Creating a Win-Win in the Telecommunications Industry: The Relationship between MVNOs and MNOs in Taiwan

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Abstract
This paper assesses the key factors leading to a win-win for both mobile virtual network operators (MVNOs) and mobile network operators (MNOs) in Taiwan by analyzing the latest trends in MVNOs' development. This study applies the method known as planning assistance through technical evaluation of relevance number (PATTERN) to establish a relevant system for researching the factors, and utilizes the multicriteria decision-making (MCDM) method of fuzzy analytic hierarchy process (AHP) to evaluate these factors and the importance of the related issues. The conclusion is that if MVNOs and MNOs hope to create a win-win situation, then the following five factors, listed in order of importance, must be considered: supervision mechanism, facilities dependency, product orientation, complementary business models, and capital connections.

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Keywords: mobile virtual network operators (MVNOs); mobile network operators (MNOs); multicriteria decision making (MCDM) method; analytic hierarchy process (AHP); telecommunications

Résumé
La présente étude évalue les principaux facteurs qui permettent de créer une situation de gagnant-gagnant entre les opérateurs des réseaux virtuels mobiles (MVNOS) et les opérateurs des réseaux mobiles (MNOS) en Taiwan, à partir d'une analyse des dernières tendances de développement des MVNO. Elle se sert de la méthode dénommée PATTERN (planning assistance through technical evaluation of relevance number) pour mettre en place un système adéquat permettant la recherche des facteurs ; elle utilise également la méthode de prise de décision multicritère (MCDM) du processus de la hiérarchie analytique (AHP) pour évaluer ces facteurs et leur importance. Les résultats de l'étude indiquent que si les MVNO et les MNO espèrent créer une situation de gagnant-gagnant, ils doivent prendre en compte les cinq facteurs ci-après, présentés par ordre d'importance : mécanisme de supervision, dépendances des installations, orientation du produit, modèle d'entreprise et connections des capitaux.

Mots Clés : opérateurs de réseau virtuel mobile (MVNO) ; opérateur de réseau mobile (MNO) ; prise de décision multicritère (MCDM) ; processus de la hiérarchie analytique (AHP); télécommunications

A regulator should take each society's development and demand into account when opening up the market in order to satisfy customers, promote competition for the overall telecommunications market, and generate economic benefits (Melody, 2001).

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The growing trend now is for enterprises to outsource those businesses with inferior strength while tightly controlling their most competitive businesses, such as patents, distribution channels, and products that are highly value added (Zook & Allen, 2001). Mobile network operators (MNOs) need a lot of manpower and material resources to maintain and administer their operational systems. In addition, they have to invest resources to increase their market share and meet consumers' demand. In a diversified society, it is important that people work together on a project, as

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each of them accomplishes different things (Camillus, 1997).

The emergence of mobile virtual network operators (MVNOs) is more positive than negative for the mobile communications industry as a whole (Matthews & Sweet, 2000). MVNOs resell the mobile communications services provided by MNOs. Though MVNOs inevitably compete with MNOs, these two kinds of companies are interdependent economic entities. It is hence crucial for both of them to position their own market and to avoid any direct conflict (Matthews & Sweet).

In light of MVNO development in Europe, we believe that MVNOs could be the best business opportunity for 3G communications development in Taiwan. This paper intends to probe the major factors that will lead to a win-win situation for MVNOs and MNOs. We investigate the trends followed by MVNOs in the last three years and analyze the strategies that can contribute to the success of Taiwan's telecommunications industry and marketing. By doing so, we hope that the telecom operators can gain competitive advantages, while consumers' rights and interests are protected, too.

We have surveyed experts from industry, government, and academia and invited them to examine a set of criteria selected through the analytic hierarchy process (AHP) method. Adopting the fuzzy concept, we have come up with the main factors that lead to a win-win situation for both MVNOs and MNOs in Taiwan. We hope this paper can provide some business perspectives for telecom authorities, telecom operators, 3G licensed operators, potential MVNOs, and equipment manufacturers. If a win-win situation needs to be created for both MVNOs and MNOs, then the following five factors, listed in order of importance, must be considered: supervision mechanism, facilities dependency, product orientation, complementary business models, and capital connections.

This paper has five sections. Following this introduction, we cover the emergence of MVNOs and their impact on 3G mobile communications, and introduce the characteristics, operational strategies, and key factors in the success of an MVNO. The third section introduces the research methodology. In the fourth and fifth sections we offer some discussions and arrive at some important conclusions.

Mobile Virtual Network Operators (MVNOs)

We analyze here the definitions and types of MVNOs, the service development of MVNOs, and their impact, and then we introduce the factors in their success.

The Development and Impact of MVNOs

The concept of MVNO originated with a Norwegian firm, Sense Communications (Halbo, Mallett, Freestone, & Trill, 1999a, b). Many European countries have since started to acknowledge the existence of MVNOs and have set about drafting related regulations.

The International Telecommunications Union (ITU, n.d.), which references each country's MVNO development, provides the following two-part definition of MVNOs:

1. MVNOs offer mobile communications services to end users without having their own radio spectrum, that is, MVNOs do not own licenses and must lease network capacity or equipment from licensed operators.
2. An MVNO can be a provider of a mobile communication service or a value-added service and possess its own mobile network code (MNC) and SIM cards.

An MVNO has its own trademark and resells the products and services of MNOs through its marketing strategies. Its success does depend on a successful business model, as its revenue and profits hinge on the scale of the network. While MVNOs combine communication technologies with marketing in order to satisfy customers' needs, the patterns of success or failure for developing MVNOs within each country are quite different.

MVNOs can be categorized into four levels, as identified by Taiwan's Ministry of Transportation and Communications (MOTC, n.d.), based on the extent to which they rely on MNOs for service:

Level 1 MVNOs are involved only in the sale of their SIM cards, not in building infrastructure or installing switching equipment.

Level 2 MVNOs possess only limited network elements to provide value-added services. They lease radio interfaces, registration systems, authentication systems, MNCs, mobile switching centres (MSCs), and transmission systems from MNOs. They make the most use of MNOs' facilities in order to reduce their operations costs.

Level 3 MVNOs, aside from using MNOs' radio interfaces, install some or all of the switching equipment and network elements themselves. They possess at least their own registration and authentication systems, and in addition to MNC, even establish their own MSC. However, the provided telecommunications services are completely through the infrastructure of MNOs. This mode of operation allows this MVNO type to focus on the provision of its own special services. Level 3 MVNOs are usually considered to be more advanced service

resellers, aiming at providing subscribers with special services.

Level 4 MVNOs are also called "full" or "pure" MVNOs, which means that their mobile communications services, to some extent, are similar to those of MNOs, but they do not have an allocation of spectrum. This type of MVNO tries to replicate much of the host MNOs' infrastructure. It may establish its own MNC, home location register (HLR), MSC, billing systems, and even some mobile ISP infrastructure such as a WAP gateway. Furthermore, it has full control over branding and pricing, and it has maximum independence from its host MNOs.

Factors in the Success of MVNOs and Opportunities for MVNOs in Taiwan

This section offers a discussion of virtual operation and value chain, MVNOs' core competence and major revenue streams, followed by MVNOs' requirements for the success and events in Taiwan as related to MVNOs.

An MNO operating in Taiwan must be licensed by the MOTC, whose permit system involves radio frequency resources. The MNO must apply for a license within a limited time after being chosen. Providing an MVNO service, however, does not require a license. One can apply and participate as an operating MVNO at any time. Licensed MNO providers still need to pay license fees, registration fees, business taxes, and so on to the government. Before opening up Taiwan's market to MVNO services, the acceptable process was to first have negotiations and discussions between the MOTC and incumbent operators.

Based on the opinions collected from the MOTC's consultation documents, possible mechanisms for deregulating MVNOs in Taiwan are as follows.

MVNO applicants shall sign an agreement with MNOs in advance, which should be submitted along with a business plan to Taiwan's MOTC for approval. MVNOs' subscriber phone numbers shall be offered by MNOs after both parties negotiate. The MOTC shall not establish any related rules in advance to regulate this. Number portability (NP) and roaming services shall be provided by MNOs. With MVNOs' marketing expertise, MNOs can avoid losing customers and further boost their revenues and profits, while MVNOs can help MNOs attract new subscribers at lower costs.

The core competence and major revenue streams and requirements for the success of MVNOs. There are fewer entry requirements for an MVNO than for an MNO, but the challenges an MVNO faces and the resources it needs to obtain are by no means less than those of an MNO. Enterprises positioned differently in the value chain can play different roles in the industry and make profits from different resources (Bititci & Carrie, 1998; Evans, 2001; Porter, 1985; Prahalad & Hamel, 2004). As such, MVNOs have a great influence on the telecommunications industry (Ulset, 2002; Wirtz, 2001).

The core competence of MVNOs consists of partnerships, trademarks, diversified services, and distribution channels. Through their trademark advantage, MVNOs form a partnership with MNOs, retailers, application software suppliers, and content providers to develop new products due to popular demand (Secker, 2002; Williamson, 1991).

Virgin Mobile is an example of a successful MVNO. Virgin Mobile officially started its business in the UK in November 1999 and within one year it had 500,000 subscribers. In 2000, it was ranked number one in terms of consumer satisfaction in the UK. The following conditions contributed to the success of Virgin Mobile (Smith, 2005): (a) the market size was large enough to support it; (b) support of MNOs to MVNOs' cost structure was in place; (c) the power of channels made the consumers accessible; and (d) trademark advantages provided a quality brand image.

Along with reasonable price, another factor that makes MVNOs successful is their provision of special value-added services. If these two issues cannot be resolved, then it will be very difficult to run an MVNO successfully (Ulset, 2002; Zook & Allen, 2001).

MVNOs in Taiwan. The Telecommunications Act of Taiwan (DGT, n.d.), similar to those of South Korea and Japan, classifies telecommunications businesses into two types. Type I (facilities-based) operators are required to construct their own infrastructure. Their business includes local, long-distance, and international call service, circuit-leased service, radio paging, mobile communication service, and so on. The Type II (nonfacilities-based) operators deal with simple voice resale, Internet telephony service, and other value-added services.

Type II operators need to lease their network and equipment from Type I operators. While there are already quite a few Type II operators that provide value-added services in terms of fixed network services, there are comparatively fewer Type II operators that specialize in mobile communications. The reason is that the resources of radio spectrum are somewhat exclusive.

MVNOs do not possess their own networks and need to lease equipment and radio bandwidth from MNOs so that they can provide mobile communication services for customers. Therefore, the MOTC in Taiwan considers Level 1, Level 2, and Level 3 organizations (as mentioned in a previous section of this paper) to be Type II operators according to the Telecommunications Act. Level 4 MVNOs fall into the category of Type I operators.

Taiwan's MOTC successfully issued five 3G operational licenses in January 2002. Taiwan officially deregulated its MVNO sector in September 2003 (DGT, 2003). By July 2005 Taiwan had issued licences to three MVNOs', though only one had begun operating.

Taiwan has a population of more than 23 million. According to data released by the MOTC in Taiwan in April 2005, mobile phone users have exceeded 23 million, which means its mobile phone penetration rate is over 100%. Even eliminating the possibility of a person owning multiple mobile phones or multiple SIM cards, we believe that Taiwan's actual mobile phone penetration rate is quite close to that of the UK. Such a mature market as Taiwan could be highly advantageous to the development of MVNOs when its value-creation is well accepted by customers.

Methodology

We try to compare MVNOs with MNOs so as to identify the key factors that would create a win-win situation for both parties. We perform a two-stage analysis to do so. At the initial stage, we apply the method known as planning assistance through technical evaluation of relevance number (PATTERN) and concept (NASA, 1965, 1966; Tzeng, 1977; Tzeng & Shiau, 1987) in order to establish a hierarchy for researching and evaluating the differences among the key factors that influence the profits for both MVNOs and MNOs. Second, we adopt the fuzzy decision-making theory and AHP so as to determine the weightings of the criteria for an evaluation (see the Appendix; Bellman & Zadeh, 1970; Saaty, 1994; Tzeng, Teng, Chen, & Opricovic, 2002).

A System for Evaluating Factors that Influence Profit for MVNOs and MNOs

We used the PATTERN method and concept to establish a hierarchical strategic system for evaluating the differences between the key factors that influence profit for both MVNOs and MNOs. The analytical procedures included three steps: (a) scenario writing, (b) establishing a relevance tree, and (c) evaluation. In this section we focus on scenario writing and establishing a relevance tree. Scenario writing is based on using the habitual domain (Yu, 1985, 1990, 1995), that is, the past understanding of problems, experience, knowledge, and information, derived from brainstorming techniques, so as to probe those differences mentioned above (goal level). We considered these problems from the following perspectives: (a) complementary business models, (b) capital connections, (c) product orientation, (d) facilities dependency, (e) supervision mechanism.

The elements (nodes) are a "relevance set" composed of statements derived from "goal" (the highest level) through aspects, objectives, policy, or strategic planning to implementation (the lowest level). We defined and identified elements (nodes) of relevance trees in hierarchy strategies through the action of brainstorming as well as through a series of pretests with domain experts: two professors (one in an MBA program, the other in a Telecommunications Technical Centre), four experienced mobile operators, and six government officers. These experts were asked to rate the accuracy, adequacy, and relevance of the criteria and dimensions and to verify their "content validity" in terms of the differences between the key factors that influence profit for both MVNOs and MNOs. Table 1 shows the hierarchies of goals, objectives, and criteria of the evaluation schemes. Expert consultations, the literature review, and the pre-test included all of the experts' opinions. Such details can be found in Tables 1 and 2.

Determination of the Evaluation Criteria Weights

Since the criteria for opening MVNOs that influence profit for both MVNOs and MNOs have diverse significance and meaning, we could not assume that each evaluation criterion is of equal importance. There are many methods we could have employed to determine weights (Hwang & Yoon, 1981), such as the eigenvector, weighted least square method, entropy method, AHP, and linear programming techniques for multidimensional of analysis preference (LINMAP). An appropriate method depends on the nature of the problem. Since the AHP systematizes complicated problems, is easy to operate, and integrates most of the experts' and evaluators' opinions, it was selected for the determining weights (Saaty, 1980).

Bellman and Zadeh (1970) were the first to probe the decision-making problem under a fuzzy environment, and they heralded the initiation of Fuzzy MCDM. Our study combined this fuzzy decision-making theory method with AHP, considering the possible fuzzy subjective judgment of the evaluators between the two beneficial factors that influence evaluation. The procedure for AHP can be summarized as follows:

1. Set up the hierarchy system by decomposing the problem into a hierarchy of interrelated elements.
2. Generate input data consisting of comparative judgments of decision elements.
3. Synthesize the judgment and estimate the relative weight.
4. Determine the aggregate relative weights of the decision elements to arrive at a set of ratings for the decision alternatives/strategies.

Table 1
Evaluation of the Hierarchical Structure of the Differences among the Key Factors that Influence Profits for both MVNOs and MNOs.

Goal	Objectives	Criteria (C_i)
How deregulating MVNOs benefits both MVNOs and MNOs	1. Complementary Business Models	1. Telecommunications operators are complementary to each other in terms of running an MVNO. (C_1)
		2. Non-telecommunications businesses and telecommunications operators are complementary to each other in terms of running an MVNO. (C_2)
	2. Capital Connections	3. Telecommunications operators licensed to run an MVNO without 3G operational licenses cooperate with 3G operators to establish an MVNO, in the form of a stock swap. (C_3)
		4. 3G operators ally themselves with non-telecom-businesses that possess trademarks and channels to form a joint venture. (C_4)
	3. Product Orientation	5. MVNOs develop an orientation towards high-priced products. (C_5)
		6. 3G operators develop an orientation towards high-priced products. (C_6)
		7. MVNOs take full control of marketing. (C_7)
	4. Facilities Dependency	8. How do Level 1 MVNOs rely on MNOs? (C_8)
		9. How do Level 2 MVNOs rely on MNOs? (C_9)
		10. How do Level 3 MVNOs rely on MNOs? (C_{10})
	5. Supervision Mechanisms	11. NP (number portability) needs to be implemented. (C_{11})
		12. The government needs to establish rules regulating network capacity to be leased. (C_{12})
		13. The government does not need to establish rules regulating network capacity to be leased. (C_{13})
		14. The government needs to protect consumers' rights. (C_{14})

Getting the Fuzzy Weights for the Hierarchy Process

Because an evaluator always perceives the weight with his/her own subjective evaluation, an exact or precise weight for a specified criterion was not given. This led to the use of the fuzzy weights of criteria. Buckley (1985) initially investigated fuzzy weights and fuzzy utility for the AHP technique (Saaty, 1980), extending it by the geometric mean method to derive the fuzzy weights. In Saaty (1980), if $A = [a_{ij}]_{m\times m}$ is a positive reciprocal matrix from a pairwise comparison of evaluators (including five groups: scholars, mobile operators, Type II operators, equipment manufacturers, and government officers), that is, $a_{ij} = w_i / w_j$ in criteria C_i and C_j, then the geometric mean of each row ri can be calculated as $r_i = \left(\prod_{j=1}^{m} a_{ij}\right)^{1/m}$. Here, Saaty defined λ_{max} as the largest eigenvalue of A and the weights w_i as the components of the normalized eigenvector corresponding to λ_{max}, where $w_i = r_i / (r_1 + \cdots + r_m)$. Buckley considered a fuzzy positive reciprocal matrix $\tilde{A} = [\tilde{a}_{ij}]$, extending the geometric mean technique to define the fuzzy geometric mean of each row $\tilde{r}_i$ and fuzzy weight $\tilde{w}_i$ corresponding to each criterion as follows:
$\tilde{r}_i = (\tilde{a}_{i1} \otimes \cdots \otimes \tilde{a}_{im})^{1/m}$; $\tilde{w}_i = \tilde{r}_i \otimes (\tilde{r}_1 \oplus \cdots \oplus \tilde{r}_m)^{-1}$.

Driving the Synthetic Utility Values

The evaluators chose a performance value for each criterion. In this investigation we used the geometric mean method to aggregate the anticipated performance values. The result of the fuzzy synthetic decision reached by each strategy was a fuzzy number. Therefore, it was necessary that the nonfuzzy ranking method for fuzzy numbers be employed during the comparison of the strategies. In previous works the procedure for defuzzification (Opricovic & Tzeng, 2003) had been to locate the best nonfuzzy performance (BNP) value. Methods of such defuzzified fuzzy ranking generally include three types: mean of maximal (MOM), centre of area (COA), and α-cut (Opricovic & Tzeng; Tang, Tzeng & Wang, 1999; Tsaur, Tzeng, & Wang, 1997; Zhao & Govind, 1991). We utilized the COA method to determine the

Table 2
Descriptions of the Criteria

Criteria	Descriptions
1. Telecommunications operators are complementary to each other in terms of running an MVNO. (C_1)	Both companies are engaged in telecommunications business. One company possesses a 3G operational license, but does not have 2G infrastructure. The other company does not possess a 3G operational license, but has a 2G network and is willing to operate an MVNO. Through bilateral negotiations, the latter assists the former in constructing a 3G system. As a result, the latter obtains an opportunity of running a virtual mobile business. For example, some telecommunications operators in Europe have to pay dearly for a 3G license. Therefore, there is a shortfall in their budget for the development of 3G-network infrastructure. On the other hand, there are also some 2G operators that lost out in the bidding for 3G licenses. These two types of operators end up cooperating with each other to reduce their investment. Similarly, MNOs and MVNOs can participate in 3G mobile communications and see mutual benefit by building up a relationship of complementation.
2. Non-telecommunications businesses and telecom operators are complementary to each other in terms of running an MVNO. (C_2)	With minimum impact on the existing supervision mechanism, a telecommunications company and a non-telecommunications company can cooperate to provide MVNO services. For example, One-2-One, the fourth mobile phone telecommunications service operator in the UK, entered the market late and still had a lot of unused capacity. The Virgin Group, a non-telecommunications company, possesses a strong trademark and a variety of distribution channels in Europe, as they have engaged in transportation and communication businesses, retail business, finance, and tourism. Both parties have formed a complementary alliance by taking advantage of their strengths respectively.
3. Telecommunications operators licensed to run an MVNO without 3G operational licenses cooperate with 3G operators to establish an MVNO, in the form of a stock swap. (C_3)	Telecommunication operators without 3G licenses may consider forming alliances with those operators having 3G licenses, in the form of a stock swap.
4. 3G operators ally themselves with non-telecommunications businesses that possess trademarks and channels to form a joint venture. (C_4)	The successful bidders of 3G licenses may consider allying with non-telecommunications businesses that possess powerful trademarks and distribution channels, in the form of establishing a new mobile service company with fifty-fifty capital from both parties.
5. MVNOs develop an orientation towards high-priced products. (C_5)	MVNOs need to develop an orientation towards high-priced services as opposed to low-priced products of MNOs.
6. 3G operators develop an orientation towards high-priced products. (C_6)	3G MNOs focus on high-priced services, as opposed to the low-priced products of MVNOs.
7. MVNOs take full control of marketing. (C_7)	3G MNOs are encouraged to concentrate on the construction and maintenance of the infrastructure, and MVNOs are mainly in charge of marketing.

Table 2 (continued)
Descriptions of the Criteria

Criteria	Descriptions
8. How do Level 1 and Level 2 MVNOs rely on MNOs? (C_8)	The government deregulates Level 1 and Level 2 MVNOs, but not Level 3 and Level 4 ones. Level 1 and Level 2 MVNOs lease network capacity from MNOs so as to provide services. They possess their own billing systems and customer relationship management systems. This criterion is adopted to measure the extent to which Level 1 and Level 2 operators depend on MNOs in terms of facilities.
9. How do Level 1, Level 2, and Level 3 MVNOs rely on MNOs? (C_9)	The government deregulates Level 1, Level 2, and Level 3 MVNOs, but not Level 4 ones. Level 1, Level 2, and Level 3 MVNOs do not have their own switching equipment, but possess their own billing systems, customer relationship management systems and sales platforms. This criterion is adopted to measure the extent to which Level 1, Level 2, and Level 3 operators depend on MNOs in terms of facilities.
10. How do Level 1, Level 2, Level 3, and Level 4 MVNOs rely on MNOs? (C_{10})	The government deregulates Level 1, Level 2, Level 3, and Level 4 MVNOs. These four levels of MVNOs lease only necessary wireless equipment or base stations from MNOs. They have their own network resources. They are also called "full" or "pure" MVNOs. This criterion is adopted to measure the extent to which Level 1, Level 2, Level 3, and Level 4 operators depend on MNOs in terms of facilities.
11. NP (Number Portability) needs to be implemented. (C_{11})	This criterion is adopted to evaluate whether NP (Number Portability) should be implemented.
12. The government needs to establish rules regulating network capacity to be leased. (C_{12})	The government needs to ensure MNOs provide spectrum or network capacity for MVNOs.
13. The government does not need to establish rules regulating network capacity to be leased. (C_{13})	The government does not need to ensure MNOs provide spectrum or network capacity for MVNOs.
14. The government needs to protect consumers' rights. (C_{14})	This criterion considers whether the governmental supervision department should get involved in protecting consumers' rights.

BNP is a simple and practical method, and there was no need to introduce the preferences of any evaluators. The BNP value $\tilde{w}_i$ of the triangular fuzzy number $\tilde{w}_i = (l_i, m_i, u_i)$ can be found as follows: BNP: $\tilde{w}_i = (l_i + [(m_i - l_i) + (u_i - l_i)]/3$.

The Weightings of the Criteria

There were 24 evaluators in this study. They included seven scholars, eight experienced mobile operators (four 2G, one 3G, and three Type II operators), five equipment manufacturers (Alcatel, Ericsson, Motorola, Nokia, and Siemens), and four government officers (including MOTC officers). We started with the hierarchy in Table 1, analyzed the data from the experts, and ended with the resultant weights in Tables 3 and 4.

After the fuzzy integrated decision was made and subsequently the non-fuzzy ranking method employed, the fuzzy numbers changed into non-fuzzy values (BNP). Though there are methods to rank these fuzzy numbers, this study used COA to find the BNP value

Table 3
Weights (w) (final normalized BNP) of the Objectives and Ranking (r)

Expert type / Objectives	Scholars		Mobile Operators		Type II Operators		Equipment Manufacturers		Government Officers		Overall Rank	
	w	r	w	r	w	r	w	r	w	r	w	r
1. Complementary Business Models	0.144	5	0.133	4	0.179	4	0.189	4	0.345	1	0.189	4
2. Capital Connections	0.158	4	0.109	5	0.180	3	0.131	5	0.110	5	0.131	5
3. Product Orientation	0.197	3	0.139	3	0.184	2	0.199	3	0.182	3	0.199	3
4. Facilities Dependency	0.246	2	0.313	1	0.151	5	0.210	2	0.123	4	0.210	2
5. Supervision Mechanism	0.255	1	0.306	2	0.306	1	0.272	1	0.240	2	0.272	1

Note:
r denotes the rank of objective according to its weight.

(shown in Table 4) which was used to rank each criterion overall:

$$C_2>C_8>C_{14}>C_1>C_5>C_6>C_{11}>C_3>C_{13}>C_4>C_{10}>C_9>C_7>C_{12}.$$

A system is evaluated by the control hierarchy that can be obtained from its multicriteria and goal-directed priorities. The total estimate of criteria for global weight (presented in Table 4) at the lowest level was obtained by a synthesis weighing down those among each level. In order to solve the problem and achieve the goal, priority should be arranged to integrate upward according to the global weight at a lowest level (see the Appendix).

Discussion

Analysis of Objectives

The last column in Table 3 provides the overall ranking of all evaluators. Note that the overall ranking of Supervision Mechanisms (0.272) is the most important of the five objectives for the success of MVNOs and MNOs because of: (a) supervised culture and (b) supervision mechanism. Beginning in 1996, Taiwan implemented a series of telecommunications reforms, led mainly by the local telecommunications regulator, the MOTC, which has full control of MVNOs' deregulation and draws up all guidelines on deregulation and its timetable. In other words, the government is dominant in restructuring the telecommunications industry, and the traditional industries rely on governmental supervision. Supervision mechanism is the meta-objective above the other four objectives. The other four objectives can be achieved through negotiation among the operators, but the Supervision Mechanisms factor is beyond the reach of the MVNO players.

Capital Connections is considered the least important factor because the cost of capital is very low in Taiwan and all companies have already raised their operating funds without difficulty.

Mobile operators. The third column in Table 3 lists the mobile operators' ranking. Note that Facilities Dependency (0.313) is the most important of the five objectives for the success of MVNOs and MNOs, because it has to do with the actual management of an MVNO. An MVNO flourishes only when the rights and duties for both MVNOs and MNOs are made explicit and when both parties trust each other.

Government officials. The sixth column in Table 3 considers that the Complementary Business Models (0.345) between MNOs and MVNOs are the most important, because these officials think the government should be responsible for the success of the industry. For

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cal Weights (LW,Horizontal View) and Global Weights (GW,Vertical View) (the objects are weight times the local weights) (final normalize P of the criteria)

Expert type / teria	Scholars		Mobile Operators		Type II Operators		Equipment Manufacturers		Government Officers		Overall Rank	
	LW	GW	LW	GW	LW	GW	LW	GW	LW	GW	LW	G
Complementary Business Models												
C_1	0.473	$0.068_{(10)}$	0.497	$0.066_{(8)}$	0.229	$0.041_{(11)}$	0.355	$0.067_{(7)}$	0.565	$0.195_{(1)}$	0.440	0.08
C_2	0.527	$0.076_{(7)}$	0.503	$0.067_{(7)}$	0.771	$0.138_{(1)}$	0.645	$0.122_{(1)}$	0.435	$0.150_{(2)}$	0.560	0.10
Capital Connections												
C_3	0.509	$0.080_{(3)}$	0.746	$0.081_{(6)}$	0.315	$0.057_{(9)}$	0.452	$0.059_{(11)}$	0.627	$0.069_{(7)}$	0.515	0.06
C_4	0.492	$0.078_{(4)}$	0.254	$0.028_{(14)}$	0.685	$0.123_{(2)}$	0.549	$0.072_{(6)}$	0.373	$0.041_{(10)}$	0.485	0.06
Product Orientation												
C_5	0.385	$0.076_{(8)}$	0.325	$0.045_{(12)}$	0.423	$0.078_{(5)}$	0.311	$0.062_{(10)}$	0.435	$0.079_{(4)}$	0.375	0.07
C_6	0.388	$0.077_{(6)}$	0.382	$0.053_{(10)}$	0.040	$0.040_{(12)}$	0.293	$0.058_{(12)}$	0.386	$0.070_{(6)}$	0.346	0.06
C_7	0.227	$0.045_{(13)}$	0.293	$0.041_{(13)}$	0.066	$0.066_{(8)}$	0.396	$0.079_{(4)}$	0.179	$0.033_{(13)}$	0.279	0.05
Facilities Dependency												
C_8	0.445	$0.109_{(1)}$	0.362	$0.113_{(2)}$	0.551	$0.083_{(4)}$	0.470	$0.099_{(2)}$	0.361	$0.045_{(9)}$	0.433	0.09
C_9	0.242	$0.060_{(12)}$	0.313	$0.098_{(4)}$	0.194	$0.029_{(14)}$	0.303	$0.064_{(9)}$	0.319	$0.039_{(12)}$	0.275	0.05
C_{10}	0.313	$0.077_{(5)}$	0.325	$0.102_{(3)}$	0.256	$0.039_{(13)}$	0.228	$0.048_{(13)}$	0.320	$0.039_{(11)}$	0.292	0.06
Supervision Mechanism												
C_{11}	0.237	$0.061_{(11)}$	0.266	$0.083_{(5)}$	0.253	$0.077_{(6)}$	0.268	$0.073_{(5)}$	0.276	$0.066_{(8)}$	0.268	0.07
C_{12}	0.132	$0.034_{(14)}$	0.388	$0.121_{(1)}$	0.138	$0.042_{(10)}$	0.156	$0.042_{(14)}$	0.080	$0.019_{(14)}$	0.156	0.04
C_{13}	0.272	$0.069_{(9)}$	0.15	$0.047_{(11)}$	0.242	$0.074_{(7)}$	0.245	$0.067_{(8)}$	0.352	$0.085_{(3)}$	0.245	0.06
C_{14}	0.359	$0.091_{(2)}$	0.195	$0.061_{(9)}$	0.332	$0.090_{(3)}$	0.332	$0.090_{(3)}$	0.293	$0.070_{(5)}$	0.332	0.09

e. ( ) denotes the rank of criteria according to its weight.

example, the successful story of the Virgin Group benefits from One 2 One. Take the MVNOs overseas, for example. Only when MNOs and MVNOs have thrived on the complementary business models can they help benefit their customers and contribute to the deregulation of MVNOs.

Scholars, Type II operators, and equipment manufacturers. As shown in Table 3, scholars (second column), Type II operators (fourth column), and equipment manufacturers (fifth column) all place the greatest emphasis on Supervision Mechanisms, which they give weights of 0.255, 0.306, 0.272, respectively.

All three types of reviewers consider Supervision Mechanisms to be the most important because, during the modification of telecommunications regulations, Taiwan's movement towards a brand new age of free competition was achieved. On this basis, the MOTC, following deregulation, has aimed at supervising the telecommunications industry and maintaining a legal telecommunications development environment in order to stimulate development of the industry and create an environment for reasonable and fair competition. Hence, the greatest importance is placed on Supervision Mechanisms.

Analysis of Criteria

We are now ready to analyze the criteria referred to in Table 4 and Figure A1 of the Appendix. The local weights are those summed to one at each criteria level for each objective. These weights can be thought of as a horizontal view in the tree structure of Figure A1. A global weight of a criterion in C_1, C_2...or C_{14} can be obtained by multiplying the local weights of the corresponding pair of objectives and criterion as explained in the Appendix. These weights are thought of as a vertical view in the tree structure of Figure A1 as if following the link from the root down to a leaf node.

Local weights (for a horizontal view of the criteria level, refer to Table 4). We observe that Type II Operators hold opposing opinions to those of government officers under capital connections criteria (C_3 and C_4). Type II Operators that want to play a more important role in MVNO give a higher weight for criterion C_4 of 0.685 (3G operators ally themselves with non-telecommunications businesses that possess trademarks and channels to form a joint venture) than for C_3 at 0.315 (telecommunications operators licensed to run an MVNO without 3G operational licenses cooperate with 3G operators to establish an MVNO, in the form of a stock swap).

Government officers give a higher weight for criterion C_3 (0.627) than for C_4 (0.373). This could be because for criterion C_3, 2G and 3G operators are almost the same professional company and have been in the industry for a long while, and they have collaborated with government departments for a long time. As a result, government officials favour C_3 over C_4 since these companies are more familiar with regulations and supervisor mechanisms.

Global weights (for a vertical view of the criteria level, refer to Table 4). The overall survey considers the following in order:

$C_2 > C_8 > C_{14} > C_1 > C_5 > C_6 > C_{11} > C_3 > C_{13} > C_4 > C_{10} > C_9 > C_7 > C_{12}$.

Here, C_2 means non-telecommunications businesses and telecom operators are complementary to each other in terms of running an MVNO, and it is of greatest importance. With C_2, one can operate in the current situation, and all kinds of resources (including equipment and frequency spectrum and personnel) can be well utilized. This is an ordinary regulation for free market operations. On the other hand, C_{12} is very restrictive in that the government needing to establish rules regulating network capacity to be leased is considered not welcome by most evaluators. The results of the survey suggest that the government should not get involved in regulating the capacity to be leased. The reason is that this issue can be resolved through negotiations among the operators.

The mobile operators (MNOs) ranked C_{12} (the government needs to establish rules regulating network capacity to be leased) as the most important, because they believe that the radio spectrum is a precious and scarce resource and therefore the government needs to establish rules regarding how network capacity should be leased. Ever since telecommunications liberalization, the local mobile communications market has been equally divided among the three operators (Chunghwa Telecom, Taiwan Cellular Corporation, and FarEastTone Telecommunications Co.) with almost equal spectrum resources. However, the three companies hope that the government can regulate spectrum resources and keep their market shares at status quo without breaking the existing balance. These incumbent mobile companies are lobbying the government to release the minimum of their existing spectrum for rental capacity to MVNOs.

These three operators have run their businesses for eight years since the opening of the mobile phone market. They know how to handle customers very well and they know how to raise their market share. They need the spectrum recourses to provide their services and are reluctant to release unused or planned spectrum usage.

If there are going to be changes, then mobile operators hope that the government can establish a consistent and clear regulation system regulating the network capacity to be leased. The operators also believe that if they cooperate with each other, then they can canvass the government to establish rules beneficial to them for leasing network capacity to MVNOs. The reason that C_4 (3G operators ally themselves with non-telecommunications

businesses that possess trademarks and channels to form a joint venture) is the least important is because these mobile operators are proven winners in their channels, and they do not see the need for allying themselves with non-telecommunications businesses.

The government officers ranked C_1 most important because they believe that a strategic alliance between a company with a 2G infrastructure and a company with a 3G license can benefit both companies. The monitoring organism does not have to do too much to change. If the businesses of 2G and 3G operators can be balanced, then the demand from the market can be well satisfied. On the other hand, C_{12} (the government needs to establish rules regulating network capacity to be leased) is considered the least important. Based on the experience of a series of telecommunications liberalization activities, the government has also recognized that administrative regulations should minimize interference in private economic behaviour.

The scholars ranked C_8 (how Level 1 and 2 MVNOs rely on MNOs) as the most important, because they like to see the government deregulating Level 1 and Level 2 MVNOs and letting Level 1 and Level 2 companies lease network capacity from MNOs for providing services. The reason for this is that scholars like to see a free or deregulated economy. Scholars also want to see lower barriers for MVNOs to success.

Compared to C_9 and C_{10}, C_8 has a lower threshold of capital management. This may facilitate more corporations to engage in the business of running an MVNO and activate the telecommunications market as well. The situation fits the expectations of the scholars in regards to the liberalization of telecommunications. The more accessible the market, the better the benefits it will bring to the consumers. Here, C_{10} makes the MVNO similar to the MNO. The threshold of capital to run an MVNO firm is too high, and it may carry some problems like future corporate mergers and the transfer of ownership. This affects the rights of the consumers and offers little guarantee to them.

The reason that C_{12} (the government needs to establish rules regulating network capacity to be leased) is the least important is that Taiwan has been implementing telecommunications liberalization actively over the last eight years according to the preset schedule. In the process of this liberalization, the MOTC hired scholars in economics and in telecommunications for consultation. These experts told the MOTC to open up the telecommunications market by speeding up the liberalization process. As to the opening of the MVNO sector, the consultants also believe that the government should not interfere too much in the market activities. Therefore, C_{12} is considered to be the least important (establishing the rules to regulate the network capacity to be leased). In other words, a win-win solution should be based on the natural agreement between MVNOs and MNOs.

The Type II operators (potential MVNOs) ranked C_2 (non-telecommunications businesses and telecom operators are complementary to each other in terms of running an MVNO) as the most important, because they believe that when a company does not have machines and equipment, its business should focus on its own expertise in value-added services and distribution channels. In other words, Type II operators naturally favour the notion that non-telecommunications businesses and telecom operators are complementary to each other in terms of running an MVNO. Additionally, without sufficient funding these operators naturally will not favour C_9, which is more or less stuck in the middle of the economic scale.

Parallel to Type II operators, equipment manufacturers ranked C_2 (non-telecommunications businesses and telecom operators are complementary to each other in terms of running an MVNO) as the most important, because their main purpose is to sell their equipment and they like to see more new MVNOs participating for potential purchase orders. Note that, when allying with non-telecommunications businesses (C_2), the operators need to set up a billing system and an information management system when starting a new company. On the other hand, C_{12} (regulating network capacity to be leased) is the least important reason, because equipment manufacturers wish that the government will not interfere too much in regulating the network capacity allocation. They are advocates of a free economy, and unnecessary restrictions have been removed, as the scholars described earlier.

Conclusions

In this paper we assess the key factors that might provide benefits to the growth of MVNOs in Taiwan and study the key factors that are considered by experts when evaluating a win-win strategy between MVNOs and MNOs. This understanding may influence how firms enter the business as well as how government regulators consider deregulation. Only if both MVNOs and MNOs become winners can the government and the customers be winners as well, and even equipment manufacturers can also earn benefits from it. Future research can focus on suitable combinations between MVNOs and MNOs, such as partnerships between 2G and 3G operators or partnerships between 3G operators and service resellers.

References

Bellman, R.E. & Zadeh, L.A. (1970). Decision making in a fuzzy environment. *Management Science, 17* (4), 141-164.

Bititci, U.S. & Carrie, A.S. (1998). *Strategic management of the manufacturing value chain*. Dordrecht, Netherlands: Kluwer.

Buckley, J.J. (1985). Fuzzy hierarchical analysis. *Fuzzy Sets and Systems, 17* (3), 233-247.

Camillus, J.C. (1997). Shifting the strategic management paradigm. *European Management Journal, 1* (15), 1-7.

DGT (Directorate General of Telecommunications, Taiwan). (n.d.) Telecommunications Act. Retrieved from www.dgt.gov.tw/English/Regulations/Telcommunication-sACT. shtml

DGT. (2003). Telecommunications Policy White Paper. Taiwan: DGT. MOTC.

Evans, R.B.B. (2001). Conceptualising and operationalizing the business to business value chain. *Industrial Marketing Management, 30* (1), 135-148.

Halbo, G., Mallett, C., Freestone, M., & Trill, M. (1999a). Exploiting the edge in intelligence to build a SoftTelco business. *Kjeller, Telenor R&D Report*, R 108/99.

Halbo, G., Mallett, C., Freestone, M., & Trill, M. (1999b). Business plan for 'Facet,' a software based telco. *Kjeller, Telenor R&D Report*, R 109/99.

Hwang, C.L. & Yoon, K. (1981). *Multiple attribute decision making: Methods and applications*. New York: Springer-Verlag.

International Telecommunications Union (ITC). (n.d.). Regulatory treatment of mobile VNOs. Retrieved from www.itu.int/osg/spu/ni/3G/resources/MVNO/index.html

Matthews, J. & Sweet, S. (2000). *Virtual mobile services: Strategies for fixed and mobile operators*. London: Ovum Ltd. (ISBN 1 9022566-37-8)

Melody, W.H. (2001). Technology trends and their implications for telecom regulation. Denmark: Schultz DocuCenter.

Ministry of Transportation and Communications, Taiwan (MOTC). (n.d.). Retrieved from www.motc.gov.tw/en/hypage.cgi?HYPAGE=Eng_Index.htm

NASA. (1965). *PATTERN relevance guide* (3 vols). Springfield, VA: National Technical Information Service.

NASA (1966). *PATTERN procedure manual*. Honeywell Aero Report. Springfield, VA: National Technical Information Service.

Opricovic, S. & Tzeng, G.H. (2003). Defuzzification for a fuzzy multicriteria decision model. *International Journal of Uncertainty, Fuzziness and Knowledge-Based Systems, 11* (5), 635-652.

Porter, M. (1985). *Competitive advantage*. New York: Free Press.

Prahalad, C.K. & Hamel, G. (2004). *The core competence of the corporation*. Cambridge, MA: Harvard Business School Press.

Saaty, T.L. (1980). *The analytic hierarchy process*. New York: McGraw-Hall.

Saaty, T.L. (1994). Fundamentals of decision making and priority theory with AHP. Pittsburgh: RWS Publications.

Secker, M. (2002). The right MVNO cocktail? - View from the top. London: Telecommunications International, Horizon House Publications.

Smith, B. (2005). Virgin Mobile: From doubt to MVNO leader. *Wireless Week*, March 15. [On-line]. Available: www.wirelessweek.com/article/CA510500.html

Tang, M.T., Tzeng, G.H., & Wang, S.W. (1999). A hierarchy fuzzy MCDM method for studying electronic marketing strategies in the information service industry. *Journal of International Information Management, 8* (1), 1-22.

Tsaur, S.H., Tzeng, G.H., & Wang, G.C. (1997). The application of AHP and fuzzy MCDM on the evaluation study of tourist risk. *Annals of Tourism Research, 24* (4), 796-812.

Tzeng, G.H. (1977). The PATTERN method for the decision process in the public system. *Japan Journal of Behaviormetrics, 4* (2), 29-44.

Tzeng, G.H., Teng, M.H., Chen, J.J., & Opricovic, S. (2002). Multicriteria selection for a restaurant location in Taipei. *International Journal of Hospitality Management, 21* (2), 171-187.

Tzeng, G.H. & Shiau, T.A. (1987). Energy conservation strategies in urban transportation: Application of multiple criteria decision-making. *Energy Systems and Policy, 11* (1), 1-19.

Ulset, S. (2002). Mobile virtual network operators: A strategic transaction cost analysis of preliminary experiences. *Telecommunications Policy, 26* (9/10), 537-549.

Wirtz, B.W. (2001). Reconfiguration of value chains in converging media and communication markets. *Long Range Planning, 34*, 489-506.

Williamson, O.E. (1991). Strategy research: Governance and competence perspectives. *Strategic Management Journal, 20*, 1087-1108.

Yu, P.L. (1985). *Multiple criteria decision making: Concepts, techniques and extensions*. New York: Plenum.

Yu, P.L. (1990). *Forming winning strategies: An integrated theory of habitual domains*. Berlin, Heidelberg, New York: Springer-Verlag.

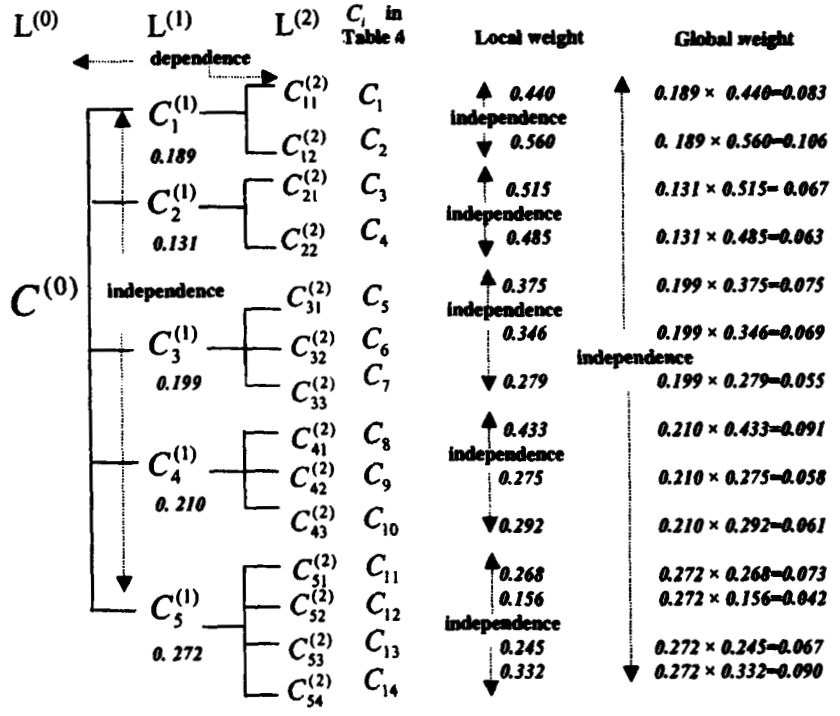
Yu, P.L. (1995). *Habitual domains*. Shawnee Missions, KS: Highwater Editions.

Zhao, R. & Govind, R. (1991). Algebraic characteristics of extended fuzzy numbers. *Information Science, 54* (1), 103-130.

Zook, C. & Allen, J. (2001). *Profit from the core: Growth strategy in an era of turbulence*. Boston: Bain & Company.

Appendix

Figure A1
The overall weights at each level of the hierarchy



Referring to Figure A1, let $L^{(0)}$, $L^{(1)}$, and $L^{(2)}$ denote the Level 0 (goal), Level 1 objectives), and Level 2 (criterion), respectively.

In the tree structure, a node is decomposed into a few subordinate nodes or partitions. For instance, $C^{(0)}$ is decomposed into $C_1^{(1)}$, $C_1^{(2)}$, $C_1^{(3)}$, $C_1^{(4)}$ and $C_1^{(5)}$. Local weights or a relative contribution/importance of subordinate nodes at the same level sum up to normalization 1.

For example, $\sum_i W_i^{(1)} (C_i^{(1)} \mid C^{(0)}) = 1$, for $i = 1,2,3,4,5$ where $W_i^{(1)}$ are local weights at level 1.

Node $C^{(1)}$ depends on $C^{(l-1)}$, for $l = 1,2$.

Node $C_{ij}^{(1)}$, $j = 1,\ldots,n_i$, depends on $C_i^{(l-1)}$, where n_i is the number of criteria at node $C_i^{(l)}$.

The computation of global weights follows the tree branches as dependent events. For instance, the global weight of $C_{32}^{(2)}$ is given by:

$$C_{32}^{(2)} = 0.199(C_3^{(2)}) \times 0.346 \text{ (local weight)} = 0.069$$

Notice that the sum of the local weights of each , $C_{ij}^{(2)}$, $i = 1,2,3,4,5$, $j = 1,2\ldots$ ni is normalized to 1, while the sum of all 14 global weights amounts to 1.

$$\sum_i W_{ij}^{(2)} (C_{ij}^{(2)} \mid C^{(0)}.C_i^{(1)}) = 1$$