possibility of complementarity. In fact, our result has some parallels with those obtained in the analyses of diffusion models such as Lee et al. (2011) and Wulf et al. (2013). Note that, however, diffusion models do not explicitly estimate own and cross price elasticities which are essential to derive policy implications regarding market definition or effect of merger.

Ⅱ. Brief Overview of the Korean Broadband Internet Market

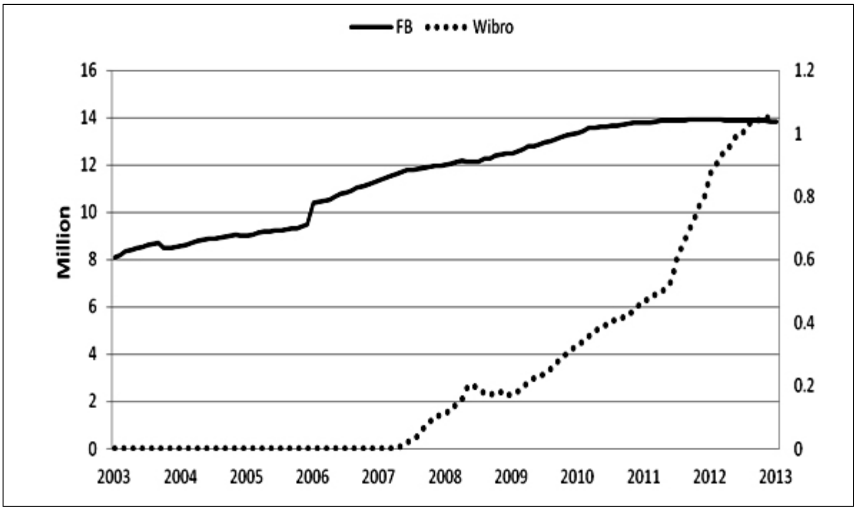
Korea is one of the leading countries in broadband development with a very high level of broadband penetration. By the end of 2013, 90.3% of private households in Korea had internet access and, moreover, most of them use broadband connection (less than 1000 households use dial-up or other access) (KISDI, 2013a). Such a high broadband internet penetration is due to the geographical characteristic of concentrated population in several main cities and well developed network infrastructure and technologies.

Fixed line internet services became available in 1994 when *Korea Telecom* (KT) introduced dial-up internet access. Broadband access via DSL has been introduced in 1999, and grown rapidly with other broadband services such as Cable and Fiber. In Korea, there are three major internet service providers (KT, SKT, LGU+), which have nationwide broadband networks. They occupy 83.1% of market share in fixed broadband access, and the rest is shared by regional cable companies. In most cases, uniform fixed prices are charged for internet services with unlimited data usage. In December 2012, the market shares of major fixed broadband services were as follows: DSL 11.8%, Cable 27.0%, LAN 36.2%, and Fiber 24.9%. Although we recently observed slight changes in market share (DSL and Cable have declined a bit while LAN and Fiber have increased), the Korean fixed internet service market is by and large mature and saturated.

In March 2006, two internet operators, KT and SKT, launched commercial mobile broadband services called *Wibro* (wireless broadband). *Wibro* technology was developed by *Samsung Electronics* and *Electronics and Telecommunications Research Institute* (ETRI). Its download speed reached 39.8Mbps, falling short of 54Mbps of ADSL and 100Mbps of Fiber. At first consumers rarely subscribed to the Wibro service because of its instability and high price. However, the introduction of netbooks and tablet PCs stimulated the need of mobile internet access and boosted the demand for the Wibro service. As the quality of service improved and the price has become affordable to consumers, the number of mobile broadband connection reached 1,049,788 in December 2012, which comprised 5.3% of the total number of Korean households. Figure 2 below shows the number of fixed broadband and Wibro subscribers.

Major telecommunications operators in Korea have significant market power, and so they are regulated by *Korean Communications Commission* (KCC). Internet services providers should obtain a permission to change their prices. Also, excessive subsidies for promoting sales are prohibited. *Korea Information Society Development Institute* (KISDI), in their annual competition report on the Korean telecommunications market in 2013, noted that fixed and mobile internet services are not in the same antitrust market by conducting “Critical Loss” analysis, but emphasized that regulatory authorities should keep monitoring on fixed-mobile substitution as technologies advance.

【Figure 2】 The number of fixed broadband and Wibro subscribers5)



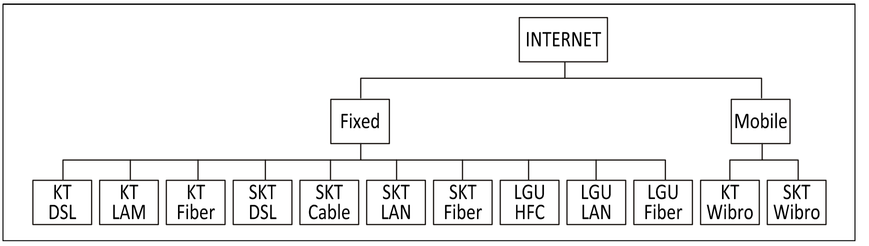
Source: Korea Communication Commission.

Ⅲ. Empirical Framework

In order to examine consumer choice over fixed and mobile broadband internet service, this paper assumes a multi-stage budgeting in which a consumer allocate his (or her) total expenditure across stages, as in Hausman et al. (1994) and Hausman (1996). Figure 3 shows the stages of the consumer decision making process.

5) The left axe is for fixed broadband access and the right is for Wibro.

【Figure 3】 Decision tree for the multi-level demand model



Note: For the broadband service, consumers may choose either fixed or mobile internet service or both. Then consumers choose one service under each segment.

At the top level, the overall demand for broadband internet service is specified as follows:

$$\log q_t = \beta_0 + \beta_1 \log y_t + \beta_2 \log \pi_t + \delta Z_t + \varepsilon_t \qquad (1)$$

where q_t is the overall subscription of internet service, y_t is real disposable income and π_t is the deflated price index for internet service in time t. Z_t includes a time trend variable to control for a possible trend in the Wibro service.[6] The middle level involves demand equations for fixed and mobile broadband internet services:

$$\log q_{mt} = \beta_m \log y_{bt} + \textstyle\sum_{k=1}^{K} \beta_k \log \pi_{kt} + \gamma Z_t + \varepsilon_{mt} \qquad (2)$$

where q_{mt} is the subscription of segment m (fixed or mobile), y_{bt} is the total expenditure on internet service, and π_{kt} is the price index of segment k.[7] Therefore, the cross price elasticity between fixed and mobile internet services, which is the main interest of this paper, is measured at this stage. We estimate it with and without imposing

6) Some existing services or new technologies may induce consumers to switch from one service to the other. For instance, 3G and LTE services might have induced consumer switching.

7) We use a weighted average price index of Laspeyres type, which is suggested by Hausman et al. (1994).

the Slutsky symmetry. A time trend variable, Z_t, is also included.

At the bottom level, within segment m, individual $i\,(i=1,\ldots,I)$ chooses good j among mutually exclusive alternatives, which gives her the highest utility. The random utility function of good j for individual i in time t is given as:

$$U_{ijt} = x_{jt}\,\beta + \alpha\, p_{jt} + \varepsilon_{ijt} \tag{3}$$

where x_{jt} and p_{jt} are the vector of characteristics and the price of good j in time t, respectively. The error term, ε_{ijt}, is an *iid* extreme value type I. The probability that individual i chooses good j is as follows.

$$P_{ijt}(U_{ijt} > U_{ikt}) = \frac{\exp(x_{jt}\beta + \alpha\, p_{jt})}{\sum_{l=1}^{J}\exp(x_{lt}\beta + \alpha\, p_{lt})} \tag{4}$$

At the bottom level, the AIDS model is generally used as in Hausman et al. (1994) since it allows flexible cross price elasticities between products. However, our data set with a small number of observations is likely to suffer a multi-collinearity problem. Therefore, we instead estimate the logit model of each service provider-access technology market share on prices and product characteristics using the aggregate data.[8] Each product price is the net price after we subtract subsidy from the price. For the availability of the outside good, we define the market size as the number of households. Using a logit model reduces the number of parameters to estimate and also relieves the multi-collinearity problem between product prices in our setting at the last stage for the fixed broadband where we have ten different products across 3 service providers and

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8) Hausman et al. (1994) also mention that the particular form of demand specification is not crucial at the bottom level.

4 different access technologies with a small number of observations in the sample. However, at the same time, the use of a logit model brings some limitation. First, the independence of irrelevant alternatives (IIA) property cannot be avoided within each segment. Bearing this weakness, we focus on the substitutability between fixed and mobile internet services at the middle level. Second, the endogeneity problem may exist with respect to prices since we use net prices after discounts or subsidies. Since the internet service providers cannot adjust their prices frequently under the regulation in Korea, the prices of internet services can be considered to be predetermined.[9] However, subsidies and/or discounts are easily changeable and responsive to consumer demand and, hence, may cause the endogeneity problem. Therefore, this paper uses the price before discounts as an instrumental variable, which is highly correlated with the net price, but is not correlated with the short-term demand as it is predetermined. Lastly, we assume that if an individual chooses to purchase a fixed (or mobile) broadband, he or she chooses only one product within each segment. Regarding the fixed broadband, in 27 European countries only less than 2% internet users buy more than one fixed internet service (Grzybowski and Verboven, 2013). Korea also shows a similar pattern; less than 0.1% internet users buy more than one fixed internet service (KISDI, 2013c). Meanwhile, people are likely to buy only one mobile internet service since one mobile internet service provides internet access

9) In 1991, the Korean government required telecommunication service companies to get approval for the prices of telecommunications service. Since 1997, it has changed from the approval system to the report system. However, dominant firms with market share of 30% above still need to get approval on price changes from the Ministry of Strategy and Finance. That is, KT's local telecommunications service and internet service, and SKT's mobile telecommunications service are subject to government approval. Therefore, it is practically difficult to change prices as quickly as possible in responding to demand or other changes.

almost everywhere. Hence our assumption seems appropriate.

Ⅳ. Data

This paper uses the data of broadband service provider across access technologies during the period of February 2009-January 2013. The number of subscribers for each service provider and different access technologies was obtained from the Korean Communications Commission. The market shares of broadband internet service providers are provided in Tables 1 and 2. KT, which has been a monopolist until March 1999, has the highest market share of 46.5%, followed by SKT with 23.4% market share and LGU+ with 14.2% market share.[10] Monthly prices in Table 2 are net prices after price discounts (or subsidies). While the monthly nominal prices collected from service providers do not change much, the internet service providers usually offer price discounts (or subsidies) to new subscribers. So the subsidy data were collected from the website, ‘www.ppomppu.co.kr’ that posts the amount of subsidy of each internet service provider every day. Then we used the subsidy data on the fifteenth of each month in order to calculate the effective prices taking into account subsidies.[11] Variations in the prices come from price differences across internet service providers and changes in prices over time. Overall, fixed broadband services tend to be more expensive than mobile broadband services. The fixed broadband using Fiber charges the highest price while the fixed

10) Hanaro Telecommunications, which was acquired by SKT, entered the internet service market with ADSL in April 1999. It became very popular as it provided the internet service with 8 Mbps, which was eight times faster than the speed of the existing ISDN service, 64 Kbps.

11) The effective price is calculated as follow. If a consumer signs a “A” month contract with monthly fee “B” and get a subsidy “C”, the effective price is A*B-C.

broadband via Cable charges the lowest price. Guaranteed minimum speed was obtained from the Competition report published by the *Korean Information Society Development Institute* (KISDI, 2013). The internet access using LAN and Fiber provides the highest guaranteed minimum speed while those using DSL and Cable have offer lower speed. In addition, the macroeconomic variables such as the number of population, the number of household, and the monthly household income are obtained from the *Ministry of Security and Public Administration and Statistics Korea.*

【Table 1】 Market shares of broadband service providers across technologies (Dec, 2012)

ISP	Fixed				Mobile	Total
	DSL	Cable	LAN	Fiber		
KT	1,761,370 (9%)	-	2,810,157 (15%)	3,464,652 (18%)	934,310 (5%)	8,970,489 (47%)
SKT	352,469 (2%)	1,428,560 (7%)	1,646,328 (9%)	966,766 (5%)	115,478 (1%)	4,509,601 (23%)
LGU+	-	1,005,983 (5%)	1,616,626 (8%)	120,542 (1%)	-	2,743,151 (14%)

Notes: 1. The total number of subscribers as of December 2012 is 19,302,449 including regional cable internet service providers.. 2. The numbers in the parentheses are the percentage of the number of subscribers of each service to the total number of subscribers.

【Table 2】 Monthly price and guaranteed minimum speed across broadband technologies (Korean won*)

Access Technology	Monthly price (Unit: Korean won)				Average Guaranteed minimum speed(Mbps)
	Mean	Standard Deviation	Minimum	Maximum	
DSL	23,402	734	24,988	20,573	2.23
Cable	16,228	1,663	19,266	11,689	5
LAN	23,682	1,122	25,857	20,664	50
Fiber	26,794	1,508	29,015	22,820	50
Mobile	16,273	3,604	19,442	11,611	-

Note: * one thousand Korean won is approximately one U.S. dollar, as of May 2014.

Ⅴ. Estimation Results

5.1. Bottom level estimation

At the bottom level, the estimation results for the fixed and mobile internet services are shown in Table 3. The coefficients of prices in both fixed and mobile services are significantly negative as expected. The probability of purchasing broadband access increases with the declining monthly fee. The odds ratio of having a fixed broadband access relative to having outside option increases by 13.21% when the monthly fee of the fixed broadband decreases by one thousand Korean won, approximately 1 US dollar.[12)] The odds ratio of having a mobile broadband access increases by 7.07%. In the fixed broadband, we find the strong preference for KT, which is followed by SKT and LGU+. The broadband service using LAN is the most preferred, which is followed by Cable, Fiber and lastly DSL. In the mobile broadband internet service, KT is preferred to SKT. It is in line with the fact that KT provides more stable and wider network coverage (KISDI, 2013b).

The own- and cross-price elasticities are shown in Table 4. The own-price elasticities of the fixed broadband services vary from -1.756 to -3.189. In terms of access technologies, Fiber and LAN tend to have higher price elasticities followed by DSL and Cable. In other words, the users of Cable and DSL are less price sensitive than those of LAN and Fiber. In addition, KT's services tend to show higher price elasticities, followed by SKT and LGU+. For instance, LGU+'s internet service through Cable shows the lowest price elasticity, i.e., 1% increase of the price leads to 1.756% decline of the demand. On

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12) The proportional increase of the odds of having a fixed broadband is 1.1321(=$exp[(-0.0001241)\times(-1{,}000)]$) and that of having a mobile broadband is 1.0707(=$exp[(-0.0000684)\times(-1{,}000)]$) when the monthly fee decreases by 1,000 Korean won.

the other hand, KT's service through Fiber shows the highest price elasticity, i.e., 1% increase of the price leads to 3.189% decline of the demand. Meanwhile, the cross price elasticities vary from 0.010 to 0.489. For instance, KT's internet service through Fiber has the highest cross elasticity of 0.489, i.e., 1% increase of the Fiber price of KT results in 0.489% increase of the demand for the other service. On the other hand, the price increase of SKT's DSL has little impact on the demand for the other services. In the mobile internet service, KT and SKT show similar own price elasticities. The own-price elasticities of the mobile broadband service are a bit lower than those of the fixed broadband service. The cross-price elasticities are in the range of 0.003 and 0.025, lower than those of the fixed broadband service.

【Table 3】 The bottom level demand estimation results

Fixed broadband

Variables	Coefficients
Price	-0.1241***
	(0.0563)
LGU+	-4.255***
	(0.691)
SKT	-2.624***
	(0.475)
Cable	2.893***
	(0.310)
LAN	2.905***
	(0.354)
Fiber	1.828***
	(0.325)
Constant	-0.931
	(1.404)
N of observations	471
Wald Chi-Sqaure (6)	495.37
(p-value)	(0.0000)
R-squared	0.5129

Notes: 1. The base case is KT's fixed internet service through DSL. 2. The standard errors are in parentheses. 3. *,**, *** indicate significance at the 10% level, 5% level, and 1% level, respectively.

Mobile broadband

Variables	Coefficients
Price	-0.0684***
	(0.00878)
SKT	-2.999***
	(0.149)
Constant	-3.605***
	(0.153)
N of observations	100
Wald Chi-Sqaure (2)	528.54
(p-value)	(0.0000)
R-squared	0.8410

Notes: 1. The base case is KT's mobile internet service. 2. The standard errors are in parentheses. 3. *,**, *** indicate significance at the 10% level, 5% level, and 1% level, respectively.

【Table 4】Price elasticities of fixed and mobile broadband services

Fixed broadband

Provider	KT			SKT				LGU+		
Technology	DSL	LAN	Fiber	DSL	Cable	LAN	Fiber	Cable	LAN	Fiber
Own price elasticity	-2.610	-3.181	-3.189	-2.166	-2.028	-2.393	-2.436	-1.756	-2.053	-2.151
Cross price elasticity	0.358	0.465	0.489	0.010	0.148	0.154	0.109	0.097	0.187	0.011

Mobile broadband

Provider	KT	SKT
Own price elasticity	-1.073	-1.207
Cross price elasticity	0.025	0.003

In general, the own price elasticity of each broadband technology is quite elastic while the cross price elasticity across different technologies is small. The ranges of these elasticity estimates are comparable with those of Cardona et al. (2009), Ida and Kuroda (2006), Pereira and Riberio (2011), and Srinuan et al. (2012).

5.2. Middle level estimation

The middle level demand system in equation (2) is estimated with and without the Slutsky symmetry condition. Table 5.1 shows the estimation result when the Slutksy symmetry is imposed; the conditional own-price elasticities are -0.779 and -0.218 for the fixed and the mobile broadband services, respectively. When the Slutksy symmetry is not imposed, the conditional own-price elasticities are -0.633 and -0.473 for the fixed and mobile broadband internet services, respectively, as shown in Table 5.2. The price elasticity of the mobile broadband service is a bit lower than that of the fixed broadband service. Overall, they show inelastic demands at the segment level, which is quite different from elastic demands at the product level. In Korea, the broadband penetration rate is high as 90.3% as of December 2013, and the monthly price is competitive and cheaper relative to those of other countries (OECD, 2014). This indicates that broadband access is a kind of necessity to Korean internet users; they are less sensitive to price changes for internet access.

Now we move to our interest of this paper, the cross price elasticity between fixed and mobile broadband. When the Slutsky symmetry is imposed, the cross price elasticity is -0.0217 as in Table 5.1. If the price index for fixed (mobile) broadband internet service decreases by 1%, the demand for the mobile (fixed) broadband internet service increases by 0.0217%. The negative cross-price elasticity means that fixed and mobile broadband services are complements rather than substitutes. Note that its magnitude is quite small, although it is statistically significant.

On the other hand, when the Slutsky symmetry is not imposed, we have notable changes. First, the fixed broadband service is still complementary to the mobile broadband service, but its magnitude becomes much stronger. When the price of fixed broadband decreases by 1%, the demand for mobile broadband increases by 2.392%. However, the mobile broadband service becomes a weak substitute or independent to the fixed broadband service. When the price of mobile broadband decreases by 1%, the demand for fixed broadband decreases by 0.026%, which is quite small. This result is opposite to those of Cardona et al. (2009) and Srinuan et al. (2012) which show substitutability between the fixed and mobile broadband services. However, note that their results were based on the specifications that do not allow the possibility of complementarity.

【Table 5】 The middle level estimation results for segments

With the Slutsky symmetry

Variables	Fixed broadband	Mobile broadband
Constant	2.776***	-0.851
	(0.72)	(4.027)
log(Expenditure)	0.652***	0.473***
	(0.032)	(0.152)
log(Price index of Fixed broadband)	-0.779***	-0.0217***
	(0.034)	(0.008)
log(Price index of Mobile broadband)	-0.0217***	-0.218***
	(0.008)	(0.053)
Time	-0.0005***	0.033***
	(0.0002)	(0.001)

Without the Slutsky symmetry

Variables	Fixed broadband	Mobile broadband
Constant	4.523***	-28.69***
	(0.569)	(5.688)
log(Expenditure)	0.552***	2.042***
	(0.025)	(0.276)
log(Price index of Fixed broadband)	-0.633***	-2.392***
	(0.027)	(0.333)
log(Price index of Mobile broadband)	0.026***	-0.473***
	(0.005)	(0.060)
Time	0.0004***	0.025***
	(0.0001)	(0.001)

This asymmetric result can be interpreted as follows. Consumers may obtain higher utility as they have alternative access to the internet, especially outside of the existing broadband range. For instance, a user of fixed broadband at home learns the pleasure of using the internet. Then, he or she may be willing to connect to mobile broadband for using the internet outside of the house. Mobile broadband, however, does not replace fixed broadband which provides faster and more stable internet access.

Our results of complementarity between fixed and mobile broadband are closely related to that of Grzybowski and Verboven (2013) which show the fixed and mobile 'voice' telephone services are weak complements in Sweden, the Netherlands and Malta and independent in the UK, Luxembourg and Slovenia. Furthermore, this result is in line with the finding of Lee and Marcu (2011) and Wulf and Brenner (2013) who suggest a complementary relationship between fixed and mobile broadband in terms of diffusion pattern. They show that mobile broadband benefits from the high level of diffusion in fixed broadband while fixed broadband services are little replaced by mobile broadband services.

5.3. Top level estimation

Lastly, the demand estimation for the internet service is shown in Table 6. The own-price elasticity of internet service is -0.161. If the price of internet service increases by 10%, it's demand decreases by 1.61%. The inelastic demand for internet service implies that internet service is considered as a kind of a necessity in Korea. As a matter of fact, Galperin (2013) shows that the price elasticity for internet service is -0.34 in OECD countries. The income elasticity for internet service is 0.009 which is statistically insignificant. This inelastic income elasticity seems to reflect the fact that the market is already in the mature stage.

【Table 6】 Estimation result of the demand for broadband internet service

Variables	Internet
Constant	11.67***
	(1.240)
log(income)	0.009
	(0.082)
log(Price index of broadband services)	-0.161***
	(0.0699)
Time	-0.001***
	(0.0002)
N of observations	48
Wald Chi-Sqaure (3)	17.31
(p-value)	(0.0006)
R-squared	0.0893

Ⅵ. Conclusion

In this paper, we analyze substitution or complementarity between fixed and mobile broadband internet services using four-year panel data from Korean telecommunications market. We employ a multi-level demand model proposed by Hausman et al. (1994) in order to avoid the caveat of discrete choice models which essentially assume that a consumer use either fixed-line service or mobile service, not both.

We find that fixed and mobile broadband services are complementary rather than substituting each other. This result contrasts with previous studies that suggested strong substitutability based on discrete choice models which intrinsically exclude the possibility of complementarity. Our study is the first attempt at examining demand relationship between fixed and mobile broadband based on a proper estimation method, which is consistent with consumer behavior.

This paper also discovers an asymmetric pattern of the competitive effect between mobile and fixed internet access. That is, mobile broadband (weakly) substitutes fixed broadband services while the diffusion of fixed broadband boosts the demand for mobile broadband access. This asymmetric result seems to ascribe to consumer heterogeneity in perception of the demand relationship between two services. It would be interesting to figure out in more detail what causes the asymmetry.

Our results give some implications for regulatory policy. In defining an antitrust market, it is crucial to assess whether goods are complements or substitutes. The previous researches conclude that fixed and mobile internet services are substitutes and therefore should be regarded as in the same market. This proposition, however, may be misleading since the substitutability result is a direct consequence of the assumption of their empirical models themselves. Based on the analysis of a more appropriate model, we argue that fixed and mobile internet services have their distinctive markets at least in the early stage of mobile broadband development.

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유무선 광대역인터넷서비스: 이들은 대체재인가 보완재인가?

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논문초록

본 논문은 방송통신위원회와 국내 통신3사의 패널자료를 이용하여 유무선 광대역인터넷서비스가 대체재인지 보완재인지 여부를 실증분석 하였다. 소비자들이 차별화된 제품을 보완적으로 사용할 가능성을 고려하고 있는 Hausman 외(1994)의 multi-level demand 모형을 사용하여 분석한 결과, 무선 광대역 인터넷서비스는 유선 광대역 인터넷서비스를 (약하게) 대체하는 반면 유선 광대역 인터넷서비스는 무선 광대역 인터넷서비스를 보완하는 것으로 나타났다. 이는 이산선택모형을 사용하여 유무선 인터넷서비스가 대체재로서 서로 경쟁관계임을 보인 기존의 실증분석과 대조되는 것으로서 관련 시장의 획정에 대한 새로운 시사점을 제공한다 볼 수 있다.

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