

Hong, Areum; Nam, Changi; Kim, Seongcheol

## Conference Paper

# Estimating the potential increase in consumer welfare from the introduction of 'Super Wi-Fi' service

25th European Regional Conference of the International Telecommunications Society (ITS): "Disruptive Innovation in the ICT Industries: Challenges for European Policy and Business", Brussels, Belgium, 22nd-25th June, 2014

### Provided in Cooperation with:

International Telecommunications Society (ITS)

*Suggested Citation:* Hong, Areum; Nam, Changi; Kim, Seongcheol (2014) : Estimating the potential increase in consumer welfare from the introduction of 'Super Wi-Fi' service, 25th European Regional Conference of the International Telecommunications Society (ITS): "Disruptive Innovation in the ICT Industries: Challenges for European Policy and Business", Brussels, Belgium, 22nd-25th June, 2014, International Telecommunications Society (ITS), Calgary

This Version is available at:

<https://hdl.handle.net/10419/101374>

### Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

### Terms of use:

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*

# Estimating the Potential Increase in Consumer Welfare from the Introduction of ‘Super Wi-Fi’ service

Areum Hong<sup>1</sup>, Changi Nam<sup>2</sup>, Seongcheol Kim<sup>3</sup>

## Abstract

With the increasing use of smart devices recently, mobile traffic has been increasing rapidly, which in turn results in greater demand for the frequency. Many countries have attempted to use the vacant frequencies known as TV White Space (TVWS) in an effort to solve the frequency problem. Super Wi-Fi service, a wireless Internet service based on TVWS, is one of the ways TVWS is being utilized. This paper applies conjoint analysis to evaluate consumers’ willingness to pay for each of the attributes of Super Wi-Fi service and estimates how much consumer welfare could be improve by the introduction of Super Wi-Fi service. The attributes of 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 (MWTP) amount per month for Super Wi-Fi service is KRW 4,717 (USD 4.6). Moreover, the MWTP amount in non-urban areas for this service is greater than that in urban areas, implying that the introduction of Super Wi-Fi service is expected to increase consumer welfare, especially in non-urban areas.

---

<sup>1</sup> Department of Business and Technology Management, Korea Advanced Institute of Science and Technology, Korea, N22, 291 Daehak-ro, Yuseong-gu, Daejeon 305-701, Republic of Korea ([nymphadora90@kaist.ac.kr](mailto:nymphadora90@kaist.ac.kr))

<sup>2</sup> Department of Business and Technology Management, Korea Advanced Institute of Science and Technology, Korea, N22, 291 Daehak-ro, Yuseong-gu, Daejeon 305-701, Republic of Korea ([cgnam@kaist.ac.kr](mailto:cgnam@kaist.ac.kr))

<sup>3</sup> School of Media and Communication, Korea University, Korea, 145, Anam-dong, Seongbuk-gu, Seoul 136-701, Republic of Korea ([hiddentrees@korea.ac.kr](mailto:hiddentrees@korea.ac.kr))

## **Acknowledgement**

This research was funded by the MSIP (Ministry of Science, ICT & Future Planning), Korea in the ICT R&D Program 2014. This work was supported by the National Research Foundation (NRF) of Korea grant funded by the Korean government (NRF-2013S1A3A2043357).

## **1. Introduction**

Given the recent increase in the use of smart devices, mobile traffic has been increasing rapidly as well. Mobile traffic increased in Korea by nearly 277 times, from 303 TB in October of 2009 to 84,078 TB in December of 2013, after the release of Samsung's Omnia2 and Apple's iPhone in the Korean mobile device market in 2009 [1, 2]. In addition, global mobile data traffic is expected to grow at a compound annual growth rate (CAGR) of 61 percent from 2013 to 2018, reaching 15.9 EB per month by 2018 [3]. In consequence, many new technologies like WCDMA, HSPDA, LTE, WiBro and others, have been introduced in an effort to address the increased demand for mobile traffic.

In addition, as the demand for mobile traffic increases, the demand for frequency also increases. This is a serious problem because frequency is a finite resource. Therefore, many countries have focused on the use of TV white space (TVWS) as a solution to this problem. In particular, Super Wi-Fi service is highlighted as one way of utilizing TVWS [4].

TVWS is defined as "portions of spectrum left unused by broadcasting, also referred to as interleaved spectrum," according to the ITU.<sup>4</sup> With traditional analogue television, television channels that are very close each other cannot be used at the same time in order to prevent interference, as these signals easily conflict each other. TVWS refers to an unused gap of frequency band, between two continuous analogue television channels in order to prevent this interference [5].

Super Wi-Fi, a term coined by the FCC, has been called 'Wi-Fi on steroids' or 'Wi-Fi 2.0'. This

---

<sup>4</sup> International Telecommunication Union

service is a wireless internet service that utilizes TVWS, an empty frequency band not being used for TV broadcasting. Super Wi-Fi service offers a wider service coverage range and higher transmissivity to the inside areas of buildings or to underground areas than the existing Wi-Fi service, as TVWS operates at a low frequency [6]. Owing to its wide coverage, Super Wi-Fi service requires fewer wireless access points, making it useful when used as wide wireless network in rural areas, which typically have a less developed network infrastructure compared to urban areas. The wide coverage and high transmissivity of Super Wi-Fi service can resolve the mobile traffic problem common in urban areas, thus creating a stable and seamless network. As a result, Super Wi-Fi service based on TVWS may be a viable solution given its 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 non-urban areas.

In addition to the advantages addressed above, operators who are not existing communication service providers can provide Super Wi-Fi service because TVWS is a not licensed frequency. Thus, in the US, many companies, such as Dell, HP, Google, Intel, Microsoft, and Philips, attempts to use white space and have demonstrated broadband Internet services using TVWS as a trial service [4, 7]. This participation in Super Wi-Fi service by other operators can be a new growth engine for the mobile communications market.

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

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

## II. Literature Review

Advanced studies of for Super Wi-Fi have addressed TVWS expansively rather than dealing with only Super Wi-Fi. Moreover, wireless Internet using TVWS is referred to with several terms, such as Super Wi-Fi, Wi-Fi 2.0, White-Fi or Wi-Fi on steroids, in different studies. There are technological research reports, political reports and those about using TVWS with regard to wireless service providers.

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 empty space that is not used temporarily, and there are licensed primary users of the band. Super Wi-Fi service providers must lease this empty space and must not interfere with primary users. Therefore, the continuous development of these models or technologies is needed to ensure stable Super Wi-Fi service. Bahl[8] suggests the design and implementation of what was termed 'WhiteFi' and presented an extensive system evaluation through a prototype and its simulation. A the new application of a signal recognition technique called SIFT, which allows for the rapid discovery of an access point (AP) and the management of disconnections without interfering with ongoing wireless transmissions was presented. And Kim[9, 10] described a channel-handover method for Super Wi-Fi. Because TVWS should 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 the Super Wi-Fi service. These works demonstrated how an AP can move to an active sub-channel without interruptions to incumbent users and while notifying mobile stations of other usable channels for fast handovers of mobile stations.

Several studies have focused 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[11] presents 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[12, 13] investigate the competition in a duopoly Super Wi-Fi market between two co-located 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 non-cooperative game. The results indicated that as the customer arrival rate increases or the leasing cost decreases, wireless service providers achieve more profit. They also showed that channel utilization decreases as the arrival rate increases. Feng[14] also suggests a business model for a TVWS database under a hybrid pricing scheme. It models the competition between secondary users as a non-cooperative game, like the study of Kim, Choi, and Shin, and finds the Nash equilibrium at which point the database operator maximizes its profit. Taparia et al.[15] 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 observed a generic trade-off in which the trade facilitation cost increases as the length of the lease time become shorter while also 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 to other TVWS trading scenarios and that trading markets based on local areas are more likely to be successful.

On the other hand, many advanced studies discuss the political implications of TVWS. Koo et al.[6] study 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.[16] 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<sup>5</sup> model. These studies of

---

<sup>5</sup> Cognitive radio systems for efficient sharing of TV White spaces in European context

TVWS policies usually focus on those pertaining to for technology regulations, spectrum trading, or the protection of primary users.

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

Conjoint analysis has been used in many telecommunication studies to estimate consumer preferences and welfare. Ahn et al.[17] use conjoint analysis and a rank-ordered logit model to analyze consumer preferences for Wireless LAN and mobile Internet services. Cho[18] evaluate the willingness to pay for a HSDPA service using this analysis. Kwak and Yoo[19] 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 [20], making it a useful method for estimating consumer utility [21]. Therefore, this study applies conjoint analysis to analyze consumer welfare after the introduction of Super Wi-Fi service.

### **III. Research Design and Methodology**

#### **1. Research Design**

##### **1) Attributes for Conjoint Analysis**

Super Wi-Fi service is expected to function as a supplementary service with regard to existing wireless LAN services in an effort to address the problem of increasing mobile traffic, rather than as a replacement service. This study attempts to select the main attributes which can be additionally provided to customers when Super Wi-Fi service and other existing wireless internet services are provided together.

Conjoint analysis is a methodology that can derive the metric known as the marginal willingness to pay for each attribute level of Super Wi-Fi service. To use it here, it is necessary to determine the specific attributes and the level of each attribute that can be provided by the Super Wi-Fi service. This paper derived the set of attributes from an extensive review of the literature and identified the following four attributes of Super Wi-Fi: 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 the utility. Table 1 shows these attributes and details how each level of the attributes is defined.

**Table 1: Attributes and Levels of Super Wi-Fi**

Attribute	Level	Range
Coverage	1	Current level
	2	To provide more seamless and stable communication service in underground areas, inside buildings and in non-urban area with fewer access points than urban areas
A Reduction of communication expense 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 expense 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 which do not have a 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 service.
	2	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)	1	No additional expenditure
	2	Additional expenditure of 1,500 won
	3	Additional expenditure of 3,000 won
	4	Additional expenditure of 4,500 won



### **① Coverage**

Coverage is the typical attribute expected to change with the introduction of Super Wi-Fi. 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 to existing Wi-Fi services. It also has very high transmissivity such that one AP can cover an entire town or building [22]. Therefore, Super Wi-Fi can provide a more seamless and stable communication service in underground areas or inside of buildings as well as in rural areas or non-urban areas where there are typically fewer access points than in urban areas.

### **② Reduction in communication expenses when using mobile data**

Consumers, when they use smart devices, 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, which can supplement existing wireless Internet, wireless Internet can be provided in many more areas, which will reduce the amount of mobile data used through 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.

### **③ Ability to use multiple-screens**

‘Multiple-screens’ refers to ‘the behavior of using more than two devices at the same time’. The ability to use multiple-screens in this survey is the ability to use not only a smart phone but also other smart devices at the same time. Existing mobile data services or Wi-Fi services provided by communication providers are available only on the smart phones or smart devices that had a USIM and were connected to the existing communication service. If consumers want to use devices without a USIM, such as a tablet PC or a laptop for Internet service, the only possible way is to utilize tethering. If the Super Wi-Fi service is introduced, consumers will be able to use the Internet not only

on their smart phones, but also on mobile devices which do not have a USIM, without tethering, as the area in which consumers can use the wireless Internet will be extended.

#### **④ A wide range of Wi-Fi service providers**

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

#### **⑤ Additional expenditure for using Super Wi-Fi service**

Additional expenditure for using Super Wi-Fi service refers to the amount of money customers would willingly pay to use the Super Wi-Fi service. This item is included in the survey in order to measure monetary value of the utility of each attribute consumers may judge 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.

## **2) Choice Sets and Survey Design**

The survey for 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, a wide range of Wi-Fi service providers. We suggest

alternatives which consist of a combination of levels of 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 done to construct a choice set such that alternatives composed of many various attributes affect the choice probability of the respondents. This study uses 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 service’ have two levels each and the price attributes have four levels. Therefore, there are a total 64 of 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 among sixteen 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 utility of attribute 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 which 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. A sample choice set that was actually used is shown in the Appendix.

### **3) Sample Selection and Survey Method**

An online survey was conducted, and the total number of respondents was 1,060. 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. Twenties numbered 245; 242 were in their thirties, 235 were in their forties, and 237 were in their fifties. The numbers of respondents in urban areas and non-urban areas were nearly identical, at 480 and 479, respectively. The average income per month was normally distributed around KRW 4 million (approximately USD 40,000). The mobile communication expense amount per month was distributed such that 9% of the respondents were in the category of less than 30,000, 30% reported 30 ~ 50,000, 32% reported 50 ~ 70,000, 23% reported 70 ~ 100,000, 5% reported 100 ~ 150,000, and 1% reported more than 150,000 in Korean Won.

## **2. Methodology**

### **1) Random Utility Model**

After conducting a survey based on the aforementioned conjoint analysis, a multinomial logit model with random utility theory was used as an estimation model to find the MWTP for the Super Wi-Fi service. Random utility theory explains how a respondent makes a choice by specifying a function for the utility that can be derived from alternatives which are available. This function can be estimated by the multinomial logit model developed by McFadden [23]. Multinomial logit model has been used in many researches which evaluate the value of mobile communication technology and services. This can provide a statistical system for individual attributes so as to standardize the effect on the selection probability of respondents. The process of this model is briefly summarized 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 equation (1).

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

In equation (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 which 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 equation (2) below.

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

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 equation (3):

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

Each respondent's multinomial response as obtained from the survey can be interpreted as the results 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'. Equation (4) shows this log-likelihood function.

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

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 [24].

## 2) WTP Model

The deterministic component of the indirect utility function,  $V_{ij}$ , can be expressed as a linear combination function, as in equation (5).

$$V_{ij} = \beta_1 Z_{1,ij} + \beta_2 Z_{2,ij} + \beta_3 Z_{3,ij} + \beta_4 Z_{4,ij} + \beta_5 Z_{p,ij} \quad (5)$$

In the equation above,  $Z_1$  to  $Z_4$  represent each attribute vector and  $Z_p$  denotes the price attribute vector. In addition,  $\beta_k$  denotes parameters which are calculated for each attribute. With the total derivative, the MWTP value for each attribute can be obtained.

$$MWTP_{Z_k} = -(dV/dZ_k)/(dV/dZ_{price}) = -dZ_{price}/dZ_k = -\beta_k/\beta_{price} \quad (6)$$

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

*Potential increase in consumer welfare*

$$= \left( \sum (MWTP)_{all\ attribute} \right) \times \text{Expected number of consumers} \quad (7)$$

## IV. Empirical Result

### 1) Empirical Result from All Observations

This study estimates equation (5), applying the observations to the multinomial logit model using

the XLSTAT program. The Wald statistic was computed and found to be 1278.76 with a corresponding p-value of 0.000. This implies that the null hypothesis that all coefficients for the attributes were zero is rejected at the 1% level of significance

**Table 2: Statistical Significance of the Model**

Statistic	Result
Number of observations	12234
Log-likelihood	1501.34
Wald-statistic(p-value)	1278.76(0.000)

Table 3 presents the estimation results, 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 decreased the respondents' utility. The results show that the respondents consider the ability to use multiple-screens as the most important attribute when they use the 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.

**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
A 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 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 1,045 (USD 1.02); the reduction in communication expenses when using mobile data was KRW 1,363 (USD 1.33); the ability to use multiple-screens was valued at KRW 1,501 (USD 1.46), and a wide range of Wi-Fi service providers was valued at KRW 807 (USD 0.79).<sup>6</sup>

**Table 4: Marginal Willingness to Pay Estimates (KRW) and their Confidence Intervals**

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

In sum, consumers of wireless Internet service in Korea are willing to pay a total of KRW 4,717 (USD 4.6) per month if Super Wi-Fi service, which has wider coverage, reduces communication expense when using mobile data, provides environment on which the consumer can use multiple-screens, and has more diverse service providers, is introduced. If we assume that ten percent of the 51,265,870 current wireless Internet users in Korea accept this service, the potential increase in consumer welfare for one year would be KRW 290 billion(USD 283 million) [25].

## 2) Empirical Results from Urban and Non-urban Observations

Equation (5) was estimated once again from two subsets of observations based on geographic area, i.e. urban or non-urban areas. Seoul and seven metropolitan cities are categorized as urban areas and other districts are denoted as non-urban areas. The Wald statistics for the urban and non-urban 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.

<sup>6</sup> The exchange rate is KRW 1,025 per dollar



**Table 5: Statistical Significance of the Model (Urban and Non-urban Areas)**

Statistic	Urban	Non-urban
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 Non-urban Areas)**

Variables	Urban			Non-urban		
	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
A 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

As shown in Table 6, all coefficients of the attributes in both cases were significant at the 1% level. Similar to the result of the overall observations, all coefficients of the attributes except for the price attribute were 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 of overall observations and urban, and non-urban observations, 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 amount for each attribute is identical between the urban and non-urban groups, the total MWTP of the non-urban respondents is greater than that of the urban respondents. This indicates that the Super Wi-Fi service provides greater utility to non-urban customers than it does

to urban customers.

In more detail, non-urban consumers are willing to pay more than urban consumers with regard to the attributes of coverage, a reduction in communication expenses when using mobile data, and the ability to use multiple-screens. Non-urban areas, usually surrounded by mountains, have fewer Wi-Fi zones than urban areas. Therefore, in non-urban 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 natural features. Therefore, consumers feel that the first three attributes are more important. However, they do not care about who provides the service.

**Table 7: Marginal Willingness to Pay Estimates (KRW) and their Confidence Intervals**

Attributes	MWTP(Urban)	MWTP(Non-urban)
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
A wide range of Wi-Fi service providers	899.4	710.9
Total	4672.8	4767.2

## V. Policy Implications and Conclusion

This study presents evidence that consumer welfare may be increased if Super Wi-Fi service is introduced and used 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.

This result has a number of policy implications. First, Super Wi-Fi service is 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 service. Second, the utility of the Super Wi-Fi service in non-urban areas is greater than that in urban areas; therefore, the government can utilize this service as a welfare tool in information-alienated non-urban areas. Third, the high MWTP to reduce in communication expenses when using mobile data and the ability to use multiple-screens imply that consumers may consider the Super Wi-Fi service 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 service without any resistance from customers.

Finally, while this paper is the first to analyze consumer welfare arising from introduction of Super Wi-Fi service 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, the selection of attributes or the separation of each level could be arbitrary. Further research could select attributes and their levels based on much more objective evidence.

## References

1. Jeoung, J., et al., *A Study on Consumer Protection Issue and Policy for Telecommunication Providers' Traffic Management*. 2011, ETRI.
2. MSIP, *Statistics of Mobile Data Traffic(Feb. 2014)*. 2014.
3. Cisco, *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2013-2018*. 2014.
4. Jahng, J.H., *TV White Space Ecosystem and Commercial & Trial Service Trends*, in *2013 Electronics and Telecommunications Trends*. 2013, ETRI.
5. ITU, *TV White Space: Managing Spaces or Better Managing Inefficiencies?*, in *GSR 2013 Discussion Paper*. 2013.
6. Koo, J., et al., *A study on Plan of Use and Service Activation in TV White Space*. 2011, Korea Radio Promotion Association.
7. Stirling, A., *White Spaces the New Wi-Fi?* International Journal of Digital Television, 2010. **1**(1): p. 69-83.
8. Bahl, P., et al., *White space networking with Wi-Fi like connectivity*. ACM SIGCOMM Computer Communication Review, 2009. **39**(4): p. 27-38.
9. Kim, M., et al., *A study on the Channel Handover Method for Super Wi-Fi Service Continuity in TV White Spaces*. The Journal of Korea Information and Communications Society, 2012. **37**(11): p. 1050-1057.
10. Kim, M., et al. *A seamless channel handover method for service continuity in Super Wi-Fi*. in *Consumer Electronics (ICCE), 2013 IEEE International Conference on*. 2013. IEEE.
11. Kim, T.-H. and H.-S. Song, *Evaluation and Promotion Policy for Promising Business Models Based on TV White Space*. The Journal of Korean Institute of Electromagnetic Engineering and Science, 2012. **23**(8): p. 909-922.
12. Kim, H., J. Choi, and K.G. Shin. *Wi-Fi 2.0: Price and quality competitions of duopoly cognitive radio wireless service providers with time-varying spectrum availability*. in *INFOCOM, 2011 Proceedings IEEE*. 2011. IEEE.
13. Kim, H., J. Choi, and K.G. Shin, *Hierarchical Market Competition in a Duopoly Super Wi-Fi Spectrum Market*. Selected Areas in Communications, IEEE Journal on, 2013. **31**(11): p. 2580-2591.
14. Feng, X., Q. Zhang, and J. Zhang. *Hybrid pricing for TV white space database*. in *INFOCOM, 2013 Proceedings IEEE*. 2013. IEEE.
15. Taparia, A., T.R. Casey, and H. Hammainen. *Towards a market mechanism for heterogeneous secondary spectrum usage: An evolutionary approach*. in *Dynamic Spectrum Access Networks (DYSPAN), 2012 IEEE International Symposium on*. 2012. IEEE.
16. Forde, T., et al., *Policies to enable efficient spectrum sharing over TVWS at European level*.

- 2009, COGEU.
17. Ahn, J., et al., *An analysis of consumer preferences among wireless LAN and mobile internet services*. ETRI Journal, 2006. **28**(2).
  18. Cho, S.-K., *An Estimation of Willingness To Pay for HSDPA Service Using a Conjoint Analysis*. Productivity Review, 2010. **24**(2): p. 131-148.
  19. Kwak, S.-Y. and S.-H. Yoo, *Ex-ante evaluation of the consumers' preference for the 4th generation mobile communications service*. Technological Forecasting and Social Change, 2012. **79**(7): p. 1312-1318.
  20. Kim, Y., *Estimation of consumer preferences on new telecommunications services: IMT-2000 service in Korea*. Information Economics and Policy, 2005. **17**(1): p. 73-84.
  21. Choi, B., et al., *An Analysis of the socio-economic effects of mobile communication*. 2007, KIET.
  22. KIAT, *Economic and Social Value of White Space Frequency*, in *KIAT Industrial Technology Policy Brief*. 2013.
  23. McFadden, D., *Conditional logit analysis of qualitative choice behavior*. 1973.
  24. Stern, S., *Simulation-based estimation*. Journal of economic Literature, 1997. **35**(4): p. 2006-2039.
  25. MSIP, *Statistics of Wireless Communication Service (Mar. 2014)*. 2014.

**Appendix: 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	
A 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 1,500 won	Additional expenditure of 4,500 won	
	<input type="checkbox"/> Select Alternative A	<input type="checkbox"/> Select Alternative B	<input type="checkbox"/> Select neither