Telecommunications Policy 34 (2010) 616–632

Contents lists available at ScienceDirect

Telecommunications Policy

URL: www.elsevierbusinessandmanagement.com/locate/telpol

MVNO services: Policy implications for promoting MVNO diffusion

Dong-Hee Shin *

Department of Interaction Science, Sungkyunkwan University, B307 International Hall, 53 Myeongnyun-dong 3-ga, Jongno-gu, Seoul 110-745, South Korea

ARTICLE INFO

Keywords:
Mobile virtual network operator
Consumer acceptance
UTAUT
Mobile policy

ABSTRACT

This study seeks to validate a comprehensive model of consumer acceptance in the context of MVNOs. While the MVNO business model has gained much popularity over the past few years, it shows a sign of drastic decrease. This study uses the unified theory of acceptance and the use of technology (UTAUT) model with constructs from the innovation diffusion theory (IDT) such as compatibility, relative advantage and social influence. Structural equation modeling is used to construct a predictive model of attitudes toward the MVNO services. While the model confirms the classical role of technology adoption factors (i.e., perceived usefulness and ease of use are key antecedents to consumers' intention), the results also show that users' intention and usage are influenced by IDT factors. The model brings together extant research on MVNO and provides an important cluster of antecedents to eventual technology acceptance via constructs of behavioral intention to use and to the actual MVNO usage. Policy implications of MVNO are discussed in terms of consumer adoption and market diffusion.

1. Introduction

The recently emerging telecommunication technology drives fundamental changes to the way the mobile industry does business. The ability to utilize emerging technology to offer a differentiated product or service experience to the mobile consumer has become a key competitive advantage. Along with these benefits, technology has brought along several challenges, including much more sophisticated and better informed customers, as well as lowering the traditional barriers to market entry. Most of all, emerging technology has a disruptive effect on the mobile industry, which is best illustrated by mobile virtual network operators (MVNO). An MVNO is a mobile carrier that provides mobile phone services but does not have its own licensed frequency allocation of radio spectrum, nor does it necessarily have the entire infrastructure required to provide mobile telephone services (Shin, 2008). A company that does have frequency allocations and the required infrastructure to run an independent mobile network is simply known as a mobile network operator (MNO). MVNOs are gaining significant market share, changing the supply chain of telecommunications, and are increasing churn and subscriber acquisition costs in mobile markets (Kim & Seol, 2007). Because most MVNOs have focused on offering discounted services, they have increased competition to the benefit of consumers, but they also offer the government the possibility of maintaining some control over the minutes passing over the network in which the government has made a substantial investment.

* Tel.: +82 02 740 1864; fax: +82 02 740 1856.
E-mail address: dshin@skku.edu
URL: http://is.skku.edu

0308-5961/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.telpol.2010.07.001

MVNOs have been launched in increasing numbers in recent years (Ovum, 2009). Once offering mainly cheap, often subscriber identity module-based, prepaid voice and short message services, MVNO offerings now span a wider range of mobile services, including 3G-based content and data services. As with many rollouts, however, MVNOs have recently started to lose their momentum showing a clear sign of downfall. The fundamental weakness of the underlying MVNO business model is that it only works for niches or areas where the network operators are not prepared to venture. The MVNO model has a systemic competitive disadvantage, which is that the underlying operators always have a cost advantage. The failures of many MVNOs were rooted in not offering something that could be had cheaper from the network operators (Ovum, 2009). Virgin mobile in the UK for example leverages the Virgin brand and bundled offerings from other Virgin group companies, something that cannot be reproduced by other network operators. Other problems have to do with the technology. MVNO providers have struggled over how to personalize phones over the air, as well as how to enable a better experience for using mobile applications via the phone. Another challenge is posed by the many competing standards; it is necessary to standardize protocols, schemes and services.

Among other problems, consumer apathy seems to be the greatest barrier. According to TeleGeography (2008), some consumers are uncomfortable with the idea of the MVNO—that is, the concern of unstable services—and they may be getting used to having services from traditional mobile carriers and may have been affected by network effects (network externalities) by the dominant incumbent carriers. While there is widespread enthusiasm and hope for consumer-oriented mobile services, there are also fears of unstable mobile services. MVNOs can customize their products to cater to a very distinct segment of the market, but there is a concern that such customized services may not be provided in a stable manner. The quality of such services and content has not yet been confirmed.

Despite concerns over consumer preferences (Ovum, 2009), such issues have been addressed in only a few studies; however, those few studies focus on the sheer technical aspects of services and neglect user dimensions. There is much talk about the market potential for MVNO from industry perspectives (particularly economics of MNO, MVNO and MVNE), but little robust customer research from scholarly perspectives. Some academic studies on MVNOs have focused on the success factor of MVNO business models such as mobile network infrastructure and competition (Cricelli, Grimaldi, & Ghiron, 2009), market structure (Shin, 2008), government regulations (Lee, Chan-Olmsted, & Ho, 2008), financial perspectives (Varoutas et al., 2002) and the relationship between MNO and MVNO (Ovum, 2009). However, user preference for adopting MVNO services has not been thoroughly investigated in past studies. The lack of attention can be ironic in that the key idea of MVNOs has been consumer-focused and customer-directed. The majority of MVNOs have been consumer focused and the future success of MVNOs will be determined by how MVNOs effectively respond to consumers' needs. Yet, there remained unanswered questions as to how consumers feel about MVNO services, what have been current users' experiences of the services in various contexts and what will make future consumers engage with such services. It may be important to investigate how consumers perceive usability, how their intentions are formed, what cognitive perceptions are fulfilled and what factors influence consumers' usage behavior. For these questions, UTAUT is applied to propose a research model that incorporates perceived quality, usefulness, ease of use, compatibility, relative advantage, switching cost and subjective norm as enhancing constructs to predict users' motivations for adopting MVNO services over MNO services.

With the integrated theoretical framework, this study aims at understanding the user preference for adopting MVNO services in the U.S. market. The MVNO market in the U.S. has been one of the largest markets in the world (TeleGeography, 2008). It is expected to generate $22.7 billion in revenues by 2011 (Cricelli et al., 2009). Thus, it is worthwhile to research the consumer behavior of MVNOs in this growing market. Using Structural Equation Modeling as a method of analysis, this study examines the motivations and intentions of MVNO consumers. Although such findings from U.S. consumers may not generalize to other markets, it offers a set of implications that can help telecom researchers and MVNOs better understand how consumers develop perceptions of features and how it contributes to their usage intentions. The findings should be of interest to both academics and industry concerned with understanding and improving approaches to services and marketing planning. From a theoretical perspective, this study provides a model for identifying antecedents of user intention to adopt an MVNO service in reference to UTAUT and the innovation diffusion theory (IDT). From a practical standpoint, the findings should guide an industry promoting MVNOs in how to develop user dimensions by enhancing usability and appeal, as well as ensuring quality of services. The MVNO industry is facing the challenge of how to improve MVNO services that are useful, cheap, secure and customized (Lee et al., 2008). However, interface designs and related elements are rarely examined as qualities in the context of a consumer acceptance perspective. The findings in this study should be useful for the MVNO industry to improve their business. Implications and directions for future study are also discussed in the paper.

2. Literature review

2.1. MVNO trends

An MVNO is a mobile service operator that does not have its own licensed spectrum and does not have the infrastructure to provide mobile services to its customers (Fig. 1). Instead, MVNOs lease wireless capacity from pre-existing mobile service providers and establish their own brand names different from the providers, that is, they do not own the network on which their voice and data traffic services are carried (Cricelli et al., 2009).

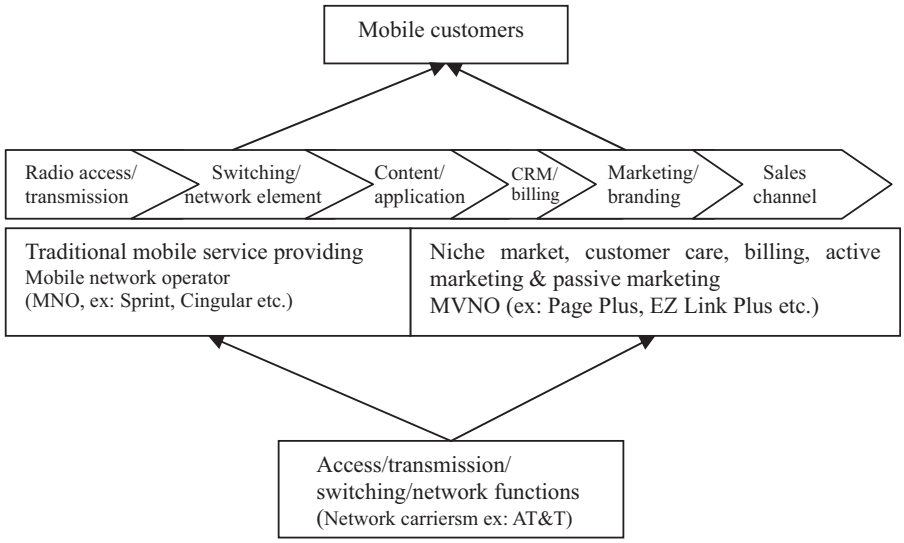

Fig. 1. MVNO, MNO and customers.

Back in the early days of MVNOs, a group of researchers predicted MVNOs were totally poised to be the next big thing. Instead, the MVNO business model has proven to be disastrous and not so competitive in some markets. The companies, which buy airtime from providers such as AT&T, Verizon and Bell Canada on a wholesale basis, have disappeared from the North American wireless scene almost as quickly as these companies appeared. Many researchers started to question the viability of the MVNO model. Cricelli et al. (2009) argue that some MVNO models have proven to be a difficult proposition in the hyper-competitive mobile phone market. Most MVNOs seem not to have what it takes to succeed in the wireless market. New customer acquisition is a game of switching from one carrier to the other. MVNO's will fuel this problem and drive churn rates even higher. Helio cast doubt on the viability of the business model, when it closed its operation in the U.S. with a dismal record over less than 2 years. Virgin Mobile has shut down operations in Singapore. Voce, Disney Mobile, ESPN Mobile and Amp'd Mobile have disappeared from the U.S. market over the past 18 months.

In the case of the U.S., mobile number portability was a significant factor that allowed customers to switch to the new MVNO services (Shin & Kim, 2008). In addition, the telecommunication infrastructure was modular and advanced to allow separation between technical and business aspects of telecommunication services. Moreover, during this period the 3 and 3.5 G technologies have become widely available in the U.S., which allowed more services to be embedded within mobile technology, and these services became complex enough to make it in the interest of MNOs to outsource some of these advanced services to different operators. In addition, the price of the 3 G license is very high compared to a 2 G license. Since 3 G services had proved to be unattractive in the U.S. to many customers, the MNO started looking for alternate methods to market those services. MVNOs started to offer discount packages and prepaid payment plans for those who were concerned about their payments.

Although there have been numerous studies on MVNOs since their inception (Shin & Bartolacci, 2007; Shin, 2008), few have attempted to evaluate the MVNO consumer dimensions. The overriding perception remains that MVNOs have the potential to disrupt network operators' businesses. However, the actual customers' perception and experience have not been extensively studied. As MVNOs have had ups and downs, a rising question is: "How are consumers accepting MVNOs with what factors?" and "How do consumers perceive the MVNO services compared to MNO?" It may be true that the MVNO is an innovative business model that can provide consumers with great convenience, but are consumers ready to embrace this innovative but unstable mobile service? What barriers/incentives might reduce/increase the diffusion of MVNOs in the consumer market? These are still the elusive questions. This study approaches these questions by analyzing consumer acceptance behavior.

2.2. The UTAUT model

The UTAUT aims at explaining the users' intention to use technologies and their subsequent usage behavior. The theory holds that four key constructs (performance expectancy, effort expectancy, social influence and facilitating conditions) are direct determinants of usage intention and behavior (Venkatesh, Morris, Davis, & Davis, 2003). These determinants will be used to extend the proposed research model. Although the UTAUT originally integrates eight user acceptance models including IDT, such factors of IDT should be highlighted when considering MVNO due to its innovative nature. The modified UTAUT model will enable a better explanation of MVNO acceptance and usage behavior (Table 1). The utility of the modified model stems from the fact that MVNO services are heavily technology-driven, as well as consumer-oriented

Table 1
UTAUT and the adapted model in this study.

UTAUT	Adapted model
Performance expectancy	Relative advantage Perceived usefulness
Effort expectancy	Compatibility Perceived ease of use
Facilitating condition	Switching cost Perceived quality Perceived price level
Demographic factors	Not considered
Social influence	Social influence
Behavioral intention	Behavioral intention
Use behavior	Use behavior

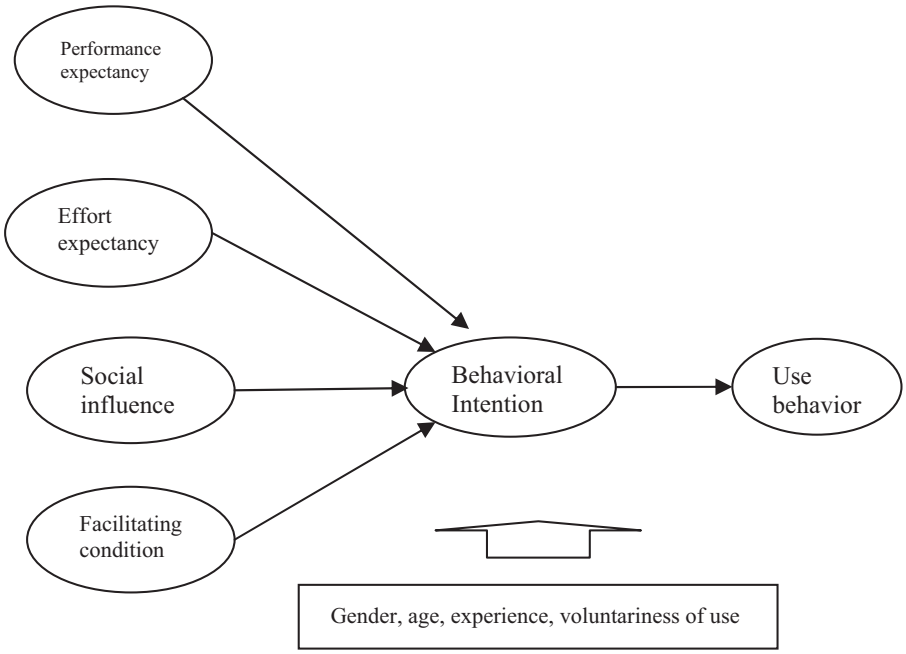

Fig. 2. The UTAUT model of Venkatesh et al. (2003).

and niche-focused. Thus, the model is well suited to reflect the nature of MVNO because it addresses the evolutionary progression of technology and usage dynamics toward a more innovative and unpredictable service. In applying this modified model to a technology-driven environment, the classical technology acceptance model (TAM) variables are posited as key drivers of MVNO adoption, and, in consideration of the UTAUT, the model integrates additional key drivers, such as switching cost, quality and compatibility. All the key drivers are defined and explained, and their relationship to transaction intentions and the acceptance of the MVNO are examined. Placing these variables under the nomological structure of the UTAUT and precisely describing their interrelationships integrates them into a coherent and parsimonious research model (Fig. 2).

3. Hypotheses

This study proposes the adaptation of the UTAUT that incorporates as variables switching cost, social influence, perceived quality, relative advantage, compatibility, perceived usefulness (PU) and perceived ease of use (PEoU) that determine behavioral intent, and two constructs influencing usage behavior (behavioral intent and facilitating conditions). Fig. 3 presents the MVNO acceptance/use model proposed here. The acceptance of MVNO was evaluated using a UTAUT model modified from the one originally proposed by Venkatesh et al. (2003). UTAUT has been extensively used to

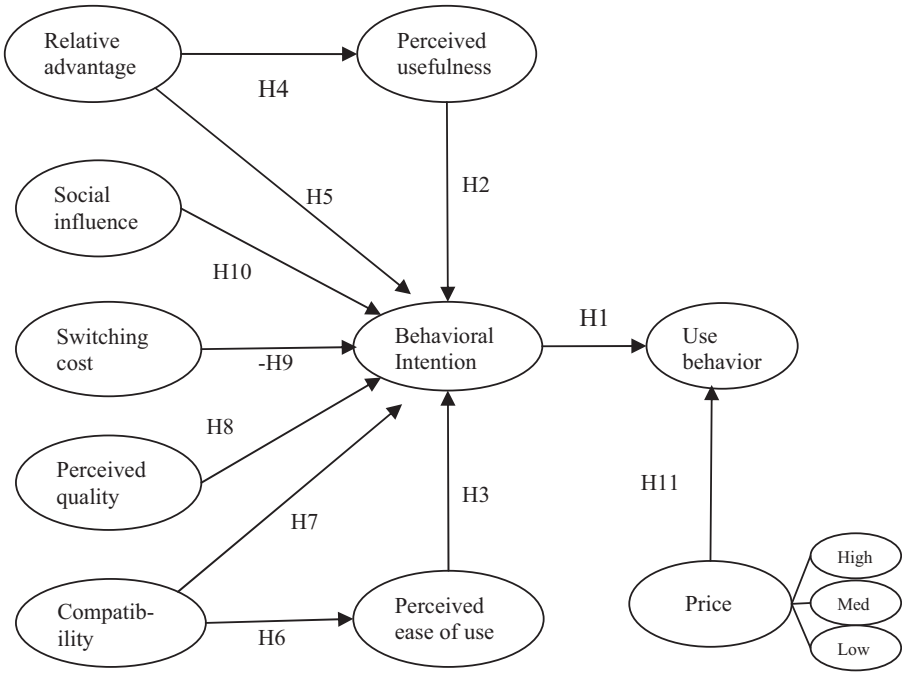

Fig. 3. Proposed research model of MVNO.

investigate users' acceptance of mobile services (Carlsson, Carlsson, Hyvonen, & Walden, 2007; Liu, Huang, & Chen, 2008; Wu, Tao, & Yang, 2007).

3.1. Behavioral intention and usage

The UTAUT suggests that a person's performance of a specified behavior is determined by his or her behavioral intention to perform the behavior, and the behavioral intention is jointly determined by the person's attitudes and subjective norms. The best predictor of behavior is intention, which is the cognitive representation of a person's readiness to perform a given behavior, and it is considered to be the immediate antecedent of behavior. In this study, behavioral intention is a dependent or endogenous variable, as well as an intermediary variable.

H1. An individual's intention to use MVNOs will have a positive effect on that individual's usage behavior concerning MVNO services.

3.2. PU and PEoU from the TAM

The TAM uses two distinct but interrelated beliefs—perceived usefulness and perceived ease of use—as the basis for predicting end-user acceptance of computer technology. In PU, the study highlights the aspect "capable of being used advantageously" compared with MNO services. This study attempts to conceptualize PU in relation to relative advantage; how consumers perceive MVNOs as being useful and advantageous compared with MNO services. PEoU refers to the degree to which a person believes that using a particular system will be effortless (Davis, 1989).

H2. PU has a positive effect on the behavioral intention of MVNO services.

H3. PEoU has a positive effect on the behavioral intention of MVNO services.

3.3. Relative advantage

Relative advantage is defined as the degree to which the innovation is perceived as being better than the alternative it supersedes (Rogers, 1995). As previous studies have shown, relative advantage and PU are conceptually similar constructs. Moore and Benbasat (1996) use the PU scales to measure relative advantage. However, there exists an important distinction between the two. Relative advantage explicitly contains a comparison between the innovation and its precursor, while this comparison is not an integral part of PU. As such, it may be worthwhile to see how relative advantage affects PU of MVNO. Lopez-Nicholas, Molina-Castillo, and Bouwman (2008) found that relative advantage significantly

affects PU. This study attempts to understand the user's perceptions of the advantages of the MVNO services over the MNO services.

H4. Relative advantage of MVNO services has a positive effect on PU.

H5. Relative advantage of MVNO services has a positive effect on the behavioral intention of MVNO services.

3.4. Compatibility

Compatibility is defined as the degree to which an innovation is perceived as being consistent with existing values, past experiences, and needs of potential adopters (Rogers, 1995, p. 15). Services compatible with existing standards and technologies are adopted more rapidly than services that are not. Shin (2009) found that perceived compatibility had the strongest effect on behavioral intention among the determinants of mobile banking acceptance. It can be inferred that making mobile services more compatible with potential users' lifestyles and needs is critical for mobile service providers when promoting users' adoption of the new technologies. In particular, the compatibility and interoperability of MVNO services to other mobile services (e.g., MNO services) can be important factors for consumers. For example, the values of MVNO services can be increased by SIM cards. This kind of convenience is related to compatibility of how one service can be compatibly used with other services in an interoperable manner. However, at the same time, user-perceived compatibility can be decreased by possible network effects that might exist for a set of competing or dominant carriers with incompatible services or standards. The relation (compatibility and PEoU) has been validated by previous research (Karahanna, Agarwal, & Angst, 2006; Tornatzky & Klein, 1982). Thus, the following hypotheses can be drawn.

H6. Compatibility has a positive effect on PEoU of MVNO services.

H7. Compatibility has a positive effect on the behavioral intention of MVNO services.

3.5. Perceived quality

Service quality is especially important in the context of mobile services because consumers become reluctant to use mobile services when they experience frequent delays in response, frequent disconnection, lack of access and poor security (Aladwani & Palvia, 2002). Lin and Lu (2000) examined information quality, response time and system accessibility as system qualities and showed that these three variables are useful predictors of PEoU and PU. Since response time and system accessibility, and other factors such as system reliability and security, can be understood as attributes that explain system quality. Cheong and Park (2005) found positive causal relationships with perceived system quality and PU. Customers' perceived quality is particularly important in the adoption of MVNO because MVNO has targeted providing quality of services. Customers would evaluate quality when they consider adopting new MVNO services over MNO. On the basis of these findings, the following hypothesis is proposed:

H8. Perceived quality has a positive effect on the intention to use MVNO services.

3.6. Switching cost

Perceived switching cost is the degree to which an individual believes that switching service providers would incur certain cost to him or her (Shin & Kim, 2008). Perceived switching cost rather than actual switching cost explains customer switching intention and affects the market outcome. Perceived switching costs constructed by carriers can be strategically used to retain customers, even when customers are less than satisfied with the provider (Lee & Kim, 2004). Because these costs may vary with customer characteristics and the nature of the product, these costs can be used as attributes for market segmentation and targeting. Fornell (1992) distinguishes search, transaction, and learning and emotional costs, as well as loyal customer discounts, customer habit, cognitive effort and financial, social, and psychological risks for the consumer as switching costs. For MVNO services, customers may be less inclined to switch when financial, social and psychological costs are involved. Thus, switching cost is hypothesized:

H9. Switching cost is related to the customers' intention to adopt MVNO.

3.7. Social influence

As noted by a number of researchers (Davis, 1989), the contemporary technology acceptance literature is incomplete in one key respect: it does not account for social influence in the adoption and utilization of new technologies. The importance of normative pressure on intention to use mobile services is revealed in studies that are based on system perspectives. Shin (2007) found that social influence (subjective norm) is a determinant in the unique feature of mobile Internet via mobile devices. Based on previous studies on social influence, the research model hypothesizes a positive

relationship between subjective norm and intention. This is confirmed by recent empirical studies (Shin, 2007), by industry reports (Ovum, 2009); by a review of the literature (Dahlberg, Mallat, Ondrus, & Zmijewska, 2008); and by theoretical models such as the theory of reasoned action and the theory of planned behavior (Lucas & Spitler, 2000; Venkatesh et al., 2003). In particular, MVNOs are new services, and thus, customers may rely on other people's opinion and experience in their adoption decision.

H10. Social influence positively influences customers' intentions to use MVNOs.

3.8. Perceived price level

Perceived price may be a very complicated concept related to monetary cost or price, psychological cost (in psychology and sociology), cognitive cost (team cognition literature), or social cost (in group/team study and organizational behavior literature). Incorporating these concepts together, this study defines perceived price as user's perception of the magnitude of the costs using an MVNO (monetary, stress, and time) that add negative value to users when making a decision. This definition is similar to that of Teo et al. (2004) and Chen and Thurmaier (2006) who measure price in relation to customers' perceptions.

H11. Perceived price level negatively influences customers' usage behavior.

4. Study design

The survey questionnaire was developed through several comment rounds of an expert panel consisting of professors and researchers, as well as telecommunication experts. Prior to its use, the questionnaire was tested by administering a pilot survey among possible users, who provided a comprehensive review of individual responses to the pretest survey. The pilot test analysis consists of a detailed comparison of the data for each of the pretest survey participants with other responses. A pilot test was undertaken to examine test–retest reliability and construct reliability before conducting the fieldwork. Twenty students who had had experience with MVNOs participated, with tests given at a three-week interval. The participant group was familiar with MVNO services, and, prior to answering the questionnaire, they were strictly instructed to ask the experimenter any questions about the questionnaire items that they did not understand. With these precautions, the possibility of participants' filling out some questions without exactly understanding the content of those questions was eliminated.

The finished survey was administered online. From August to December 2008, a web-based survey questionnaire was posted on discussion forums devoted to mobile services, mobile commerce and mobile games, and on the forums of several professional associations, and the members of each community were cordially invited to participate. A cover letter was attached to explain its purpose and to ensure confidentiality. By the time the survey ended, 638 visitors had browsed it, and 326 questionnaires were submitted. Of the submitted questionnaires, 30 were excluded because of incomplete answers, leaving 296 usable responses. The web site where the questionnaire was posted had a tracking function showing how many users had visited the site: 2289 over the 6-month period. A total of 2520 people visited the site and presumably saw the invitation, but declined to participate (response rate 30.3%).

As the use of the MVNO is still an emerging phenomenon, it was important to ensure that the participants had an appropriate level of exposure to, and experience of, MVNO services (Chou et al., 2004). Hence, a screening questionnaire was used to determine whether or not the respondents had had substantial knowledge and experiences with this new mobile service. It asked respondents about their usage patterns, their frequency of use of various mobile services, including MVNO, and their average amount of use. Respondents with substantial experience were invited to the survey. In order to increase validity and generalizability, the subjects were recruited from various MVNO providers, such as Virgin Mobile, Amp'd, Visage and Mobile ESPN.

Table 2 presents the sample demographics. The final sample is rather unbalanced in terms of age, education and experience. This may have resulted from the pre-screening procedure that selected users of substantial experiences with mobile usage. Given the nature of MVNOs, however, this unbalance is understandable because a large number of mobile users are young and educated and able to afford a computer or interested in having one. Thus, the collected sample in this study reflects the general population of mobile services. For the analysis of statistics, AMOS, a maximum likelihood-based SEM software, was used. AMOS is a covariance-based approach, in which the covariance structure, derived from the observed data, is used to simultaneously fit the measurement and structural equations specified in the model.

4.1. Measurement development

The participants indicated their agreement with a set of statements, using a 7-point Likert-type scale (ranging from "strongly disagree" to "strongly agree") drawn from previously validated instruments. The measures of PU, PEoU and behavioral intention were adapted from previous studies relating to the TAM model, mainly from Davis (1989). The measure used to assess perceived quality was taken from Shin (2009). To measure relative advantage, three items taken

Table 2
Characteristics of respondents (total=296).

Age	Number	%	MVNO experience	Number	%
Under 21	70	23.6	1–3 months	25	8.4
21–30	167	56.4	3–6 months	33	11.1
31–40	49	16.6	6 months–1 year	48	16.2
41–50	9	3.0	1–2 years	126	42.6
Over 50	1	0.3	2–3 years	37	12.5
			Over 3 years	27	9.1
Education	**Number**	**%**	**Gender**	**Number**	**%**
High school or lower	41	13.9	Female	128	43.2
College	183	61.8	Male	168	56.8
Graduate or greater	72	24.3			

Note: Age=296; Exper=284; Education=298; Gender=303.

Table 3
Discriminant validity.

Construct	Mean	SD	1	2	3	4	5	6	7	8	9	10
Perceived quality	4.42	1.18	**0.81**									
Perceived usefulness	4.81	1.28	0.25	**0.69**								
Perceived ease of use	4.25	1.40	0.23	0.18	**0.71**							
Social influence	4.38	1.68	0.14	0.22	0.57	**0.82**						
Switching cost	5.25	0.93	0.17	0.23	0.05	0.21	**0.72**					
Compatibility	4.32	1.09	0.06	0.15	0.14	0.29	0.09	**0.81**				
Relative advantage	4.32	1.21	0.03	0.16	0.08	0.31	0.21	0.03	**0.73**			
Intention	4.80	1.07	0.35	0.14	0.10	0.29	0.28	0.22	0.03	**0.82**		
Usage behavior	4.24	0.91	0.21	0.15	0.18	0.14	0.24	0.34	0.61	0.14	**0.68**	
Perceived price level	4.11	1.34	0.18	0.21	0.31	0.01	0.31	0.11	0.21	0.24	0.31	**0.70**

Notes: Bold-faced elements on the diagonal represent the square root of the average variance extracted.

from Vishwanath and Goldhaber (2007). Social influence was measured with items from Shin (2007). The final scales used in this study consisted of 27 items, three items per factor.

4.2. Measurement instrument

The reliability and validity of the measurement instrument were evaluated with SPSS15, using reliability and convergent validity criteria. The reliability of the survey instrument was established by calculating Cronbach's alpha to measure the internal consistency. Each construct was tested for reliability and content validity, using Cronbach's alpha (Cronbach, 1971). Most of the scores were above the acceptable level, that is, above 0.70. The variables in this study, derived from the existing literature, exhibited strong content validity.

The convergent and discriminant validity of the model were examined using the procedure suggested by Fornell and Larcker (1981), who recommend measuring the reliability of each measure and each construct, and the average variance was extracted (AVE) for each construct. The reliability of each item was examined using a principle components factor analysis. Table 3 shows the results of this analysis, with varimax rotation on the original 26 items (four items were eliminated due to low loading). According to Hair et al. (1995), a measurement item loads highly if its loading coefficient is above 0.6. This analysis showed that most items had factor loadings higher than 0.7, which Fornell and Larcker (1981) consider to be very significant. Each item loaded significantly on its underlying construct ($p < 0.001$ in all cases). Therefore, all constructs in the model had adequate reliability and convergent validity. To examine discriminant validity, this study compared the shared variance among constructs with the AVE from the individual constructs. The shared variance between constructs was lower than the AVE from the individual constructs, confirming discriminant validity (Table 3). In short, the measurement model demonstrated adequate reliability, convergent validity and discriminant validity.

The wording used in the questionnaire items was similar, so that the responses could be highly inter-correlated. Possible multi-collinearity problems can be effectively removed by a principal component analysis. In addition, a correlation analysis of Pearson's R (a correlation coefficient) shows an acceptable level of correlation among variables (Table 4).

Table 4
Principal component analysis with varimax rotation.

Component	1	2	3	4	5	6	7	8
PQ1	**0.773**	0.134	0.189	0.299	0.123	0.152	0.239	0.321
PQ2	**0.747**	0.292	0.232	0.045	0.211	0.134	0.135	0.311
PQ3	**0.700**	0.219	0.264	0.370	0.233	0.023	0.272	0.011
PEoU1	0.163	0.287	0.243	**0.810**	0.150	0.151	0.363	0.122
PEoU2	0.262	0.194	0.301	**0.751**	0.180	0.121	0.116	0.219
PEoU3	0.227	0.224	0.273	**0.762**	0.190	0.338	0.258	0.293
PU1	0.199	0.329	0.119	0.229	0.253	**0.815**	0.225	0.299
PU2	0.099	0.263	0.109	0.444	0.629	**0.863**	0.256	0.189
PU3	0.279	0.192	0.171	0.383	0.240	**0.737**	0.327	0.173
SI1	0.292	0.231	0.240	0.114	**0.796**	0.198	0.084	0.134
SI2	0.199	0.192	0.291	0.196	**0.790**	0.166	0.215	0.211
SI3	0.093	0.201	0.181	0.047	**0.729**	0.250	0.187	0.321
SC1	0.134	0.189	0.299	0.123	0.152	0.239	**0.772**	0.199
SC2	0.292	0.232	0.045	0.211	0.134	0.135	**0.742**	0.109
SC3	0.219	0.264	0.370	0.233	0.023	0.272	**0.701**	0.264
C1	0.228	0.101	**0.715**	0.476	0.182	0.206	0.276	0.091
C2	0.193	0.234	**0.723**	0.326	0.185	0.199	0.326	0.093
C3	0.048	0.305	**0.812**	0.316	0.240	0.155	0.116	0.392
RA1	0.277	**0.741**	0.285	0.088	0.180	0.190	0.018	0.323
RA2	0.277	**0.758**	0.228	0.273	0.182	0.199	0.193	0.194
RA3	0.120	**0.811**	0.204	0.382	0.249	0.200	0.292	0.193
IT1	0.293	0.178	0.242	0.261	0.130	0.167	**0.799**	0.093
IT2	0.224	0.283	0.264	0.139	0.212	0.157	**0.802**	0.119
IT3	0.293	0.218	0.139	0.392	0.251	0.511	**0.807**	0.281
PL1	0.093	0.201	0.181	0.047	0.229	0.250	0.187	**0.621**
PL2	0.134	0.189	0.299	0.123	0.152	0.239	0.172	**0.799**
PL3	0.292	0.232	0.045	0.211	0.134	0.135	0.042	**0.609**
UB1	**0.740**	0.199	0.329	0.119	0.229	0.253	0.326	0.110
UB2	**0.753**	0.099	0.263	0.109	0.444	0.629	0.316	0.213
UB3	**0.812**	0.279	0.192	0.171	0.383	0.240	0.088	0.119
α-Value	0.8883	0.8961	0.8477	0.8511	0.9101	0.8877	0.8672	0.8333
AVE	0.74	0.69	0.73	0.77	0.72	0.71	0.78	0.79

Note: Numbers in bold show the loading coefficients for the items in each construct.

Table 5
Fit indices for the measurement model and structural model.

Fit statistics	Structural model	Recommended value
Chi-Square/df	268.352, df=269; p=0.000	–
Normed Chi-Square	1.98	$<$ 5 (Bagozzi & Yi, 1988)
AVE	–	$>$0.50 (Fornell & Larcker, 1981)
p-Value	0.000	$<$0.05 (Bentler, 1990)
Goodness of fit index (GFI)	0.95	$>$0.9 (Bagozzi & Yi, 1988)
Adjusted goodness of fit index (AGFI)	0.89	$>$0.8 (Etezadi-Amoli & Farhoomand, 1996)
RMSEA (Root Mean Square Error Approximation)	0.067	$>$ 0.06 (Joreskog & Sorbom, 1996) $>$ 0.05 (Byrne, 2001)
Standardized RMR	0.027	The smaller the RMR, the better the fit (Byrne, 2001)
TLI (Tucker-Lewis Index)	0.91	Approaches 1 (Byrne, 2001)

4.2.1. Structural model

Structural equation modeling was used to analyze the data. Structural modeling evaluates whether the data fit a theoretical model. Table 5 shows the estimates from the structural modeling. The overall fit of the model is satisfactory, with all of the relevant goodness of fit indices greater than 0.90. The GFI is 0.95, the AGFI 0.89 and the TLI 0.91. Similarly, there is no evidence of misfit, with the RMSEA showing a very satisfactory level of 0.067, which favorably compares to the benchmarks by Joreskog and Sorbom (1996), who suggest that the values of 0.06 or more reflect close fit. The standardized RMR was also fairly good, at 0.027, well below the threshold for a good overall fit. Another positive test statistic was the normed chi-square value (a chi-square divided by the degrees of freedom) of 1.98, a value that is appropriately below the benchmark of three, to indicate good overall model performance. Given a satisfactory measurement of the model's fit to the data, the path coefficients of the structural model were assessed.

5. Results

5.1. Structural paths and hypotheses tests

To test structural relationships, the hypothesized causal paths were estimated. All ten hypotheses were supported with satisfactory levels of significance (Table 6). The results are reported and depicted in Table 5 and in Fig. 4. The overall fit of the model is sufficiently good, since the goodness-of-fit statistics are satisfactory and acceptable. The results generally support the proposed model, illustrating the new dimension of MVNO user acceptance. The specified relationship between PU and relative advantage (H4) was supported by the data, as indicated by a significant critical ratio (CR=3.012). Also, the relationship between the perceived ease of use and compatibility (H6) was supported by significant critical ratio (CR=3.254). The CR is a *t*-value obtained by dividing the estimate of the covariance by its standard error. According to Arbuckle (2005), CR values larger than 1.96 and 2.32 are statistically significant at 0.05 and 0.01, respectively. Ease of use of MVNO services, which is enhanced by compatibility, is related to reaching a higher level of positive intention (H7; CR=3.113). The usefulness of MVNO services, which is influenced by relative advantage over MNO services, significantly affects intention to adopt MVNO (H2; CR=4.152). Besides PU and PEoU, the switching cost was the strongest determinant of user intention for MVNO services (H9; CR=3.913). The high effect of switching cost is in line with other significant effects (relative advantage and compatibility). Given the factors are related concepts, we may infer the hidden relations among switching cost, relative advantage and compatibility. Quality is also a great factor to user intention (H8; CR=2.211). Finally, there is a strong positive relationship between social influence and intention (H10; CR=2.392).

Fig. 4 displays all the structural relationships among the studied constructs. The figure indicates that the variance in MVNO usage explained by the model is 72 percent, which is fairly high, given that numerous factors may affect acceptance of, and intention to use, the service. The results show that the variance in individual intentions toward accepting the MVNO services can be explained by the large proportion of PU and PEoU, along with a large proportion of switching cost. Variance in behavioral intention to usage behavior of the MVNO services was explained 40 percent by behavioral intention.

5.2. The effect of price sensitivity on customers' purchase decisions

As the price variable is shown as a significant factor, it is worthwhile to consider the possible influence of price sensitivity, that is, how price sensitivity influences customers' purchase decisions of MVNOs. Three levels of price difference

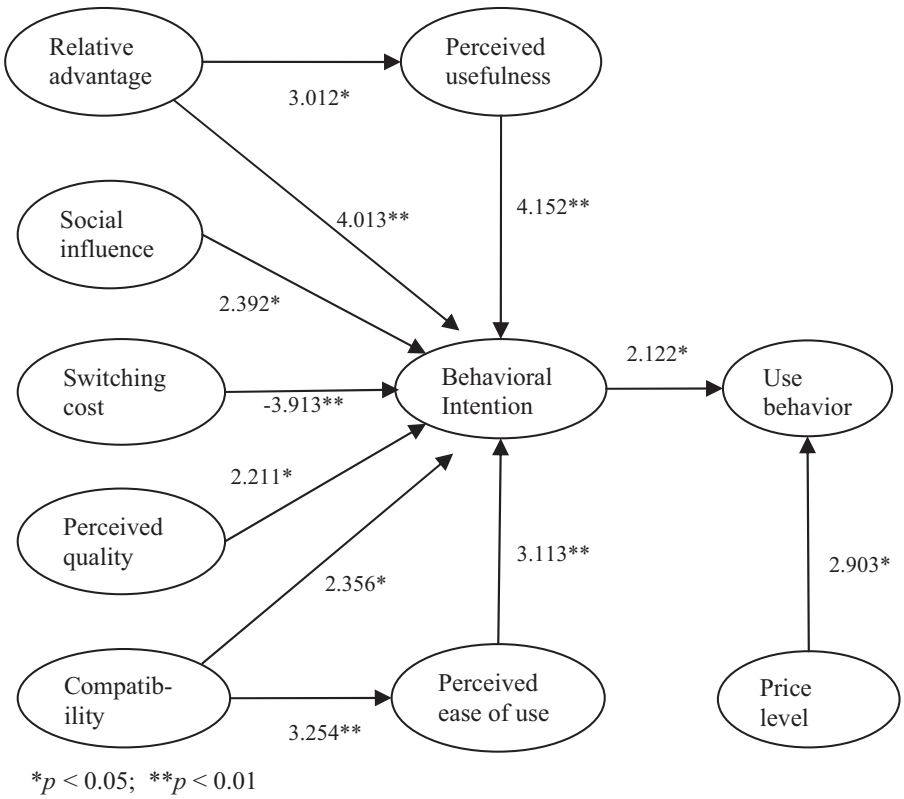

Fig. 4. Result of the research model.

Table 6
A summary of the hypothesis tests.

Hypothesis	Standardized coefficient	S.E.	C.R.	Support
H1: Intention → Usage	0.54	0.014	2.122*	Yes
H2: PU → Intention	0.39	0.103	4.152	Yes
H3: PoEU → Intention	0.22	0.016	3.113**	Yes
H4: Relative advantage → PU	0.21	0.091	3.012	Yes
H5: Relative advantage → Intention	0.38	0.459	4.013	Yes
H6: Compatibility → PEoU	0.40	0.218	3.254	Yes
H7: Compatibility → Intention	0.38	0.130	2.356	Yes
H8: Quality → Intention	0.23	0.013	2.211	Yes
H9: Switching cost → Intention	0.42	0.231	−3.913	Yes
H10: Social influence → Intention	0.38	0.154	2.392	Yes
H11: Price → Usage	0.53	0.201	2.903	Yes

Notes: S.E. is an estimate of the standard error of the covariance.
C.R. is the critical ratio obtained by dividing the covariance estimate by its standard error.
* Values are critical ratios exceeding 1.96, at the 0.05 level of significance.
** Values are critical ratios exceeding 2.32, at the 0.01 level of significance.

Table 7
Model selection using AIC and SBC.

Model	Price sensitivity	AIC	SBC
Model 1	Structural model without price sensitivity	498	519
Model 2	Model with higher price	271	289
Model 3	Model with medium price	201	216
Model 4	Model with lower price	133	147

(high, medium and low) are compared. The levels of prices come from MVNO prices compared with the price of normal services provided by MNO.

Variable	Price sensitivity	Comparison
Perceived price level (*H*)	High	MVNO services > MNO services
Perceived price level (*M*)	Medium	MVNO services = MNO services
Perceived price level (*L*)	Low	MVNO services < MNO services

In the price level factor, the three levels of price are given and three models arise. To evaluate and select the model of best fit, Akaike's information criterion (*AIC*), a measure of the goodness of fit of an estimated statistical model is used. *AIC* is a test between models—a tool for model selection. Given a data set, several competing models are ranked according to their *AIC*, with the one having the lowest *AIC* being the best. The chosen model is the one that minimizes the Kullback–Leibler distance between the model and the truth. It is based on information theory, but a heuristic way to think about it is as a criterion that seeks a model that has a good fit to the truth but few parameters. It is defined as

$$AIC = -2[\ln(likelihood)] + 2K$$

where *likelihood* is the probability of the data given a model and K is the number of free parameters in the model. *AIC* scores are often shown as the difference between the best model (smallest *AIC*) and each other model. Simply put, the smaller the values of these criteria, the better the generalization of the model. Along with *AIC*, Schwarz's Bayesian criterion (*SBC*) was performed to verify the selection results. Table 7 shows that the extended model with moderating effects is the best fitting model, indicating that customers respond to price sensitivity. The model with the lower price variable shows the best fit. This finding is consistent with the effect of price on MVNO diffusion (using Logistic, Gompertz, and Bass model) considered in Section 7 below.

6. Discussion

The purpose of the current study was to explain the development of individuals' behavioral intentions toward, and their use of, MVNO services. For this goal, new constructs were adapted from other sources to reflect the features of MVNO. Using the integrated model of UTAUT, this study found that traditional antecedents of behavioral intention, PEoU and PU, can be linked to IDT-related variables, such as compatibility and relative advantage. The results promise to add to our understanding of users' attitudes and intentions in MVNO, to clarify implications for the development of effective MVNO

applications and to further produce policy implications concerned with the diffusion of MVNO to increase competition and promote market dynamics. The results show that the models demonstrate good predictive powers and explain behavioral intentions toward MVNOs.

Consistent with prior research, the results show that PU and PEoU are the two main predictors of intention. Previous studies and industry reports have shown that usability concerns are the most important factors in considering an MVNO. The present study confirms the importance of actual usefulness and ease of use as well as perceived features, and further shows that PU and PEoU can be enhanced and moderated by IDT factors including switching cost. These findings together raise a need to highlight the customer's subjective viewpoint. As Ovum's study (2009) shows the perception of MVNOs held by consumers is one major factor for the market breakthrough of the system. Although the issue of viability has emerged as a major inhibitor of MVNO acceptance (Shin, 2008), the research on this issue is quite rare to date, especially from the viewpoint of consumers. The current study approaches the issue from an empirical perspective in order to better understand the concept of MVNO user adoption. The findings shed light on the underlying distinction between the dimensions of MVNO and other mobile services provided by MNO. In this study, the consumer subjective norm, based on social influence, shows a much stronger impact on intention than previous studies of mobile use have indicated (Dahlberg et al., 2008; Shin, 2009). This suggests that MVNO consumers are more influenced by their peers in their decisions to use than by other mobile application users. Given the immature stage of MVNOs, customers may seek a subjective norm, which increases their intention to adopt and use. The extended model reveals the vital role of social influence in the adoption process.

The findings in the current study identify a significant role for switching cost and its underlying linkage to other variables—namely, how it is related to intention and how other factors affect switching cost. As antecedent variables, the roles of switching cost are important, because one of the limitations of the current literature is that it does not help explain acceptance in ways that guide development, beyond suggesting that each consumer's psychological burden of switching has an impact on behavioral intentions and usage behavior. Therefore, it is essential to understand the antecedents of the key acceptance variables in order to be able to explain individuals' switching behavior. This study seeks the answers by focusing on the actual consumer perspective, how they perceive and interact with MVNO and what are the facilitating factors of consumers having MVNO services.

The findings in general are in line with previous research on mobile service adoption. Just like the findings in previous research, consumers' intentions and usages are much affected by their perception of usability, quality and other facilitating (compatibility/advantage) and hindering factors (switching cost). The findings go beyond such implications in that the findings imply that MVNO consumers perceive quality, usability and service overall differently from other mobile services. Although the new mobile services provided by MVNOs are of little difference from those provided by MNOs, customers in reality feel the difference. Specifically, they may expect the MVNO services to be more customized to the needs of individuals and more accessible/convenient to use (high-end niche services at the same time compatible with generic mobile service). In this light, the findings in this study can be a guide to designing and developing MVNO services that should target specific consumer-oriented preferences. Based on the consumers' expectation, it can be inferred that MVNO services would evolve to provide better value and be more innovative. There will be a growing market for MVNO services that strongly attract a niche market. Designing services that can appeal to and retain niche consumers requires special attention and strategies.

Finally, the findings are resonant with the recent telecom industry analyses of MVNOs. Industry forecasts predict MVNOs becoming more fragmented with the power of brands and distribution, together with the emergence of new low-cost aggregators favoring the development of emerging niche markets based on a small social community (Ovum, 2009). The industry forecasts, however, have neglected to notice the importance of the consumer dimension. This study sought an answer to MVNO viability and sustainability from the customers' point of view. MVNO can be more viable and competitive, but purely competing on technology or a business model cannot be sustained as a long-term strategy if they neglect to understand consumers. Developing new business models of the MVNOs should be heavily based on the customers' viewpoints as understanding their preferences would be the key to success.

7. MVNO forecasting using diffusion model

As the effects of consumers' perceptions of MVNOs are shown to be significant, it is worthwhile investigating the impact of economic variables such as price and competition. Hwang, Cho, and Long (2009) used diffusion forecasting models in investigating the factors affecting the mobile service diffusion. The components of their models include price, competition, other services, and data service. Using their model, this study analyzes how economic factors (in particular price) affect the MVNO diffusion:

$$\text{Diffusion rate} = f(price, HHI, service, data)$$

where *HHI* is the yearly Herfindahl index of market concentration, *service* is total cumulative annual mobile subscribers, and *data* is the cumulative annual revenue of data-based services.

7.1. Input data

The data on MVNO subscribers during the study period (2000–2009) is the cumulative numbers gathered from annual reports to the Telecom Associations. One potential concern over the data is that there are only 10 data points. Because MVNOs in the U.S. have only been in existence for about a decade, the study period is limited. Yet, because one advantage of diffusion models is that they perform well even with a limited number of data points (Bass, 1969), the availability of 10 observations is appropriate for the estimation.

7.2. Estimation

For estimating the model, the methodology used by Hwang et al. (2009) is followed. Their approach is to compare three models: Logistic, Bass and Gompertz. For the Logistic model,

$$F = 1/(1+e^{-(a+bt)})$$

where a and b refer to the timing and rate of diffusion. For the Bass model,

$$S(t) = m\frac{(p+q)^2}{p}\frac{e^{-(p+q)t}}{(1+(q/p)e^{-(p+q)t})^2}$$

where t=1,2,3,…,T. $S(t)$ is sales in the tth time interval. For the Gompertz model,

$$F = e^{-e^{-(c+qt)}}.$$

Table 8 shows that the coefficient of potential market for the Logistic model is 92% with significance. Although the coefficient of the Gompertz model is 89%, it is insignificant. The estimated number of MVNO adopters in the Bass model is unusually high at 210% of the population, which is considered an error. Thus, the Bass model is deleted from consideration.

7.3. The effect of price on MVNO diffusion

In determining the factors affecting MVNO diffusion, the Logistic model can be used. In the investigation, the role of the price variable in consumer adoption and diffusion overall can be clarified. To see the effect of price, the variable is added last in the model. The equation of the Logistic model is

$$b = b_0 + b_1 * service + b_2 * data + b_3 * HHI + b_4 * price \ (b \text{ is a function of input variables})$$

The estimation results are shown in Table 9. They reveal that the contribution of price to the rate of diffusion is highly significant. This result implies that price plays a significant role in accelerating MVNO diffusion in the U.S. During the period 2000–2009, the price factor is found to be much more important than service, data and competition.

Table 8
Estimation results.

Parameter	Logistic			Bass			Gompertz		
	Estimate	S.E.	t-Stat	Estimate	S.E.	t-Stat	Estimate	S.E.	t-Stat
a	−5.234	0.59	9.21	2.103	0.391	12.311	0.1	0.21	0.789
b	0.392	0.014	18.31	0.031	0.01	2.11	0.393	0.031	5.391
s	0.92	0.523	0.00	210.33	134.39	0.211	0.891	1.391	0.681
R^2		0.892			0.913			0.911	

Table 9
The estimation result of factors impact on MVNO diffusion.

Parameter	Estimate	Standard error	t-Statistic	p-Value
s	0.73123	0.192313	0.931223*	0.000
a	−8.3213	0.234244	−13.2133*	0.000
b_0	0.78233	0.029233	1.43922*	0.000
b_1, Other services	0.19312	0.62342	5.39321*	0.001
b_2, Data	−0.2123	0.138312	−5.32931*	0.002
b_3, HHI	−29012	0.321231	−9.23123*	0.000
b_4, Price	0.47492	0.113912	10.3132*	0.000
R^2=0.99211				

* Refers to significance at 99% confidence level.

The lower *HHI*, the higher is the competition in the mobile market. In Table 9, the value of coefficient b_3 is negative, implying that a decrease in market concentration or a higher level of competition increases the diffusion speed of MVNO services. Other related services, as shown in Table 9 (b_1 is positive), are complementary to MVNO services. This is because as the users of similar services increase, the number of customers adopting MVNO service also grows. As to data services, it has a negative sign in relation to MVNO diffusion. This refers to the fact that an increase in data service subscribers for voice and other value-added services in the market will lead to a decrease MVNO diffusion, because such value-added services can replace the demand for MVNO services. Conversely, this also implies that MVNO services will have a significant market transformation if the MVNO services target specialized niche services. Overall, the estimations imply that MVNOs may stand out beyond price competition and lead new innovations in the market through platform independence, innovative services, customer understanding, and content offering.

8. Implications for theory and practice

The results of this study contain several implications for researchers as well as for the mobile industry. This discussion is related to generalizability of the findings in this study. The practical variables such as switching cost, price, compatibility and service quality can provide the generalizable consideration to policy implication, whereas theoretical variables such as perceived usefulness, ease of use, and relative advantage can provide generalizable theoretical results in the technology-adoption scholarly communities.

The empirical findings demonstrate that highlighting IDT factors would be a worthwhile extension of the UTAUT in the context of emerging new mobile services, as both are found to be influential in predicting the attitude and behavioral intention to use MVNO services. Despite the growing interest in the field of MVNOs, to date, there has been limited empirical literature that explor the consumers' attitudes and intentions toward the services. The role that external variables and intention to use have played in predicting actual usage has received little attention. To fill the gap, this study investigates the actual usage behavior along with diffusion factors and switching cost, rather than just behavioral intention to use, and this study attempts to identify the factors that determine usage behavior of MVNOs. Moreover, the influence of external variables is examined. A primary contribution of this study is that it highlights the roles of quality and social influence in the context of a new mobile environment. It is notable that the work contributes to the emerging body of research by integrating UTAUT and IDT. Traditional antecedents of behavioral intention, PEoU and PU can be linked to diffusion-related variables, such as social influence, relative advantage and compatibility.

Although many studies are presented in an emerging mobile research literature, few have used integrated models or methods to assess these factors. Prior research on mobile adoption examined the impact of PU and PEoU on intentions for mobile services, assuming that the perceived features of specific services would have an effect on intention to use the service (i.e., Dahlberg et al., 2008). However, previous studies have neglected to investigate the relationship of PU and PEoU to other factors of innovation characteristics. The present study indicates that compatibility and relative advantage, as innovation characteristics, exerts important influences on consumers' intentions, as well as on their usage behavior indirectly. In addition, it is worthwhile to see how the mobile-specific factor, switching cost, is related to other variables including intention. Behavioral intention can be viewed as an individual's underlying attitude, which ultimately determines behavioral intentions via attitude (Ajzen, 1991). Thus, this study contributes to the literature on the UTAUT research by confirming that innovation characteristics from IDT, as salient beliefs, can influence behavioral intention and usage behavior through PU and PEoU.

The links identified in this study can be a first step toward a synthesized and integrated model of MVNO. However, future studies should further investigate the complex interrelationships among PU, PEoU and social influence to clarify possible intricate relations. In particular, as the findings show that switching cost can be effectively researched with a diffusion perspective, future studies may further delve into the complicated effects of switching cost on diffusion. As Kraft and Salies (2008) have shown, switching cost can be an important topic of study in terms of diffusion and policy implications.

Practical implications for industry can be drawn from the findings, in terms of strategies and new models for MVNO services. The results of this study can be used by both MNOs and MVNOs to better understand markets and to plan their preferred strategies on whether or not to engage in a relationship. The findings provide useful insight into developing appropriate marketing strategies to meet customer demands *and to further retain and expand a customer base.* The finding that PU and PEoU impact usage behavior through intention indicates that carriers should establish consumer perception of MVNOs by ensuring that their services are conducted in accordance with users' expectations—namely, that their contents are high quality, services are reliable and that promises and commitments are kept.

In conclusion, considering the ever-changing nature of the advanced mobile environment, this study offers help in understanding phenomena associated with MVNOs, and in understanding the implications of developing more effective mobile services. As consumers accept the MVNO as a new channel of mobile services, and as carriers provide enabling platforms for users, the MVNO services might become a killer application for the next generation of wireless communication. However, in order to become popular, MVNOs have several challenges to overcome, and consumer acceptance is probably the most important one. Service developers need a better understanding of individual perceptions concerning the level of security and the influence of social influence on intention to use and return to use. This study

provides a basis for an evaluative framework to determine the adoption potential of new innovative mobile services. The unified framework in this study can be a good tool for understanding market potential by analyzing users' demands and prototyping market profiles.

9. Policy implication promoting MVNO diffusion

The findings of this study offer generalizable discussion to policy makers providing the policy implication of promoting MVNO diffusion. Although the models in this study are collective typology, and thus, do not have specific answers, the structural relations of the factors in the models provide important implications for telecom policy, which is itself a combination of numerous factors in the ever-changing telecom ecology. Previous studies (Cricelli et al., 2009; Kim & Seol, 2007; Shin, 2008) have shown various benefits of MVNO diffusion in telecom markets such as increasing competition, lowering entry barriers, etc. However, these studies describe the specific economic factors in a limited setting and fail to provide the overall picture of how the individual factors are structurally related to overall factors in the telecom context. Given the significant results of this study, policy makers may draw insights from this study on how to promote MVNOs in markets to increase competition and promote public benefits.

First, the finding that switching cost plays a key role in behavioral intention and use behavior provides an important implication (C.R. = −0.3913 and confounding effects with relative advantage: C.R. = 3.039, social influence: C.R. = 2.572, compatibility: C.R. = 1.948). Policy makers should make efforts to lower the switching cost in order for consumers to more freely move from MNO to MVNO. Currently in the U.S., mobile number portability has been enforced allowing customers to switch to new mobile services including MVNOs. When consumers can freely switch from one service to another, there is a greater struggle to capture consumers. In this perspective, policy should be introduced in order to promote MVNOs so that customers feel a significantly lowered switching cost. In this study, consumers (current and/or prospective) perceive of switching cost as one of the key factors in their decision of behavioral intention and continuing use behavior. This finding is supported by Ovum (2009) that switching cost and MNP are significant aspects for subscribers to bargain to use MVNO services. Consumers may feel certain higher barriers or risk than other mobile services because most MVNOs are small-sized or new names in telecom markets.

Second, related to the first suggestion, consumers' discomfort and burden of switching may be related to low compatibility. As mentioned, most MVNO services are new brands and are provided by small or new carriers in markets, so consumers may worry about whether or not innovative and cheap services provided by MVNOs are compatible with other MNO services. At a common sense level, consumers may feel more comfortable in switching if new services of new carriers are interoperable across different carriers. This interoperability is related to the standardization of mobile services. A large part of current MVNO services are provided by middleware platforms of networks, which are provided by network operators. The middleware software plays a key role in making MVNO services interoperable with other services that are provided by different networks and different carriers (Ovum, 2009). Although middleware can facilitate making services more interoperable and compatible across the industry, policy can make it more effective by enforcing an appropriate standard in mobile services. This suggestion can be particularly important because MVNOs are targeting very specific services of niche mobile consumers. In this light, Kim and Seol (2007) argue that the viability of launching an MVNO depends on the compatibility or applicability of the service offered to the existing host operator's service offering. In this line of arguments and the supporting findings in this study, policy makers who wish to promote MVNO may consider adopting a new standardization mechanism for MVNO.

Third, policy makers may consider adopting a rule of relationship between MNOs and MVNOs. The latter have raised a series of questions as to whether the MVNO business model is sustainable without regulatory interference. In the U.S., the case for regulation has traditionally rested on concerns about market power and monopoly leveraging opportunities and the desire to capture beneficial network externalities (Cricelli et al., 2009). Because competition in the wireless sector has long been considered robust in the U.S., regulators believe that pro-MVNO regulatory intervention is not warranted. Thus, U.S. regulators seem not to be concerned about anti-competitive leveraging opportunities and forbear from imposing most regulatory constraints on wireless service providers, including pro-MVNO intervention. The findings of this study shed some light on whether MVNOs need regulatory protection or if they have sufficient appeal to thrive on their own. The variables like compatibility, quality and relative advantage can be the positive and sufficient factors for MVNO to thrive on their own. On the other hand, switching cost can be the area that needs regulatory protection or intervening mechanism to promote MVNOs (Lee et al., 2008; Shin, 2008). Regarding this, there exists an interesting contrast: MVNOs in Western countries, including the U.S., are competitive enough to battle against MVO without regulatory intervention, while on the other hand, MVNOs in non-Western countries rely on regulation because the MNOs and network operators in such countries have dominant powers over MVNOs. The dominant authorities over infrastructure held by MNOs enable them to exert clout when negotiating terms and conditions. Thus, MVNOs in the region normally have lower quality, less compatibility, and less useful services. MNVOs in such countries should not be left to the players to negotiate on a purely commercial basis. MVNOs in such countries rely on regulatory measures (e.g., lowering switching cost) to compete against MNOs. The findings in this study imply the need for suitable regulatory intervention to assist MVNOs, such as establishing guidelines requiring network operators to lease or to open the networks to MVNOs. Such guidelines enable MVNOs to offer quick launches of customized, secure and quality mobile services. The regulator should monitor the market, and player

behavior in the market, to ensure that MNOs conduct negotiations in good faith and fairly, so that the policy objectives of the MVNO decision are fulfilled. If an MNO is engaging in any form of anti-competitive conduct or approaches negotiations other than on a good-faith basis, it would be in the public interest for the regulator to intervene and adjudicate and, if necessary, make a determination appropriate in each circumstance or case.

Fourth, given the high effects of social influence on intention and usage, governments may enhance public relations and advertising to increase consumers' awareness of MVNOs and to improve positive notions about MVNOs. This study found that social influence is a significant predictor of intention to use the service. Social pressure represents important antecedents of consumers' intentions to use MVNOs. It implies that social norm-related influences have significant effects on the intention to use MVNOs. This is even more accurate in an environment like the U.S. where there is a market that favors high technology and where the consumers are highly sensitive to new trends and rapid shifts in trend and style. Mobile consumers may be conscious of what other people think about the mobile service asking their opinion and comparing their behaviors. The MVNO consumers may be influenced by word of mouth from other consumers (Ha, Yoon, & Choi, 2007). A growing number of studies suggest that a normative pressure is the significant factor to explain the rapid adoption of mobile services, and the findings of this study also confirm a positive effect of normative pressures on intention to use MVNOs. This suggests to carriers to consider the social context in which the MVNO service is used and the fact that normative pressures exist for various services. This also suggests that policy makers need to consider governmental efforts to promote public awareness of lowered switching cost, quality and the advantage of MVNOs to promote competition in markets.

10. Limitations and future studies

Several limitations narrow the scope of the above conclusions. First, the findings reflect only limited aspects of consumer experiences with MVNOs. Because MVNOs are not yet mainstream phenomena in the U.S. (Shin, 2008), this research is exploratory, which leads to a limited generalizability. Since this study specifically focused on MVNOs, it is hard to generalize the findings to other generic mobile services and other populations. Given that the mobile population currently runs to over several million, the sample size of 296 may be disproportionate to the whole population of mobile users. In addition, the research model is only valid for the U.S. mobile market due to the difficulty of cross-sectional and cross-national data collection.

Because MVNOs have been in the U.S. market only for a few years, data collection was limited. Due to lack of valid data, this study could not consider more sophisticated models such as incorporating price variation in the SEM. Future studies should consider these kinds of factors when MVNOs become mainstream phenomenon in the markets. Finally future studies consider adopting generalizability coefficients (Generalizability theory) to the SEM in order to increase generalizability of the factors identified by this study.

With all these limitations, the remaining question is: To what extent do the findings of this study reflect the actual customers' behaviors toward MVNOs? Future studies will be able to sample a larger and more typical number of subscribers. This may be achieved using stratified sampling or a quota sampling method to ensure a certain distribution of demographic variables. A generalized application of the extended model would require a global data collection process for a more thorough validation. In addition, since several intrinsic natures of motivations, such as perceived quality and social influence, are additional antecedents of intention and usage behavior, it is not possible to generalize the findings to other mobile applications. For example, since switching cost and perceived price level are subjective matters, all mobile consumers would claim a burden regarding switching, but there are differing psychological burdens and varying responses to those burdens. In all, this study took a first step at exploring user experience with MVNOs, which have not been researched well, and found a number of metrics to be reliable and nomologically valid. Despite its several limitations, one important contribution may be exploring and testing the metrics of consumer behaviors in regard to the emerging MVNOs. In addition to the fact that all the scales used in the study showed high reliability, those of quality, switching cost, compatibility and relative advantage also demonstrated high nomological validity. Therefore, future research can use these metrics with some careful assurance. Testing them against other factors (such as regulatory factors and demographics) will advance the understanding of MVNO adoption and diffusion in the next generation mobile era.

Acknowledgments

This research was supported by WCU (World Class University) program through the National Research Foundation of Korea funded by the Ministry of Education, Science and Technology (Grant No. R31-2008-000-10062-0). This work was supported by the National Research Foundation of Korea Grant funded by the Korean Government (NRF-2010-B00171).

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211.

Aladwani, A., & Palvia, P. (2002). Developing and validating an instrument for measuring user-perceived web quality. *Information and Management*, *39*(6), 467–476.

Arbuckle, J. L. (2005). *Amos TM 6.0 User's Guide*. Chicago, IL: SPSS, Inc.
Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the Academy of Marketing Science*, *16*, 74–94.
Bass, F. M. (1969). A new product growth model for consumer durables. *Management Science*, *15*, 215–227.
Bentler, P. M. (1990). Comparative fit indices in structural models. *Psychological Bulletin*, *107*, 238–246.
Byrne, B. M. (2001). Structural equation modeling with AMOS, EQS, and LISREL. *International Journal of Testing*, *1*(1), 55–86.
Carlsson, C., Carlsson, J., Hyvonen, K., & Walden, P. (2007). Adoption of mobile devices/services—Searching for answers with the UTAUT. In *Proceedings of the 39th annual Hawaii international conference on system sciences.* Retrieved from 〈http://doi.ieeecomputersociety.org/10.1109/HICSS.2006.38〉.
Cricelli, L., Grimaldi, M., & Ghiron, N. (2009). Modeling the competition of an HNO versus an MVNO in the mobile telecommunications industry. *International Journal of Technology, Policy and Management*, *9*(3), 277–295.
Cronbach, L. J. (1971). Test validation. In R. L. Thorndike (Ed.), *Educational Measurement* (2nd ed.). Washington, D C: American Council on Education.
Davis, F. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319–340.
Dahlberg, T., Mallat, N., Ondrus, J., & Zmijewska, A. (2008). *Past, present and future of mobile payments research*, *7*(2), 165–181*Electronic Commerce Research and Applications*, *7*(2), 165–181.
Etezadi-Amoli, J., & Farhoomand, A. F. (1996). A structural model of end user computing satisfaction and user performance. *Information and Management*, *30*(2), 65–73.
Fornell, C. (1992). A national satisfaction barometer: The Swedish experience. *Journal of Marketing*, *56*(1), 6–21.
Fornell, C., & Larcker, V. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18*, 39–50.
Ha, I., Yoon, Y., & Choi, M. (2007). Determinants of adoption of mobile games under mobile broadband wireless access environment. *Information & Management*, *44*(3), 276–286.
Hwang, J., Cho, Y., & Long, N. (2009). Investigation of factors affecting the diffusion of mobile telephone services. *Telecommunications Policy*, *33*, 534–543.
Joreskog, K. G., & Sorbom, D. (1996). *LISREL 8: Users reference guide.* Chicago, IL: Scientific Software International.
Karahanna, E., Agarwal, R., & Angst, C. M. (2006). Reconceptualizing compatibility beliefs in technology acceptance. *MIS Quarterly*, *30*(4), 781–804.
Kim, B., & Seol, S. (2007). Economic analysis of the introduction of the MVNO system and its major implications for optimal policy decisions in Korea. *Telecommunications Policy*, *31*(5), 290–304.
Kraft, J., & Salies, E. (2008). The diffusion of ADSL and costs of switching Internet providers in the broadband industry. *Research Policy*, *37*(4), 706–719.
Lee, S., Chan-Olmsted, S., & Ho, H. (2008). The emergence of MVNOs: An examination of the business strategy in the global MVNO market. *International Journal of Media Management*, *10*(1), 10–21.
Lin, J., & Lu, H. (2000). Towards an understanding of the behavioral intention to use a web site. *International Journal of Information Management*, *20*, 197–208.
Liu, M., Huang, L., & Chen, A. (2008). Chinese consumer's adoption intention towards 3G mobile phone. *Journal of Mobile Communications*, *6*(6), 770–786.
Lopez-Nicholas, C., Molina-Castillo, F., & Bouwman, H. (2008). An assessment of advanced mobile services acceptance. *Information and Management*, *45*(6), 359–364.
Lucas, H. C., & Spitler, V. K. (2000). Implementation in a world of workstations and networks. *Information & Management*, *38*(2), 119–128.
Moore, G. C., & Benbasat, I. (1996). Integrating diffusion of innovations and theory of reasoned action models to predict utilization of information technology by end-users. In K. Kautz, & J. Pries-Heje (Eds.), *Diffusion and adoption of information technology* (pp. 132–146). London, England: Chapman & Hall.
Ovum, J. (2009). *Virtual mobile services: Strategies for fixed and mobile operators*. London, England: Ovum April.
Rogers, E. M. (1995). *Diffusion of innovations* (4th ed.). New York, NY: Free Press.
Shin, D. (2007). User acceptance of mobile Internet: Implication for convergence technologies. *Interacting with Computers*, *19*(4), 45–59.
Shin, D. (2008). Overlay networks in the West and the East: A techno-economic analysis of mobile virtual network operators. *Telecommunication Systems*, *37*(4), 157–168.
Shin, D. (2009). Towards an understanding of the consumer acceptance of mobile wallet. *Computers in Human Behavior*, *25*(6), 1343–1354.
Shin, D., & Bartolacci, M. (2007). A study of MVNO diffusion and market structure in the EU, U.S., Hong Kong, and Singapore. *Telematics and Informatics*, *24*(2), 86–100.
Shin, D., & Kim, W. (2008). Forecasting customer switching intention in mobile service. *Technological Forecasting and Social Change*, *75*(6), 854–874.
TeleGeography (2008,. MVNO Report Packages, August.
Teo, T., Tan, M., & Peck, S. (2004). Adopters and non-adopters of internet stock trading in Singapore. *Behaviour & Information Technology*, *23*(3), 211–223.
Tornatzky, L. G., & Klein, R. J. (1982). Innovation characteristics and innovation adoption-implementation. *IEEE Transactions on Engineering Management*, *29*, 28–45.
Varoutas, D.A., Katsianis, D., Sphicopoulos, T., Cerboni, A., Kalhagen, K.O., & Stordahl, K., et al. (2002,. 3G MVNOs financial perspectives. In *Proceeding IST mobile & wireless telecommunications, summit 2002* (pp. 16–19, 557–561). Retrieved from 〈http://ssrn.com/abstract=717381〉.
Venkatesh, V., Morris, M., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, *3*, 425–478.
Vishwanath, A., & Goldhaber, G. (2007). An examination of the factors contributing to adoption decisions among late-diffused technology products. *New Media and Society*, *5*(4), 547–572.
Wu, Y., Tao, Y., & Yang, P. (2007). Using UTAUT to explore the behavior of 3G mobile communication users. *IEEE International Conference on Industrial Engineering and Engineering Management*, *2*(4), 199–203.