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Estimating the potential increase in consumer welfare from the introduction of Super Wi-Fi services in Korea

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ABSTRACT

With the increasing use of smart devices recently, mobile traffic has been increasing rapidly, which in turn has resulted in greater demand for frequency. Many countries have attempted to use the vacant frequencies known as television white space in an effort to solve the frequency problem. Super Wi-Fi, a wireless Internet service based on television white space, is one of the ways television white space is being utilized. This paper applies conjoint analysis to evaluate consumers' willingness to pay for each of the attributes of a Super Wi-Fi service and estimates by how much consumer welfare could be increased by the introduction of a Super Wi-Fi service. The attributes of a Super Wi-Fi service are coverage, a reduction in communication expenses when using mobile data, the ability to use multiple screens, and a wide range of Wi-Fi service providers. The results based on user surveys indicated that the marginal willingness to pay per month for a Super Wi-Fi service is KRW 4717 (USD$4.6). Moreover, marginal willingness to pay in nonurban areas for this service is greater than that in urban areas, which implies that the introduction of a Super Wi-Fi service is expected to increase consumer welfare, especially in nonurban areas.

1. Introduction

Given the recent increase in the use of smart devices, mobile traffic has also been increasing rapidly. Mobile traffic increased in Korea by nearly 277 times, from 303 TB in October 2009 to 84,078 TB in December 2013, after the release of Samsung's Omnia II and Apple's iPhone in the Korean mobile device market in 2009 (Jeoung et al., 2011; MSIP, 2014a). In addition, global mobile data traffic is expected to grow at a compound annual growth rate of 61% from 2013 to 2018, reaching 15.9 EB per month by 2018 (Cisco, 2014). Consequently, many new technologies such as wideband code division multiple access, high speed downlink packet access, long term evolution (LTE), WiBro, and others, have been introduced in an effort to address the increased demand for mobile traffic.

As the demand for mobile traffic increases, the demand for frequency also increases. It is not easy to solve this problem because frequency is a finite resource. One of the ways to handle this problem is spectrum reallocation, which involves

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giving up part of the broadcasting spectrum to make more room for wireless broadband. While this spectrum reallocation might be considered as an efficient use of the spectrum by wireless mobile service providers, broadcasters argue that spectrum reallocation needs to encompass broader public policy objectives such as universal service, local journalism, and public safety (Eggerton, 2009).

In the meantime, many countries, including Korea, have studied the efficient use of television white space (TVWS). In particular, a Super Wi-Fi service is highlighted as one way of utilizing TVWS (Jahng, 2013). For example, KT, one of Korea's telecom operators, started a pilot project in a specific region in 2014 as a member of a consortium initiated by the Korean Ministry of Science, ICT and Future Planning. According to KT, the consortium will use vacant frequencies made available at locations where the spectrum is not being used following the shift from analog TV to digital TV in 2012, and the bandwidth can be used for low-frequency Internet access for up to 10 km. KT also planned to provide public services such as transportation and weather information at bus stops for tourists in the service region (Shin, 2013).

TVWS is defined as "portions of spectrum left unused by broadcasting, also referred to as interleaved spectrum," according to the International Telecommunication Union (ITU). With traditional analog television, television channels that are very close to each other cannot be used at the same time in order to prevent interference because these signals easily conflict with each other. TVWS utilizes an unused space in the frequency band between two continuous analog television channels in order to prevent this interference (ITU, 2013).

Super Wi-Fi, a term coined by the Federal Communications Commissions, has been called 'Wi-Fi on steroids' or 'Wi-Fi 2.0'. This service is a wireless Internet service that utilizes TVWS, an empty frequency band not being used for TV broadcasting. It has smaller bandwidth than Wi-Fi (Kim, Shin, & Joo, 2013) and it is slower than existing Wi-Fi or LTE services. In addition, further technical development might be necessary to supply Super Wi-Fi services using TVWS without interference.

However, Super Wi-Fi services offers a wider service coverage range and higher transmissivity to the inside areas of buildings and to underground areas than existing Wi-Fi services because TVWS operates at a low frequency (Koo et al., 2011). Because of its wide coverage, Super Wi-Fi services require fewer wireless access points (APs), making them useful when used as wide wireless networks in rural areas, which typically have a less developed network infrastructure compared with urban areas. The wide coverage and high transmissivity of Super Wi-Fi services can help to resolve the mobile traffic problem common in certain urban areas by providing a stable and seamless network. As a result, Super Wi-Fi services based on TVWS may be a viable solution, given their ability to handle the expected increase in mobile traffic, to complement existing Wi-Fi services or mobile communication services, and to solve the 'digital divide' in nonurban areas.

Another possibility regarding Super Wi-Fi services is that there might be potential entrants that can provide Super Wi-Fi services in the mobile communication market because TVWS is a nonlicensed frequency. Thus, in the US, many companies, such as Dell, HP, Google, Intel, Microsoft, and Philips, are attempting to use white space and have demonstrated broadband Internet services using TVWS as a trial service (Jahng, 2013; Stirling, 2010). Participation in Super Wi-Fi services by these potential operators might be a new growth engine for the mobile communications market.

Although a new potential entrant plans to provide mobile communication services using Super Wi-Fi, the new service may not replace existing wireless services fully. Actually, it is difficult for Super Wi-Fi services to be the main mobile communication services because it focuses on data service rather than voice service. In addition, Super Wi-Fi still has several issues such as a social consensus on the use of TVWS as well as investment for full network coverage. However, because of its advantages, it is expected to function as a supplementary service to existing wireless services.

In sum, there are many ways to utilize TVWS. It can be used for either broadcasting services or mobile communication services. If it is utilized for mobile communication services, then an important issue is what kind of mobile communication service, such as Super Wi-Fi, wireless microphone, machine to machine, smart grid, is appropriate. However, a key issue is which service is the best alternative to TVWS, which is important because frequency is a finite resource. Therefore, estimating the change in consumer welfare from the introduction of Super Wi-Fi services could provide useful insights into solving this complex problem.

The purpose of this paper is to analyze the potential value of TVWS by estimating consumers' marginal willingness to pay (MWTP) for each attribute of Super Wi-Fi services and by estimating the potential increase in consumer welfare when Super Wi-Fi services are introduced.

The remainder of the paper is organized as follows. Section 2 presents a literature review. Section 3 presents the research design, including the attributes of Super Wi-Fi services and the survey design. Section 4 explains the methodology of the research, including a statistical model of the random utility model used to estimate willingness to pay. Section 5 presents the empirical results. Section 6 presents the policy implications and offers concluding remarks.

2. Literature review

Previous studies, including technological research reports and political issue reports have addressed TVWS extensively. Furthermore, wireless Internet using TVWS is referred to by several names, such as Super Wi-Fi, Wi-Fi 2.0, White-Fi, or Wi-Fi on steroids, in different studies.

In terms of technology, researchers have attempted to find a model or type of technology that can use TVWS as wireless Internet without interference or disconnections. TVWS refers to the temporarily unused space in the frequency band where licensed users are the primary users of the band. Super Wi-Fi service providers must lease this empty space and must not interfere with the primary users. Therefore, the continuous development of these models or technologies is needed to ensure

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stable Super Wi-Fi services. Bahl, Chandra, Moscibroda, Murty, and Welsh (2009) suggest the design and implementation of what was termed 'White-Fi' and presents an extensive system evaluation using a simulated prototype. A new application of a signal recognition technique called SIFT, which allows for the rapid discovery of an AP and the management of disconnections without interfering with ongoing wireless transmissions was presented. Kim, Jeon, Park, and Park (2012) and Kim, Choi, and Shin (2013) describe a channel-handover method for Super Wi-Fi. Because TVWS needs to give up a channel in use when an incumbent user is activated in the same service area, a seamless channel-handover technique is needed for good continuity of Super Wi-Fi services. These studies demonstrate how an AP can move to an active subchannel without interruptions to incumbent users and while notifying mobile stations of other usable channels for fast handovers of mobile stations.

Several studies focus on the use of TVWS in the market from the perspective of wireless service providers. Some discuss business models for TVWS and others investigate pricing methods between primary users and secondary users of TVWS. Kim and Song (2012) present four promising business models for TVWS: a fixed broadcasting type, a mobile broadcasting type, a network-oriented type and a user-oriented type. They evaluate these in terms of technology, business, and users, and devise the political aspects of these models. In addition, Kim, Choi, and Shin (2011, 2013) investigate competition in a duopoly Super Wi-Fi market between two colocated wireless service providers who attempt to lease better quality channels from licensed primary users and set prices to attract more customers. Their study modeled this competition as a hierarchical noncooperative game. The results indicate that as the customer arrival rate increases or the leasing cost decreases, wireless service providers earn more profit. They also show that channel utilization decreases as the arrival rate increases. Feng, Zhang, and Zhang (2013) also present a business model for a TVWS database under a hybrid pricing scheme. It models the competition between secondary users as a noncooperative game, as in Kim, Choi, and Shin (2011, 2013), and finds the Nash equilibrium at the point the database operator maximizes its profit.

Taparia, Casey, and Hammainen (2012) study the market mechanisms of heterogeneous secondary usage between different market players involving both wide-area and local-area operators, creating a win–win scenario for all participants. In the simulations, they observe a generic tradeoff in which the trade facilitation including transaction, brokerage, and auction costs increase as the lease time shortens while finding that trade activity is insufficient if the lease time is too long. They also show that Super Wi-Fi capacity markets perform better compared with other TVWS trading scenarios and that trading markets based on local areas are more likely to be successful.

On the other hand, some studies discuss the political implications of TVWS. Koo et al. (2011) present a plan for the use and activation of services in TVWS. They analyze the current state of TVWS utilization, its environment and regulations, and attempt to devise a service model and policy to support industries related to TVWS. Forde et al. (2009) also present the current status of the regulatory framework pertaining to the use of cognitive TVWS systems and current policies in the European market and propose several regulatory policies to enable the COGEU model, which means cognitive radio systems for efficient sharing of television white spaces in the European context. These studies of TVWS policies usually focus on those pertaining to technology regulations, spectrum trading, or the protection of primary users.

These studies mainly represent the position of policy-makers, licensed primary users of the bands, or wireless service providers. However, there is no study that addresses the value of Super Wi-Fi with regard to service users as consumers. Therefore, it is worthwhile analyzing Super Wi-Fi from a customer viewpoint, and this paper estimates consumer welfare using conjoint analysis and a random utility model.

3. Research design

Conjoint analysis has been used in many telecommunication studies to estimate consumer preferences and welfare. Ahn, Lee, Lee, and Kim (2006) use conjoint analysis and a rank-ordered logit model to analyze consumer preferences for wireless LAN and mobile Internet services. Cho (2010) evaluates the willingness to pay for a HSDPA service using this analysis. Kwak and Yoo (2012) conduct a choice experiment to estimate consumers' willingness to pay for 4G technology. Conjoint analysis can be applied to derive consumers' valuations of new products, services, or technologies that are not yet on the market (Kim, 2005) by way of estimating consumer utility (Choi, Park, Cho, & Cho, 2007). In the same context, this study applies conjoint analysis to analyze consumer welfare after the introduction of Super Wi-Fi services.

3.1. Attributes for conjoint analysis

Super Wi-Fi services are expected to function as a supplementary service with regard to existing wireless Internet services in an effort to address the problem of increasing mobile traffic, rather than as a replacement service. This service will coexist with existing wireless Internet services, as Wi-Fi service coexist with 3G, LTE, and other mobile communication services. This study attempts to select the main attributes that can be additionally provided to customers when Super Wi-Fi services and other existing wireless Internet services are provided together.

Conjoint analysis is a methodology that can derive the MWTP metric for each attribute level of Super Wi-Fi services. To use it here, it is necessary to determine the specific attributes and the level of each attribute that can be provided by Super Wi-Fi services. This paper derives the set of attributes from previous studies and identifies the following four attributes of Super Wi-Fi services: coverage, a reduction in communication expenses when using mobile data, the ability to use multiple screens, and a wide range of Wi-Fi service providers. Price was included as one of the attributes to quantify changes in utility. Table 1 shows these attributes and details how each attribute level is defined.

Table 1
Attributes and levels of Super Wi-Fi services.

Attribute	Level	Range
Coverage	1	Current level
	2	To provide more seamless and stable communication services in underground areas, inside buildings and in nonurban areas with fewer APs than urban areas
A reduction in communication expenses when using mobile data	1	Current level
	2	Due to the reduction in the use of mobile data through 3G or LTE by the introduction of Super Wi-Fi, communication expenses incurred by using mobile data are reduced
The ability to use multiple screens	1	To use the Internet on a smart phone
	2	To use the Internet not only on a smart phone, but also on mobile devices that do not have a universal subscriber identity module (USIM), such as tablet PCs or laptops, without tethering
A wide range of Wi-Fi service providers	1	Only existing communication service providers provide communication services
	2	In addition to existing communication service provider, various providers such as cable TV or Internet portal business operators provide Super Wi-Fi services
Additional expenditure for using Super Wi-Fi services (Korean won)	1	No additional expenditure
	2	Additional expenditure of 1500 won
	3	Additional expenditure of 3000 won
	4	Additional expenditure of 4500 won

3.1.1. *Coverage*

Coverage is an important attribute for customers because it is related to the question of where the service can be used. Therefore, coverage is an important attribute that should be considered with the introduction of Super Wi-Fi services. In terms of coverage, Super Wi-Fi is wider than hotspots, but narrower than LTE. The coverage and transmissivity of Super Wi-Fi are excellent because Super Wi-Fi uses TVWS, which operates on a low frequency. It has three times the range and nine times the coverage width per cell compared with existing Wi-Fi services. It also has very high transmissivity such that one AP can cover an entire town or building (KIAT, 2013). Therefore, Super Wi-Fi services can provide a more seamless and stable communication service in underground areas or inside of buildings as well as in rural areas or nonurban areas where there are typically fewer APs than in urban areas. Even though mobile data coverage covers almost all areas in Korea, it is difficult for users to find seamless networks because APs are lacking in island and mountain areas. Therefore, wide coverage of Super Wi-Fi services is an important attribute for Korean consumers.

3.1.2. *Reduction in communication expenses when using mobile data*

Super Wi-Fi services are expected to be provided free or at a lower price than present services. Super Wi-Fi does not need many APs because of its coverage and transmissivity; therefore, the construction cost is low. Furthermore, service operators incur a lower cost for the frequency because this service uses the unlicensed TVWS frequencies. Therefore, this service can lower the price of wireless Internet access services (NIPA, 2013). Furthermore, the US government has been trying to construct free public Super Wi-Fi networks, and IT companies such as Google and Microsoft want to provide free public networks using the unlicensed TVWS frequencies (Anthony, 2012; Fitzpatrick, 2013; Kang, 2013).

When consumers use smart devices, they usually use mobile data through 3G or LTE when in places where Internet connectivity is not provided through Wi-Fi. However, upon the introduction of Super Wi-Fi services, which can supplement existing wireless Internet services, wireless Internet for free or lower prices can be provided in many more areas, which will reduce the amount of mobile data using 3G or LTE. This offers consumers the opportunity to change the current rate system of their mobile communication service to one that is less expensive, which should consequently reduce their communications costs.

3.1.3. *Ability to use multiple screens*

The term ‘multiple screens’ refers to using more than two devices at the same time. Using multiple screens in this study is the ability to use not only a smart phone, but also other smart devices at the same time. Existing mobile data or Wi-Fi services provided by communication providers are available only on smart phones or smart devices that have a USIM and are connected to the existing communication services. If consumers want to use devices without a USIM, such as a tablet PC or a laptop for Internet services, the only possible way is to use tethering. If Super Wi-Fi services are introduced, consumers will be able to use the Internet without tethering not only on their smart phones, but also on mobile devices that do not have a USIM because the area in which consumers can use wireless Internet will be extended.

3.1.4. *A wide range of Wi-Fi service providers*

Introduction of Super Wi-Fi services can increase the number of Wi-Fi service providers. Many IT companies including Google, Microsoft, Dell, HP, Intel, and Philips have been lobbying for the opening of TVWS for the promotion of ubiquitous and affordable broadband Internet access in the US (Stirling, 2010). In particular, Google and Microsoft have tried to construct a Super Wi-Fi service on a university campus through the AIR.U project (Rushton, 2012). Also in Korea, only one of the mobile network operators participated in the construction of a Super Wi-Fi network, while the other participants are mobile virtual network operators, some noncommunication operators and local governments (MSIP, 2013).

Various service providers, such as cable TV service operators or Internet service operators as well as existing communication service providers can offer Super Wi-Fi services using the infrastructure of their current services. While a frequency license for a mobile communication service is usually obtained through an auction, TVWS, which is used for Super Wi-Fi services, is a nonlicensed band. Therefore, providers who do not currently provide mobile communication services can use this frequency band easily and at lower cost. By providing Super Wi-Fi services for free or at a low price, cable TV operators attract subscribers to not only wired networks, but also to wireless networks and set a new foundation for a content distribution service. Likewise, Internet portal operators can also provide Super Wi-Fi services for free or at a low price by building infrastructure that helps users access it more frequently.

3.1.5. Additional expenditure for using Super Wi-Fi services

Additional expenditure for using Super Wi-Fi services refers to the amount of money that customers would willingly pay to use a Super Wi-Fi service. This item is intended to measure the monetary value of the utility of each attribute consumers may value after the introduction of this service. In other words, the respondents report how much they are willing to pay for the Super Wi-Fi service when each level of the four attributes changes.

3.2. Choice sets and survey design

The survey used in this study is based on a comparison of alternatives to a virtual wireless Internet service composed of four attributes: coverage, a reduction in communication expenses when using mobile data, the ability to use multiple screens, and a wide range of Wi-Fi service providers. In the survey, the respondents are asked to choose one of the alternatives which consist of a combination of each level of the different attributes—alternative A and alternative B—and one status-quo alternative for respondents who do not want either of those alternatives. This data-generating process is used to construct a choice set such that alternatives composed of many various attributes affect the choice probability of the respondents. This study uses an orthogonal main effects design, which is effective when used to separate the effect of each attribute with respect to choice behavior.

The four attributes except for ‘additional expenditure for using Super Wi-Fi services' have two levels each and the price attributes have four levels. Therefore, there are a total of 64 alternatives ($2 \times 2 \times 2 \times 2 \times 4$). However, it is impossible for the respondents to compare all of the 64 alternatives realistically. Therefore, this study used a technique in which the minimum alternatives appropriate to estimate the model were extracted from all alternatives with an SPSS orthogonal plan. As a result, the respondents only have to compare a minimum of 16 alternatives ($64/[4 \times 1]$).

However, four of the 16 cards had the current level of the price attribute, and these were removed because they can be unrealistically interpreted as the price being the same even though the utility of the attribute had increased. As a result, 66 choice sets in total were derived based on 12 extracted cards. Furthermore, 15 impractical choice sets were removed, leaving only 51 choice sets that were examined in the study. Impractical choice sets, for example, included a case in which the additional expense of alternative A is greater than or equal to that of alternative B despite the fact that all levels of the attributes of alternative B are higher than those of alternative A.

Finally, 51 choice sets were divided into eight blocks (five blocks with six choice sets and three blocks with seven choice sets) to increase the quality of the survey responses, which could decrease if the respondents answered too many questions, such as questions about all 51 choice sets. In addition, two holdout cards are inserted into each block in order to filter out unreliable respondents. The sample choice set that was actually used is shown in Appendix A.

3.3. Sample selection and survey method

An online survey was conducted, and the total number of respondents was 1060. After discarding unreliable responses from respondents who chose irrational alternatives on the holdout card test, 959 responses were included in the following analysis. The gender and age of the respondents were almost uniformly distributed. There were 461 males and 498 females, and 245 were in their 20s, 242 were in their 30s, 235 were in their 40s, and 237 were in their 50s. The numbers of respondents in urban areas and nonurban areas were nearly identical, at 480 and 479, respectively. The average income per month was normally distributed around KRW 4 million (approximately USD 4000). The mobile communication expense amount per month in Korean won was distributed such that 9% of the respondents were in the category of less than 30,000, 30% reported 30,000–50,000, 32% reported 50,000–70,000, 23% reported 70,000–100,000, 5% reported 100,000–150,000, and 1% reported more than 150,000 won.

4. Methodology

4.1. Random utility model

After conducting a survey based on the aforementioned conjoint analysis, a multinomial logit model incorporating random utility theory was used for estimation to find the MWTP for Super Wi-Fi services. Random utility theory explains how a respondent makes a choice by specifying a function for the utility that can be derived from alternatives that are available. This function can be estimated by the multinomial logit model developed by McFadden (1974). Multinomial logit models have been used in many studies that evaluate the value of mobile communication technology and services. This can provide a statistical system for estimating the effect of each attribute on the selection probability of respondents (Choi et al., 2007). This model is summarized briefly below.

The random utility model is based on the indirect utility function U_{ij} of an individual respondent. The indirect function U_{ij} for each respondent i who chooses alternative j in choice set C_i can be expressed by

$$U_{ij} = V_{ij}(Z_{ij}, S_i) + e_{ij} \tag{1}$$

In Eq. (1), U_{ij} consists of a deterministic component, V_{ij}, and a stochastic component, e_{ij}. Here, V_{ij} is a function of the response to the attributes Z_{ij} in alternative j that is chosen by respondent i and for the characteristics S_i of respondent i. e_{ij} is a statistical term that represents the unobservable influence on the individual choice. Furthermore, if $U_{ij} > U_{ik}$ for all $j \neq k$ in choice set C_i, the probability that respondent i will choose alternative j is expressed by the equation below:

$$Pr(j|C_i) = Pr(V_{ij} + e_{ij} > V_{ik} + e_{ik}) = Pr(V_{ij} - V_{ik} > e_{ik} - e_{ij}) \tag{2}$$

The multinomial logit model assumes the independence of irrelevant alternatives such that the probability that any particular alternative j is chosen as the most preferred can be expressed by

$$Pr_i(j|C_i) = \exp(V_{ij}) / \sum_{k \in C_i} \exp(V_{ik}) \tag{3}$$

Each respondent's multinomial response as obtained from the survey can be interpreted as the result of the choice for the respondents' utility maximization. In this study, each respondent was given six or seven choice sets and asked to choose from among three alternatives including the status-quo alternative. The choice result for alternative j of any given respondent i was either 'yes' or 'no.' Eq. (4) shows this log-likelihood function.

$$\ln L = \sum_{i=1}^{N} \sum_{j=1}^{3} (y_{ij} \ln[Pr(j|C_i)]) \tag{4}$$

Here, y_{ij} is a binary whose value is one when respondent i chooses alternative j from among the three alternatives; it is zero otherwise, and N is the total number of respondents. The parameters of this log-likelihood function can be estimated by the maximum likelihood estimation method (Stern, 1997).

4.2. Willingness-to-pay model

The deterministic component of the indirect utility function, V_{ij}, can be expressed as a linear combination function, as in

$$V_{ij} = \beta_1 Z_{1,ij} + \beta_2 Z_{2,ij} + \beta_3 Z_{3,ij} + \beta_4 Z_{4,ij} + \beta_p Z_{p,ij} \tag{5}$$

In the equation above, Z_1 to Z_4 represent each attribute vector and Z_p denotes the price attribute vector. In addition, β_k denotes parameters that are calculated for each attribute. From the total derivative, the MWTP value for each attribute can be obtained.

$$MWTP_{Z_k} = -(dV/dZ_k)/(dV/dZ_p) = -dZ_p/dZ_k = -\beta_k/\beta_p \tag{6}$$

The MWTP values of each attribute indicate the marginal rate of substitution between each attribute and the price. A consumer's total MWTP for Super Wi-Fi services can be estimated by summing all of the MWTP values. By multiplying the expected number of consumers by this total MWTP value, the potential increase in consumer welfare from the introduction of Super Wi-Fi services can be calculated.

$$\text{Potential increase in consumer welfare} = \left(\sum (MWTP)_{all\ attribute}\right) \times \text{Expected number of consumers} \tag{7}$$

5. Empirical results

5.1. Empirical results from all observations

This study estimates the coefficients of Eq. (5), applying the observations to the multinomial logit model with maximum likelihood estimate using the XLSTAT program. Although R^2 is not so big, both log-likelihood and Wald statistic are significant with the same corresponding p-value of 0.0001. This implies that the null hypothesis that all coefficients for the attributes are zero is rejected at the 1% level of significance (Table 2).

The results of the estimation are presented in Table 3, which show that all coefficients of the attributes are significant at the 1% level. Moreover, all coefficients of the attributes except for the price attribute are positive, which means that an improvement in the level of each attribute except price increases the respondents' utility. The coefficient of the price attribute was negative, which implies that an increase in the level of the price attribute decreases the respondents' utility.

Table 2
Statistical significance of the model.

Statistic	Result
Number of observations	12234
R^2 (Cox and Shell)	0.115
R^2 (Nagelkerke)	0.157
Log-likelihood (p-value)	1501.34(0.0001)
Wald-statistic (p-value)	1278.76 (0.0001)

Table 3
Coefficients and p-values of the attributes.

Attributes	Coefficients	Wald Chi-square	p-Value
Coverage	0.59184	217.45	0.000
Reduction in communication expenses when using mobile data	0.77238	266.94	0.000
Ability to use multiple screens	0.85059	259.89	0.000
Wide range of Wi-Fi service providers	0.45734	79.21	0.000
Additional expenditure for using Super Wi-Fi service	−0.00057	1035.18	0.000

The results show that the respondents consider the ability to use multiple screens as the most important attribute when they use a Super Wi-Fi service. The reduction in communication expenses when using mobile data ranked next, coverage third, and a wide range of Wi-Fi service providers fourth.

The respondents' MWTPs for a one-unit increase from the less-preferred level of each attribute can be calculated by dividing the coefficient of each attribute by that of the price attribute. These results are presented in Table 4. The average MWTP for improved 'coverage' is KRW 1045 (USD 1.02); the reduction in communication expenses when using mobile data was KRW 1363 (USD 1.33); the ability to use multiple screens was valued at KRW 1501 (USD 1.46), and a wide range of Wi-Fi service providers was valued at KRW 807 (USD 0.79).[1]

In sum, consumers of wireless Internet services in Korea are willing to pay a total of KRW 4717 (USD 4.6) per month if Super Wi-Fi services are introduced, which has wider coverage, reduces communication expense when using mobile data, provides an environment in which the consumer can use multiple screens, and has more diverse service providers. Total MWTP for a Super Wi-Fi service is about 8.6% of average monthly mobile communication expenses per capita of smart phone users in Korea, which was KRW 55,000 (USD 53.7) (Nielsen, 2013). Although it is difficult to forecast the total number of Super Wi-Fi subscribers, if 10% of the 51,265,870 current wireless Internet users in Korea are assumed to purchase this service, the potential increase in consumer welfare for one year would be KRW 290 billion (USD 283 million) (MSIP, 2014b).

5.2. Empirical results from urban and nonurban observations

To see if there exist any different behavioral attitudes between urban and nonurban potential customers, the coefficients of Eq. (5) were estimated once again from two subsets of observations based on geographic area, i.e., urban or nonurban areas. Seoul and six metropolitan cities are categorized as urban areas and other districts are denoted as nonurban areas. The gross disposable per capita income of individuals of urban areas was KRW 16,472,000, and that of nonurban areas was KRW 14,342,000 in 2012 (Statistics Korea, 2012). Furthermore, Internet usage in urban areas (84%) was higher than that in nonurban areas (80%) (KISA, 2013). The Wald statistics for the urban and nonurban groups are 654.55, and 626.43, respectively. This implies that the null hypothesis that all coefficients of the attributes are zero is rejected at the 1% level of significance in both cases (Table 5).

As shown in Table 6, all coefficients of the attributes in both cases were significant at the 1% level. Similar to the results using all observations, all coefficients of the attributes except for the price attribute are positive, with the coefficient of the price attribute being negative. In addition, the rank order of the relative importance of the attributes is identical in three cases; overall observations, urban, and nonurban observations, such that the ability to use multiple screens is first, followed by a reduction in communication expenses when using mobile data, coverage, and a wide range of Wi-Fi service providers.

The MWTPs of each of the attributes in both cases are presented in Table 7. While the rank order in terms of the average MWTP for each attribute is identical between the urban and nonurban groups, the total MWTP of the nonurban respondents is greater than that of the urban respondents. This indicates that Super Wi-Fi services provide greater utility to nonurban customers than to urban customers.

[1] The exchange rate is KRW 1025 per dollar.

Table 4
Marginal willingness to pay estimates (KRW).

Attributes	MWTP
Coverage	1044.6
Reduction in communication expenses when using mobile data	1363.3
Ability to use multiple screens	1501.3
Wide range of Wi-Fi service providers	807.2
Total	4716.5

Table 5
Statistical Significance of the Model (Urban and Nonurban Areas).

Statistic	Urban	Nonurban
Number of observations	6122	6112
Log-likelihood	773.63	731.96
Wald-statistic (*p*-value)	654.55 (0.000)	626.43 (0.000)

Table 6
Coefficients and *p*-values of the attributes (urban and nonurban areas)

Variables	Urban			Nonurban		
	Coefficients	Wald Chi-square	*p*-Value	Coefficients	Wald Chi-square	*p*-Value
Coverage	0.58170	105.07	0.000	0.60262	112.58	0.000
Reduction in communication expenses when using mobile data	0.75559	128.08	0.000	0.78969	139.05	0.000
Ability to use multiple screens	0.87589	135.55	0.000	0.82778	124.78	0.000
Wide range of Wi-Fi service providers	0.52754	51.80	0.000	0.38910	29.09	0.000
Additional expenditure for using Super Wi-Fi service	−0.00059	545.74	0.000	−0.00055	489.71	0.000

Table 7
Marginal willingness-to-pay estimates (KRW).

Attributes	MWTP (Urban)	MWTP (Nonurban)
Coverage	991.8	1101.0
Reduction in communication expenses when using mobile data	1288.3	1442.8
Ability to use multiple screens	1493.4	1512.4
Wide range of Wi-Fi service providers	899.4	710.9
Total	4672.8	4767.2

In more detail, nonurban consumers are willing to pay more than urban consumers are with regard to the attributes of coverage, a reduction in communication expenses when using mobile data, and the ability to use multiple screens. Nonurban areas, usually surrounded by mountains, have fewer Wi-Fi zones than urban areas. Therefore, in nonurban areas, consumers may require free or low-cost wireless networks such as a Wi-Fi zone, while also needing a seamless mobile Internet that is free from interruptions caused by the natural landscape. Therefore, consumers feel that the first three attributes are more important. However, they do not care about who provides the service.

6. Policy implications and conclusion

This study showed that consumer welfare may be increased if Super Wi-Fi services are introduced and used in conjunction with existing Wi-Fi services. How much consumers are willing to pay with respect to four attributes—coverage, a reduction in communication expenses when using mobile data, the ability to use multiple screens, and a wide range of Wi-Fi service providers—of such a Super Wi-Fi service was examined by means of conjoint analysis.

Our results have a number of policy implications. First, Super Wi-Fi services are expected to increase consumer welfare through an improvement in coverage, a reduction in communication expenses when using mobile data, by offering the ability for consumers to use multiple screens, and by offering a wide range of service providers. Therefore, policy-makers should accelerate the introduction of Super Wi-Fi services. Second, the utility gained from Super Wi-Fi services in nonurban areas is greater than that in urban areas; therefore, the government can utilize this service as a welfare tool in information-alienated nonurban areas. This kind of policy may improve public welfare by solving the digital divide problem not only in Korea, but also in other developing countries. Third, the high MWTP to reduce communication expenses when using mobile data and the ability to use multiple screens imply that consumers may consider Super Wi-Fi services as a type of infrastructure akin to a Wi-Fi zone. Fourth, the lowest MWTP with regard to a wide range of Wi-Fi service providers implies that new providers such as cable TV service operators or Internet portal operators can initiate Super Wi-Fi services without any resistance from customers.

Finally, while this paper attempted to analyze consumer welfare arising from the introduction of Super Wi-Fi services empirically, there are some limitations. First, Super Wi-Fi is an unfamiliar concept to customers because it is not yet on the market. Consequently, there is a possibility that the respondents answered the survey questionnaires without sufficient understanding of this service. Second, this paper only considered consumers' welfare from the introduction of Super Wi-Fi services. However, it is also important to estimate the Super Wi-Fi construction cost for service providers. If future research estimates the construction cost and compares utility to cost, it would provide more useful information to policy makers and service providers.

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Appendix A

See Table A1.

Table A1
A sample choice set used in this study.

Comparison 1	Alternative A	Alternative B	Alternative C
Coverage	Current level	Current level	To select neither
Reduction in communication expenses when using mobile data	Due to the reduction in the use of mobile data through 3G or LTE by the introduction of Super Wi-Fi, communication expense incurred by using mobile data are reduced	Due to the reduction in the use of mobile data through 3G or LTE by the introduction of Super Wi-Fi, communication expense incurred by using mobile data are reduced	
Ability to use multiple screens	To use the Internet on a smart phone	To use the Internet on a smart phone	
Wide range of Wi-Fi service providers	Only existing communication service providers provide communication service.	In addition to existing communication service provider, various providers such as cable TV or Internet portal business operators provide Super Wi-Fi service.	
Additional expenditure for using Super Wi-Fi service (Korean won)	Additional expenditure of 1500 won	Additional expenditure of 4500 won	
	□ Select Alternative A	□ Select Alternative B	□ Select neither

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