Residential Demand for Internet Access and ISPs*

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Abstract

This paper presents a study on subscribers' demand in Taiwan for Internet access and the factors influencing their choice of Internet Service Providers. Revealed preference and stated preference data are collected employing face-to-face interviews and Internet questionnaires. An individual demand model using three-layer nested logit (Internet usage, Internet access, and ISP selection) or multinomial logit is constructed. The model indicates greater variety of digital content, wider bandwidth, and higher service quality increase the demand for Internet subscription. Households with Cable TV and better knowledge of Cable Modem have a higher demand for CM service. Since the cross elasticity of dominant incumbent, Hinet's Asymmetric Digital Subscriber Loop to other Internet accesses is high, this suggests Hinet's ADSL can effectively compete in the market with active price strategies. The cross elasticity of ADSL to CM service is high, indicating they are in the same service market. This raises a question for the National Communication Commission in Taiwan: should broadband services be regulated symmetrically or asymmetrically?

Keywords: Internet service provider (ISP), Cable Modem (CM), ADSL, Multinomial logit model, Nested logit model

1. Introduction

The global telecommunications environment is being driven towards liberalization, digitalization, and globalization. Vigorous development of the Internet has made the knowledge-based economy a key factor in the upgrade of local enterprises as well as national development. For the Internet, the broadband industry provides one of its most important links. According to International Telecommunications Union (ITU), in 2002, Taiwan had 8.59 million users. The penetration rate was 28.25%, and broadband access was rated the 5th in the world at 28%.[1]

Since the launch in 2001 of Taiwan's National Information Development Plan, broadband subscriber growth has increased at a quarterly rate of 20.79%, reaching 2.89 million users at the end of 2003. Dial-up subscribers still accounted for 41% of total Internet users, suggesting plenty of room for broadband development. To attract consumers and to promote revenue/market share, Internet Service Providers (ISPs) need to know well the demands of present/future subscribers. The success of the broadband industry lies in the accurate forecast of this demand, which is a tough task, made more difficult by the rapid development of new technology and provision of new services in this market. Therefore, it is critical to analyze Internet access and the selection behavior of Internet users.

This paper presents a study on the demand of Internet users in Taiwan from an overall perspective and an analysis of their selection behavior. A three-layer nested logit model is constructed which serves as our individual demand model for Internet access and ISP. The first layer of the model concerns Internet usage: specifically, subscribers choose either no Internet usage, narrowband usage or

[1] The top four were South Korea (94%), Iceland (51%), Canada (50%), Hong Kong (42%).

broadband usage. The second layer concerns Internet access: narrowband connection, ADSL connection or CM connection. The last layer concerns subscribers' ISP selection. We analyze the demand for Internet access and the factors influencing ISP selection. Finally, we examine whether CM and ADSL are in the same market or not. This will provide a reference for regulatory policy decision on broadband services in Taiwan. All tables and figures are contained in the appendix at the end of the paper.

2. Taiwan's Internet Service Market

Internet access includes dial-up and broadband services, differing in transmission speed and transmission principle. Dial-up uses a modem to transmit data through a phone line at speeds up to 56K/bps. Broadband connections apply compression and enhanced digitalization technology on existing networks to increase transmission capacity and speed. Specifically, ADSL is a technology that uses an ADSL-specific modem to transmit digital data at the downloading speed of 1.5-8M/bps and at the uploading speed of 64K-1M/bps over an existing telephony line. Its main characteristic is that downloading (Internet to user) and uploading (user to Internet) speeds are asymmetric, suitable for typical usage patterns. In contrast, CM uses the coaxial cable of Cable TV operators to transmit data. Downloading speed can be as high as 36M/bps and uploading speed can be as high as 10M/bps. There is, however, a major drawback in CM service in the current stage: total bandwidth is shared by all users, resulting in the instability of transmission speed. This seriously reduces the attraction of CM service to Internet users.

ISPs provide Internet access service and on-line value-added services. Serving mainly academic institutions since the 1990s, Taiwan Academia Network (TANet), was the earliest ISP in Taiwan. Software Engineering Environment Development (Seednet) and ChungHwa Telecom's Hinet sequentially entered the market in 1992 and 1994, respectively. The ISP market is highly concentrated, and the 2003 market shares of Hinet, EBT/APOL and Seednet were 79%, 7% and 5%, respectively. In terms of ADSL, Hinet and Seednet held market shares of 84% and 6%, respectively. Total subscribers to Hinet's ADSL reached 3.26 million in May, 2005. Primary CM ISPs were EBT/APOL (61%) and Giga Media (19%). Figure 1 shows subscriber numbers using different Internet access methods in Taiwan. Subscribers to dial-up connection, though more than half of Internet users, have been dropping fast in number in recent years.

The primary Internet application in Taiwan is information browsing (80%). Other purposes include E-mail (36.9%), on-line entertainment (18.7%), and job search (16.3%). As for on-line entertainment, most used services are on-line music (67.4%), on-line games (55.1%), and on-line chatting (24.8%). Further, 36% of Internet users are willing to pay for digital music downloading (e-Common Magazine, 2004).[2]

3. Literature Review

Table 1 presents a review of literature on Internet usage, Internet access

[2] Yahoo Music Unlimited has started to offer a paid music downloading service since May 2005. Subscribers in the US who pay USD $4.99 per month (on a two-year contract) are allowed to listen on-line and download more than one million songs legally to the MP3 player. This has impacted on Apple's iTune service, whereby subscribers pay USD $0.99 per song. KKBOX in Taiwan has been providing similar services by streaming media technology since October 2004. Their subscribers are allowed to listen to music on-line legally, but not to download music to the MP3 player.

and ISP selection using the categories of study object, data acquisition, research method, social economic variables, attribute variables, and main conclusion. The research methods used are mainly descriptive statistics, multivariate analysis (factor, cluster and variate analyses), regression analysis and individual demand model (binary probit, logit, multinomial logit (MNL) and nested logit (NL)). Literature on individual demand models contains more detailed setups of social economic variables, for example, see Madden and Simpson (1996, 1997), Madden et al. (1999), Eisner and Waldon (2001), and Madden and Goble-Neal (2003). Social economic variables as well as Internet attribute variables (such as installation fee, connection fee, Internet experience, and connection number,) play a key role in Internet usage. When subscribers choose their Internet access, besides service price, they consider Internet attributes, such as bandwidth, transmission speed, stability, reliability (Jackson et al., 2002). When subscribers choose their ISPs, they consider service price, retrieving/saving speed, reliability, available on-line service, provider's reputation and service bundling (see Teo and Tan, 1998; Madden and Goble-Neal, 1999).

Madden et al. (1999) found subscribers' social economic characteristics and service attributes affected their loyalty to ISP and service quality affected an operator's market share. Madden et al. (2002) estimated a stated-preference MNL model of Australia-wide broadband delivered entertainment service subscription considering the impact of an installation fee and rental price, service attributes and household demographic variables on subscription. Bauer et al. (2002) examined the effects of public policies towards traditional communications infrastructures on Internet access in the EU and in the US using a panel of data. Rappoport et al. (2002) used individual demand models to

study the demand for Internet access by households. Since households' access choice may differ in areas, they defined choice sets as follows: (1) Internet usage; (2) Internet usage, dial-up and CM/ADSL; (3) Internet usage, dial-up, CM and ADSL. Three individual demand models, namely, a binary logit, multinomial logit and nested logit model are subsequently constructed. Savage and Waldman (2004) used survey data from 2003 to empirically assess US residential demand for Internet access. Econometric results indicate that service reliability, speed, and the ability to share music and video files are highly valued attributes.

As for regulatory issues pertaining to US telecommunications markets, the Federal Communication Commission (FCC) currently adopts asymmetrical regulation on broadband services. In other words, incumbent local exchange carriers (LECs) of xDSL are regulated by a price-cap regulation when leasing their broadband network to competitors at a "reasonable wholesale price." Asymmetrically, cable operators of CM services face no regulation. Crandal et al. (2002) used a nested logit model to estimate the probability of subscriber Internet access and to examine justification of the US's asymmetrical regulation on broadband services. They assumed subscribers would choose no Internet usage, narrowband service, or broadband service. Influential variables included income, sex, age and education. If broadband service was chosen, then subscribers could choose either xDSL or CM in which the influential variable was service price. The estimated price elasticity (-1.184) of xDSL showed the demand for xDSL was elastic. The estimated cross elasticity of xDSL to CM was high (0.591), implying that xDSL and CM belonged to the same service market. Hence, xDSL providers had no significant market power to increase service price by restricting their

outputs. The authors suggested that the FCC should adopt symmetrical regulation for broadband services.

As indicated above, most researchers have used revealed preference (RP) data to build logit models. However, before broadband service is brought to the market, stated preference (SP) data can be adopted to investigate the consumer's demand for broadband service. By so doing, operators can analyze possible market reactions to future broadband service. Since SP can be applied to simulate virtual scenarios of certain service attributes and contents, in this paper we fully utilize these advantages and collect the data needed by both RP and SP.

4. Demand Models

4.1 Multinomial Logit Model

The individual demand model is derived from consumer theory with a stochastic utility. The consumer is a rational decision-maker and chooses the alternative that provides him/her with the highest utility from all available alternatives. The utility function comprises a measurable part (V_{it}) and an un-measurable part (ε_{it}). The utility of an individual t when choosing alternative i (U_{it}) is then:

$$U_{it} = V_{it} + \varepsilon_{it} \tag{1}$$

where V_{it} is affected by an individual t's social economic characteristics and by alternative i's subjective attributes. The random error term ε_{it} is a summary of measurement error, taste variation, missing variables and unobserved error. It measures the error or reflects the heterogeneity of individual tastes.

It is assumed that the error terms ε_{it} s are independently and identically distributed (i.i.d.) with a Gumbel distribution. A multinomial logit model can then be derived (McFadden, 1973). The probability that an individual *t* chooses alternative *i* is:

$$P_{it} = \frac{e^{V_{it}}}{\sum_{j \in A_t} e^{V_{jt}}} \tag{2}$$

where A_t is the choice set of individual *t*. The log-likelihood function is:

$$\ln L = \sum_{t=1}^{T} \sum_{i \in A_t} f_{it} \ln(P_{it}) \tag{3}$$

where $f_{it} = 1$ if individual *t* chooses alternative *i*; $f_{it} = 0$ otherwise; T is the number of observations.

4.2 Combined Estimation with RP and SP Data

Measurable utility V_{it}^{rp} of revealed preference is defined as follows:

$$V_{it}^{rp} = \alpha_i + \beta^{rp} X_{it}^{rp} \tag{4}$$

where α_i is the specific coefficient of alternative *i*; X_{it}^{rp} is the attribute vector that influences individual *t* to choose alternative *i*; and β^{rp} is the corresponding coefficient vector to be estimated. We substitute (4) by (2), and apply the maximum likelihood method to obtain the coefficient estimates under RP when the equation in (3) is maximizing.

Measurable utility V_{it}^{sp} of stated preference is defined as follows:

$$V_{it}^{sp} = \gamma_i + \beta^{sp} X_{it}^{sp} + \delta Z_{it} \tag{5}$$

where γ_i is the specific coefficient of alternative *i*; X_{it}^{sp} is the attribute vector that influences individual *t* to choose alternative *i*; Z_{it} is the factor vector, solely related to SP, that influences individual *t* to choose alternative *i*; and β^{sp} and δ are the corresponding coefficient vectors to be estimated. Similarly, we substitute (5) by (2), and apply the maximum likelihood method to obtain the coefficient estimates under SP.

Louviere et al. (1981) indicated that the theories based on both SP and RP models are identically, except for different data used. Thus, their error terms differ and the utility functions of both models may have inconsistent scales. To integrate the two sets of data into a combined model, scale correction should be carried out. Different correction procedures may result in different parameter estimations of the combined model, for instance, sequential estimation and conjoint estimation (Swait et al., 1994). The second method is discussed below and used in this paper.

Swait et al. (1994) corrected the utility function by a scale factor, separately estimating the RP model and the corrected SP model, and estimating all parameters by maximizing the sum of the likelihood functions of the two models. As in Ben-Akiva and Marikawa (1990), we assume the relationship between error terms is:

$$Var(\varepsilon^{rp}) = \mu^2 Var(\varepsilon^{sp}) \quad \Rightarrow \quad (\alpha_i, \beta^{rp}) = \mu(\gamma_i, \beta^{sp}) \tag{6}$$

where μ is a scale factor. By (6), ε^{rp} and $\mu\varepsilon^{sp}$ have a consistent distribution. Only some (not all) *X* variables in the two models need to be the same. We multiply the utility function in SP by μ, and combine RP data with SP data to obtain the mixed data model of conjoint estimation. We estimate the unknown parameters by maximizing the conjoint log-likelihood function in (7):

$$\ln L(\alpha,\beta,\gamma,\delta,\mu)=\sum_{t=1}^{T}\sum_{i\in A_t} f_{it}^{rp}\ln(P_{it}^{rp})+\sum_{t=1}^{T}\sum_{i\in A_t} f_{it}^{sp}\ln(P_{it}^{sp}) \tag{7}$$

where $\beta=\beta^{rp}=\beta^{sp}$ and V_{it}^{sp} is substituted by μV_{it}^{sp}.

Utility function in the conjoint model is nonlinear with the inclusion of the scale factor. This paper adopts Alogit statistical software and uses artificial nested structure in estimation. We assume the utility function of virtual alternative as in (8), so, the estimated inclusive value μ is the scale factor in the SP model:

$$V_j^{comb}=\mu\ln\sum_{j=1}^{J}\exp(V_j^{sp}) \tag{8}$$

4.3 Nested Logit Model

A multinomial logit model needs to be independent of irrelevant alternatives (IIA). If this is violated, then the estimation will be biased. McFadden (1981) proposed a Generalized Extreme Value Distribution and used random utility maximization to derive a nested logit model (NL) able to deal with the relevance between alternatives. The NL model sorts out relevant alternatives in one independent nest layer and uses inclusive values connecting alternatives in each nest layer. We construct a common utility function for relevant alternatives and build MNL models for other independent alternatives. We assume that the random error terms of alternatives in the same nest layer are independently and identically extreme-value distributed while the random error terms of alternatives in different nest layers are not.

For convenience of exposition, suppose there are two nest layers according to the relevance of alternatives. The selection of individual *t* is modeled in two steps.

First, an alternative *m* is chosen from *M* available alternatives in the second irrelevant nest layer (higher nest layer). Then, the utility-maximizing alternative *n* is chosen from *N* relevant alternatives included in the previously chosen alternative *m* (lower nest layer). Measurable utility V_{mn}^{t} of individual t from alternative mn can be set up as:[3]

$$V_{mn}^{t} = \alpha X_{mn} + \beta Y_{m} \tag{9}$$

where X_{mn} are the attribute variables relevant to the alternatives in the first and second nest layers; Y_{m} are the attribute variables relevant to the alternatives only in the second nest layer; and α and β are the parameters to be estimated.

According to the probability density function of extreme value distribution, the probability P_{mn}^{t} of individual *t* choosing alternative *mn* is:

$$P_{mn}^{t} = \frac{\exp\left[\alpha X_{mn} - \theta I_{m} + \beta Y_{m}\right]}{\sum_{a \in A}\sum_{b \in B} \exp\left[\alpha X_{ab} - \theta I_{a} + \beta Y_{a}\right]} \tag{10}$$

where *A* and *B* are the sets of alternatives available to individual *t* in the second and first nest layer, respectively. Inclusive value I_{a} is defined by $I_{a} = \ln \sum_{b} \exp(\alpha X_{ab})$. The parameter θ is the relevance index and satisfies utility maximization if $0 \le \theta < 1$. If $0 < \theta < 1$, there exists a certain correlation between the alternatives in the first layer. If θ is close to 1, these alternatives are not only relevant but also perfectly substitutive. If θ equals to 0, these alternatives are not relevant and the NL model can be simplified to the MNL model.

The estimation of the parameters in the MNL model usually adopts the Full Information Maximum Likelihood Method (FIML). Its likelihood function is as

[3] For simplicity, the superscript *t* in attribute variables is omitted from hereon.

follows:

$$\ln L(\alpha,\beta,\theta) = \sum_{t=1}^{T} \sum_{m\in A_t} \sum_{n\in B} f_{mn}^{t} \ln P_{mn}^{t}(\alpha,\beta,\theta,X,Y) \qquad (11)$$

where f_{mn}^{t} is 1 if individual *t* chooses alternative *mn* and 0 otherwise.

4.4 Research Framework

To truly reflect actual selection behavior of Internet users, this paper uses data collected by RP. However, to analyze the consumption inclination of future service contents, we have also collected SP data by scenario simulations to overcome insufficient variations in RP data and possible omission of latent variables. We then combine RP data and SP data, and use NL to construct an individual demand model of subscribers in Taiwan for Internet access and ISPs (see Figure 2.) There are three nest layers in our model. Two are RP layers (Internet access and ISP selection) and one is a SP virtual layer corrected with an adjusted scale. The model setup allows us to obtain the scale factor of SP data relative to RP data, the relevance index between alternatives, and the estimated parameters.

5. Data

5.1 Questionnaire Content and Data Acquisition

We summarized important variables from a literature review to form the pretest questionnaire. Some variables were subsequently adjusted as a consequence of pretest results, and the formal questionnaire then drawn up. Questionnaire contents comprised four parts:

(1) RP data of each subscriber's Internet usage (Internet access and ISP selection), for instance, Internet surfing experience, knowledge of CM, download/upload speed, service price, and service quality of his/her chosen alternative & other substitutive alternatives (such as transmission stability, connection security's reliability, ISP's brand image & overall image, service contents, and operator's attitude and ability) . These were evaluated by a 10-point scale of satisfaction.

(2) SP data of subscribers' Internet usage under four virtual scenarios.[4]

(3) Subscriber demand for content services, such as (a) e-mail, on-line antivirus scanning, Internet hard-drive, A/V multimedia, online game, interactive learning, on-line teaching, video phone, mobile multimedia, and on-line chatting; (b) future on-line service: virtual library, on-line health consultation, multimedia on demand (MOD), legal music downloading). These services were evaluated on a 5-point of Likert scale.

(4) Social economic characteristics of subscribers and households.

Since the validity and reliability of Internet questionnaires are often challenged by researchers, we collected the data through both face-to-face interviews and Internet questionnaires. Interviewed subjects were randomly selected in 3C stores, wholesales stores, department stores, and Chunghwa Telecom's service centers in Tainan City in March, 2004 (407 effective samples were obtained, a response rate of 84.8%). The Internet questionnaire was processed and distributed by e-mails in discussion areas of main entrance websites in Taiwan (471 effective samples were obtained, a response rate of 89%).

[4] Respectively, they were (a) service content and IP number, (b) gift and marketing activity, (c) multimedia and entertainment service contents, and (d) knowledge-related and future multimedia service contents, which operators provided. The first two relate to operators' marketing strategies and the latter two to operators' digital service contents.

5.2 Descriptive Statistics of Data

The basic characteristics of data obtained from interviews and internet questionnaires did not differ much. We tested whether all parameter estimates obtained by different data sources were the same by the likelihood ratio test. The likelihood ratio statistic = 20.97 was less than $\chi^2(17, 5\%) = 27.59$ and, thus, the null hypothesis that all parameter estimates obtained by different data sources would be the same, was accepted. Since the selection behaviors of respondents in the two data sources did not significantly differ, we combined the data for further analysis.

Samples were about equal in terms of genders. Half of respondents were aged between 20 and 25, college educated, students, and with a monthly income of NTD 30,000 (USD:NTD = 1:32). Almost three-quarters of the samples (70%) used ADSL and the rest used CM, dial-up or no Internet. Further, respondents' selection behaviors differed in terms of social economic characteristics. Younger, highly educated and student groups tended to prefer broadband service, whereas older and less educated groups seldom used Internet services. Different income groups displayed little differentiation in selection behaviors possibly because more than half of study samples were students. As for non-student samples, respondents with lower income preferred no Internet usage.

Respondents using different Internet services (such as Chunghwa Telecom's Hinet's ADSL, non-Hinet ADSL, and CM) were shown, by MANOVA, to have significantly distinct views about transmission stability, reliability of Internet security, operator's brand image and overall image, service contents, and operator's attitude and ability. They also more higher evaluated on the alternative they chose than other

alternatives. Hence, service quality may be influential in respondents' Internet access and ISP selection.

Table 2 shows respondents under simulated scenarios inclined to choose their RP selections (28%, 46.3%, 34.5%, and 71.5% chose dial-up, Hinet's ADSL, non-Hinet ADSL, and CM, respectively). CM respondents showed very high loyalty. As for ADSL, Hinet's ADSL subscribers had higher loyalty than non-Hinet ADSL subscribers. Hence, Internet access and operator's experience of subscribers have a certain impact on SP selections.

6. Empirical Results

6.1 Model Estimation

This paper used RP and SP data to construct individual demand models of subscribers in Taiwan for Internet access and ISP selection. The utility function was set up to be additively linear. In RP data, independent variables included frequency of Internet usage at school/company, frequency of Internet usage at Internet cafes, frequency of Internet usage at home, (high/low) acceptance degree of new high-tech products, time since first contact with the Internet, download/upload speed, service price, number of frequent Internet users in the household, transmission stability, connection security's reliability, ISP's brand image and enterprise's image, service bundling, Cable TV at home, knowledge of CM, age, education, and personal income. A dummy variable for alternative used "no Internet usage" as base.

As regards SP data, independent variables included service price, download

speed, upload speed, fixed/floating IP address, IP number, ISP's gift provisions (such as e-mail service, on-line antivirus scanning, Internet hard drive space, and USB disk,) ISP's discounted offers (i.e. free Internet contents, discounted contract, prepaid discount, and discounted price for 3C products,) and digital service contents (i.e. audio/video multimedia, video phone, mobile multimedia, on-line game, on-line chatting, interactive learning & on-line teaching, virtual library, on-line health consultation, MOD, and legal music download).

In this paper, we first construct a conjoint selection model of Internet access and ISP by NL. The upper nest layer in the NL model relates to Internet access and the lower nest layer relates to ISP selection (see Figure 2.) If the parameter estimate of the inclusive value is between 0 and 1, there exists a certain correlation between alternatives in the first nest layer. If it is zero, then the NL model can be replaced by the MNL model. The inclusive value in the NL model is estimated to be 1.366, clearly not between 0 and 1. Thus, NL theory is violated, and not applicable for analysis. Hence, we use the MNL model to analyze subscribers' Internet access and ISP selection by the combined estimation with RP and SP data.

The parameter estimates in the MNL model are presented in Table 3. ρ^2 = 0.2074, suggesting the MNL's model's explanatory ability is good. The signs of independent variables also satisfy prior expectation. Estimate of the scale factor (0.333), significantly differs from 1, implying that the variation in error in SP data is larger than that in RP data. Most estimates in the MNL model are significant at the 5% significance level and all their signs are reasonable.

Estimate results in the combined model are summarized as follow: the higher the download/upload speed and the better the service quality (stability and security reliability, brand image & service ability, and service bundling), the higher the

inclination of respondents to use a particular Internet access and ISP. But service price may negatively affect the inclination. Further, the more frequent Internet users within a household, the higher the possibility the household will use broadband service. If a household has installed with Cable TV and is familiar with CM service, the more likely it will be to use CM service.

Dial-up service was the earliest Internet service available in the market. Thus, the earlier a household used this Internet service, the more probable its continued use of it. Newer Internet users tend to use broadband services. Hence, consumers not using an Internet service are highly potential users of broadband services and broadband ISPs should provide sufficient incentives to attract them.

Finally, IP number, promotion, and digital content services increase respondents' inclination to use that ISP. In particular, on-line chatting, legal music download, virtual library, on-line game, and interactive learning & on-line teaching are the most favored service contents. Therefore, to gain a competitive edge in the Internet service market, ISPs should move towards full integration of ISP and Internet content provider (ICP).

6.2 Elasticity Analysis

Elasticity analysis studies the impact of change in service price on the quantity of Internet service demanded. Self price elasticity $E_{X_{itk}}^{P_{it}}$ is the impact of change in the *k*th attribute of alternative *i* on alternative *i* individual *t* chooses. Cross price elasticity $E_{X_{jtk}}^{P_{it}}$ is the impact of change in the *k*th attribute of another alternative *j* on alternative *i* individual *t* chooses. The formulae are respectively:

$$E_{X_{itk}}^{P_{it}} = \frac{\partial \ln P_{it}}{\partial \ln X_{itk}} = \beta_k X_{itk}(1 - P_{it}) \quad (12)$$

$$E_{X_{jtk}}^{P_{it}} = \frac{\partial \ln P_{it}}{\partial \ln X_{jtk}} = -\beta_k X_{jtk} P_{it} \quad (13)$$

and their estimates are listed in Table 4 below.

The estimates of self price elasticities of four alternatives are between -0.479 and -1.097, among which, CM service has the highest price elasticity and dial-up service has the lowest. Findings suggest subscribers of CM are the most sensitive to variations in service price.

The impact of price change in dial-up service on the quantities of Hinet's ADSL, non-Hinet ADSL and CM demanded is low (0.025 ~ 0.037). Thus, this finding suggests that in broadband users' view, reduction in price cannot compensate for the drawback of low transmission speed. We consider next the impact of price change in Hinet's ADSL on the quantities of dial-up, non-Hinet ADSL and CM demanded (0.307 ~ 0.824). Users of dial-up, non-Hinet ADSL, and CM are sensitive to price variations in Hinet's ADSL. Hence, Hinet can attract users of other Internet accesses and ADSL ISPs by pricing strategies. Notably, the price sensitivity of non-Hinet ADSL users to Hinet's ADSL is 0.824, implying ADSL ISPs are highly substitutive. Hence, non-Hinet ADSL ISPs may differentiate their services from Hinet's ADSL by promoting service quality to reduce users' price sensitivity. As for the two ADSL alternatives, the cross elasticity (0.824) of Hinet's ADSL to non-Hinet ADSL is far larger than that of non-Hinet ADSL to Hinet's ADSL (0.337). This implies Hinet's ADSL users have higher loyalties, and non-Hinet ADSL users are more likely to switch to Hinet's ADSL through price reduction. This is, indeed, observed. Hinet ISP competes in

the service market with active price strategies, and other non-Hinet ADSL ISPs can only passively resist its competition by further price reductions.

Finally, the impact of price change in CM service on the quantities of dial-up, Hinet's ADSL, and non-Hinet ADSL demanded is low (0.035 ~ 0.113). Thus, a price change in CM does not have an influential effect on ADSL and dial-up users. In order to attract more users, CM ISPs should improve the quality of CM services by promoting downloading/uploading speed. For example, guarantee a minimum downloading/uploading speed. Further, many consumers view CM ISPs as Cable TV operators which provide Cable TV services only, and have little knowledge of CM. CM ISPs should therefore widely set up service centers to increase consumers' recognition of what CM ISPs provide and offer rather than focus on price reductions.

Similar to asymmetric regulations in the US, ADSL and CM services in Taiwan have different regulatory bodies. A new governmental institute, NCC, founded in mid 2005, is in charge of regulation relating to telecommunications and communication. However, there are still no clear guidelines regarding regulation of ADSL and CM. Since their estimated cross elasticities were between 0.307 ~ 0.687, ADSL and CM belong to the same service market, similar to the results (0.591) reported by Crandal et al. (2002). It seems appropriate that the NCC should adopt symmetric regulations on broadband services. However, the market share of CM is far too low (10.7% of total broadband services), compared to 68.5% in the US broadband service market. Symmetric regulations in the two markets will further limit the growth of the CM market. The recent recession in the US telecommunications market may not necessarily occur in Taiwan's telecommunications market. The NCC's future regulatory policy on whether to

adopt symmetric or asymmetric regulations on broadband services, deserves an in-depth study.[5]

6.3 Simulation of Price Reductions in ADSL

Hinet reduced its ADSL circuit and connection fees by 24% in June, 2003, claiming price reduction cost has contributed to a revenue loss of NTD 140 million per month. It should be borne in mind that price reduction in Hinet's ADSL has an impact on other ISPs. In this subsection, we use the elasticity derived from the above estimates to simulate seven different scenarios when Hinet reduces its ADSL tariff in order to analyze possible impact on the Internet service market.

Consider scenario 1 when Hinet reduces its ADSL tariff by 20% but non-Hinet ADSL ISPs' circuit and connection fees remain unchanged. The result shows Hinet's ADSL's market share increases by 12%, mainly due to attracting non-Hinet ADSL subscribers and CM subscribers. Hinet is the sole dominant ISP and the price leader in the market. A price reduction in Hinet's ADSL will force non-Hinet ADSL to reduce their tariffs as well in order to maintain their competitive edge. Hence, we turn to scenario 2 when Hinet reduces its ADSL tariff by 20% and non-Hinet ADSL ISPs reduce their tariffs by 20%. In this case, Hinet's ADSL's market share increases by 5.3% and non-Hinet ADSLs' increases by 4.34%. Thus, Hinet's ADSL still has an advantage over its rivals with equal price reductions. If the cost of CM subscribers switching to ADSL is overlooked, the CM ISPs' market share decreases by 19.88%.

[5] We thank Kai-Sheng Kao, deputy director of the Directorate General of Telecommunications in Taiwan for helpful discussions on this issue.

Consider the next case when non-Hinet ADSL reduce their tariffs more than Hinet. In scenario 3, Hinet's ADSL's tariff is reduced by 20% and non-Hinet ADSL ISPs reduce their tariffs by 25%. If the cost of CM subscribers switching to ADSL is overlooked, Hinet's ADSL's market share increases by 3.62% and that of non-Hinet ADSLs increases by 9.55 %.

However, mere price reduction may result in ISPs incurring losses. To study whether non-Hinet ADSL ISPs are able to resist Hinet's ADSL's price reduction by content provision together with an appropriate price reduction, we consider the following four scenarios. In scenario 4, Hinet's ADSL's tariff is reduced by 20% and non-Hinet ADSL ISPs reduce their tariff by 15% together with multimedia contents (A/V multimedia, video phone, and mobile multimedia) provision. In scenario 5, apart from price reductions, non-Hinet ADSL ISPs provide entertainment contents (on-line game and on-line chatting). In scenario 6, apart from price reductions, non-Hinet ADSL ISPs provide knowledge-related contents (interactive learning & on-line teaching, virtual library, and on-line health consultation). In scenario 7, apart from price reductions, non-Hinet ADSL ISPs provide future multimedia contents (MOD and legal music download). The results show that provision of entertainment contents and future multimedia contents by non-Hinet ADSL ISPs is effective in promoting their market share.

Overall, service price has a great impact on the Internet service market. Taking into account ISPs' costs, an appropriate price reduction is an effective strategy to attract new subscribers. But if the last miles (subscriber loops) are not open to competitors, non-Hinet ADSL ISPs are just the price followers of the dominant player, Hinet's ADSL. Hence, openness of subscriber loops is the first indispensable task for fair competition in Taiwan's Internet service market.

Finally, as discussed above, digital content provision can effectively maintain non-Hinet ADSLs' competence and increase their market share.

7. Conclusion

This paper has studied subscriber demand for Internet access and factors influencing ISP selection in Taiwan. By means of a questionnaire (a web survey and face-to-face interviews), we collected the revealed preference data of subscribers' choice behavior regarding Internet access and ISP, as well as their stated preference data under virtual scenarios of certain service attributes and contents. We first derived, by factor analysis, the latent influential variables of subscriber Internet access and ISP. We first constructed a three-layer nested logit model which served as our individual demand model for Internet access and ISP. Since the estimated inclusive value in NL model is not within the interval of 0 and 1, we used the MNL model to analyze subscribers' Internet access and ISP selection by combined estimation with RP and SP data. The empirical results are summarized below:

(1) Product: Wider bandwidth and better service quality (stability & security reliability, brand image, and content bundling) increase subscribers' demand for Internet access and ISP. Further, a household with Cable TV

and with better knowledge of CM has a higher demand for CM service.

(2) Price: Lower tariffs increase the Internet service demanded, and this in turn increases the ISP's market share as shown by the cross price elasticity estimates.

(3) Promotion: ISPs should offer preferred contracted tariffs to effectively attract new subscribers. Hence, tariff instead of gift provision is a crucial factor when subscribers choose Internet access and ISPs.

(4) Position: ISPs that provide a greater variety of digital services attract more subscribers. In particular, online chatting, legal music downloading, virtual library, online game, interactive learning and online teaching service are favored most. Therefore, ISPs should strive to integrate the role of ISP and Internet Content Provider (ICP).

Given the fact that the growth of broadband service in Taiwan has slowed down and the cross elasticity of broadband service to narrowband service is low, broadband ISPs should actively provide promotions and convenient switching processes (besides low tariffs) to attract latent narrowband users. CM ISPs should widely set up service centers and promote their service sales. Finally, the cross elasticity of ADSL to CM is high (0.307~0.687) which indicates they are in the same service market. However, ADSL service in Taiwan was developed earlier by Chunghwa Telecom than CM service and CM service transmission in the early stage was not reliable. In addition, there exist switching costs for users between CM and ADSL services. Thus, market share (10.7%) of CM service is relatively

small to that of ADSL service. Symmetric regulations may deter CM service market growth. Finally, the NCC's future regulatory policy on whether to adopt symmetric or asymmetric regulations on broadband services deserves an in-depth study.

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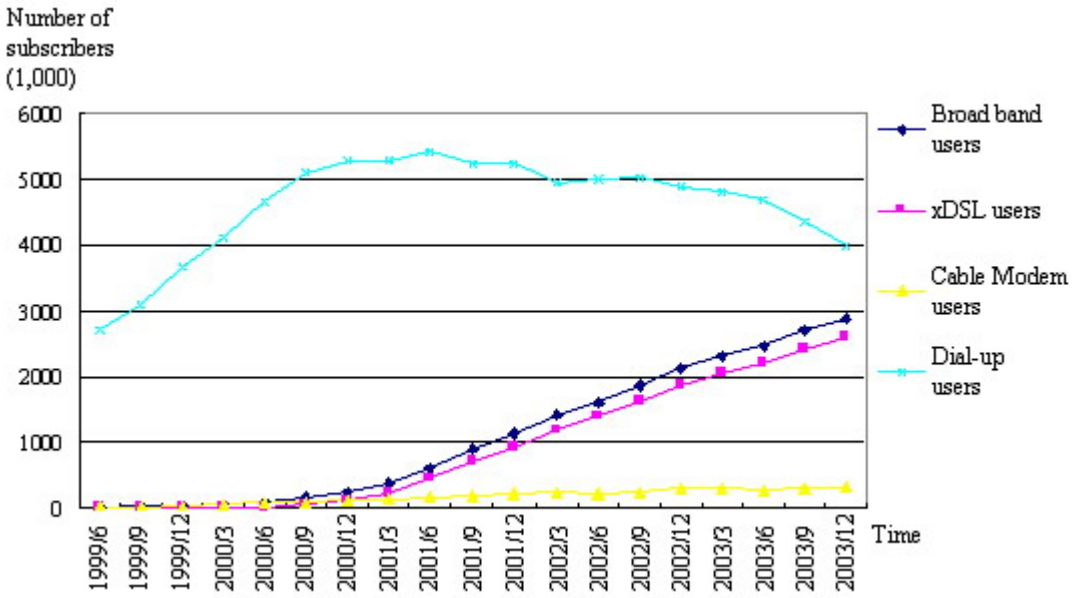

Figure 1 - *Internet Subscribers in Taiwan*

Source: ECRC-FIND webpage: http://www.find.org.tw

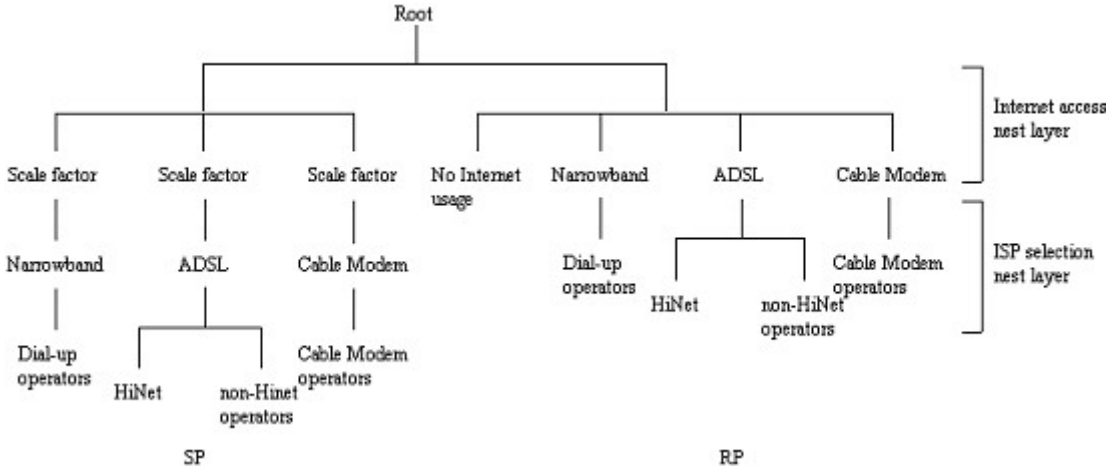

Figure 2 - *Research Framework*

Table 1 – *Review of Literature on Internet Usage, Internet Access, and ISP Selection*

Paper	Madden and Simpson (1996)	Savage and Simpson (1997)	Madden and Simpson (1997)	Teo et al. (1997)	Teo and Tan (1998)
Research objects	Households in State capital and Canberra in Australia	Households in metropolitan areas of New South Wales, Victoria, Western Australia	Households in State capital and Canberra, New South Wales, Victoria, Western Australia	Singapore's residents	500 companies in Singapore
Data acquisition	Interview	Interview	Interview	Internet questionnaire	Mail
Research method	Individual demand model	Individual demand model	Individual demand model	Descriptive statistics	Descriptive statistics
Model	Binary probit model	Binary logit model	Binary logit model	–	–
Social economic variables	Dummy for race/sex, age, income, employment status, no. of persons in household, no. of children in household, mortgage, dummy for computer use in workplace, job	Income, no. of persons in household, no. of children in household, age, employment status, education & technology ability, race	Monthly household income, dummy for retailers, age, no. of persons in household, race, dummy for retirement, dummy for female with part time job, dummy for rented house, dummy for part time job, dummy for computer use at workplace/school with computer at home, multimedia equipment	–	–
Internet attribute variables	–	Installation fee, connection fee	Installation fee, connection fee	Time to connect to ISP, webpage's design	Convenience for information surfing, time surfing the Internet
Conclusion	Social economic attributes have a high impact on Internet usage.	Social economic attributes and service price have a high impact on Internet usage of educational and information contents. Acceptance of new services is affected by installation fee and connection fee.	Household's income and installation fee are the main influential factors of Internet usage. Income elasticity and price elasticity changes with income. Recipients are more price sensitive with regard to installation fee than connection fee.	Time to connect to ISP and webpage's design are the main influential factors of Internet usage.	Convenience for information surfing (time surfing the Internet) is the main influential factor of (no) Internet usage.

Table 1 - *Review of Literature on Internet Usage, Internet Access, and ISP Selection (continued)*

Paper	Busselle et al. (1999)	Gloy and Akridge (2000)	Eisner and Waldon (2001)	Sultan (2002)	Madden and Coble-Neal (2003)
Research objects	Students and faculties in Univ. of Washington	US farmers	Subscribers of 7 LECs in the UK	US households	West Australian farmers and remote areas
Data acquisition	Phone interview	Mail	PNR & Associates' (PNR) Bill Harvesting II data bank	Mail	Phone interview
Research method	Regression	Logistic regression	Individual demand model	Ante and post analysis	Individual demand model, regression
Model	Regression	Logistic regression	Binary probit model	—	Binary logit model, regression
Social economic variables	Sex, age, acceptance degree of new technology	Age, education, farmer's total revenue, time needed for planning in industry, dummy for whether workers hired and recipients participated in labor	No. of persons in household, dummy for householder less than 35 years old, dummy for householder over 54 years old, dummy for married householder, dummy for divorced householder, dummy for white householder, no. of children between 6-12 years old in household, no. of children between 13-17 years old, dummy for professional, dummy for salesman, dummy for college educated, household income, dummy for household in MSA	Acceptance degree of innovative invention, household income, knowledge of new technology, time, no. of persons in household	Distance between home and nearest city, no. of persons with full time job in household, income, no. of persons in household, dummy for company owner, dummy for college educated, dummy for professional
Internet attribute variables	—	—	Availability of internet services, distance between home and ISP	—	Monthly budget for communication, dummy for fax machine, no. of phone lines installed, no. of personal computers, average hourly expense for Internet
Conclusion	Age, sex, and acceptance degree of new tech. affect consumers' use of internet service.	Age, education, time needed for planning in industry, and dummy for whether workers hired and recipients participated in labor, affect the possibility of consumers accepting the Internet.	2nd phone line decision closely relates to Internet usage, implying an increase in demand for broadband service.	Social economic attributes affect household's intention towards Internet usage in the early stage and household's willingness to pay for Internet service. The latter decreases with time.	Internet usage is greatly affected by the need in education and job. Reduction in connection fee increases the time for Internet usage.

Table 1 - *Review of Literature on Internet Usage, Internet Access, and ISP Selection (continued)*

Paper	Jackson et al. (2002)*	Crandal et al. (2002)*	Rappoport et al. (2002)*	Teo and Tan (1998)**	Madden et al. (1999)**
Research objects	US households	US households	US households	500 companies in Singapore	Australian ISP subscribers
Data acquisition	Mail	Marketing Science Corporation	TNS telecoms	Mail	Internet questionnaire
Research method	Individual demand model	Individual demand model	Individual demand model	Descriptive statistics	Individual demand model
Model	Binary probit model	NL model	Binary Logit, MNL, NL models	—	Binary logit model
Social economic variables	Education, income	Sex, age, education, income	Income, no. of persons in household, education, age	—	Household income, age, sex, no. of persons in household
Internet attribute variables	Monthly cost for Internet, saving/retrieving speed, reliability	Service price (DSL, CM)	Service price, household's Internet type, penetration rate of ADSL & CM, bandwidth, speed	Saving/retrieving speed, technology support, ISP's reputation, service bundling, service price	Tariff plans for connection, main functions of Internet service, time since first contact with Internet, no. of ISPs used, purpose of internet use, reason for choosing the ISP
Conclusion	Monthly cost for Internet, saving/retrieving speed, and reliability etc. affect the selection of Internet access.	Recipients with an income less than 35,000, non-college educated, and older have little interest in broadband service. Self-price elasticity of DSL is -1.184. Cross price elasticity of DSL to CM is 0.591, implying they are in the same service market and hence should be symmetrically regulated.	Social economic attributes have significant impact on Internet usage and Internet access. Price elasticity (-1.491) of broadband is higher than that of dial up. Price elasticity (-1.462) of ADSL is higher than that of CM. Cross price elasticity of ADSL to CM is 0.618.	Saving/retrieving speed, technology support, ISP's reputation, service bundling, and service price have significant impact on ISP selection.	Social economic attributes and Internet attributes influence households' loyalty probability to their ISP. Higher reliability in Internet service decreases the probability that households switch ISPs.

Note: Literature on Internet access and ISP selection are indicated by * and **, respectively. The rest papers are literature on Internet usage.

Table 2 - *Selection Distribution between SP and RP*

SP selection / RP selection	Dial-up	Hinet's ADSL	non-Hinet ADSLs	CM	Total
Dial-up	92 (28.75%)	83 (25.94%)	46 (14.38%)	99 (30.94%)	320
Hinet's ADSL	54 (3.06%)	818 (46.32%)	392 (22.20%)	502 (28.43%)	1766
non-Hinet ADSLs	14 (1.89%)	169 (22.87%)	255 (34.51%)	301 (40.73%)	739
CM	6 (2.48%)	33 (13.64%)	30 (12.40%)	173 (71.49%)	242
No Internet usage	75 (17.20%)	142 (32.57%)	100 (22.94%)	119 (27.29%)	436
Total	241	1245	823	1194	3503

Table 3 - *Parameter Estimates in MNL with combined RP and SP data*

Independent variables	Parameter estimates
Dummy variable for Hinet's ADSL (RP)	0.061 (0.1)
Dummy variable for non-Hinet ADSLs (RP)	-0.758* (-1.7)
Dummy variable for CM (RP)	-5.659** (-6.2)
Dummy variable for Hinet's ADSL (SP)	4.308** (7.1)
Dummy variable for non-Hinet ADSLs (SP)	3.303** (6.4)
Dummy variable for CM (SP)	2.907** (5.8)
Inertia Indicator for Dial-up (SP)	4.021** (5.7)
Inertia Indicator for Hinet's ADSL (SP)	2.154** (6.0)
Inertia Indicator for non-Hinet ADSLs (SP)	1.126** (3.5)
Inertia Indicator for CM (SP)	4.181** (5.9)
Time to use Internet service at household (RP) (1)	0.075 (1.2)
Download speed (SP、RP)	0.039** (7.0)
Upload speed (SP、RP)	0.182** (3.6)
Service price (SP、RP)	-3.014** (-8.7)
Number of frequent Internet users (RP) (2，3，4)	0.477** (3.1)
Stability and security reliability (RP)	0.246** (4.0)
Brand image and service ability (RP)	0.127** (2.3)
Dummy variable for operator's service bundling*acceptance degree of hi-tech service (RP)	0.118* (1.9)
Dummy variable for Cable TV in household (RP) (4)	1.531** (2.4)
Knowledge of CM (RP) (4)	2.236** (4.2)
IP number (SP)	0.079* (1.7)
Promotion (SP)	1.500** (2.0)
Multimedia (SP)	0.231** (2.1)
Video phone (SP)	0.275 (1.5)
Mobile multimedia (SP)	0.246* (1.9)
Dummy variable for on-line game*student (SP)	0.453** (2.9)
On-line chatting (SP)	0.364** (3.7)
Interactive learning and on-line teaching (SP)	0.450** (2.1)
Virtual library (SP)	0.393** (3.0)
On-line health consultation (SP)	0.224* (1.6)
MOD (SP)	0.278* (1.7)
Legal music downloading (SP)	0.610** (3.5)
Scale factor	0.333** (7.8)
Log Likelihood(0)	-6195.3631
Log Likelihood(β)	-4910.5278
ρ^2	0.2074
Number of cases	4476

Note: 1. Numbers in parenthesis are t-values. A variable significant at the 5% (10%) significance level is indicated by ** (*) if its t-value is no less than 1.96 (1.6).

2. Alternatives 1, 2, 3, and 4 are dial-up, Hinet's ADSL, non-Hinet ADSLs, and CM, respectively.

Table 4 - *Self Price Elasticity and Cross Price Elasticity of Alternatives*

	Dial-up	Hinet's ADSL	non-Hinet ADSLs	CM
Dial-up	-0.479	0.307	0.127	0.025
Hinet's ADSL	0.035	-0.602	0.337	0.070
non-Hinet ADSLs	0.037	0.824	-1.041	0.113
CM	0.036	0.687	0.307	-1.097

Table 5 - *Sensitivity Analysis in Content Provision and Price Reduction in ADSL*

		Dial-up	Hinet's ADSL	non-Hinet ADSLs	CM
Scenario 1	20% price down in Hinet's ADSL, unchanged in non-Hinet ADSLs	-6.14%	+12.04%	-16.48%	-13.74%
Scenario 2	20% price down in Hinet's ADSL, 20% price down in non-Hinet ADSLs	-8.68%	+5.30%	+4.34%	-19.88%
Scenario 3	20% price down in Hinet's ADSL, 25% price down in non-Hinet ADSLs	-9.32%	+3.62%	+9.55%	-21.42%
Scenario 4	20% price down in Hinet's ADSL, 15% price down in non-Hinet ADSLs plus multimedia content provision	-8.35%	+5.28%	+3.24%	-20.15%
Scenario 5	20% price down in Hinet's ADSL, 15% price down in non-Hinet ADSLs plus entertainment content provision	-8.55%	+4.28%	+5.14%	-21.05%
Scenario 6	20% price down in Hinet's ADSL, 15% price down in non-Hinet ADSLs plus knowledge-related content provision	-8.35%	+4.78%	+3.84%	-20.45%
Scenario 7	20% price down in Hinet's ADSL, 15% price down in non-Hinet ADSLs plus future multimedia content provision	-8.55%	+4.28%	+5.14%	-20.95%