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Consumer Demand of Mobile Devices for Wireless Broadband Internet Services and Its Implications

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Abstract

The provision of wireless broadband Internet service and mobile devices to connect to it is increasingly seen as an attractive market opportunity as the markets for wireless voice communications and fixed broadband Internet become saturated and performances of mobile devices are improved a lot. This study surveys South Korean consumers on preferences regarding mobile devices for wireless broadband Internet services. A multivariate probit model with Bayesian estimation is used to allow for the simultaneous choice of multiple options. The estimations reveal that monthly cost weighs heavily in consumers' choice of service/device combinations and that consumers value highly being able to use a wireless Internet service seamlessly while on the move. In addition, rather than unconditional access to content and networks, wireless Internet consumers will be most satisfied with the same range of content and network access as they are used to with a fixed service. Finally, simulated scenarios show that competition among wireless services is affected by the pairing of connectivity devices with services.

Keywords : wireless broadband Internet service, mobile device, consumer preference, Bayesian multivariate probit model

I. Introduction

In South Korea, as in many other countries, the fixed broadband Internet service market and the wireless voice communications service market have both grown explosively over the past decade (Lehr and McKnight, 2003), but they now face saturation. Thus telecommunications service providers in South Korea are motivated to seek new profit sources, and many regard wireless broadband Internet services as a good candidate.

Recently, the South Korean broadband Internet services marketplace has seen the introduction of several wireless communications services, among them wireless Local Area Network (WLAN or Wi-Fi), portable Internet service (or Wireless Broadband, WiBro) or mobile Internet services such as wideband code division multiple access (WCDMA) or high-speed downlink packet access (HSDPA) (Nam et al., 2008). The services based on these standards have their own competitive merits in terms of price, data transfer speed, mobility and their promulgation is expected to bring about dramatic changes in the South Korean Internet connectivity marketplace (Ahn et al., 2004). Thus, whether consumers will embrace or reject these service options, how they will compete with one another, and what effects they will have on society are issues that have been raised in many previous studies (Rao and Parikh, 2003; Tanguturi and Harmantzis, 2006; Okazaki, 2006; Lu et al., 2005; Loomis and Swann, 2005) and especially in studies concerned particularly with the South Korean broadband Internet services

universe(Nam et al., 2008; Yoon and Kim, 2007; Kang et al., 2004; Kang et al., 2005; Yoo and Moon, 2006; Ahn et al., 2006; Kim, M. et al., 2006; Kim and Jee, 2006; Jeon et al., 2007).

In addition to questions about consumer adoption of and competition among the wireless Internet services themselves, there is another related issue. Complementary interrelationships between those services and the mobile connectivity devices consumers use to access the services are of importance as well(Kim et al., 2005; Bruner II and Kumar, 2005). Many researchers, especially in the private sector, have begun to look at the preferences consumers manifest with regard to the effects of attributes of specific wireless Internet services on the demand for mobile connectivity devices and in turn, the effects of the patterns of demand for mobile devices on competition among wireless Internet services(Nam et al., 2008; Ahn et al., 2006).

Meanwhile, until now, issues of quality and the relatively limited variety of wireless Internet services available have compelled South Korean consumers to use only one mobile device to access their service. With the advent of more kinds of wireless broadband service with improved performance and increased compatibility between services and various kinds of mobile devices, however, the possibility for consumers to use more than one mobile device to connect to one or more than one wireless broadband Internet service option is increasing as consumer needs are getting diverse. Information on whether and how consumers are likely to show multiple-choice behaviour(e.g., using more than one device to access an Internet service or perhaps subscribing to more than one service/device combination at one time) will be of relevance to both service providers and device manufacturers, especially in this era of

digital convergence. However, despite such significance, the topic has to our knowledge not been dealt with by previous studies. Therefore, including such multiple-choice behaviour as an important additional research theme is necessary.

The goal, then, of this study is to analyze consumer preferences for representative mobile devices for wireless Internet service and effects of features of wireless Internet services on choices of mobile devices, and to measure the possibility of simultaneous choices of more than one of them. To conduct a comprehensive analysis, consumers' choices among wireless Internet service and mobile devices for wireless Internet service are modelled, and the interdependence of one choice on another was analyzed. More specifically, it is attempted to find the empirical answers to the following research questions: What are consumers' preferences regarding mobile devices and attributes of the wireless broadband Internet service connected by them? How do those preferences influence their choice of mobile connectivity device? What patterns in consumer choice regarding combinations of mobile device and wireless broadband Internet service can one expect? What kinds of consumers' simultaneous choices of mobile devices are likely to occur? Is simultaneous choice behaviour likely to be prevalent in the future?

To derive the consumer preference results, conjoint analysis—a method researchers frequently use to derive preference information regarding nonexistent or very recently introduced services or products(Kim et al., 2005; Roe et al., 1996; Batt and Katz, 1997; Layton, 2000; San Miguel et al., 2000; Huber and Train, 2001; Alvarez-Farizo and Hanley, 2002; Bryan and Parry, 2002; Carlsson, 2003; Kim, 2005; Jeong et al., 2008; Koh, 2010; Kim, Y. et al.,

2006)– is used. The survey was conducted on 1000 South Korean consumers to gather preference data, while the respondents being allowed to choose more than one alternative combining wireless broadband Internet services and mobile devices if they desired. To estimate the consumer preferences quantitatively, a multivariate probit model along with a Bayesian approach(Chib and Greenberg, 1998; Edwards and Allenby, 2003; Rossi et al., 2005) is used, designed to reflect consumers' possible simultaneous choices of more than one device or service.

This study proceeds as follows: section 2–identification of main research questions; 3–description of characteristics of the sample and survey; 4–explanation of the research model and its specifications; 5–presentation of estimation results; 6–discussion of main findings and simulation analysis; and 7–concluding remarks.

Ⅱ. Main Research Questions

In this section, the main questions to be addressed in this research are presented.

From the perspective of consumers, the following are all important issues regarding wireless broadband Internet service that is connected through mobile devices: Can the service be used while consumers are on the move? How much data transfer speed can be realized with stability on the service? How much does the service cost? What type of content is provided(for example, only modified and simplified, unfamiliar content or the same content consumers experience on their desktop PCs with a fixed broadband service)? And can more than one network be accessed with the service?

One might assume that the wireless broadband Internet service that has the highest combined level of such attributes would be preferred most by consumers, since that service would increase consumer utility as much as possible. Yet one must reject that idea, since many trade-off relationships exist among the attributes characterizing the various wireless broadband Internet service options. For example, as Table 1 shows, services based on WLAN (or Wi-fi), 2.3-GHz portable Internet service(WiBro), Mobile Internet services such as 3G(WCDMA or HSDPA) all have their own strengths in specific aspects(Nam et al., 2008; Ahn et al., 2004; Jeon et al., 2007; Kim, M. et al., 2006; Ahn et al, 2006; Yoo and Moon, 2006).

As a result, how consumers value and prioritize attributes should prove to be a key factor in determining competition patterns among wireless broadband Internet services, in determining the upcoming direction of the wireless broadband Internet service market. The subject has been analyzed in many studies. Rao and Parikh(2003), Loomis and Swan(2005), Lu et al.(2005), Okazaki(2006), and Tanguturi and Harmantzis(2006) are the previous international studies on wireless broadband Internet services and related markets. Ones focusing on the Korean wireless broadband Internet service market are Yoon and Kim(2007), Jeon et al.(2007), Nam et al.(2008), Kim and Jee(2006), Kim, M. et al.(2006), Ahn et al.(2006), Yoo and Moon(2006), Kang et al.(2005) and Kang et

Table 1. Comparison of representative wireless broadband Internet services

Characteristics	WLAN[1)]	WiBro	Mobile Internet[2)]
Data transfer speed	Very fast	Fast	Moderate
Mobility	Very low	Moderate	Very high
Main mobile terminals	notebook PC, Tablet-PC, Smart phone	notebook PC, Tablet-PC, Smart phone	Smart phone Mobile phone
Monthly service charge	low	Moderate	Rather high
Main type of content	Same content as provided by fixed broadband Internet service	Same content as provided by fixed broadband Internet service	Simplified or modified content specialized for small devices

Note : 1) same as Wi-fi.
2) 'Mobile Internet' refers to the HSDPA or W-CDMA which provide wireless Internet services through 3G(third generation) or 3.5 G mobile telephone communications networks.

al.(2004).

Furthermore, consumer preferences vis-à-vis such attributes will affect their choice of mobile connectivity device. Consumers no doubt will favour a mobile device that is best suited to their preferred characteristics of wireless broadband service. Given that the IT industry is making excellent progress in the area of device convergence, and given that many regard wireless broadband Internet as the new killer application, analyzing how consumer preferences for the attributes of wireless broadband Internet service affect their choices of mobile devices is a worthwhile research endeavour. Nam et al.(2008), Ahn et al.(2006), Kim et al.(2005), and Bruner II and Kumar(2005) included mobile devices in their analysis related to wireless Internet services. However, the former two studies dealt with devices just as an attribute affecting demand for WiBro or wireless Internet services, respectively, and the latter two focused more on the mobile devices in the way of including availability of wireless Internet service as an attribute; such approaches are somewhat limited. Therefore, the following was set as the first main research question:

RQ1 : What are consumers' preferences regarding attributes of wireless broadband Internet service and how do those preferences influence their choice of mobile connectivity device?

Meanwhile, because of technological advances in IT and the assumption that consumers are increasing their IT service budgets, one might expect consumers to own and use more than one mobile device or subscribe to more than one wireless broadband Internet

service. However, the opposite may in fact continue to be true-that is, budgetary burdens will force most consumers to use just one pairing of a device and wireless broadband Internet service. The outcome will affect market competition in both the mobile device industry and the wireless broadband Internet service industry. Therefore, verifying whether one can truly expect multiple-choice behaviour(i.e., a single consumer's simultaneous choice and use of multiple services/devices) and whether it will be a dominant trend is meaningful.

Additionally, for the time being, until a dominant technology such as 4G asserts itself, various wireless broadband Internet services will compete in the market using their respective strengths. In this situation, then, both service and mobile device providers will find consumer preference information critical to establishing marketing strategies. Therefore, determining what service/device pairings consumers might find optimal, as well as what pairings of multiple services and devices consumers might prefer, is meaningful. This has not been analyzed in previous studies. Therefore, the following was set as the second main research question:

RQ2 : What patterns in consumer choice regarding combinations of mobile device and wireless broadband Internet service can one expect, and what kind of consumers' simultaneous choices of mobile devices/wireless broadband Internet services are likely to occur? Is simultaneous choice behaviour likely to be prevalent in the future?

Lastly, in terms of policy or regulatory implications, what principles and policies are best suited to open access,

interconnection between networks, and content sharing, based on consumer preferences, is of interest. Open access, interconnection between networks, and content sharing are closely related issues. With open access, in addition to the founding company that established a certain network, companies with or without their own network can use the founding company's network equivalently after paying proper compensation. If interconnection between networks is available, a company with one network can employ the networks of other companies as complements by paying appropriate interconnection charges. Also, if content provided by some services or networks is sharable, then companies can provide more abundant and familiar contents to consumers. All these things lead to reduced costs and maximization of benefits for the whole society. Through an indirect network effect, open access, interconnection between networks, and content sharing can bestow added benefits to consumers for the same cost. As a result, to increase consumer welfare per one unit of cost, proper care for these actions through policies or regulations may be desirable.

However, unconditional or compulsory open access, interconnection, and content sharing might not always be desirable as it can decrease service providers' motivation and it does not always increase the welfare of the consumer. When too many kinds of services and content are available to consumers by virtue of compulsory open access, interconnection, and content sharing, the possibility arises that consumers will have to negotiate through some additional procedures to get to the services or content they originally want to use. They could have to expend more effort to find the very information they want because there is too much information. In such situations, consumer utility or welfare may suffer.

Therefore, identification of the kind of network (e.g., characteristics and type of content) for wireless broadband Internet service that can maximize consumer welfare should precede the establishment of firm guidelines for open access, interconnection, and content sharing. Whether these are indeed linked to an increase in consumer utility should be verified. It will be desirable to consider the direction of basic principles regarding open access or interconnection in wireless broadband Internet services after this kind of information is obtained. Accordingly, the following was set as the third main research question:

RQ3 : What policy or regulatory implications regarding open access, interconnection, or content sharing can be drawn based on consumer preferences regarding wireless broadband Internet service and mobile devices?

Ⅲ. Sample and Survey

The survey was administered to 1000 respondents living in Seoul, South Korea. The sample was drawn based on age, gender, and inhabitancy distribution in of the population of Seoul. To improve the reliability of the results, well-trained interviewers used a face-to-face interview method. Before the survey, whether he or she has intention to use wireless broadband Internet service in future in addition to the fixed one in 11-point scale was asked. Finally, those who answered 'definitely no intention to use wireless broadband Internet service' which is represented as 0 in 11-point scale, were excluded. All the respondents had their own Mobile or Smart phones (including PDAs) that can be used to connect to the wireless Internet network. However, only a few had Tablet-PCs(n=32) or notebook PCs(including netbooks) (n=98), suggesting that currently, not many consumers use more than one device to connect to wireless broadband Internet services.

The approach of conjoint analysis was used to gather consumer preference information regarding mobile connectivity devices and for wireless broadband Internet services. That method entails asking each respondent to report his or her preferences by ranking, assigning a rating to, or choosing among hypothetical alternatives. Those hypothetical alternatives consist of attributes and attribute-levels, and thus from estimation the consumer's preference or valuation for each attribute can be obtained(Alvarez-Farizo and Hanley, 2002). Therefore, conjoint analysis is one of the most

suitable methods by which to analyze consumer preferences regarding services or products that are not on the market yet or are newly introduced. The method has been used in many fields such as marketing(Huber and Train, 2001); transportation research (Carlsson, 2003); health economics(San Miguel et al., 2000; Bryan and Parry, 2002); environmental economics(Roe et al., 1996; Layton, 2000); and new IT products and services(Kim et al., 2005; Batt and Katz, 1997; Kim, 2005; Jeong et al., 2008; Koh, 2010; Kim, Y. et al., 2006). Using conjoint analysis is appropriate for the case of this study because, of the mobile devices and wireless broadband Internet services under consideration, some are not yet perfected for use or are just now being made available for use.

Table 2 shows the attributes and attribute-levels designed for the wireless broadband Internet options of interest. The attributes

Table 2. Attributes and attribute levels of wireless Internet services used in the survey

Attribute	Attribute Levels
Monthly cost[1)]	40,000, 70,000, 100,000 won/month
Mobility	Fixed use only
	Available to use while walking(3-4 km/h)
	Available to use while moving very fast(60 km/h)
Data transfer speed	1, 5, 10Mbps
Type of content or interconnectivity between networks	Simplified and modified content only
	Same content as provided by fixed broadband Internet service
	Both types available

Note : 1) Sum of monthly wireless broadband Internet service charge and instalment of mobile device.

considered—mobility, data transfer speed, type of content or interconnectivity between networks, and monthly service charge (included in monthly cost with the monthly instalment for a mobile device)—are extremely important to consumers in choosing among wireless broadband Internet services. They were chosen by considering the results of previous studies and their significance to managerial and policy-related points of view.

Regarding monthly cost, which is the sum of the monthly service charge for wireless broadband Internet access and the monthly instalment for mobile devices, 40,000, 70,000, and 100,000 won per month are set as the attribute-levels. It is believed that represents a realistic range of money that consumers can afford and that service providers and mobile device providers can charge. The following attribute-levels for mobility were determined: "fixed use only", "available to use while walking(such as at 3-4 kilometres per hour)", and "available to use while moving very fast(such as at 60 kilometres per hour in an automobile)." It was explained to the respondents that mobility is defined as the speed at which the wireless broadband Internet service provides the user optimal service, not the maximum speed at which it works. The attribute-levels for data transfer speed were set as 1 megabit per second (Mbps), 5 Mbps, and 10 Mbps. In so doing the range of current data transfer speeds of various wireless Internet service options as well as realistic target data transfer speeds of the services in the near future were considered.

Regarding type of content or interconnectivity between networks, the attribute-levels are set as "simplified and modified content only", "same content as provided by fixed broadband Internet service", and "both types available". "Simplified and modified content only" means

that the wireless broadband Internet service provides to consumers for use on their mobile devices only content that has been simplified, modified, or specialized for the service, compared with content consumers generally use on a fixed broadband Internet service. "Same content as provided by fixed broadband Internet service" means that the wireless broadband Internet service provides to consumers via their mobile devices exactly the same content as a fixed broadband Internet service would provide. That is to say, consumers can avail themselves of the same Internet content with which they are most familiar. Additionally, at this attribute-level, the wireless broadband Internet network is required to interconnect with fixed broadband networks and corresponding contents providers. "Both types available" means that the wireless Internet service provides to consumers for use on their mobile devices both simplified and modified content and the same content a fixed broadband Internet service would provide. That is to say, consumer can benefit from a huge amount of content on the familiar Internet as well as from additional types of content or interconnecting with other wireless networks. Similar to the case of "same content as provided by fixed broadband Internet service", the wireless broadband Internet service is required to interconnect with fixed broadband networks, and other wireless broadband Internet services specialized in providing simplified and modified content. As a result, this requires a very high level of compatibility or interconnectivity. Consumer preferences or valuations with regard to this attribute's levels can reveal a pattern of consumer preference for compatibility or interconnectivity, and that can inform the setting of policy with regard to the degree and direction for interconnection between wireless broadband service networks.

Finally, the respondents in the survey were asked to choose hypothetical mobile connectivity devices combined with the above-mentioned attributes and attribute-levels. Three such devices were included in the survey: Mobile or Smart phone, Tablet-PC, and notebook PC. Those choices were settled on because they are the most probable types of mobile device the average consumer would use with wireless Internet services on the move, as noted in previous studies such as Ahn et al.(2006), and they can be distinguished by their competitive areas. In spite of the advent of digital IT convergence, which blurs the clear distinction between types of mobile devices, the devices can be categorized relatively, as shown in Table 3, in terms of display size, portability, computing power, and convenience or usability of input equipment when using Internet services.

Regarding display size, a notebook PC will usually have the largest display(over 10 inches), followed in order by the Tablet-PC(6~10 inches) and the Mobile or Smart phone(2~4 inches). As for degree

Table 3. Categorization of mobile devices in terms of some important features

Characteristics	Mobile or Smart phone	Tablet-PC	Notebook PC
Display size	Small (2~4 inches)	Medium (6~10 inches)	Large (over 10 inches)
Portability	High (small and light)	Medium	Low (large and heavy)
Computing power	Low	Medium	High
Convenience in input	Low (touch-screen)	Medium (touch-screen)	High (keyboard)

of portability, the order is exactly reversed. With regard to the device's relative computing power and convenience or usability of input equipment when using Internet services, the order is the same as for display size.

Meanwhile, in the survey procedure, respondents were allowed to take more than one alternative, if they wished, while being asked to consider their budgetary constraints. In addition to the allowance of simultaneous multiple choices, respondents were allowed to not choose any of the alternatives. After applying fractional factorial design, the total number of alternative cards representing three types of hypothetical mobile devices combined with attributes and attribute-levels for wireless broadband Internet services, was reduced to nine. Again, the cards were divided into three groups with each group consisting of alternatives associated with the Mobile or Smart phone, Tablet-PC, and notebook PC, respectively, while carefully controlling so that the multicollinearity problem did not occur. To sum up, from one group that contained three hypothetical alternative cards representing one of the mobile devices combined with attributes of wireless broadband Internet services, respondents were asked to choose an alternative(or alternatives) as they wished, repeating this procedure three times.

Ⅳ. Methodology

1. Multivariate Probit Model

To reflect the multiple-choice behaviour of the consumer with regard to mobile devices for wireless broadband Internet services, a multivariate probit model(Chib and Greenberg, 1998; Edwards and Allenby, 2003; Baltas, 2004; Koh and Lee, 2010) is employed. For this study, utility is assumed to be specified by a deterministic element and an unobserved stochastic element; the deterministic part consists of the linear combination of alternative-specific constants(ASCs), attributes or attribute-levels and their coefficients, and individual characteristics and their coefficients, as shown in equation (1):

$$U_{n,j} = \beta_{j,o} + \sum_{k} \beta_{j,k} X_{j,k} + \sum_{l} \alpha_{j,l} S_{n,j,l} + \varepsilon_{n,j} \quad (1)$$

$$Y_{n,j} = \begin{cases} 0 \text{ when } U_{n,j} > 0 \\ 1 \text{ when } U_{n,j} < 0 \end{cases} \quad (2)$$

$$\varepsilon \sim N(0, \Sigma)$$

Here, n, j, k, and l represent the nth consumer, jth alternative, kth attribute, and lth individual characteristic, respectively. Thus, in equation (1), $U_{n,j}$ represents the utility of consumer n from

alternative j; $\beta_{j,o}$ is an alternative-specific constant; $\beta_{j,k}$ is a coefficient for the kth attribute or attribute-level of the jth alternative, $X_{j,k}$; and $\alpha_{j,l}$ is a coefficient for the lth individual characteristic of the nth consumer, $S_{n,j,l}$; while $\varepsilon_{n,j}$ is an unobserved disturbance term following normal distribution with mean 0 and covariance Σ. In equation (2), $Y_{n,j}$ is an observed choice of the jth alternative. The jth alternative is chosen($Y_{n,j}$=1) when the utility from it, $U_{n,j}$, exceeds 0, and this can be applied to all other alternatives and related utilities. From this setting, the model can reflect the consumer's simultaneous multiple-choice behaviour, and relations between choices of each alternative can be linked in the multivariate probit model. Especially, covariance Σ can reflect relationships among unobserved factors of choices or coincidences of alternatives.

2. Empirical Model Specification and Estimation

The multivariate probit model is empirically specified as in equation (3).

$$
\begin{aligned}
U_{n,\,MobileSmart} &= \beta_{MobileSmart,\,0} + \sum_{k=1}^{K} \beta_k X_{MobileSmart,\,k} + \sum_{l=1}^{L} \alpha_l S_{n,l} + \varepsilon_{MobileSmart} \\
U_{n,\,TabletPC} &= \beta_{TabletPC,\,0} + \sum_{k=1}^{K} \beta_k X_{TabletPC,\,k} + \sum_{l=1}^{L} \alpha_l S_{n,l} + \varepsilon_{TabletPC} \qquad (3) \\
U_{n,\,Notebook} &= \beta_{Notebook,\,0} + \sum_{k=1}^{K} \beta_k X_{Notebook,\,k} + \sum_{l=1}^{L} \alpha_l S_{n,l} + \varepsilon_{Notebook}
\end{aligned}
$$

$$\varepsilon \sim N(0,\ \Sigma)$$

$$\Sigma \sim \begin{cases} 1 & \sigma_{MobileSmart-TabletPC} & \sigma_{MobileSmart-Notebook} \\ \sigma_{TabletPC-MobileSmart} & 1 & \sigma_{TabletPC-Notebook} \\ \sigma_{Notebook-MobileSmart} & \sigma_{Notebook-TabletPC} & 1 \end{cases}$$

Here, j = *Mobile or Smart phone, Tablet-PC*, and notebook PC, and each utility consists of an alternative-specific constant, $\beta_{MobileSmart,\ 0}$, $\beta_{TabletPC,\ 0}$, and $\beta_{Notebook,\ 0}$, attributes of wireless broadband Internet service for each mobile device, $X_{MobileSmart,\ k}$, $X_{TabletPC,\ k}$, and $X_{Notebook,\ k}$, and individual characteristics, $S_{n,l}$. This means that each equation represents choices of mobile devices while considering the basic intrinsic utility from each mobile device (by ASC), the effects of the attributes of a wireless broadband Internet service, and individual characteristics (by β_k, α_l).

Note that $\beta_{MobileSmart,\ k}=\beta_{TabletPC,\ k}=\beta_{Notebook,\ k}=\beta_k$ is assumed in equation (3), which means that coefficients for the same attributes or individual characteristics in each alternative's utility are set to be common. Meanwhile, ASCs, $\beta_{MobileSmart,\ 0}$, $\beta_{TabletPC,\ 0}$, and $\beta_{Notebook,\ 0}$, are allowed to have a different value alternative by alternative, representing basic intrinsic utilities or preferences for corresponding mobile terminals that are not explained by the included wireless Internet service attributes and individual characteristics; that is, this differs by each equation.[1] The covariance of ε, Σ is set as a correlation due to the identification problem in the multivariate probit

1) The other model specification was estimated with different coefficients for the same attribute ($\beta_{MobileSmart,\ k} \neq \beta_{TabletPC,\ k} \neq \beta_{Notebook,\ k}$) in each equation. However, meaningful estimation results were not obtained except for the significant alternative-specific constants and correlations. It is speculated that this is a result of insufficient variation in attributes equation by equation because of the way the survey was formulated.

model(Koh and Lee, 2010; Edwards and Allenby, 2003; Baltas, 2004; Zhao and Harris, 2004).

Next, for $X_{j,k}$, since the levels for mobility and type of content or interconnectivity between networks are qualitative, they are dummy variables in the model specification; "fixed use only" and "simplified and modified content" are the references for mobility and type of content or interconnectivity between networks, respectively. The variables of monthly cost and data transfer speed are quantitative variables. For $S_{n,l}$, dummy variables are used for age and gender, so that teenaged or in one's 20s, in one's 30s, in one's 40s, and male are included, and greater than 50 years old and female are set as references for age and gender, respectively. As for education year, the additional years spent on education after high school graduation are added into the model to reflect the relative effect of additional education after high school. Lastly, total monthly expenditure on telecommunications services and monthly income are included, while dividing monthly income by 1,000,000 won for matching scale.

Finally, to compare the effects of basic intrinsic preferences for each mobile connectivity device by alternative-specific constant, the effects of attributes of wireless broadband Internet services, and the effects of individual characteristics, three model specifications are estimated. The first is estimated with ASCs only, the second with ASCs and wireless broadband Internet attributes, and the third with ASCs, wireless broadband Internet attributes, and individual characteristics.

For the estimation, a Bayesian approach using Gibbs sampling is employed instead of a classical approach based on maximum likelihood estimation. Because the multivariate probit model is an extension of the well-established multinomial probit model, in that it

considers more than one choice simultaneously, the same idea of the Bayesian approach in a traditional discrete choice model can be applied(Rossi et al., 2005). The Bayesian approach has some advantages over the classical approach. For example, because the Bayesian approach does not need to find the maximum likelihood function, it does not suffer from the problem related to finding the global maximum(Chib and Greenberg, 1998; Edwards and Allenby, 2003; Rossi et al., 2005).

V. Estimation Results

To estimate the Bayesian multivariate probit model, a multivariate normal distribution with very large variances as a diffuse prior distribution is assumed for coefficients. An inverted Wishart distribution is assumed as a prior distribution for Σ. Based on those prior distributions, conditional posterior distributions can be obtained, and 40,000 draws from the conditional posterior distributions were taken, which converge to those from joint posterior distribution by using the Gibbs sampling and data augmentation. The first 30,000 draws were discarded and every 10th draw from the next 10,000 draws was chosen and used for inference to avoid serial correlation among draws.

As mentioned earlier, estimation results are derived for three model specifications. Table 4 shows the estimation results of each model specification.

1. Estimation Results of the Three Model Specifications

In the first model specification estimated with the ASCs only, all of the ASCs are highly significant, and it is found that, without controlling for other variables, consumers prefer the Mobile or Smart phone the most among the mobile devices concerned for use

Table 4. Estimation results of the three model specifications

	1st Model Specification		2nd Model Specification		3rd Model Specification	
Coefficients	Mean[1)]	STD[2)]	Mean	STD	Mean	STD
$\beta_{MobileSmart,\ 0}$ (ASC for Mobile or Smart phone)	−0.6411	0.0245	−0.0067*[3)]	0.0583	−0.2424	0.0571
$\beta_{TabletPC,\ 0}$ (ASC for Tablet-PC)	−0.8030	0.0255	−0.1756	0.0597	−0.4129	0.0671
$\beta_{Notebook,\ 0}$ (ASC for Notebook PC)	−0.8585	0.0268	−0.2310	0.0605	−0.4701	0.0865
Monthly cost			−0.1338	0.0063	−0.1348	0.0065
Available to use while walking			0.1482	0.0395	0.1503	0.0385
Available to use while moving very fast			0.2192	0.0380	0.2227	0.0386
Data transfer speed			0.0112	0.0041	0.0110	0.0041
Same content as provided by fixed broadband Internet service			0.1393	0.0375	0.1028	0.0368
Both types available			0.1050	0.0377	0.1385	0.0344
Male					0.0374*	0.0307
Teenager and 20s					0.1002	0.0428
30s					0.1563	0.0419
40s					0.0490*	0.0451
Additional education years after graduation of high school					0.0293	0.0094
Monthly income					0.0028*	0.0135
Expenditure on telecommunications services					0.0018*	0.0017
Correlation	Mean	STD	Mean	STD	Mean	STD
$\sigma_{MobileSmart-TabletPC}$	−0.2003	0.0354	−0.1302	0.0442	−0.1189	0.0278
$\sigma_{MobileSmart-Notebook}$	−0.1552	0.0409	−0.1054	0.0449	−0.0754	0.0263
$\sigma_{TabletPC-TabletPC}$	−0.0246	0.0326	−0.0464*	0.0383	−0.0762	0.0409

Note : 1) posterior mean.
2) posterior standard deviation.
3) *: not significant at 1% significance level in the classical sense.

with wireless broadband Internet, followed by the Tablet-PC and the notebook PC. This result is similar to those found by Nam et al. (2008) and Ahn et al.(2006), but somewhat different from that found by Kim et al.(2005), which predicted that PDA-like mobile devices relative to mobile phones and notebook PCs are likely to be the dominant future direction of device convergence according to consumers' high preference for a midsized display and keyboard.

Although it can be seen from Table 3 that the Mobile or Smart phone is inferior to the other mobile devices in all aspects except for portability, it is still greatly preferred relative to the others; and, likewise, the Tablet-PC, inferior to the notebook PC with the exception of portability, is preferred to the notebook PC. Such results lead us to deduce that portability is the most important factor affecting choice of mobile device for use with a wireless broadband Internet service. Based on the correlation results, it can be expected that multiple-choice behaviour with regard to mobile devices is not likely to occur as a general case for the time being, if other attributes are not being considered, since the correlations for them are negative and significant. On the other hand, if the relative magnitudes of significant correlations are compared, it can be expected roughly that the probability of consumers owning a Mobile or Smart phone and notebook PC simultaneously is a little greater than that for a Mobile or Smart phone and Tablet-PC.

In the second model specification, all of the ASCs and the coefficients are highly significant except for the correlation between Tablet-PC and notebook PC. The estimation results for the ASCs and correlations are somewhat different from those attained in the first model specification but show similar patterns. For mobility and type of content or interconnectivity between networks, diminishing

marginal returns in utility as the quality level increases are observed. For example, a larger increase in utility is noted when moving from "simplified and modified content only" to "same content as provided by fixed broadband Internet service" than when moving from "same content as provided by fixed broadband Internet service" to "both types available." Oddly, even a decrease in utility is observed for type of content or interconnectivity between networks, which means that the provision of the same content as provided by the fixed broadband Internet service is sufficient for consumers.

In the last model specification, no critical differences from the second model specification are observed regarding the coefficients for attributes and the correlations, with the exception of some magnitude differences. The estimated ASCs show some differences but follow the same trend as in the first and the second specifications. With regard to gender, there is no significant effect on the choice of wireless Internet service. As for age, relative to consumers aged 50 or older, consumers between 30 and 40 years of age are more likely to use mobile devices for a wireless Internet service, followed by teenagers and other consumers in their 20s. As for the education level, spending an additional year on education after graduating from high school does not seem to contribute much to the choice probability. However, consumers who spend a long time adding significantly to their education level exhibit a much greater probability of adopting new mobile devices for wireless broadband Internet services.

The coefficients of expenditure on telecommunications services and monthly income are very small and not significant, which means it is not certain that they affect the choices consumers make regarding mobile devices for wireless broadband Internet services.

This result is somewhat contrary to our basic intuition. It could be the result of the general bias observed in the stated preference data.

2. Relative Importance of Variables

In the meantime, the estimation results can be used to calculate another useful measure, the relative importance of the attributes. The relative importance of an attribute is calculated as the part-worth of the attribute divided by the total sum of part-worths. Part-worth is calculated as the estimate multiplied by variation between the maximum and minimum levels of an attribute(Kim, Y. et al., 2006). Table 5 shows the relative importance of each attribute calculated using the estimation results from the second model specification.

These results show that consumers regard monthly cost, including the monthly service charge for use of the wireless broadband Internet service and the monthly instalment payment for the mobile device, as the most important criteria when choosing a

Table 5. Relative importance of each attribute concerned

Variable	Relative Importance
Alternative-specific constant	15.4%
Monthly cost	53.4%
Mobility	14.6%
Data transfer speed	7.4%
Type of content or interconnectivity between networks	9.3%

combination of mobile device and wireless broadband Internet service, as was found in many previous studies. It accounts for more than half of the total sum of the part-worths. However, unlike our expectation, an increase in data transfer speed does not affect consumers' choices much. This result is similar to what Jeong et al. (2008) and Koh(2010) found—that is, a marginal difference(e.g., 1 Mbps) in data transfer speed does not affect consumers' choice among various broadband Internet services, whereas a difference of more than 10 Mbps can matter.[2)]

To sum up, this result shows that consumers consider mobility to be more important than data transfer speed with respect to wireless broadband Internet services.

2) However, the result of this study is different from those of two previous studies, Nam et al.(2008) and Ahn et al.(2006), which show that data transfer speed is the second most important attribute. It is speculated that this is because there are differences in the ways data transfer speed and other attributes are set in the surveys. For example, in Nam et al.(2008), attribute levels for data transfer speed of WiBro are shown as slow, middle, and fast.

VI. Discussion and Implications

1. Implications of Consumer Preferences for Wireless Broadband Internet Service Attributes and Their Effect on Choice of Mobile Devices

Based on the finding that monthly cost is the most important factor in the choice of mobile devices for wireless broadband Internet services, providers might regard reducing the monthly service charge for wireless broadband Internet service and the cost of devices as top priorities. To meet those priorities, the industry could look to enhancements in wireless data transmitting technology to cut down on costs and increase efficiencies, and to the development of cheaper mobile devices for specific wireless broadband Internet services.

Judging by the high relative importance given to mobility of wireless Internet services and the high valuation put on portability of mobile devices, consumers put great value on being able to use a wireless Internet service seamlessly while on the move. Therefore, wireless Internet services adopting technologies or standards that hold an advantage in mobility are likely to be competitive, and service providers should pursue that strategy. Additionally, manufacturers of mobile devices should consider the portability of their product as a priority, and wireless Internet service providers need to develop services that are suitable to the portable mobile

devices without sacrificing other benefits, as much as that is possible.

As for data transfer speed, it is observed that a small difference in throughput speed does not affect consumers' choice of mobile device for wireless broadband Internet services. A relatively larger difference, such as 10 to 20 Mbps, can affect choice; however, such a difference is very hard to realize in the wireless environment in the short term.

As for the attribute "type of content or interconnectivity between networks," judging from the fact that the coefficient for "same content as provided by fixed broadband Internet service" is the largest, it is clear that consumers value the type of environment they have experienced on their desktop PCs through fixed broadband Internet services. However, an unconditional increase in the availability of more content and additional access to other types of networks or services is not always the optimal choice. According to our results, consumers assign more value to a change in attribute-level from "simplified and modified content only" to "same content as provided by fixed broadband Internet service" than they do to a change to "both types available." This means that for consumers to be able to use the same content a fixed broadband Internet service would provide or, in turn, to be able to connect to the networks of fixed broadband Internet services is the optimal option. Adding more types of content or interconnectivity between other networks won't contribute much to increasing consumer utility or to the choice probability among mobile devices.

Wireless Internet service providers should keep that result in mind. Mobile Internet services such as HSDPA or WCDMA, both of which mainly provide different or modified content specialized to the

Mobile or Smart phone with its small display and low level of computing power, are not likely to increase demand for a certain mobile device by themselves. In contrast, WLAN(or Wi-fi) or WiBro, with their ability to provide a fixed broadband Internet-like service, are more likely to increase demand for mobile devices for usage with wireless Internet service.

Meanwhile, although the results are focused mainly on demand for mobile devices used for wireless broadband Internet services, and on factors affecting that demand, the competitiveness of each wireless broadband Internet service can be compared intuitively based on the results or this study from the perspective of consumers. Table 6 shows how competitive WLAN, WiBro, and Mobile Internet are expected to be with regard to the attributes of each service(as shown in Table 1) based on the current status of their technology.

As can be seen, overall, as a wireless broadband Internet service itself, Mobile Internet is expected to be less competitive than the others, although that could change in the future depending on technological developments and service providers' investments.

Table 6. Comparison of competitiveness between wireless broadband Internet services by attribute based on consumer preferences

Attribute	WLAN	WiBro	Mobile Internet
Monthly service charge	Very high	High	Low
Mobility	Low	High	Very high
Type of content	High	High	Medium
Data transfer speed	Very high	High	Medium

This intuitive prediction is similar to the simulation result in Ahn et al.(2006). To better its position, Mobile Internet needs to take measures to provide the same content a fixed broadband Internet service would provide at low cost and higher data transfer speed.

2. Implications of the Expected Preferred Pairings of Mobile Device and Wireless Broadband Service, and Choices of Multiple Devices and/or Services

In this section, the simulation results ran to predict consumers' choices of mobile device(or devices) for use with WiBro, WLAN, and Mobile Internet, are reported in more detail.

For the simulation, 1,000 draws are abstracted from multivariate normal distribution with mean 0 and correlation matrix as shown in Table 4, while the estimation results of the last model specification with sample mean for individual characteristics used. Each attribute level of wireless Internet service is set as shown in Table 7, in accordance with Table 1 and the current representative status of the technology for each type of wireless broadband Internet service.

Five scenarios are simulated in total. The first four look at the preferred choice of mobile device(s) for use with WiBro, WLAN1, WLAN2 and Mobile Internet separately. The last scenario looks at choices from among the following combinations: Tablet-PC and WiBro; notebook PC and WLAN1; and Mobile or Smart phone and Mobile Internet. For this scenario a specific mobile device was combined with a specific wireless Internet service in this way in

Table 7. Assumed attribute levels for each wireless broadband Internet service used in the simulation analysis for all scenarios

Attribute	Assumed Attribute Levels for Each Simulation		
	WiBro	WLAN1,2[1)]	Mobile Internet
Monthly service charge	20,000 won/month	8,000 or 0 won/month	35,000 won/month
Mobility	Available to use while walking (3−4 km/h)	Fixed use only	Available to use while moving very fast (60 km/h)
Data transfer speed	3 Mbps	5.4 Mbps	2 Mbps
Type of content or interconnectivity between networks	Both types available	Same content as provided by fixed broadband Internet service	Simplified and modified content only

Note : 1) WLAN1 represents the subscribed WLAN (or Wi-fi) service with monthly service charge of 8,000 won, while WLAN2 represents the free WLAN service without any service charges.

order to see the competitiveness of these wireless Internet services when they are combined with the mobile device the industry has mainly targeted for use with the service. In general, as shown in Table 1, the Tablet-PC and Mobile or Smart phone are said to be the most suitable mobile devices for WiBro, the Mobile or Smart phone and Tablet-PC for Mobile Internet as well, and the notebook PC and Tablet-PC for WLAN.

For the simulation, the average price of a Mobile or Smart phone for use with wireless Internet service is assumed to be 480,000 won, that of a Tablet-PC, 720,000 won, and that of a notebook PC, 1,200,000 won. Generally, the relative price of each of the three type of mobile device, in descending order, is notebook PC, Tablet-

Table 8. Simulated choice probabilities of mobile devices with respect to each wireless broadband Internet service(the first three simulations)

Choice pattern	Choice probability[1] (%)							
	WiBro		WLAN1		WLAN2		Mobile Internet	
Mobile or smart phone only	25.6	50.5	26.3	52	27.6	62.5	22.6	46.6
Tablet-PC only	13.6		13.9		19.9		13.1	
Notebook PC only	11.3		11.8		15.0		10.9	
Mobile or smart phone + Tablet-PC	7.2	18.2	7.2	18.4	8.1	21.1	4.9	10
Mobile or smart phone + notebook PC	5.9		6.1		7.1		3.1	
Tablet-PC + notebook PC	5.1		5.1		5.9		2.0	
All	2.7		2.8		3.3		1.3	
None	28.6		26.8		13.1		42.1	
Total choice of mobile or smart phone	41.4		42.1		46.1		31.9	
Total choice of Tablet-PC	28.6		28.7		37.2		21.3	
Total choice of notebook PC	25.0		25.6		31.3		17.3	

Note : 1) simulated choice probability of each choice pattern for each wireless broadband Internet services concerned.

PC, and Mobile or Smart phone, and the usual pricing of each for use with a wireless broadband Internet service is similar to that assumed here.[3] It is assumed that the average period of usage for all devices is two years. That results in a monthly instalment of 20,000 won for a Mobile or Smart phone, 30,000 won for a Tablet-PC, and 50,000

won for a notebook PC.

The simulation results in Table 8 show that for each of the wireless Internet services studied, the Mobile or Smart phone is the connectivity device most frequently chosen by the consumer. With respect to consumers choosing to use multiple devices with one service, a relatively less proportion of consumers will choose to do so under Mobile Internet.

The last simulation, which investigates different combinations between primarily targeted mobile devices and wireless broadband Internet services, provides us with similar results as in Table 9 regarding preference of mobile device. As in the three former simulations, the Mobile or Smart phone is the most frequently chosen device even when it is combined with Mobile Internet service. As for the wireless broadband Internet services, Mobile Internet becomes the most frequently chosen technology in this simulation. With respect to consumers choosing to use multiple combinations, the simultaneous choice of Mobile or Smart phone for Mobile Internet and Tablet-PC for WiBro is the most likely.

To sum up, from these results, it can be inferred that for the average consumer's purposes in using a wireless Internet service, among the attributes of mobile devices, portability and familiarity are more important than display size, computing power, or convenience in input, since even though the Mobile or Smart phone is inferior to all other devices in terms of those attributes, it has strength in portability and familiarity. Also, with respect to competition between wireless broadband Internet services, additional implications are

3) Varying the prices, while keeping them close to those assumed here, did not change the simulation results much.

Table 9. Simulated choice probabilities of mobile devices for specific wireless broadband Internet services (the last simulation)

Choice pattern	Choice probability[1] (%)	
Mobile or Smart phone for Mobile Internet only	22.1	48.6
Tablet-PC for WiBro only	14.1	
Notebook PC for WLAN[2] only	12.4	
Mobile or Smart phone for Mobile Internet + Tablet-PC for WiBro	6.3	17.4
Mobile or Smart phone for Mobile Internet + Notebook PC for WLAN	5.8	
Tablet-PC for WiBro + Notebook PC for WLAN	5.3	
All	3.1	
None	30.9	
Total choice of Mobile or Smart phone for Mobile Internet	37.3	
Total choice of Tablet-PC for WiBro	28.8	
Total choice of Notebook PC for WLAN	26.6	

Note : 1) simulated choice probability of each choice pattern for each wireless broadband Internet services concerned.
2) WLAN here represents WLAN1 that is assumed to be the subscribed WLAN(or Wi-fi) service with monthly service charge of 8,000 won.

obtained if mobile devices are taken under consideration.

Unlike the prediction that WiBro and WLAN are more preferred and competitive than Mobile Internet when only the attributes of wireless broadband Internet services are concerned, as shown in Table 6, Mobile Internet becomes the most preferred option when it is combined with the primarily targeted mobile device, Mobile or

Smart phone.

Of course, if a scenario that includes the Tablet-PC for Mobile Internet and the Mobile or Smart phone for WiBro were to be considered, the results would be different. The remarkable implications to note are that, first, mobile connectivity devices play a significant role in competition among wireless broadband Internet services in addition to the attributes of the services themselves, and second, all the results emphasize the importance of portability and familiarity and imply that proper matching of service to Mobile or Smart phone by wireless broadband service providers is critical to gaining larger market share.

Meanwhile, multiple-choice behaviour by the consumer constitutes a considerable factor even though such behaviour does not reach an absolute level that can influence the whole market. This justifies our approach that takes multiple-choice behaviour into account. Further, the possibility of multiple choices depends on the features of the mobile devices rather than the wireless broadband Internet services. In all cases, the multiple choice of Mobile or Smart phone and Tablet-PC seems to be dominant. This implies that when considering using wireless broadband Internet services, consumers want to complement the inferiorities of the Mobile or Smart phone in terms of computing power, display, or convenience in input by additionally choosing a Tablet-PC with its moderate portability and other features, rather than choosing a notebook with its poor portability albeit excellence in other features.

3. Other Implications Related to Policy and Regulation

As noted previously, it is found that although consumers value the availability of more content and access to other networks and services, it would be better to provide an optimal level of those attributes—that is, the same environment as a fixed broadband Internet service would provide—instead of unconditionally increasing the attributes. Therefore, to maximize social welfare, the most desirable path for policymakers would be to set forth such basic principles as encouraging wireless Internet service or network providers to open their networks and permit interconnections among them and content sharing, but to obligate the providers to do only what is essential to provide wireless broadband Internet users with the same environment as that of a fixed broadband Internet service, and other than that, let the providers make their own way as dictated by their own motivations.

VII. Concluding Remarks

This study attempted to predict demand in South Korea of different types of mobile devices for wireless broadband Internet services, and to induce some implications regarding business and policy. More specifically, it was attempted to predict what effects consumer preferences regarding attributes of wireless broadband Internet service will have on choice of mobile device and on the probability that consumers might pay for and use mobile devices for wireless broadband Internet services. A conjoint analysis approach and a Bayesian multivariate probit model were employed to estimate the consumer preferences.

From the results of the estimation, it was deduced that monthly cost—consisting of a monthly service charge for the use of wireless broadband Internet services and a monthly instalment payment for the mobile devices—will be the most critical factor in determining consumer demand of mobile devices for wireless broadband Internet service, and mobility of wireless broadband Internet services on mobile devices will be the second most important factor. Even though consumers value the availability of more content and access to other networks or services, they value the same environment as provided by a fixed broadband Internet service the most and find that environment sufficient.

From the results of the simulation analysis, it was found that for use with a specific wireless Internet service, consumers will regard portability as the most important factor in their choice of mobile

device. Also, it was observed that the existence of certain types of multiple-choice behaviour with regard to mobile devices and their combinations with wireless broadband Internet services, and that there are different implications regarding competition between wireless Internet services when mobile devices are also considered. This justifies the approach taken in this study, implying that it is necessary to include consideration of mobile devices and multiple-choice behaviour in an analysis of competition in the wireless broadband Internet marketplace.

It is hoped that the results of this unique research approach will be helpful to those engaged in determining the direction of research and development, forming business strategies, or setting policy or regulations in the market related to mobile devices and wireless broadband Internet services.

References

- Ahn, J., Cha, K., Jun, D. B., and Park, M. H.(2004), "Bridging Telecommunications Service: Its Concept and Related Management Strategy," *Telecommunications Policy*, vol. 28, pp. 733-750.
- Ahn, J. W., Lee, J. S., Lee, J. D., and Kim, T.(2006), "An Analysis of Consumer Preferences among Wireless LAN and Mobile Internet Services," *ETRI Journal*, vol. 28, pp. 205-215.
- Alvarez-Farizo, B. and Hanley, N.(2002), "Using Conjoint Analysis to Quantify Public Preferences over the Environmental Impacts of Wind Farms: An Example from Spain," *Energy Policy*, vol. 30, pp. 107-116.
- Baltas, G.(2004), "A Model for Multiple Brand Choice," *European Journal of Operational Research*, vol. 154, pp. 144-159.
- Batt, C. E. and Katz, J. E.(1997), "A Conjoint Model of Enhanced Voice Mail Services: Implications for New Service Development and Forecasting," *Telecommunications Policy*, vol. 21, pp. 743-760.
- Bruner II, G. C. and Kumar, A.(2005), "Explaining Consumer Acceptance of Handheld Internet Devices," *Journal of Business Research*, vol. 58, pp. 553-558.
- Bryan, S. and Parry, D.(2002), "Structural Reliability of Conjoint Measurement in Health Care: An Empirical Investigation," *Applied Economics*, vol. 34, pp. 561-567.
- Carlsson, F.(2003), "The Demand for Intercity Public Transport: The Case of Business Passengers," *Applied Economics*, vol. 35, pp. 41-50.
- Chib, S. and Greenberg, E.(1998), "Analysis of Multivariate Probit

Models," *Biometrika*, vol. 85, pp. 347-361.

- Edwards, Y. D. and Allenby, G. M.(2003), "Multivariate Analysis of Multiple Response Data," *Journal of Marketing Research*, vol. 40, pp. 321-334.
- Huber, J. and Train, K.(2001), "On the Similarity of Classical and Bayesian Estimates of Individual Mean Partworths," *Marketing Letters*, vol. 12, pp. 257-267.
- Jeon, H., Shin, Y., and Choi, M.(2007), "Study on the Service Competitive Structure among Mobile Multimedia Services: Wibro, HSDPA, S-DMB, T-DMB," *Telecommunications Review*, vol. 17, pp. 522-537.
- Jeong, G., Koh, D., and Lee, J.(2008), "Analysis of the Competitiveness of Broadband over Power Line Communication in Korea," *ETRI Journal*, vol. 30, pp. 469-479.
- Kang, M., Hong, S., Shin, J., and Song, C.(2004), "An Analysis of the Preference Characteristics of Wireless Internet Service by Segment Groups," *Telecommunications Review*, vol. 14, pp. 483-493.
- Kang, S. W., Cho, S., and Lie, H.(2005), "The Economic Value of Next-Generation Converged Communications and Broadcasting Services," *ETRI Journal*, vol. 27, pp. 759-767.
- Kim, M. and Jee, K.(2006), "Characteristics of Individuals Influencing Adoption Intentions for Portable Internet Service," *ETRI Journal*, vol. 28, pp. 67-76.
- Kim, M., Jee, K., and Park, J.(2006), "Demand Forecasting and Market Position for Fixed-Mobile Convergence Focused on WiBro," *Telecommunications Review*, vol. 16, pp. 25-34.
- Kim, Y.(2005), "Estimation of Consumer Preferences on New Telecommunication Service: IMT 2000 Service in Korea," *Information Economics and Policy*, vol. 17, pp. 73-84.

• Kim, Y., Lee, J., and Koh, D.(2005), "Effects of Consumer Preferences on the Convergence of Mobile Telecommunications Devices," *Applied Economics*, vol. 37, pp. 817-826.
• Kim, Y., Park, Y., Lee, J., and Lee, J.(2006), "Using Stated Preference Data to Measure the Inconvenience Cost of Spam among Korean E-mail Users," *Applied Economics Letters*, vol. 13, pp. 795-800.
• Koh, D.(2010), "Analysis on the New Competition in the Saturated Residential Broadband Access Market: Using Stated Preference Data in Korea," working paper, Korea Institute of Economics and Trade.
• Koh, D. and Lee, J.(2010), "Analysis of Consumers' Choices and Time-Consumption Behaviors for Various Broadcasting and Telecommunication Convergence Services," *ETRI Journal*, vol. 32, pp. 302-311.
• Layton, D. F.(2000), "Random Coefficient Models for Stated Preference Surveys," *Journal of Environmental Economics and Management*, vol. 40, pp. 21-36.
• Lehr, W. and McKnight, L. W.(2003), "Wireless Internet Access: 3G vs. WiFi?", *Telecommunications Policy*, vol. 27, pp. 351-370.
• Loomis, D. G. and Swann, C. M.(2005), "Intermodal Competition in Local Telecommunications Markets," *Information Economics and Policy*, vol. 17, pp. 97-113.
• Lu, J., Yao, J. E., and Yu, C.(2005), "Personal Innovativeness, Social Influences, and Adoption of Wireless Internet Services via Mobile Technology," *Journal of Strategic Information Systems,* vol. 14, pp. 245-268.
• Nam, C., Kim, S., and Lee, H.(2008), "The Role of Wibro: Filling the Gaps in Mobile Broadband Technologies," *Technological Forecasting and Social Change*, vol. 75, pp. 438-448.
• Okazaki, S.(2006), "What Do We Know about Mobile Internet

Adopters? A Cluster Analysis," *Information and Management*, vol. 43, pp. 127-141.

- Rao, B. and Parikh, M. A.(2003), "Wireless Broadband Drivers and Their Social Implications," *Technology in Society*, vol. 25, pp. 477-489.
- Roe, B., Boyle, K. J., and Teisl, M. F.(1996), "Using Conjoint Analysis to Derive Estimates of Compensating Variation," *Journal of Environmental Economics and Management*, vol. 31, pp. 145-159.
- Rossi, P., Allenby, G. M., and McCulloch, R.(2005), *Bayesian Statistics and Marketing*, Wiley, Chichester.
- San Miguel, F., Ryan, M., and McIntosh, E.(2000), "Applying Conjoint Analysis in Economic Evaluations: An Application to Menorrhagia," *Applied Economics*, vol. 32, pp. 832-833.
- Tanguturi, V. P. and Harmantzis, F. C.(2006), "Migration to 3G Wireless Broadband Internet and Real Options: The Case of an Operator in India," *Telecommunications Policy*, vol. 30, pp. 400-419.
- Yoo, S. and Moon, H.(2006), "An Estimation of the Future Demand for Portable Internet Service in Korea," Technological Forecasting and Social Change, vol. 73, pp. 575-587.
- Yoon, S. and Kim, I.(2007), "Wireless Internet Services in Korea: What Makes Them Flourish?", *Telecommunications Review*, vol. 17, pp. 660-669.
- Zhao, X. and Harris, M. N. (2004), "Demand for Marijuana, Alcohol, and Tobacco: Participation, Levels of Consumption, and Cross Equation Correlations," *The Economic Record*, vol. 80, pp. 394-410.