Multi-criteria Evaluation of Mobile Network Sharing Policies in Korea

Young-Keun Song, Hangjung Zo, and Andrew P. Ciganek

Mobile operators in saturated markets increasingly favor mobile network sharing (MNS) over facility-based competition. Previous research examining MNS primarily focused on its positive effects, while the negative effects were largely overlooked. This study proposes a decision-making model using an analytic hierarchy process technique to evaluate decision-making criteria among various types of MNS policies. The decision-making model was applied to Wireless Broadband services in Korea to determine the relative importance of both positive and negative evaluation criteria and preference among multiple types of MNS policies. Positive evaluation criteria (that is, efficiency) were far greater in importance than negative evaluation criteria (that is, competition harm). The preference for adopting MNS among five alternative approaches was also revealed. The study findings offer immediate policy insights in Korea and provide a decision-making framework for policy makers in other countries to utilize.

Keywords: Mobile network sharing, telecommunications policy, competition harm, WiBro, multi-criteria decision making, AHP.

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I. Introduction

The cost of constructing new mobile networks is no longer offset by investment revenue as mobile markets are reaching saturation point in most developed countries [1]. Incremental revenue growth no longer supports the network costs required to cope with the surge in mobile data traffic and mobile services focused more on data than on voice [1] (see Fig. 1). Additional reductions in data costs are necessary to maintain profitability for mobile operators [2]. Data costs will soon exceed revenue if the data surge and pricing trends continue without cost reductions [3].

The ratio of mobile expenditures to total household expenditures in most countries is relatively high, which makes it difficult for mobile operators to offset increasing costs by raising mobile service prices. The telecommunication expenditure per household in Korea was 142 USD in 2010, which accounted for six percent of total household expenditures. The amount spent on telecommunications on a

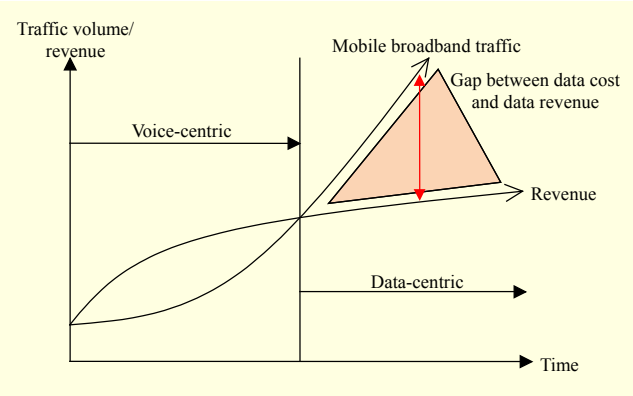

Fig. 1. Surging mobile data traffic and profitability.

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yearly basis is comparable to essential expenditures like health, clothing, and shoes. Only household expenses related to education have increased at a greater rate than telecommunications expenses over the past ten years [4].

Open networks are an attractive option as mobile operators become reluctant to build new networks in developed countries. Network neutrality, the belief that mobile operators should treat all data equally, is being addressed by developed countries throughout the world. Guidelines are being established for transparent traffic management and prohibitions against service discrimination. Network neutrality policies define basic rights for network users but not solutions to reduce the network investment burdens incurred by mobile operators.

Mobile markets that reach a plateau of growth experience decreased profitability and other constraints that deter investment in those markets. Mobile market competition has shifted with government intervention from facility-based competition (FBC) to include service-based competition (SBC). SBC stimulates competition and enhances industry development through diverse service offerings [5].

Mobile operators continuously seek solutions capable of enhancing profitability and reducing costs. Network sharing is an alternative that effectively reduces network investment costs. Mobile network sharing (MNS) allows mobile operators to decrease costs by avoiding duplicate network assets through the sharing of mobile network elements [1].

Positive benefits of MNS such as business communication efficiency and consumer benefits have been relatively easy to assess. Systematic research has not explored the possible negative effects associated with MNS. Both the positive and negative effects of MNS must be considered by respective political entities before MNS is implemented as policy.

Competition harm is a significant negative effect of MNS that is difficult to assess, nevertheless it has an important role in the implementation of MNS policies. The objective of this study is to develop a decision-making model to evaluate diverse criteria for MNS policy implementation. Decisions that incorporate both positive and negative effects constitute a classical multi-criteria decision-making (MCDM) problem. MCDM considers decision and planning problems involving multiple criteria. The objective of MCDM is to support decision makers facing problems with multiple criteria. Generally, a unique optimal solution for MCDM problems does not exist; thus, it is necessary to reflect decision makers' preferences to choose a satisfactory solution from feasible alternatives. This study examines an MCDM model for an MNS policy in development using the analytic hierarchy process (AHP) technique.

The remainder of this paper is organized as follows. Section II reviews relevant previous research. Section III describes an MCDM model to guide MNS policy decisions. Section IV applies the model to Korea's wireless broadband (WiBro) services and presents study results. Section V discusses implications, policy suggestions, and future research directions.

II. Literature Review

1. Competition Models in Telecommunications Market: FBC vs. SBC

FBC is where all telecommunication operators use their own equipment and facilities to compete against each other. SBC is where telecommunication operators compete by depending on other operators for part or all of their facilities and services. FBC promotes technological competition between operators but results in excess investment or overcapacity in the market [6]. SBC enables market entry and increased competition but inhibits innovation and new technology. The advantages and disadvantages of FBC and SBC are listed in Table 1.

FBC enables long-term distinctive competition effects and service innovation leveraging the facilities owned by individual operators. Operators are not cost-efficient when constructing their own networks, and services saturate the markets. Operators in developed countries are challenged to invest in

Table 1. Comparison of FBC and SBC.

	Advantages	Disadvantages
FBC	- Has stronger competition effect than SBC in the long term. - Promotes technological innovation with their own networks. - Has a positive effect on sales of network equipment. - Entails lower regulation cost than SBC.	- Entails excessive and redundant investment of network elements. - High cost is a significant entry barrier and reduces competition.
SBC	- Promotes market entry and fast introduction of competition. - Reduces investment risk.	- Has lower competition effect than FBC. - Ineffective in bringing about innovative changes in service. - Increases the cost of regulation for governments. - Has a negative effect on network investment, especially if pricing system is not acceptable to network provider.

new networks, such as Long-Term Evolution (LTE) and Worldwide Interoperability for Microwave Access (WiMAX), while maintaining their existing 2G/3G networks [7]. Saturated telecommunication markets must consider diverse competitive solutions tailored to each country's unique communication environment.

2. Types of MNS

MNS in previous studies has been classified into various types. Song and others [1] classified MNS into six types according to the sharing level of mobile network elements. The six types of MNS include site sharing, mast sharing, radio access network (RAN) sharing, core network sharing, network roaming, and mobile virtual network operator (MVNO). These six types are the most common forms of MNS due to their technical and operational simplicity.

Mobile operators first share the same physical space but install separate masts, towers, antennas, power supply, air conditioning, cabinets, and backhaul in-site sharing. Mast sharing is then an improvement from operators simply co-locating their sites and involves sharing a mast, towers, an antenna frame, or a rooftop. Third, RAN sharing involves the sharing of all access network equipment, such as radio equipment, masts, site compounds, and backhaul equipment [8]. Core network sharing, where two separate licenses share both radio and core network elements of the network, is next. This model logically becomes a single network company with licensees. Fifth, users in network roaming are allowed to roam onto a host network if the home network is not present in a particular region. Sixth, an MVNO is a mobile operator that provides mobile communication services but is one that does not have its own RAN [9].

3. Effects of MNS

Research on the effects of MNS primarily consists of calculating the amount of capital expenditure (CAPEX) savings and the operational expenditure (OPEX) between specific operators in a country [1]. Siemens [10] estimated the amount of CAPEX and OPEX savings for four types of MNS by 3G mobile operators in Germany. Norman and Viola [11] compared the amount of network cost savings between developed countries and developing countries. Barrett and Jackson [12] compared the reduction of CAPEX and OPEX for seven types of MNS. Kim and Seol [9] estimated the economic effect of implementing MVNOs in Korea. Industry analysts and consulting papers report network cost savings of 20% to 50% for most types of MNS.

Based on the MNS classification, Song and others [1] proposed a model for evaluating the economic effects of MNS. KISDI [13] and Han and others [14] reported that MNS might have negative outcomes, including limiting competition, quality of service (QoS) differentiation, and service innovation. Prior research has not examined the relative importance of negative outcomes associated with MNS or whether such negative effects outweigh their positive counterparts.

4. MNS cases

Some developed countries, such as Sweden, the UK, and Germany, have introduced 3G MNS through agreements between operators. The Korean mobile operators LGU+ (formerly LGT) and KT (formerly KTF) voluntarily entered into an MNS agreement. Korean mobile operators were more passive toward MNS than overseas operators because of conflicting interests. SKT, the market leader, pressed for a strategy to differentiate its network quality from that of its competitors, which led to a failure in sharing the wideband code-division multiple-access (WCDMA) network with KT and the code-division multiple-access (CDMA) network with LGU+. Korean regulators found it difficult to institutionalize obligatory MNS since KT and LGU+ are neither new operators or financially constrained.

Operators in countries that had a positive experience with FBC originally did not have a favorable impression of MNS because network coverage is a key service differentiator. Operator impressions shifted as network costs began to outpace service revenues once 2G/3G networks had expanded across entire nations. LTE services worldwide are not widely diffused, creating an opportunity for operators to differentiate their services from competitors. Demand for shared LTE networks has increased as the need for greater efficiency in network building and operations increased. Spain, Sweden, and Germany have considered MNS to develop their LTE networks [7].

III. Research Method and Model Development

This study develops a decision-making model based on the AHP technique. AHP is employed to determine the most appropriate MNS policy to pursue, accounting for both positive and negative evaluation criteria. This section develops a decision-making model based on AHP.

1. AHP

The AHP is a decision-making method that focuses on diverse factors of hierarchical structures and selects the most suitable alternative based on the importance of these factors. The AHP technique segments the entire decision-making

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process into multiple stages to ultimately reach an appropriate final decision. AHP is a methodology that effectively resolves real-world decision-making problems involving multiple diverse alternatives and conflicting factors.

AHP is widely used to examine multiple-criteria decision-making problems — for example, in supplier and site selections, evaluations of software and website performance, strategy and technology selections, and company evaluations, among other decisions [15]–[18]. AHP conducts a pairwise comparison of evaluation factors or alternatives, making it easy to gather information on a decision-maker's preference. AHP cannot effectively calculate the absolute MNS effect value, but AHP can make it easier to conduct a pairwise comparison of the alternatives for particular criteria. AHP can also account for both quantitative and qualitative factors. The positive effects of MNS are captured using quantitative factors, while the negative effects (that is, competition harm) are best measured using qualitative factors. AHP simplifies complicated decision-making problems, quantifies the relative importance of particular evaluation criteria, and is well-suited to examine decision making in the social sciences [19]–[20].

2. Decision-Making Criteria

The decision-making model in this study is designed to measure the correlation between the positive effect (that is, efficiency) and the negative effect (that is, competition harm) of MNS implementations, as well as determine the best MNS policy to pursue. This study examines several criteria to assess the multiple-criteria decision-making problem that MNS policy implementation presents. Song and others [1] analyzed the economic effect of six different types of MNS policy based on a derived demand–supply model using WiBro data in Korea. This study employs the estimation results of producer surplus and consumer surplus from Song and others [1] as the positive effects of MNS implementations (see Tables 2 and 3).

The negative effect of MNS implementations can best be measured qualitatively. Previous studies have identified several problems with network sharing [5], [10], [11], [14], [21]. Four competition-harm factors measure the negative effect of MNS implementations in this study, including the suppression of FBC, increased government regulation, reduced QoS, and hindered service innovation.

Competition based on service coverage differentiation is directly affected by MNS policy. MNS can resolve issues of duplicate investments and facilitate a more efficient use of network resources but negatively affects the service coverage differentiation strategy of mobile operators. As operators increasingly share facilities through an MNS policy, the size of base stations and network equipment markets may decrease.

Table 2. Expected producer surplus after implementing various MNS policies (unit: USD 1 million).

	1st year	2nd year	3rd year	4th year	5th year	6th year	Cumulative surplus
Site sharing	560	484	375	278	239	233	2,169
Mast sharing	693	547	452	368	333	336	2,730
RAN sharing	712	570	494	429	396	388	2,988
Core network sharing	739	582	510	449	413	396	3,090
Network roaming	692	538	426	324	284	292	2,557
MVNO	908	684	583	497	450	431	3,553

Table 3. Expected consumer surplus after implementing various MNS policies (unit: USD 1 million).

	1st year	2nd year	3rd year	4th year	5th year	6th year	Cumulative surplus
Site sharing	307	239	159	87	59	59	909
Mast sharing	299	208	143	86	62	63	860
RAN sharing	272	181	116	60	35	32	696
Core network sharing	255	166	100	44	19	14	599
Network roaming	312	222	157	99	75	78	944
MVNO	252	163	97	42	16	11	581

Sales from MNS network interconnections may rise, but mobile operators' savings on network construction costs should reduce the overall sales of mobile infrastructure vendors that supply network equipment. MNS policy may discourage mobile operators from designing and developing efficient networks of their own.

MNS implementations will increase the cost of government regulation because of the additional effort necessary to formulate MNS policy and to supervise MNS arrangements. Governmental entities must regularly examine whether consumer welfare is deliberately damaged during an MNS implementation from possible collusion among mobile operators. Transaction costs will be incurred from organizing and operating exclusive arrangements for network sharing. A high social cost may also be incurred from government-

meditated negotiations, such as the settlement of MNS prices that may favor one party over another.

Mobile operators can differentiate themselves from their competitors by their own QoS strategy, but QoS differentiation will be limited by MNS policy. Mobile operators may experience difficulties executing their own QoS strategy because of network sharing; increasing the likelihood that the diversity of QoS will be reduced. Network capacity may also be diminished by MNS policy because mobile operators will need to jointly secure, divide, and utilize capacity, as well as engage in mutual consultation concerning the addition of capacity. Coordination among traditional competitors may experience challenges over time. Network capacity greatly influences the speed of services and becomes a more important QoS factor in a data-centric mobile network. Limits to the differentiation of mobile operator services or capacity will have a negative effect on their QoS.

New service offerings and upgrading existing services are important differentiators in mobile communication services. An operator's network characteristics greatly influence innovative service delivery, especially the provision of network-based services. Mobile operators share network factors in an MNS implementation, which may lower the possibility of differentiating innovative services.

Table 4 classifies the negative and positive effects of MNS implementations into producer and consumer side factors. Figure 2 illustrates a decision-making analysis model utilizing the criteria listed in Table 4. Level 1 of the model sets the MNS policy decision as a goal. Level 2 of the model, which influences the policy decision for MNS, sets efficiency and competition harm as the decision-making criteria. Level 3 of the model sets producer surplus and consumer surplus as subcriteria for efficiency. The extent of FBC suppression, increasing government regulations, declining QoS differentiation, and diminishing service innovations are subcriteria for competition harm.

MNS policy is classified into many types. Song and others [1] identified six types of MNS policy, including site sharing, mast sharing, RAN sharing, core network sharing, network roaming, and MVNOs. Site sharing and mast sharing are combined as decision-making alternatives in this study because they exhibit similar negative effects. This study examines five types of MNS policies as decision-making alternatives.

Table 4. Structure of decision-making criteria for choosing MNS policies.

	Producer side	Consumer side
Efficiency	- Producer surplus	- Consumer surplus
Competition harm	- Extent of suppression of FBC. - Increasing government regulations.	- Declining QoS differentiation. - Diminishing service innovations.

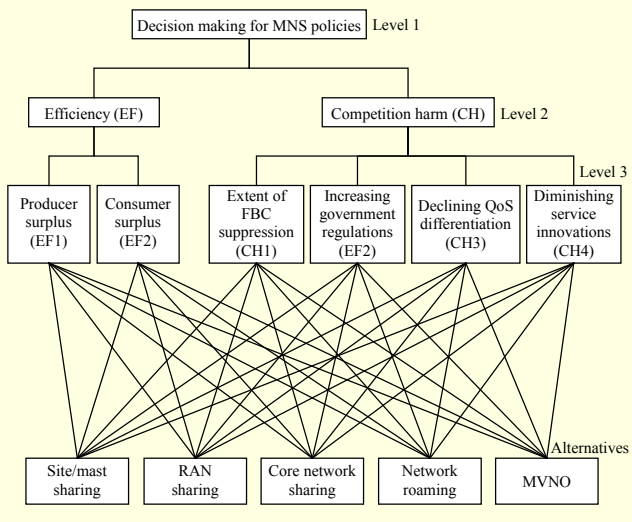

Fig. 2. AHP model for choosing MNS policies.

IV. Application

1. WiBro

WiBro is Korea's mobile broadband service, which is offered using mobile WiMAX technology that satisfies the IEEE 802.16e international standard. WiBro, based on the Global System for Mobile Communications and Universal Mobile Telecommunications Systems (UMTS) technologies, is considered as one of the fourth-generation mobile broadband technologies because it overcomes the data-rate limitation of previous generation mobile communications and adds mobility to broadband Internet access.

Two mobile incumbents offer the WiBro service commercially in Korea, but the overall adoption of the service is much slower than expected [1]. Korea's mobile incumbents are passive in investing in and activating WiBro services because they may erode the profits from their already developed 3G services or their LTE services that are in development [22].

Korea is an excellent case in which to examine MNS policy. The Korean government would like to increase the competition of WiBro services by implementing an MNS policy to minimize entry barriers and cost burdens for prospective WiBro operators. Concerns exist whether an MNS implementation may result in unpredictable side effects with existing mobile operators.

Table 5. Respondent characteristics.

Characteristics	Frequency	Percentage
Gender		
Male	33	94.3
Female	2	5.7
Age		
< 35	6	17.2
36–40	20	57.1
> 40	9	25.7
Occupation		
Mobile operators	9	25.7
Regulators	8	22.9
Public officials	3	8.6
Professors	4	11.4
Researchers	10	28.5
Other	1	2.9
Telecom industry experience (year)		
< 5	3	8.6
6–10	7	20.0
>10	25	71.4

Table 6. Final weight of criteria.

Level 2	Weight	Level 3	Weight
EF	0.771	(EF1) Producer surplus	0.300
		(EF2) Consumer surplus	0.471
CH	0.229	(CH1) Extent of suppression of FBC	0.035
		(CH2) Increasing government regulations	0.026
		(CH3) Declining QoS differentiation	0.095
		(CH4) Diminishing service innovations	0.073

Table 7. Final score and priority of each MNS type.

MNS type	Ranking	Final Score
Site/mast sharing	2	0.211
RAN sharing	5	0.149
Core network sharing	4	0.188
Network roaming	3	0.207
MVNO	1	0.246

2. Data

The relative importance and priority of decision-making criteria are determined using AHP through an evaluation of experts and final-decision makers in relevant fields. A survey approach was employed in this study, targeting appropriate experts in the Korean telecommunications industry, including mobile operators, regulators, public officials, university professors, and researchers. Fifty copies of the survey were distributed. Professors and researchers are experts who have conducted the research projects related to mobile communications policy. Thirty-five completed surveys were collected and utilized in the AHP model. Table 5 lists the demographic characteristics of the survey respondents.

3. Analysis results

Table 6 lists the final weight or importance of each decision-making criterion in MNS policy implementations. A pairwise comparison was performed between levels 1 and 2. Efficiency's weight of 0.771 was far greater than competition harm's weight of 0.229. Pairwise comparisons were performed among the six evaluation criteria in level 3. The results indicated that producer surplus variation and consumer surplus variation had weights of 0.300 and 0.471, respectively. The weights for factors measuring competition harm were 0.095 for QoS differentiation by network, 0.073 for service innovation, 0.035 for extent of FBC suppression, and 0.026 for increasing government regulation. The final weight scores and priority of the alternative types of MNS are listed in Table 7. To achieve the reliability of the judgments, the consistency ratios (CRs) for pairwise comparisons were checked. All values for CRs in levels 1 and 2 are less than 0.1. The CRs related to efficiency in level 3 are less than 0.1. The CRs related to competition harm in level 3 are less than 0.2. AHP allows for small inconsistencies in judgments because humans are not always consistent. In general AHP studies it is recommended that CRs be less than 0.1. However, if the primary purpose of this research is to obtain a general understanding of the relative importance of criteria (and relatively large samples are used), then including the AHP results when CRs that are above 0.1 are present may not distort the results [23]. In addition, CRs that are less than 0.2 are considered acceptable for many social science studies. The results indicate that the preference for MNS in Korea is, from greatest to least, MVNO, site/mast sharing, network roaming, core network sharing, and RAN sharing.

V. Discussion and Conclusion

1. Key Findings and Implications

This study has a number of key findings and practical implications regarding the application of MNS policies for WiBro services in Korea. The relative weight of the positive

effect (that is, efficiency) is far greater than that of the negative effect (that is, competition harm). A great need exists to implement MNS policies for WiBro services in Korea. The weight for the negative effect criteria of increasing government regulation was the lowest. Competition harm resulting from increasing government regulation is expected to be negligible and could be minimized through a structured regulation process.

The MVNO weight score was the greatest, presumably because the corresponding weight of efficiency (0.771) was far greater than that of competition harm (0.229). MVNO is an MNS policy approach having the largest quantity of facilities to be shared. The producer surplus efficiency index was highest in Table 2. MVNO has the highest potential total economic effect of all the MNS policy alternatives. MVNO had the greatest weight score among the five types of MNS due to a relatively high efficiency weight (Table 8). MVNOs are already institutionalized in Korea and mobile operators frequently negotiate MVNO agreements for 3G services. The familiarity with MVNOs in Korea lowers regulation uncertainty and diminishes concerns about competition harm.

Site/mast sharing received the second-highest weight score despite being the MNS policy option with the lowest efficiency weight. Site/mast sharing has a sizeable economic effect despite being considered as the simplest MNS alternative [1]. Site/mast sharing was also evaluated as the most preferable alternative in each of the four competition harm criteria (see Tables 9 and 10). Site/mast sharing had weight scores at least two times as great than the next closest MNS policy alternative (network roaming) for each of the competition harm criteria. Site/mast sharing only shares passive network elements and should be considered as a preferred alternative to minimize competition harm.

Another interesting finding was that despite having a relatively low efficiency, network roaming had a relatively high weight score. Network roaming had one of the highest weight scores for each of the competition harm criteria (see Tables 9 and 10). Network roaming is widely used in areas with only partial service coverage, which likely diminished concerns about competition harm.

Core network sharing received the lowest weight score in competition harm despite having one of the highest efficiency weight scores. Core network sharing had the lowest weight score in most of the competition harm criteria (see Tables 9 and 10). Facilities shared under core network sharing encompass the entirety of mobile network facilities. Core network sharing utilizes the same shared facilities as MVNOs with the exception of frequency. Core network sharing is not a practical alternative in countries where an MVNO system has been implemented.

Table 8. Weight analysis of MNS types for efficiency at level 3.

MNS type	Priorities with EF1 (CR = 0.071)		Priorities with EF2 (CR = 0.001)	
	Ranking	Weight	Ranking	Weight
Site/mast sharing	5	0.053	5	0.170
RAN sharing	4	0.113	4	0.186
Core network sharing	2	0.271	3	0.205
Network roaming	3	0.160	2	0.207
MVNO	1	0.402	1	0.233

Table 9. Weight analysis of MNS types for competition harm at level 3.

MNS type	Priorities with CH1 (CR = 0.134)		Priorities with CH2 (CR = 0.188)	
	Ranking	Weight	Ranking	Weight
Site/mast sharing	1	0.520	1	0.562
RAN sharing	3	0.148	4	0.062
Core network sharing	4	0.062	5	0.029
Network roaming	2	0.234	2	0.204
MVNO	5	0.035	3	0.143

Table 10. Weight analysis of MNS types for competition harm at level 3.

MNS type	Priorities with CH3 (CR = 0.125)		Priorities with CH4 (CR = 0.134)	
	Ranking	Weight	Ranking	Weight
Site/mast sharing	1	0.574	1	0.427
RAN sharing	3	0.102	3	0.117
Core network sharing	5	0.039	5	0.045
Network roaming	2	0.237	2	0.316
MVNO	4	0.048	4	0.095

2. Suggestions for WiBro Services in Korea

An approach to allocate frequencies was announced in Korea in October 2011 for the purpose of selecting new WiBro operators. More than two candidates are competing for WiBro licenses in Korea. Introducing MVNOs should not be considered in favor of new operators of the WiBro service, despite being evaluated as having the highest weight score among the MNS policy alternatives. If a new operator is not selected, then MVNOs should be considered as an attractive MNS policy option.

Policies that address site/mast sharing and network roaming should be formalized to improve the market conditions for new

entrants and to activate WiBro services. Site/mast sharing and network roaming received relatively high weight scores among the MNS policy alternatives. Site/mast sharing and network roaming are also alternatives that were rated relatively low concerning competition harm, having the potential for experiencing limited negative effects from implementation.

3. Limitations and Future Research

The decision-making criteria examined in this study are not completely independent of one another and could be correlated. The suppression of FBC may directly affect service innovation and QoS differentiation. Service innovation influences QoS differentiation. The same decision-making criteria will be repeatedly evaluated if causation exists among the criteria. Future research may resolve this issue using the analytic network process (ANP) instead of AHP. ANP enables the reflection of diverse objectives and mutual influences between evaluation indices in the evaluation model. ANP is an expanded form of AHP and accounts for dependencies between decision-making factors as well as feedback.

Expert survey respondents may not produce distinctive assessments with the AHP technique. Future research may instead introduce fuzzy logic into the pairwise comparison to compensate for this AHP deficiency, which is referred to as Fuzzy AHP (FAHP). FAHP is an efficient method to handle the fuzziness of the data involved in deciding the preferences of different decision variables [24]. Comparisons made by experts could be represented in the form of triangular fuzzy numbers to construct fuzzy pairwise comparison matrices.

This study measured positive and negative effects of MNS implementations exclusively in Korea. The study results can be used as a basic framework for an MCDM model to guide MNS policy decisions. The study results may not be generalizable to practices in other countries.

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