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Full Length Research Paper

Forecasting the usage probability of VoIP by attributes of telephone service

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This study proposes an adoption model for Voice over Internet Protocol (VoIP) with telephone service attributes as the predicative factors. We use survey data on descriptive preferences to predict the usage probability of VoIP in Taiwan. The proposed method compensates for the defects in most current forecasting methods, where the forecasting model cannot be built without historical data. Analytical results indicate that the public usage rate of VoIP in Taiwan is about 30%. The key factors influencing the usage probabilities include usage fees, set-up fees, security, and reliability. User requirements for low usage fees and high security are opportunities for VoIP service providers to expand the market, but the high set-up fees and unstable network environments are major barriers for VoIP promotion. Potential customers with the highest usage probability may be young, female, or highly educated.

Key words: VoIP, discrete choice model, service attribute, usage probability.

INTRODUCTION

The Internet has become a ubiquitous communication medium over the past decade, because of its rapid growth and the use of Internet Protocol (IP) (Bharat et al., 2006). In particular, the application of Voice over Internet Protocol (VoIP), which links telecommunications and a computer network, has greatly contributed to communication over the Internet. In recent years, due to the prevalence of using broadband networks, an enormous increase of broadband users, the popularity of Internet surfing (Chaudhuri et al., 2005; Ida and Kuroda, 2006), and low charges for VoIP (as compared to traditional telephone access), VoIP has reached maturity and become a technology with great potential. Furthermore, businesses using VoIP could increase their competitive advantages (Uys, 2009; Werbach, 2005). Taiwan's VoIP service market opened up in 2001, began to accept applications for VoIP direct-dial numbers (070), and started VoIP operations in 2005.

Taiwan's VoIP service is provided mainly by software suppliers. In June 2007, PChome and Skype introduced "Skype Local Calls", at a charge of US$0.05 per call, with the target to dominate Taiwan's local call market. This service contributed to the popularity of VoIP. Schiffman and Kanuk (1994) defined new products or services in terms of market penetration by a market-oriented concept, where products purchased by a relatively small proportion of consumers are new products. The number of VoIP accounts in Taiwan was about 100,000 by the end of 2008, while the population of Taiwan was 23 million and users of local calls comprised about 13 million households. Consequently, only a small proportion of consumers have used VoIP, as seen from the total population of users or the user population of local calls targeted by VoIP service providers.

Therefore, VoIP is still a new service to Taiwanese consumers. Marketing managers are concerned with usage probability and target customers of VoIP when introducing this new service. The recent introduction of new VoIP services has also attracted academic attention, although previous studies mainly discussed engineering technologies and seldom considered operational management. One study discussed the consumer acceptance attitude toward VoIP service through the Technology Acceptance Model (TAM) (Liao and Tsou, 2009); another performed a strategic analysis on the new service feasibility of service providers in a competitive environment (Oh et al., 2009); another analyzed users'

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satisfaction on VoIP through the Quantitative Method (Chen et al., 2006); and others researched the impact of regulation or protocol on VoIP service operation (Maeda et al., 2006; Chetty et al., 2006). However, no study in the literature has discussed the demand forecasting and market segmentation for VoIP, prompting this study to investi-gate that area. Two methods are commonly utilized to forecast: diffusion of innovations theory and discrete choice analysis. Diffusion of innovations theory considers innovation, communication channels, social systems, and time as independent variables to forecast the diffusion process and life cycle of new technology products (Rogers, 1983). Two examples are the diffusion rate forecasting of mobile phones (Botelho and Pinto, 2004) and the choice of broadband service (Robertson et al., 2007). Discrete choice analysis considers product attributes and socioeconomic characteristics of consumers as the predicating factors to estimate usage probability or market share, such as the demand esti-mations of broadband Internet (Savage and Waldman, 2005; Ida and Kuroda, 2006) or mobile phones (Iimi, 2005).

These two analysis methods utilize different forecasting principles, application ranges, and data types. The diffusion method suggests that consumers' demand for new technology products depends on the investment by service providers in the marketing and social environ-ment. It forecasts the products' life cycle trend, according to aggregate demand forecasting, and adopts previous sales data to build a forecasting model. However, discrete choice analysis indicates that consumer demand for products depends on the utility of the products, which is based on the product attributes. Hence, consumers choose which products to use by evaluating the attributes of various products. The forecasting model can be built from the initial survey data instead of historical data. Since the VoIP sector is still in a developmental stage, its historical sales data are incomplete, and so this study identifies the VoIP target market. The attributes of VoIP to consumers should be understood from the consumers' viewpoints in order to identify those target groups with a high probability of usage and so this study is based on discrete choice analysis.

ATTRIBUTES OF VOIP

The usage models of VoIP are classified as PC-PC, PC-Phone, and Phone-Phone. All three models require installing the necessary equipment on a computer or phone. The major form of VoIP service provided in Taiwan at present is PC-Phone, accounting for 80% of the total VoIP market. Hence, this study focuses on PC-Phone as the target mode. In addition to VoIP, other telephone services are available in Taiwan, such as traditional fixed-line phones and mobile phones. The transmission lines of traditional fixed-line and current VoIP are fixed, and VoIP providers consider their target market to be the traditional fixed-line market. Hence, this study only compares the service attributes of traditional fixed-line telephony and VoIP, as presented in Table 1.

The telephone and the Internet are both major communication tools, which are now converging with the advancement of communication technology. The service attributes of broadband networks include always-on, speed, price, installation, and reliability (Savage and Waldman, 2005), whereas telephony provides price, added value services, and communication quality (Iimi, 2005; Kim et al., 2004). These tools have very similar attributes, although telephone communication quality attaches more importance to the reliable measurement of noise, sound delay, or disconnection, than it does to transmission speed, which is also reflected in reliability. The added value service refers to the varied transmission content. Furthermore, security is a fundamental requirement for communication tools.

To reflect telephone service attributes accurately and to simplify the variables, this study applies telephone service attributes such as usage fees, set-up fees, reliability, security, and transmission contents. Unlike the traditional fixed-line telephone, VoIP can send both voice and data. Using VoIP requires installing peripheral equipment such as a computer, but the charge is lower than present fixed-line telephone fees. However, VoIP cannot completely avoid noise, sound delay, or disconnection, making reliability an important issue for technology providers to overcome. VoIP applies an end-to-end encryption, thus providing better security than traditional fixed-line telephony.

THE MODEL

This study develops a behavior model of individual choice for VoIP by utilizing discrete choice theory. Discrete choice analysis is based on the economic consumer theory and psychological choice behavior (Ben-Akiva and Lerman, 1985). Lancaster (1966) proposed a new approach to consumer theory, in which a product's utility comes from its attributes. A consumer utility function is built from the attributes to estimate consumer demand. Since the demand for products first undergoes a binary choice between "purchasing" and "not purchasing", the problem of whether to purchase a product is a discrete analysis problem based on product attributes. Discrete choice analysis has recently been widely utilized in estimating demand for new services (Savage and Waldman, 2005; Iimi, 2005; Chaudhuri et al., 2005) or building consumer acceptance probabilities (Thomas et al., 2006).

Consumers generally make a choice between "using" and "not using" by comparing the costs and benefits between the two. Thus, for example, if the benefit of using VoIP is higher than that of not using, then

Table 1. Attributes of telephone service

Attributes	Traditional fixed-line phone	VoIP
Transmission contents	Voice	Voice and data
Installation	Telephone	Computer, microphone, Internet, VoIP software
Usage fees	Two-part tariff (monthly fee and usage charge)	Flat rate
Reliability	Stable	Unstable
Security	Easy to be wiretapped and illegally used by others	End-to-end encryption technology applied

consumers tend to choose VoIP, and *vice versa*. The utility of VoIP comes from its service attributes. Therefore, consumers decide whether to use VoIP according to its service attributes. This study assumes that decision-makers regard utility maximization as the principle. In other words, when consumers choose VoIP, the utility of using it is undoubtedly larger than that of not using it - namely, $U_{VoIP} > U_{Non-VoIP}$. Suppose that the consumers' utility from VoIP comes from the VoIP service attributes or functions. The utility function of the k-th consumer is then as follows:

$$U_{jk} = \beta X_{jk} + \varepsilon_{jk}, j \quad C_k = \{VoIP, Non-VoIP\}, \quad (1)$$

where X_{jk} is the attribute vector of telephone service, including usage fee, set-up fee, security, reliability, and transmission content, β is the estimated parameter vector and ε_{jk} is the error term. The choice set of the k-th consumer on the telephone is $C_k = \{VoIP, Non-VoIP\}$, and the usage probability of VoIP is as follows:

$$\begin{aligned} P_k(VoIP\ j) &= P_k(U_{VoIPk} > U_{Non-VoIPk}) \\ &= P_k(\beta X_{VoIPk} + \varepsilon_{VoIPk} > \beta X_{Non-VoIPk} + \varepsilon_{Non-VoIPk}) \\ &= Pn(\varepsilon_{Non-VoIPk} - \varepsilon_{VoIPk} < \beta X_{VoIPk} - \beta X_{Non-VoIPk}) \end{aligned} \quad (2)$$

It is assumed that ε_{jn} are independent and identically Gumbel distributed, and so it is equivalent to assuming that $\varepsilon_{Non-VoIPk} - \varepsilon_{VoIPk}$ is logistically distributed. The usage probability for VoIP is then a binary logit, given by:

$$\begin{aligned} P_k(VoIP) &= P_k(U_{VoIPk} > U_{Non-VoIPk}) \\ &= \frac{\mathrm{EXP}(\beta X_{VoIPk})}{\mathrm{EXP}(\beta X_{VoIPk}) + \mathrm{EXP}(\beta X_{Non-VoIPk})} \quad (3) \\ &= \frac{1}{1 + \mathrm{EXP}(-\beta(X_{VoIPk} - X_{Non-VoIPk}))} \end{aligned}$$

As shown in Equation (3), the usage probability of VoIP is affected by the attribute difference value between VoIP and Non-VoIP. In other words, the usage probability is impacted by the relative attribute value other than the absolute value. This also indicates that the essence of choice theory is in choosing an option that is relatively better, rather than the absolute best.

There is a number of general approaches to finding estimators for the logit model. The two most commonly used methods are maximum likelihood and least squares, particularly maximum likelihood, because its estimators are consistent, sufficient, and efficient (Ben-Akiva and Lerman, 1985). This study uses the maximum likelihood method and the Limdep package to estimate parameters.

METHODOLOGY

Definition of variables

The definitions and measurements of all service attribute variables are described as follows:

(1) Usage fee: the total amount paid each month (including basic voice call and extra fees for additional functions).
(2) Set-up fee: cost of VoIP equipment.
(3) Security: security of transmission content, measured on a 5-point scale, where 1 means very insecure, and 5 means very secure.
(4) Reliability: high reliability means no noise, quality distortion, sound delay, or disconnection when communicating through VoIP. The reliability is also measured on a 5-point scale, where 1 means very unreliable and 5 means very reliable.
(5) Transmission contents: A value 0 means that voice contents are transmitted; a value 1 stands for all other cases.

Data collection

This study estimates the usage probability of VoIP among telephone users in Taiwan. Since Internet users are the mostly likely users of VoIP, this study applies quota sampling to conduct online surveys and non-online surveys. Three hundred valid samples were gathered from the Internet and 249 from non-Internet sources, giving a total of 549 valid samples. The survey contents include respondents' socioeconomic characteristics, their telephone usage behavior, and their choice of VoIP provider. To obtain respondents' preferences among alternatives, various scenarios based on the stated preference (SP) were designed to obtain the impact of

telephone attributes on the choice of VoIP. The SP model refers to

alternative plans based on decision-making factors obtained in research. The respondents' ratings, order, or selection of the alternative plans indicate the respondents' preference. We utilize a suitable parameter calibration method to estimate the decision-maker utility function. This questionnaire design method is often adopted in research on transportation, business management, and consumer behavior (Mahmassani et al., 2003; Hall et al., 2004;

Table 2. Example of simulated choice plans.

Attribute scheme	Usage fee	Set-up fee	Security	Reliability	Transmission content	Scheme choice (choose one)
Traditional fixed-line	US$47/month	None	Unstable	Unstable	Voice	Use
VoIP	US$4/month	US$210	General	General	Voice and data	Use

Table 3. Attribute content

Variable name	Level value	Scale
Security	Very insecure, Secure; General Secure, Very secure	Interval scale
Reliability	Very unstable, Unstable, General; Stable, Very stable	Interval scale
Usage fee	US$2-67	Ratio scale
Set-up fee	US$ 20 - 667	Ratio scale
Transmission contents	0: voice, 1: voice and data	Nominal scale

Table 4. Final coefficient estimates in a binary logit model.

Variables	Non-standard coefficients	Standard error	T value	P value
Usage fee	-0.00043569	8.64721e-005	-5.039	0.000***
Set-up fee	-0.00010719	2.37538e-005	-4.513	0.000***
Security	0.212837	0.0355102	5.994	0.000***
Reliability	0.158813	0.0379346	4.187	0.000***
Transmission content	-0.330168	0.117903	-2.800	0.005***

LL (0) = -755.5304; LL (β) = -620.4721;-2 (LL (0) – LL (β)) =270.1166; Degrees of freedom =5; ρ2=0.17498; No. of observations=1090.

Danielis et al., 2005). For convenient comparison of alternative plans, a traditional fixed-line telephone is treated as non-VoIP. The alternative plans include attributes of usage fees, set-up fees, security, reliability, and transmission contents. Table 2 presents the simulated selection plans. The respondents were asked whether they would choose VoIP after comparing the available options, when other conditions are the same except for these five attributes. The attributes are randomly assorted with different level values (Table 3). The socioeconomic characteristics of the respondents are as follows. The numbers of males and females are about the same; the main age group is 21 - 30 years old (60%), and about 69% have college degrees. The high proportion of graduates is due to a large number of universities in Taiwan, with admission rates of nearly 100%.

RESULTS

We use the collected SP data and Limdep software to estimate the logit mode. Since each questionnaire has two scenarios, 1090 valid samples are obtained after eliminating 8 unanswered questionnaires.

The usage probability of VoIP

Table 4 summarizes the final coefficient estimates in a binary logit model. The value of $-2\left(LL(0)-LL(\beta)\right)$ = 270.1166 and the degrees of freedom at 5 indicate that the null hypothesis - that all the parameters are zero - can be rejected at the 0.01 level of significance. The usage fee parameter is negative and reaches a significant level (t = −5.039, p = 0.00), revealing that with a higher usage fee, the consumers are less able to adopt this telephone system, and the usage probability is smaller. Because VoIP has much lower call charges than fixed-line telephones, the consumers' usage probability of VoIP is higher, which is also the biggest competitive edge of VoIP. The set-up fee is negative and reaches a significant level (t = −4.513, p = 0.00), revealing that with a higher set-up fee, the consumers' utility of adopting this telephone system is lower, and the usage probability is smaller. Because customers need to purchase some necessary equipment, the set-up fee decreases the usage probability of VoIP. The VoIP equipment can be connected to computers or not. Equipment connected to computers costs less, but the set-up fee for telephone systems connected to the Internet through a fixed-line is more expensive. Therefore, if the providers introduce a direct-dialing service in the future, then the high set-up fee may reduce the usage probability.

The security parameter is positive and reaches a significant level (t=5.994, p=0.00), indicating that with a

Table 5. Simulated values of VoIP usage probability.

Attribute	Usage fee		Set-up fee	Security	Reliability	Transmission content	Pr(VoIP)
Current situation	-200	5000	1	-1	1	1	0.3263
Break-even	-500	4000	1	0	0	0	0.5005

Table 6. Results of group t-test.

Group	Usage probability	t-value	Significance
High usage probability (N=513)	0.4698	42.192	0.000***
Low usage probability (N=437)	0.1964		

higher security parameter, the consumers' utility of adopting this telephone system is higher, and the usage probability is larger. Because present VoIP uses end-to-end encryption, VoIP thus has higher security than a fixed-line. Hence, the probability of using VoIP is higher than that of using fixed-line telephony. The reliability parameter is positive and reaches a significant level (t = 4.187, p = 0.00), revealing that with a higher reliability parameter, the consumers' utility of adopting this telephone system is higher, and the usage probability is larger. Because VoIP has lower reliability than fixed-line telephony, consumers are less willing to use VoIP, creating a challenge for VoIP providers. New hardware technology can eliminate this disadvantage. The transmission content parameter is negative and reaches a significant level (t = −2.800, p = 0.00). When the transmission contents are voice and data, the utility is lower than that of voice, revealing that consumer expectations of VoIP attributes focus on voice function. Furthermore, the combination of transmitted image and sound may decrease the smoothness of voice and affect communication quality. Thus, it may be questioned by consumers.

Table 5 presents the individual usage probability of VoIP under all attribute difference values obtained by Equation (3). According to the Skype webpage, an overseas call via VoIP is cheaper by US$1.6 per hour than the same call via a traditional fixed-line telephone. This survey found that about 70% of the respondents make international calls for less than 1 hour per week. Thus, VoIP can save about US$6.4 per month compared to traditional fixed-line telephony. According to VoIP providers, consumers need to pay US$125 - 188 for equipment simply to use VoIP. The description of telephone attributes indicates that the security of VoIP is better than that of a traditional fixed-line telephone, though the reliability is worse. However, VoIP can transmit content other than sound. Given the differences in these attributes, an individual consumer's usage probability of VoIP is about 0.3263, as computed by Equation (3). Consumers' present preference for VoIP in Taiwan is even lower than that of traditional fixed-line telephone, as indicated by these findings. However, if the transmission technology of VoIP improves in the future so the transmission quality is equal to traditional fixed-line telephone, if consumers could choose voice transmission only, if the set-up fee is cut to US$125, and if the call charge is US$15.6 cheaper per month than that of the traditional fixed-line telephone, then consumers' usage probability of VoIP will be equivalent to that of traditional fixed-line.

Segmentation for adoption probabilities

The respondents' choice probabilities estimated with discrete choice are used as the segmentation variables. We take cluster analysis to perform market segmentation in order to segment consumers into groups of high usage probability and low usage probability and to detect any statistically significant difference in their characteristics. Cluster analysis is performed through K-Means. The respondents are divided into two groups based on usage probability, as presented in Table 6. The t-test results show that these two groups significantly differ in usage probability, indicating an acceptable clustering effect.

This study further tests for socioeconomic differences between these two groups through the Chi-square test of independence, as listed in Table 7. The Chi-square value of gender variables reaches a significant level, revealing a significant difference in socioeconomic characteristics between these two groups. By comparing the actual and expected times, we find that females have a higher usage probability for VoIP than males. If the judgment of a significant level is widened, under the significant level of α=0.15, then both age and educational level are different. There are more respondents under 30 years old in the high usage probability group, revealing that younger people have higher usage probability of VoIP. Similarly, education level is relevant to usage probability of VoIP as those with undergraduate degrees or above have a higher probability of using VoIP.

Table 7. Difference of socioeconomic characteristics on group.

Socioeconomic characteristics		High usage probability	Low usage probability	Pearson's Chi-Square	Significance
Gender	Male	293 (305.6)	273 (260.4)	2.811	0.098*
	Female	220 (207.4)	164 (176.6)		
Education level	College above	68 (76.7)	74 (65.3)	2.551	0.113#
	College below	445 (436.3)	363 (371.7)		
Position	Worker	304 (300.2)	252 (255.8)	0.247	0.644
	Other	209 (212.8)	185 (181.2)		
Age(Years)	Under 30	406 (396.4)	328 (337.6)	2.242	0.134#
	30+	107 (116.6)	109 (99.4)		

Note: Data shown in the brackets are the expectation time. *Significant at 10%; #Significant at 15%.

CONCLUSION

Discussion

Based on the results of this study, we conclude that service attributes are predictive factors for building the discrete choice model for VoIP to determine the usage probability of telephone users. This model lacks the defects of most existing forecasting methods, which cannot be constructed without historical data, and is thus particularly applicable for demand forecasting of new products when no historical data can be used. Service attributes that affect consumers' choice includes usage fees, set-up fees, reliability, and security, according to logit analysis results. The first three attributes correlate with the findings of Savage and Waldman (2005), who investigated household broadband Internet access and use in the U.S. The difference is that telephone users require transmission security, whereas broadband Internet users require transmission speed, because telephone users care about wiretapping, whereas Internet users care about high speed.

In addition to security, the requirements for communicating by telephone also include transmission quality, such as no noise or disconnection. Users' perceived playfulness with VoIP has a positive effect on their usage attitude (Liao and Tsou, 2009). This study also indicates that the data-transmission function of VoIP would reduce usage probability. Thus, although VoIP can transmit non-voice data, this is not expected by most users, who focus on a phone's basic function of voice transmission.

Finally, usage probability is utilized as the segmentation factor for cluster analysis, where telephone users are divided into high and low usage probability groups. Younger individuals have a higher usage probability for VoIP, particularly individuals under 30 years old. This finding is consistent with the results of most studies in that younger individuals are more likely to accept new technology products (Chaudhuri et al., 2005). Moreover, there are more females than males in this group, which is not consistent with previous finding, which find that males are more likely to accept new technology products. This finding may be related to the Internet usage ratio of females, which is similar to that of males, while females tend to exchange information more often than males, and so lower charges are more attractive to them.

Implications

The practical contribution of this study is that the empirical results offer three main management implications for telecom providers. The first is the opportunity and threat of VoIP. This study finds that the key factors affecting usage probability of VoIP are usage fees, set-up fees, security, and reliability. Usage fees of VoIP are lower and its security is better than that of fixed-line services. Therefore, the requirement of users for low usage fees and high security is a significant opportunity for VoIP to expand in the market. However, the set-up fee of VoIP is higher and its reliability is worse than that of a fixed-line, particularly when VoIP providers introduce direct-dialing service in the future, requiring users to install phone-conversion equipment. Although installing VoIP equipment on fixed-line telephones can improve telephone interconnection convenience, it costs more than installing the equipment on computers. Consequently, the high set-up fee is an important threat for direct-dialing service. Another threat is an unstable network environment.

Second, the main client base of VoIP is young, female, and highly-educated. According to our results, younger groups commonly use VoIP, possibly owing to their curiosity, as well as a desire to try new technology. Cluster analysis indicates that the usage probability of VoIP among the young group is larger, and so providers

should focus on this potential consumer base when promoting VoIP. Moreover, females also form an important part of the client base for VoIP, owing to the increase in female Internet users. To reduce the telephone charge, they are likely to choose a low-charging VoIP provider. Therefore, marketing managers can focus on these groups when designing marketing strategies.

Finally, telephone user demand for VoIP still focuses on voice communication. Hence, whether or not VoIP has other additional functions may not be a crucial point for marketing. We suggest further examination in marketing studies. Future research may consider mobile telephony as another alternative to VoIP. One can utilize the multinomial logit (MNL) model to estimate usage probability for each type of telephone service.

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