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# Coverage Area Expansion, Customer Switching, and Household Profiles in the Japanese Broadband Access Market[*]

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**Abstract**

This paper examines diffusion process of internet broadband access in Japan by modeling the household choice behavior of broadband access modes, the choice set of which includes dial-up, integrated services digital networks (ISDN), cable television systems (CATV), asymmetric digital subscriber lines (ADSL), and optic fibers (fiber-to-the-home; FTTH). Estimates from random utility model of access demand reveal that characteristics of users, rather than those of access modes, play a significant role in demand substitution across the modes. Simulation exercises indicate that even if FTTH had been made available to the whole country in the year of 2005, merely about 11 percent of households would have switched to the mode. This result implies that inertia to existing access modes is considerably persistent and indirect network effects play an important role in the adoption of the new technology. Policy implications are also proposed.

JEL Classification: L10, L50, L96

Keywords: broadband access; coverage area; household profile; fiber-to-the-home (FTTH); simulation analysis

## 1. Introduction

The rapid expansion of broadband Internet access has been a spectacular phenomenon of the early twenty-first century. The present paper examines diffusion process of internet broadband access in Japan by modeling the household choice behavior of broadband access modes, the choice set of which includes dial-up, integrated services digital network (ISDN), cable television systems (CATV), asympetirc digital subscriber lines (ADSL), and optic fibers (fiber-to-the-home; FTTH). Furthermore, we simulate switches between access modes if FTTH becomes available to households that are currently not covered.

Although the dominant mode of access varies from one country to another, fiber-optic access is a promising mode that permits transmission over longer distances at higher data rates than other forms of wired and wireless communications do. According to OECD (2006), Korea and Japan are prominent among the OECD countries with regard to the penetration rate of optic fibers.

Most previous studies are based on a relatively strong assumption about the substitution patterns among various access modes[1]. In a recent study, Pereira and Ribeiro (2006) employed a more sophisticated demand framework using a random-coefficient logit model. According to Gaynor and Vogt (2003), however, a conventional fixed-coefficient linear random-utility model with rich microdata can be an effective substitute for a random-coefficient logit model to relax the independence from irrelevant alternatives (IIA) restriction on the substitution patterns. Therefore, the present study, with detailed information about household profile and coverage areas of municipalities, adopts a fixed-coefficient linear random-utility model promulgated by Gaynor and Vogt (2003).

Estimates from random utility model of access demand reveal that characteristics of users, rather than those of access modes, play a significant role in demand substitution across the modes. Simulation exercises indicate that even if FTTH had been made available to the whole country in the year of 2005, merely about 11 percent of households would have switched to the mode. This result implies that inertia to existing access modes is considerably persistent and indirect network effects play an important role in the adoption of the new technology. Hence, government policy should focus not only on the expansion of the FTTH coverage area, but also on the enhancement of quality and variety of software associated with FTTH.

The remainder of the paper is organized as follows. The subsequent section briefly reviews the Japanese broadband access market and describes the coverage areas for various access modes among 2,362 municipalities as of 2005. Section 3 describes the data, and Section 4 explains the empirical specifications, variable definitions, and estimation results. Section 5

[1] There is a growing literature on broadband access demand. See, for example, Crandall et al. (2002), Rappoport et al. (2003), Tanaka et al. (2004), Cerno and Amaral (2005), and Ida and Kuroda (2006).

conducts the simulations regarding the expansion of the FTTH coverage. Finally, Section 6 concludes the paper.

## 2. Broadband Access Services in Japan

### *2.1. Rapid Growth of Broadband Subscribers in Japan*

Figure 1 depicts the Japanese broadband access subscribers from June 2001 to March 2006. The number of FTTH subscribers has rapidly increased since the early 2000s (the average quarterly growth rate was 47%). In March 2006, FTTH subscribers accounted for 23% of the total broadband users. Although the dominant access mode is still ADSL, the growth rate of the ADSL subscribers gradually slowed down in the 2000s. The growth rate of the number of CATV Internet subscribers was considerably slow, and it accounted for 14% of the total as of March 2006.

= Figure 1 =

### *2.2. NCCs Dominate the Japanese ADSL Market*

Figure 2 depicts the market shares of the main carriers regarding ADSL and FTTH as of September 2005. The following points are worth noting. First, contrary to most other advanced countries, new common carriers (NCCs) dominate the ADSL market in Japan. The total share of NCCs was around 60% in September 2005. On the other hand, NTT East and NTT West account for the majority in the FTTH market, and the combined market share of the two NTT subsidiaries is 59%.

Second, FTTH consists of the following two types of access according to housing type: complex housing and detached housing. The salient feature of the complex housing service is the common sharing of an optic fiber among several households, which enables a much lower rate level per user. NTT East and NTT West accounted for 41% of the total subscribers of the complex housing service. Further, note that the corresponding market share of the detached housing was 73%.

= Figure 2 =

### *2.3. Coverage Areas of Various Broadband Access Modes in Japan*

Broadband access services, FTTH in particular, are not available for every household. Figure 3 depicts those municipalities (in black) where NTT's fiber-optic service ("B FLETS") was

available as of June 2005[2]. Table 1 presents the population coverage rate of broadband access in the nine representative regions (i.e., Hokkaido, Tohoku, Kanto, Tokai, Hokuriku, Kansai, Chugoku, Shikoku, and Kyushu). The population coverage of ADSL is more than 80% in almost all regions, whereas the coverage rate of FTTH varies according to the regions.

= Figure 3 & Table 1 =

*2.4. Probit Analysis on the Coverage Areas of FTTH*

In order to check whether there is some correlation between household characteristics and FTTH coverage areas, we employ simple probit regressions using the FTTH coverage data. This information will facilitate our demand specifications in the later sections. The unit of observation is a municipality. A dependent variable is a dummy variable that takes the value of unity if FTTH is available in that municipality as of June 2005, and zero otherwise. The explanatory variables are as follows: (i) ratio of people aged over 65 to the total population, (ii) average number of students per household, (iii) average family size per household, (iv) ratio of single-person households to the total number of households, (v) female ratio to the total population, (vi) home ownership rate, and (vii) household density.

Table 2 presents the estimation results. All the explanatory variables, with the exception of family size and home ownership rate, are statistically significant. The only significant variable with a negative sign is the ratio of people aged over 65. On the other hand, significant variables with positive signs include the ratio of single-person households, the ratio of women, and household density. Contrary to our expectation, the sign of the female ratio is positive and significant.

= Table 2 =

## 3. Brief Description of the InfoCom Survey

*3.1. Choice-based Sampling*

This paper utilizes a web-based questionnaire survey conducted by InfoCom Research, Inc., (a market research and consulting firm focusing on telecommunications industries) in June 2005 (hereafter, the InfoCom Survey). The InfoCom Survey was conducted by using a choice-based sampling. Benchmarking clusters were residential areas (zip codes), access modes, and Internet telephones. The number of effective responses was 4,917. Since this survey was not strictly

[2] In Japan, there were about 2,400 municipalities as of July 1, 2005. For details on the construction procedure of the service coverage data, see Appendix B.

based on a random sampling procedure, it is important to be sufficiently careful about whether our dataset is a representative sample of the general population. For this purpose, we compared our basic data with other relevant government statistics with regard to (i) household size and composition, (ii) population by prefecture, (iii) housing condition, and (iv) access mode. Although the differences between the InfoCom Survey and the relevant government statistics are minimal, we needed to be sufficiently careful about the demand specification as well as the selection of explanatory variables[3].

*3.2. Household Profiles and Internet Usage*

It is extremely likely that the choice of access mode is closely associated with the household profile as well as the Internet usage pattern (Rappoport, et al. 2003). Indeed, preference for Internet access varies among households. Table 3 presents some selected facts according to the InfoCom Survey. We rearranged the fifteen alternatives of the survey into the following eight access modes: (i) FTTH for detached housing, (ii) FTTH for complex housing, (iii) High-speed ADSL (at no less than 24 Mbps), (iv) Medium-speed ADSL (at no more than 24 Mbps and no less than 8 Mbps), (v) Low-speed ADSL (at no more than 8 Mbps), (vi) CATV, (vii) ISDN, and (viii) Dial‐up. We omitted 1,671 observations due to an inconsistency in the responses and due to incomplete responses on income, family size, etc. As a result, the total number of households used in this study was 3,246.

= Table 3 =

The first panel of Table 3 presents the household profile according to the choice of access modes. Roughly speaking, there are no particular differences based on access modes. It should be noted, however, that the ratio of single female households among the FTTH subscribers is much lower than that of other access modes. For example, the ratio of single female households to the total number of households who subscribe to FTTH for detached housing is 4.5%. In addition, the ratio of households living in a rented housing among the ADSL subscribers is much higher than that of other access modes. The ratio of house-renters to the

[3] The following points are worth noting. First, there is a marginal difference in the population distribution by prefecture between the Basic Resident Register (a residential census) and the InfoCom Survey. Hokkaido and Tokyo are slightly over-sampled by the order of 1.3% points (Hokkaido) and 1.4% points (Tokyo), but the differences in the other prefectures are less than 1% point. Second, home ownership rate in the InfoCom Survey is 1.9% points higher than that of the Housing and Land Survey. Third, the rate of rental complex housing in the InfoCom Survey is 3.9% points lower than the Housing and Land Survey. Fourth, the single female ratio is 5.7% and average household size is 3.1 in the InfoCom Survey, whereas in the Population Census, it is 12.8% and 2.7, respectively. Finally, the ratio of subscribers in the InfoCom Survey is 1.5% points smaller in ADSL, 4.7% points higher in FTTH, and 4.2% points higher in CATV than it is in the Information & Communications Statistics.

total number of households who subscribe to high-speed ADSL is 20.4%.

The second panel of Table 3 presents the usage intensity and history and the ratio of subscribers utilizing various service contents such as shopping, auctions, music, games, and movies. Internet subscribers to FTTH, high-speed ADSL, and CATV are obviously intensive Internet users. Users subscribing to FTTH and high and medium-speed ADSL services tend to enjoy games and movies via the Internet. For example, FTTH subscribers for detached housing use the Internet for 22.8 hours per week on average.

## 4. Estimation of Broadband Access Demand in Japan

### *4.1. Demand Specification*

Household $i$'s indirect utility $v_{ij}$ that is obtained from subscribing to access mode $j$ is specified as follows:

$$
\begin{aligned}
v_{ij} &= V(p_{ij}, x_{ij}, D_i^p, D_i^x, R_{ij}, Z_i \mid \theta) + \varepsilon_{ij} = a_{ij} p_{ij} + b_{ij} x_{ij} + R_{ij}\mu + Z_{ij}\gamma + \varepsilon_{ij} \\
a_{ij} &= \alpha + D_i^p \delta + R_{ij}\nu \qquad (1) \\
b_{ij} &= \beta + D_i^x \eta + R_{ij}\omega
\end{aligned}
$$

where $p$ and $x$ denote the price and download traffic speed, respectively. Coefficient $a$ is the marginal utility of income, and $b$ is the marginal utility of traffic speed. We assume that both these parameters depend on the row vectors of sociodemographic variables $D^p$ and $D^x$. In addition, the marginal utilities of income and traffic speed also vary with row vector $R$ that constitutes the interaction terms between the household's usage pattern and an access mode type. $Z$ is a row vector of the other control variables. The vector of parameters $\theta = (\alpha, \beta, \gamma', \delta', \eta', \mu', \upsilon', \omega')$ determines the consumer's preference. Finally, $\varepsilon$ is assumed to conform to type I extreme value distribution.

Given this specification, the probability of household $i$ choosing access mode $j$ is expressed as follows:

$$
L_{ij}(\theta) = \frac{A(i,j)\exp[V(p_{ij}, x_{ij}, D_i^p, D_i^x, R_{ij}, Z_i \mid \theta)]}{\sum_k A(i,k)\exp[V(p_{ij}, x_{ij}, D_i^p, D_i^x, R_{ij}, Z_i \mid \theta)]} \qquad (2)
$$

where

$$
A(i,j) = \begin{cases} 1 & \text{if access mode } j \text{ is available for household } i \\ 0 & \text{otherwise} \end{cases} \qquad (3)
$$

is an index function indicating that access mode $j$ is available for household $i$. Using this index function, we can explicitly incorporate the coverage area of each access mode into the model[4].

Based on the above specification, it is straightforward to estimate the preference parameters that maximize the following log-likelihood function:

$$LL(\theta) = \sum_i \sum_k I(i,k) \ln L_{ik}(\theta) \tag{4}$$

where

$$I(i,j) = \begin{cases} 1 & \text{if } i \text{ choose } j, \\ 0 & \text{otherwise.} \end{cases} \tag{5}$$

Using the estimated parameters, the average choice probability of access mode $j$ is defined as follows:

$$\overline{P}_j(\theta) = \frac{1}{N} \sum_i L_{ij}(\hat{\theta}) \tag{6}$$

where $\hat{\theta}$ represents a maximum likelihood estimator. Accordingly, the elasticity of demand for access mode $k$ with respect to the price of access mode $j$ is

$$\overline{E}_{jk}^{p} = \frac{\partial \overline{P}_k(\hat{\theta})}{\partial p_j} \frac{p_j}{\overline{P}_k(\hat{\theta})} \cong \begin{cases} \dfrac{1}{N} \sum_i a_i [1 - L_{ij}(\hat{\theta})] \dfrac{L_{ij}(\hat{\theta})}{\overline{P}_j(\hat{\theta})} p_{ij} & \text{if } j = k \\ -\dfrac{1}{N} \sum_i a_i L_{ij}(\hat{\theta}) \dfrac{L_{ik}(\hat{\theta})}{\overline{P}_k(\hat{\theta})} p_{ij} & \text{otherwise} \end{cases} \tag{7}$$

where $N$ is the number of households.

Although our demand specification is based on a simple conditional logit model, the consumer characteristics and interaction terms between the household's usage pattern and an access mode type may produce various substitution patterns that are not subject to the IIA property.

In a similar manner, we define the traffic-speed semi-elasticity that denotes the percentage change in the market share of access mode $k$ with respect to 1 Mbps change in the download traffic speed of access mode $j$, that is,

[4] For details on the construction of index $A(i,j)$, see Appendix B.

$$(8)\qquad \overline{E}^{x}_{jk} = \frac{\partial \overline{P}_k(\hat{\theta})}{\partial x_j}\frac{1}{\overline{P}_k(\hat{\theta})} \cong \begin{cases} \dfrac{1}{N}\sum_i b_i[1-L_{ij}(\hat{\theta})]\dfrac{L_{ij}(\hat{\theta})}{\overline{P}_j(\hat{\theta})} & \text{if } j=k, \\ -\dfrac{1}{N}\sum_i b_i L_{ij}(\hat{\theta})\dfrac{L_{ik}(\hat{\theta})}{\overline{P}_k(\hat{\theta})} & \text{otherwise.} \end{cases}$$

*4.2. Variable Construction*

4.2.1. Choice Set and Coverage Area

We set the following seven alternatives for Internet access modes: either (i) FTTH for detached housing or (i') FTTH for complex housing, (ii) high-speed ADSL, (iii) medium-speed ADSL, (iv) low-speed ADSL, (v) CATV, (vi) ISDN, and (vii) dial-up. It should be noted that since we regard the housing types as previously mentioned, we do not allow the two alternatives (i) and (i') at the same time[5].

We explicitly utilize the information pertaining to the availability of each broadband access mode in the computation of choice probabilities. Our availability information is based on the coverage areas of NTT East and NTT West, with the exception of CATV[6]. Table 4 presents the availability of the eight alternatives by region and city size as of June 2005. About 15% of the households could not subscribe to FTTH services. In particular, in towns and villages, almost 50% of the households live in the areas where FTTH services are unavailable.

= Table 4 =

4.2.2. Price and Download Traffic Speed

Price is defined by the basic monthly charge including an additional fee for the Internet service provider (ISP). Price data is corresponded with a household based on its selected carrier and ISP[7]. With regard to FTTH, ADSL, and CATV services, we obtained the data on price and nominal download traffic speed from InfoCom Research, Inc. The price and speed of ISDN and dial-up services are those of NTT East or NTT West[8]. Table 3 provides the average price and speed for each access mode.

[5] There are several households subscribing to either detached housing type or complex housing type services that do not actually correspond with the real housing type. We have omitted these observations from our basic dataset.

[6] Note that NTT East and NTT West are the dominant common carriers in Japan. Appendix B provides detailed information about their coverage areas.

[7] Tanaka, et al. (2004) and Ida and Kuroda (2006) defined monthly expenditure on a service as a fixed charge. In our original data, such information is unavailable.

[8] We assigned 0.064 Mbps (or 0.056 Mbps) to the download speed of ISDN (or dial-up), respectively.

One of the common difficulties faced when using a discrete choice model pertains to the assigning of prices and speeds of other alternatives that are not actually chosen. We assume that each household makes a comparison between a certain access mode and the other alternatives based on regional-averaged price and speed, depending on the location of the household.

4.2.3. Other Control Variables

We include the following sociodemographic variables as control variables: (i) dummy for single female households, (ii) household size, (iii) dummy for a household with a student, (iv) dummy for rented housing, and (v) the municipal population density of each residential area[9]. These demographic characteristics may have some effect on the mean marginal utility of income as well as the mean marginal utility of traffic speed[10].

Further, we include an NTT-user dummy that takes the value of unity if a household selects NTT's Internet access service from among FTTH, ADSL, and ISDN. In addition, we add the cross term between a CATV-user dummy and prefecture dummies for Toyama, Fukui, and Mie, because these three prefectures have a prominently high penetration rate of the CATV service. Table 5 provides the descriptive statistics of these regression variables.

= Table 5 =

4.2.4. Interaction Effect Variables

According to Table 3, subscribers to high speed Internet access modes, particularly FTTH, tend to use the Internet intensely, and the Internet history of users varies across the different access modes. Hence, these two variables represent the households' preferences with regard to Internet access speeds.

Row vector $R$ in Equation (1) represents the interaction effect between the household's usage pattern and an access mode type that produces various substitution patterns that are not subject to the IIA property. We define the two arguments of row vector $R$ by using the intensity and history of Internet usage as follows. First, we calculate the average usage hours per week and the average usage history in months for each access mode $j$. Then, we compute the difference between the reported values by each household $i$ as well as the averaged value among households, that is,

[9] We define a household with a student as a household wherein at least one member of the household is in junior high school, high school, college, or university, or is a graduate student.**[**

[10] We have omitted the income variable because the coefficient of the cross term between price and income was not significant in our experimental regressions with various specifications.

$$\Delta USAGE_{ij} = \frac{USAGE_i - \overline{USAGE}_j}{100}$$

(9)

$$\Delta HISTORY_{ij} = \frac{HISTORY_i - \overline{HISTORY}_j}{100}$$

where $\overline{USAGE}_j$ is the average value of usage intensity (hours per week) and $\overline{HISTORY}_j$ denotes the average usage history (months) of each access mode *j*.

These variables may be related to the difference in the preferences for the Internet between a household and the average subscriber with regard to each access mode. Table 6 presents the mean values of these variables. While the diagonal elements are considerably small because of the variable definitions, the off-diagonal elements depict complicated patterns. The off-diagonals are the sources of the various substitution patterns that are not subject to the IIA property.

= Table 6 =

*4.3. Estimation Results*

4.3.1. Demand Estimation

Table 7 presents the estimation results of the Internet access demand. The variables that are included in the first model are price, traffic speed, an NTT-user dummy, and interaction terms between a CATV-user dummy and the three prefecture dummies of Toyama, Fukui, and Mie, where CATV penetration rates are distinctively high. The estimated coefficients of price and speed have expected signs: the price coefficient is negative and the speed coefficient is positive. Further, both coefficients are statistically significant at the 1% level. In other words, the marginal utility of both income and traffic speed is positive.

Subsequently, in Model 2, we include the cross terms between price and the several demographic variables, i.e., a dummy for single female households, household size, dummy for a household with a student, dummy for rented housing, and the municipal population density of each residential area. Similarly, we also add the cross terms between speed and these demographic variables.

The estimation result in Model 2 suggests that the marginal utility of income is significantly affected by the following three demographic variables: the single female household dummy, household size, and the dummy for households with students. On the other hand, the marginal utility of traffic speed depends on household size and the municipal population density.

Further, we include the interaction effect variables (i.e., usage intensity and usage

history) in Model 3. As shown in Equation (1), we insert the two variables independently and the cross terms between the variables and both price and speed concurrently. The estimation result in Model 3 reveals that the coefficients of the usage intensity variable and these cross terms are statistically significant. A higher intensity of Internet usage would result in a lower marginal utility of income and a higher marginal utility of speed. We use the estimates of the third model in the following analyses.

= Table 7 =

4.3.2. Elasticities

Table 8 presents the estimates of the price elasticity and traffic speed semi-elasticity matrices that are calculated by using Equations (7) and (8). Cell entries ($i$, $j$), where $i$ indexes the rows and $j$ indexes the columns in the price elasticity matrix in the upper panel of Table 8, provide the percent change in the share of access mode $j$ with respect to a one percent change in price. Similarly, the traffic speed semi-elasticity in the lower panel of Table 8 denotes the percent change in the share of access mode $j$ with respect to a 1 Mbps change in traffic speed of $i$. Note that the corresponding cell entries (1, 2) and (2, 1) in Table 8 are always zero since we do not allow substitution between FTTH for detached housing and complex housing.

Concerning price elasticities, all estimates of the own-price elasticity are greater than unity, for example, –3.48 of FTTH for detached housing, –2.88 of FTTH for complex housing, –3.16 of high-speed ADSL services, and –2.68 of CATV[11].

Cross-price elasticities of FTTH with respect to the other access modes are smaller than those of the other access modes. For example, the first row of the upper panel of Table 8 shows that the cross-price elasticity of high-speed ADSL with respect to FTTH is 0.339, whereas the third row of the panel shows that cross-price elasticity of FTTH with respect to high-speed ADSL is 0.235. This implies that the cross-price elasticities between FTTH and ADSL are asymmetric. On the other hand, the estimates of traffic speed semi-elasticities are considerably small. In other words, in comparison with the cross-price effect, traffic speed does not significantly affect the demand substitution between access modes.

= Table 8 =

## 5. Simulations of the FTTH Coverage Area Expansion

[11] While Ida and Kuroda (2006) obtained considerably similar estimates of own-price elasticity for FTTH and CATV, our estimates for ADSL (from –2.83 to –3.16) are much larger than the estimate of Ida and Kuroda (2006) (–0.85). A possible reason for this difference could be our disaggregated definitions of high-speed, medium-speed, and low-speed ADSL services.

*5.1. Simulations for Covered and Noncovered Households*

We simulate the effect of the coverage area expansion on consumers' switching to FTTH by using the estimated demand system. The coverage area expansion does not automatically result in the increase of FTTH subscribers, because the consumers' heterogeneity affects the extent of switching between access modes.

We conduct simulations for households in municipalities where FTTH is either available or unavailable. As of June 2005, among the 3,246 households of the present dataset, 2,699 households were in an FTTH coverage area, whereas 547 households were not. Specifically, we first simulate the switches between access modes if FTTH becomes available to the noncovered households. We extrapolate the regional average price for each region (Hokkaido, Tohoku, Kanto, Tokai, Hokuriku, Kansai, Chugoku, Shikoku, or Kyushu) into the hypothetical price for the noncovered households. In addition, we assume that the traffic speed of FTTH is 100 Mbps.[12]

Table 9 presents the simulation results for the noncovered households. Column (1) is the number of households for every access mode in our dataset, and column (2) denotes the corresponding share. Column (3) presents the estimated share distribution based on the demand system (status quo), and column (4) shows the simulated share distribution if FTTH becomes available to the noncovered households.

A comparison between columns (2) and (3) suggests that there are some discrepancies between the actual and estimated choice probabilities. For example, the share of high-speed ADSL is overestimated and that of CATV is underestimated. Therefore, we use the estimated choice probabilities in column (3) as a benchmark for comparison with the simulated results in column (4).

According to column (4), the coverage area expansion causes only 10.76% of the noncovered households to switch to FTTH. The new FTTH subscribers are primarily previous ADSL and ISDN subscribers; the ADSL share falls from 54.82% to 49.77% and the ISDN share, from 30.48% to 26.45%. Thus, more than three quarters of the households remain narrow-band users.

The estimated share of FTTH for the covered households is 15.23%, whereas the corresponding simulated share of the noncovered households is 10.76%. Hence, the simulated switching probability of the noncovered households is much smaller than that of the covered households.

Moreover, the switch from narrow-band access modes to FTTH for complex housing

[12] Subsequently, we simulate switches between access modes if FTTH becomes unavailable to households that are currently covered. We need this simulation to examine whether the consumer surplus changes differently across the covered and noncovered households; this will be discussed in detail in Section 5.3.

for noncovered households is 2.48%, which is much smaller than the figure (8.22%) for covered households. One of the possible reasons for the low rate of switching among the noncovered households could be that complex housing is not prevalent in the noncovered municipalities in Japan.

= Table 9 =

*5.2. Household Characteristics and Coverage Area Expansion*

Household characteristics may affect the extent of switching between access modes. Therefore, we conduct simulations for seven subsamples, divided based on the following household characteristics: (i) single female household, (ii) household size, (iii) households with students, (iv) rented housing, (v) city size, (vi) Internet usage history, and (vii) Internet usage intensity.

Table 10 presents the simulation results. Columns (1) presents the choice probability of FTTH in status quo. Apparently, it is 0% for a noncovered household, as is shown in column (1). On the other hand, column (2) provides the simulated choice probability of FTTH.

The simulation results indicate that the most important household characteristics are the presence of a student as a household member and usage intensity. Households with a student are much more likely to switch to FTTH than those without a student. For example, if FTTH became available to noncovered households, only 9.33% of them without a student would switch to FTTH; however, 17.83% of households with students would switch to FTTH under similar conditions. Similarly, with regard to usage intensity, only 6.97% of nonheavy users switch to FTTH; on the other hand, 14.04% of heavy users switch to FTTH. We can confirm a virtually similar tendency for covered household.

= Table 10 =

*5.3. Welfare Changes due to Coverage Area Expansion*

Finally, we compute the welfare changes induced by the coverage area expansion. Given the linear income effect of the conditional logit, the change in the consumer surplus for household *i* can be estimated as follows:

$$\Delta CS_i = -\frac{\ln(\sum_j \exp V_{ij}^1) - \ln(\sum_j \exp V_{ij}^0)}{a_i} \tag{10}$$

where superscript 1 means that FTTH is available, and superscript 0 denotes that FTTH is unavailable. Table 11 presents the welfare changes due to FTTH coverage area expansion based

on our simulation results. The median increase in the consumer surplus due to the coverage area expansion is 91.57 yen for the noncovered households (per capita per month), while the same value for the covered households is 144.64 yen. This difference in the willingness-to-pay can be attributed to the preference heterogeneity: noncovered households do not consider the availability of the FTTH to be as valuable as the covered households do. In other words, the simulation results indicate that inertia to the existing access modes is considerably persistent under the current price–speed structure.

= Table 11 =

## 6. Concluding Remarks

The present paper conducted simulations regarding the accessibility to FTTH. The simulation results indicated that more than three quarters of the households remain narrow-band users despite the FTTH coverage area expansion and that the median increase in the consumer surplus due to coverage expansion is marginal. These results suggest that, under the current price–speed structure, inertia to the existing access modes, ADSL in particular, is considerably persistent in Japan. For example, around 50% (26%) of the households continue to use ADSL (ISDN). A low-speed access mode may be sufficient for some households whose Internet usage is not heavy. Hence, government policy should focus not only on the expansion of the FTTH coverage area, but also on the enhancement of quality and variety of software associated with FTTH.

Limitations of the present study are as follows. First, our simulation analyses depended specifically on the demand side assumptions, and we do not explicitly incorporate the supply side factors such as the strategic behaviors among carriers. Second, we did not explicitly consider the government regulations on access. Unbundling regulation and access price would drastically change the evolution of the broadband access market. Third, the basic data on price and speed were separately collected and merged into the InfoCom survey. Hence, it may be different from the actual price and speed for each household. Finally, the demand estimation of the present study depends only on the cross-sectional variations of the households. It is very likely that the broadband access demand dynamically changes, and therefore, we should be sufficiently careful when drawing definite conclusions from the demand estimations.

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**Appendix A: The Japanese Broadband Market**

According to OECD (2006), with regard to the penetration rate of broadband access technologies such as DSL, cables, fiber/LAN, and others, Japan ranked fourteen among the OECD member countries in December 2006 (See Figure 4).

= Figure 4 =

Japan was number one with respect to fiber optics, and the number of FTTH subscribers in Japan was larger than the total number of broadband subscribers in 23 of the 30 OECD countries.

**Appendix B: Service Areas of the Broadband Access Services and Demographic Variables**

Japanese broadband access services were unavailable throughout the nation. Thus, it is important to incorporate the information about the available access modes for each sample household into our analysis. First, we obtained the list of municipalities where NTT East/West supplied their FTTH ("B FLETS") and ADSL ("FLETS ADSL": 47 Mbps, 40 Mbps, 24 Mbps, 12 Mbps, 8 Mbps, and 1.5 Mbps) services in June 2005, from the following websites:

(i) NTT FLETS Introduction Square (http://ntt–ocn.parfait.ne.jp/): "B FLETS" (only for the east area) and "FLETS ADSL"

(ii) NTT FLETS Window (http://www.ntt–flets.jp/): "B FLETS"

(iii) NTTT West, FLETS (http://flets–w.com/): "FLETS ADSL" (only for the west area)

The web-search was conducted on September 13, 2005. On the other hand, for CATV, we employed the data from Satemaga B.I. (2005) and constructed eight dummy variables that represent the respective access modes that may or may not be available in each municipality.

Second, the municipal JIS codes and the ZIP codes were merged to the microdata, using the ZIP code as a key variable. Finally, we constructed the availability index function for our choice alternatives as follows: (i) FTTH for detached housing "B FLETS," (ii) FTTH for complex housing "B FLETS," (iv) ADSL (M) "FLETS ADSL" (12/8 Mbps), (v) ADSL (L)

"FLETS ADSL" (1.5 Mbps), and (vi) CATV (Satemaga B.I.); ISDN and Dial-up services are assumed to be available to everyone.

In addition, to computing the density within the residential area for each household, the information about the population and habitable area of each municipality was obtained from "Municipalities in Statistics" in MIC (2005b) and was merged into the database, using the JIS code.

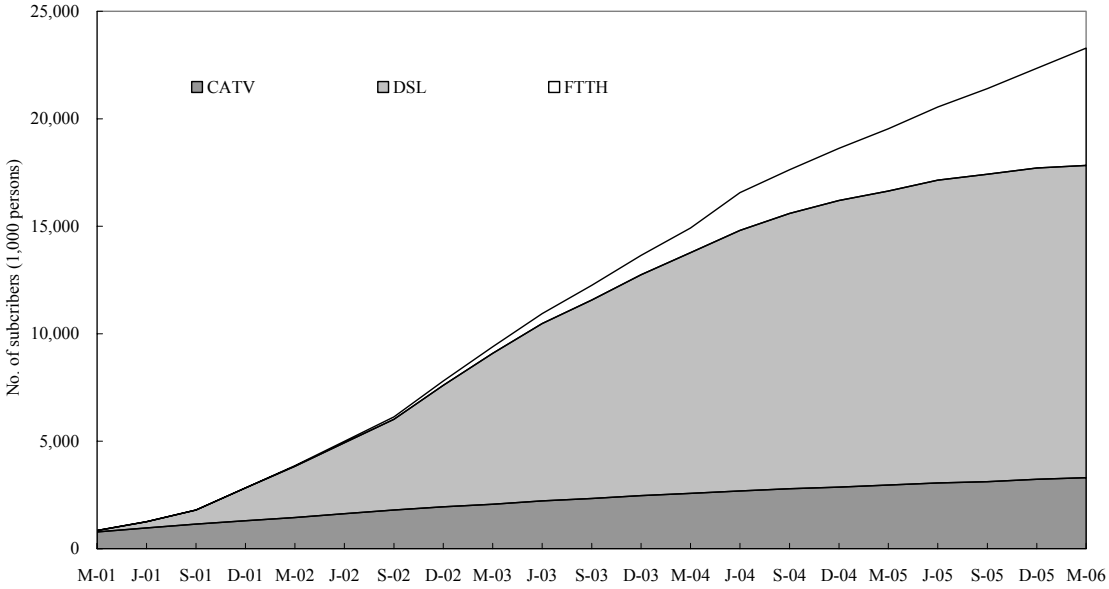
**Appendix C: Service Area Maps of Other Broadband Access Modes**

= Figure 5 to 11 =

**Appendix D: Estimates of the Elasticities Based on Other Models**

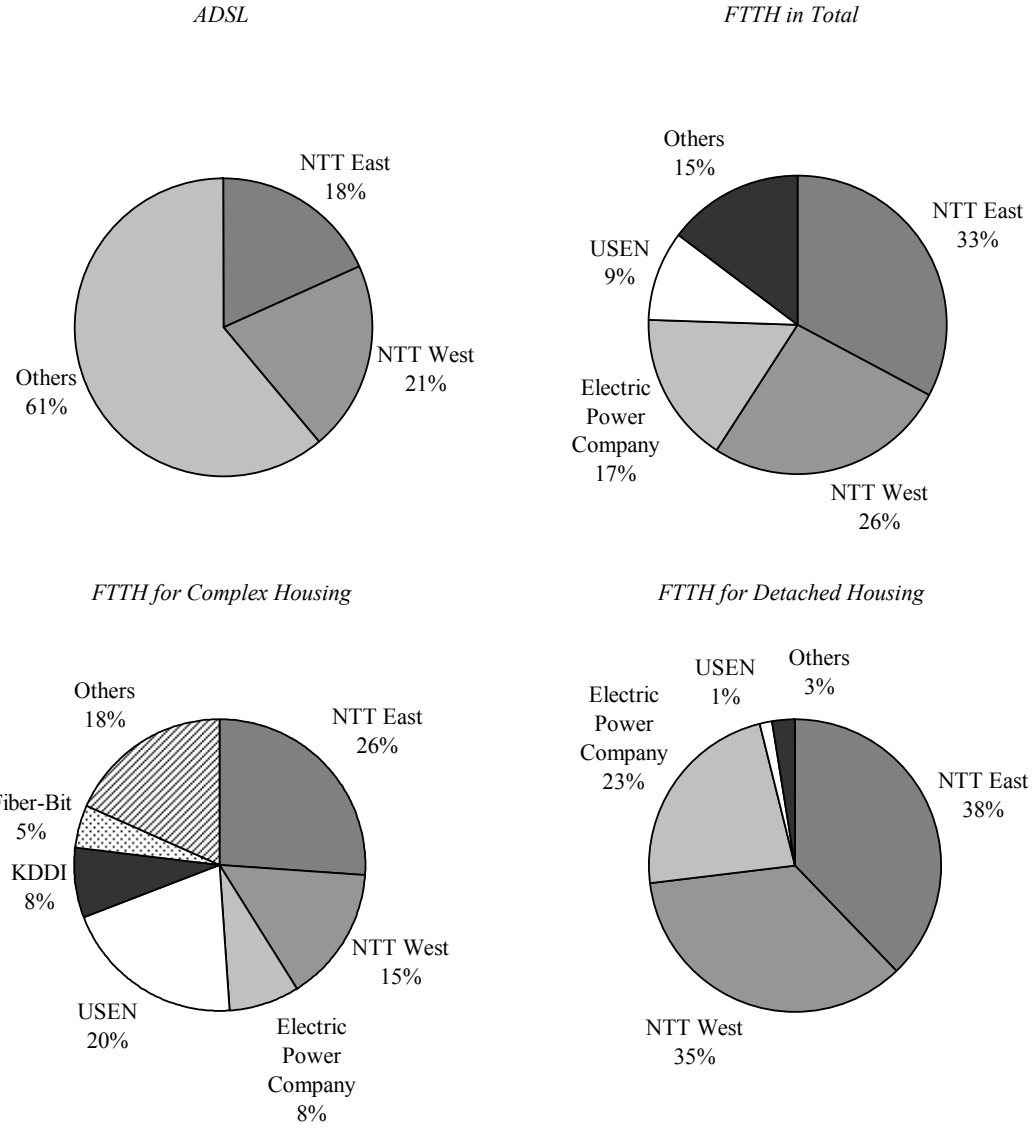
= Table 12 =

Figure 1: Growth of the Broadband Access Subscribers in Japan



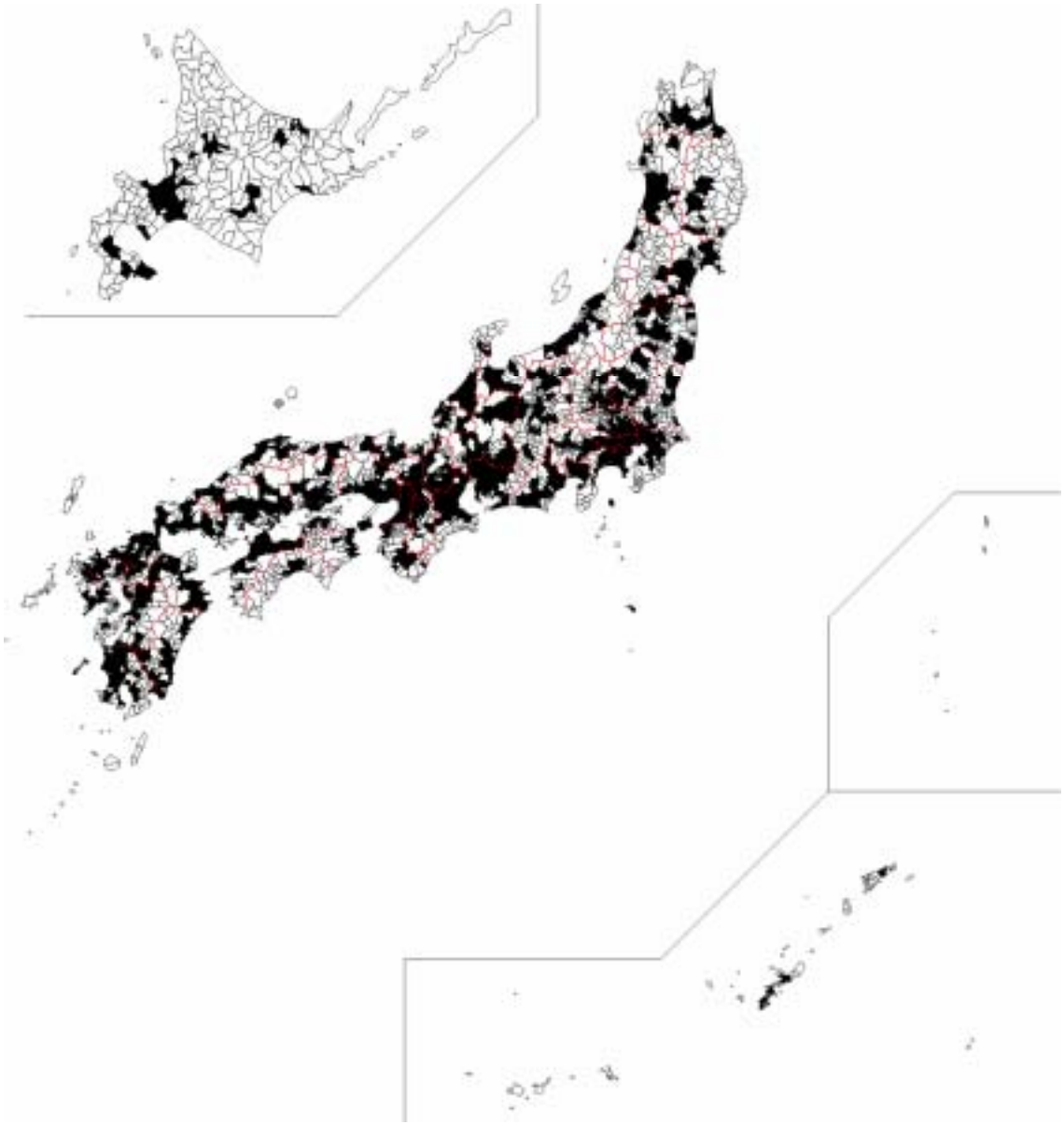

Note: The original data source of this figure is MIC (2006c). For more details, please refer to the text.

Figure 2: Market Share of Each Carrier in the ADSL and FTTH Services (September 2005)




Note: The original data source for the subscriber base is MIC (2006a). For more details, please refer to the text.

Figure 3: Service Areas of FTTH, Provided by NTT



Note: The municipalities where NTT East/West provided “B FLETS” services in June 2005 are marked in black. This information was obtained from the NTT East/West website. The map image has been produced by using the GeoLinkXL software.

Table 1: Service Coverage of Each Broadband Access Line by Population

| | FTTH | ADSL (47 M) | ADSL (40 M) | ADSL (24 M) | ADSL (12 M) | ADSL (8 M) | ADSL (1.5 M) | CATV |
|---|---|---|---|---|---|---|---|---|
| Hokkaido | 72.55% | 76.94% | 80.97% | 80.77% | 71.81% | 92.51% | 83.12% | 55.66% |
| Tohoku | 63.23% | 83.74% | 89.43% | 81.25% | 78.40% | 89.43% | 86.18% | 41.45% |
| Kanto | 86.92% | 97.58% | 97.34% | 96.37% | 96.85% | 97.58% | 97.09% | 84.50% |
| Tokai | 83.53% | 95.88% | 96.47% | 92.94% | 90.59% | 96.47% | 96.47% | 87.06% |
| Hokuriku | 75.64% | 99.22% | 98.91% | 94.06% | 69.37% | 89.26% | 96.90% | 77.76% |
| Kansai | 93.30% | 95.69% | 91.39% | 90.91% | 88.04% | 96.17% | 83.73% | 81.82% |
| Chugoku | 82.17% | 95.64% | 81.14% | 85.51% | 90.39% | 92.35% | 91.46% | 77.80% |
| Shikoku | 69.75% | 89.82% | 82.03% | 78.60% | 82.11% | 87.79% | 89.93% | 72.66% |
| Kyushu | 80.41% | 67.23% | 49.63% | 76.35% | 87.16% | 92.57% | 92.57% | 60.79% |
| Total | 82.68% | 90.55% | 87.40% | 88.98% | 88.98% | 94.49% | 92.13% | 75.20% |

Note: Information about the FTTH and ADSL services was obtained from the NTT East/West website and that about CATV, from Satemaga B.I. (2005). For more details, please refer to the text.

Table 2: Probit Estimates of the Municipal Availability of FTTH

| | Estimates | Robust S.E | $z$ | $p$-value | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| Ratio of People Aged over 65 | -17.506 | 1.594 | -10.980 | 0.000 | -20.630 | -14.382 |
| No. of Students per Household | 6.215 | 1.606 | 3.870 | 0.000 | 3.068 | 9.362 |
| Family Size per Household | -0.196 | 0.200 | -0.980 | 0.327 | -0.587 | 0.196 |
| Ratio of Single-Person Households | 2.575 | 1.459 | 1.770 | 0.078 | -0.284 | 5.435 |
| Ratio of Women | 30.993 | 4.246 | 7.300 | 0.000 | 22.672 | 39.314 |
| House Ownership Rate | -0.785 | 0.631 | -1.240 | 0.213 | -2.021 | 0.452 |
| Household Density (in 1,000 Households) | 0.864 | 0.237 | 3.650 | 0.000 | 0.399 | 1.328 |
| Constant | -12.517 | 2.455 | -5.100 | 0.000 | -17.329 | -7.705 |
| No. of Observations | 2,362 | | | | | |
| Log Pseudolikelihood | -871.635 | | | | | |

Note: The probit regression results. The sample was the municipalities. The dependent variable is the FTTH availability dummy, which is 1 if FTTH was available in June 2005 and 0 otherwise. Explanatory variables are the ratio of people aged over 65, number of students per household, family size per household, ratio of single person households, ratio of women, house ownership rate, and household density. For more details, please refer to the text.

Table 3: User Profile, Internet Usage, and Product Characteristics

| | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | | 7 | | 8 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FTTH for Detached Housing | | FTTH for Complex Housing | | High-speed ADSL | | Medium-speed ADSL | | Low-speed ADSL | | CATV | | ISDN | | Dial-up | |
| | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| **I. Household Profile** | | | | | | | | | | | | | | | | |
| Income | 599.16 | 288.56 | 561.21 | 238.82 | 529.64 | 279.12 | 483.03 | 239.01 | 474.00 | 234.86 | 557.76 | 266.99 | 475.97 | 243.47 | 498.62 | 229.47 |
| Single Female Household * | 0.00% | | 1.03% | | 1.49% | | 1.37% | | 1.72% | | 0.63% | | 1.43% | | 2.98% | |
| No. of Family Members | 3.59 | 1.19 | 2.93 | 1.28 | 2.94 | 1.46 | 3.09 | 1.39 | 3.12 | 1.36 | 3.31 | 1.46 | 3.24 | 1.45 | 2.94 | 1.44 |
| Living with Students * | 13.66% | | 6.51% | | 14.92% | | 14.29% | | 16.18% | | 15.55% | | 12.82% | | 6.09% | |
| Rent Housing * | 1.23% | | 8.63% | | 20.40% | | 19.54% | | 17.84% | | 7.50% | | 11.39% | | 13.47% | |
| Density | 0.40 | 0.36 | 0.69 | 0.44 | 0.51 | 0.50 | 0.38 | 0.45 | 0.44 | 0.46 | 0.46 | 0.47 | 0.30 | 0.40 | 0.45 | 0.43 |
| **II. Internet Usage** | | | | | | | | | | | | | | | | |
| Intensity (Hrs/week) | 22.79 | 15.70 | 22.39 | 15.14 | 21.37 | 15.58 | 19.31 | 14.98 | 17.99 | 14.57 | 22.05 | 15.04 | 17.52 | 14.51 | 11.56 | 12.32 |
| History (Months) | 58.93 | 13.82 | 58.44 | 15.00 | 55.00 | 17.53 | 53.72 | 17.28 | 54.90 | 16.28 | 57.23 | 14.31 | 57.96 | 13.20 | 58.61 | 13.36 |
| Shopping * | 97.48% | | 96.41% | | 96.17% | | 93.47% | | 92.21% | | 94.35% | | 93.39% | | 87.22% | |
| Auctions * | 61.34% | | 58.30% | | 62.10% | | 54.81% | | 57.89% | | 57.88% | | 51.25% | | 36.34% | |
| Music * | 7.14% | | 7.62% | | 7.66% | | 5.63% | | 5.89% | | 5.18% | | 3.64% | | 3.01% | |
| Games * | 26.47% | | 22.87% | | 22.38% | | 22.50% | | 15.79% | | 19.76% | | 15.03% | | 4.76% | |
| Movies * | 68.07% | | 63.68% | | 64.92% | | 60.44% | | 52.42% | | 53.88% | | 28.93% | | 26.32% | |
| Price | 6,376.26 | 761.24 | 3,870.99 | 622.74 | 4,321.42 | 418.41 | 4,110.88 | 553.43 | 4,008.62 | 827.71 | 4,545.94 | 950.34 | 4,521.92 | 539.77 | 2,500.00 | 0.00 |
| Speed | 100.00 | 0.00 | 100.00 | 0.00 | 36.38 | 11.42 | 10.12 | 1.99 | 1.55 | 0.46 | 12.73 | 10.62 | 0.06 | 0.00 | 0.06 | 0.00 |
| No. of Observations | 238 | | 223 | | 496 | | 551 | | 475 | | 425 | | 439 | | 399 | |
| Share | 7.33% | | 6.87% | | 15.28% | | 16.97% | | 14.63% | | 13.09% | | 13.52% | | 12.29% | |

Note: * denotes that the variable is a dummy variable. The total sample size was 3,246. Income was evaluated as the median value of each class of the original questionnaire, and it is yearly in 10 thousand JPY. This is same for the Internet usage per week in hours and the Internet history in months. The prices are the sum of the monthly base charges for the access line and by the ISP, and have been evaluated in JPY. The download traffic speed was evaluated in Mbps. For more details, please refer to the text.

Table 4: Availability of Each Broadband Access Mode in the InfoCom Survey

| | FTTH | ADSL (47 M) | ADSL (40 M) | ADSL (24 M) | ADSL (12 M) | ADSL (8 M) | ADSL (1.5 M) | CATV |
|---|---|---|---|---|---|---|---|---|
| *Region* | | | | | | | | |
| Hokkaido | 67.66% | 73.13% | 77.11% | 79.60% | 70.15% | 94.53% | 80.60% | 58.21% |
| Tohoku | 65.84% | 85.77% | 93.59% | 88.26% | 83.99% | 95.37% | 92.88% | 41.99% |
| Kanto | 86.70% | 98.04% | 97.05% | 96.61% | 96.07% | 97.68% | 97.68% | 83.30% |
| Tokai | 88.51% | 98.78% | 97.31% | 98.04% | 92.91% | 97.80% | 98.04% | 87.78% |
| Hokuriku | 48.74% | 81.51% | 89.92% | 63.87% | 59.66% | 89.92% | 89.08% | 74.79% |
| Kansai | 95.17% | 96.01% | 94.96% | 94.54% | 90.13% | 97.90% | 97.48% | 96.01% |
| Chugoku | 83.04% | 95.09% | 81.25% | 86.16% | 92.86% | 94.20% | 92.41% | 71.43% |
| Shikoku | 70.00% | 95.00% | 83.00% | 79.00% | 85.00% | 95.00% | 97.00% | 68.00% |
| Kyushu | 87.97% | 79.11% | 65.51% | 82.28% | 91.14% | 95.57% | 95.89% | 60.76% |
| *City Size* | | | | | | | | |
| Large Cities | 99.92% | 99.85% | 98.84% | 99.92% | 99.54% | 99.92% | 99.92% | 96.91% |
| Other Cities | 89.22% | 94.66% | 92.33% | 94.05% | 95.26% | 99.05% | 98.71% | 73.36% |
| Towns and Villages | 46.71% | 77.22% | 73.67% | 71.27% | 65.70% | 87.22% | 82.91% | 48.86% |
| Total | 83.15% | 92.48% | 90.39% | 90.85% | 89.77% | 96.52% | 95.35% | 76.80% |

Note: These figures denote the service coverage ratio by population. For FTTH and ADSL, the information about the municipalities where NTT East/West provided FTTH and ADSL (47 Mbps, 40 Mbps, 24 Mbps, 12 Mbps, 8 Mbps, and 1.5 Mbps) services until June 2005 was obtained from the NTT East/West website. On the other hand, for CATV, we used the data from Satemaga B.I. (2005). For more details, please refer to the text.

Table 5: Regression Variables and Descriptive Statistics

| Variable | Note | Mean | S.D. | Min. | Max. |
|---|---|---|---|---|---|
| Price | Monthly base charge in JPY | 4295.01 | 1102.69 | 1575.00 | 7560.00 |
| Speed | Download traffic speed in Mbps | 32.50 | 40.50 | 0.06 | 100.00 |
| Single Female Households | A dummy variable that denotes whether or not the respondent is a single female. | 0.057 | 0.232 | 0.000 | 1.000 |
| Household Size | The number of family members | 3.129 | 1.409 | 1.000 | 8.000 |
| Students | A dummy variable that denotes whether or not the household members include students. | 0.147 | 0.354 | 0.000 | 1.000 |
| Rent housing | A dummy variable that denotes whether or not it is a rented house. | 0.325 | 0.468 | 0.000 | 1.000 |
| Density | Population density of each municipality, in which the household live (in 10,000 persons | 0.441 | 0.455 | 0.002 | 1.985 |
| Δinternet Use/100 | The difference (divided by 100) between the reported weekly Internet usage and the mean weekly usage of subscribers for each access | -0.003 | 0.155 | -0.223 | 0.334 |
| Δinternet History/100 | The difference (divided by 100) between the reported monthly Internet history and the mean of the monthly history of subscribers for each access line. | -0.004 | 0.156 | -0.574 | 0.123 |
| NTT FLETS & ISDN | A dummy variable that denotes NTT FLETS (B FLETS and FLETS ASDL). | 0.224 | 0.417 | 0.000 | 1.000 |
| CATV * Toyama | A dummy variable that denotes CATV in Toyama Prefecture. | 0.001 | 0.028 | 0.000 | 1.000 |
| CATV * Fukui | A dummy variable that denotes CATV in Fukui Prefecture. | 0.001 | 0.027 | 0.000 | 1.000 |
| CATV * Mie | A dummy variable that denotes CATV in Mie Prefecture. | 0.002 | 0.040 | 0.000 | 1.000 |

Note: These have been evaluated using all observations (25,968). For more details, please refer to the text

Table 6: Interaction Effect Variables based on Internet Usage and Internet History

| | Alternatives | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Choice | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| *Internet Usage* | | | | | | | | |
| 1 FTTH (DH) | 0.0000 | 0.0040 | 0.0142 | 0.0348 | 0.0480 | 0.0074 | 0.0527 | 0.1123 |
| 2 FTTH (CH) | -0.0040 | 0.0000 | 0.0102 | 0.0308 | 0.0440 | 0.0034 | 0.0487 | 0.1083 |
| 3 ADSL (H) | -0.0142 | -0.0102 | 0.0000 | 0.0206 | 0.0338 | -0.0068 | 0.0385 | 0.0981 |
| 4 ADSL (M) | -0.0348 | -0.0308 | -0.0206 | 0.0000 | 0.0132 | -0.0274 | 0.0179 | 0.0775 |
| 5 ADSL (L) | -0.0480 | -0.0440 | -0.0338 | -0.0132 | 0.0000 | -0.0406 | 0.0047 | 0.0643 |
| 6 CATV | -0.0074 | -0.0034 | 0.0068 | 0.0274 | 0.0406 | 0.0000 | 0.0453 | 0.1049 |
| 7 ISDN | -0.0527 | -0.0487 | -0.0385 | -0.0179 | -0.0047 | -0.0453 | 0.0000 | 0.0596 |
| 8 Dial-up | -0.1123 | -0.1083 | -0.0981 | -0.0775 | -0.0643 | -0.1049 | -0.0596 | 0.0000 |
| *Internet History* | | | | | | | | |
| 1 FTTH (DH) | 0.0000 | 0.0049 | 0.0393 | 0.0521 | 0.0403 | 0.0170 | 0.0097 | 0.0032 |
| 2 FTTH (CH) | -0.0049 | 0.0000 | 0.0344 | 0.0472 | 0.0354 | 0.0121 | 0.0048 | -0.0017 |
| 3 ADSL (H) | -0.0393 | -0.0344 | 0.0000 | 0.0128 | 0.0010 | -0.0223 | -0.0296 | -0.0360 |
| 4 ADSL (M) | -0.0521 | -0.0472 | -0.0128 | 0.0000 | -0.0118 | -0.0351 | -0.0424 | -0.0488 |
| 5 ADSL (L) | -0.0403 | -0.0354 | -0.0010 | 0.0118 | 0.0000 | -0.0233 | -0.0306 | -0.0370 |
| 6 CATV | -0.0170 | -0.0121 | 0.0223 | 0.0351 | 0.0233 | 0.0000 | -0.0073 | -0.0137 |
| 7 ISDN | -0.0097 | -0.0048 | 0.0296 | 0.0424 | 0.0306 | 0.0073 | 0.0000 | -0.0065 |
| 8 Dial-up | -0.0032 | 0.0017 | 0.0360 | 0.0488 | 0.0370 | 0.0137 | 0.0065 | 0.0000 |

Note: This table presents the sample average of the alternative specific mean difference, which is defined as a difference between a reported value by each household and the sample mean of the subscribers for each alternative access line. These values were calculated for the Internet usage and history. All figures have been divided by 100. For more details, please refer to the text.

Table 7: Logit Demand Estimation Results

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | Estimate | S.E. | Estimate | S.E. | Estimate | S.E. |
| $\alpha$: Price | -0.00024 | 0.00002 *a* | -0.00014 | 0.00008 *c* | -0.00042 | 0.00009 *a* |
| $\delta$: | | | | | | |
| * Single Female Households | | | -0.00043 | 0.00010 *a* | -0.00056 | 0.00011 *a* |
| * Household Size | | | -0.00004 | 0.00002 *b* | -0.00004 | 0.00002 *b* |
| * Living with Students | | | 0.00025 | 0.00007 *a* | 0.00033 | 0.00008 *a* |
| * Rent Housing | | | -0.00009 | 0.00006 | -0.00025 | 0.00007 *a* |
| * Density | | | -0.00002 | 0.00005 | 0.00004 | 0.00006 |
| $\nu$: | | | | | | |
| * Δ Internet Use | | | | | 0.00106 | 0.00017 *a* |
| * Δ Internet History | | | | | -0.00009 | 0.00016 |
| $\beta$: Speed | 0.01000 | 0.00068 *a* | 0.00521 | 0.00233 *b* | 0.00947 | 0.00253 *a* |
| $\eta$: | | | | | | |
| * Single Female Households | | | -0.00428 | 0.00269 | -0.00454 | 0.00285 |
| * Household Size | | | 0.00129 | 0.00054 *b* | 0.00153 | 0.00057 *a* |
| * Living with Students | | | 0.00066 | 0.00187 | 0.00021 | 0.00198 |
| * Rent Housing | | | -0.00118 | 0.00153 | -0.00620 | 0.00169 *a* |
| * Density | | | 0.00297 | 0.00128 *b* | 0.00278 | 0.00135 *b* |
| $\omega$: | | | | | | |
| * Δ Internet Use | | | | | 0.01203 | 0.00418 *a* |
| * Δ Internet History | | | | | 0.00169 | 0.00417 |
| $\gamma$: | | | | | | |
| NTT | 1.20909 | 0.04841 *a* | 1.24640 | 0.05236 *a* | 1.63002 | 0.06136 *a* |
| CATV * Toyama | 1.51810 | 0.55509 *a* | 1.52702 | 0.55387 *a* | 1.30258 | 0.57622 *b* |
| CATV * Fukui | 1.27681 | 0.58986 *b* | 1.28836 | 0.59051 *b* | 1.30243 | 0.61281 *b* |
| CATV * Mie | 2.29343 | 0.32341 *a* | 2.31428 | 0.32441 *a* | 2.43304 | 0.33292 *a* |
| $\mu$: | | | | | | |
| * Δ Internet Use | | | | | -11.02866 | 1.49479 *a* |
| * Δ Internet History | | | | | 13.08318 | 1.62375 *a* |
| No. of Households | 3,246 | | 3,246 | | 3,246 | |
| No. of Observations | 21,079 | | 21,079 | | 21,079 | |
| Log Likelihood | -5,684.13 | | -5,641.86 | | -5,465.52 | |

Note: These are the estimation results of the Internet access demand. All of them are the results of the conventional conditional logit model. *a*, *b*, and *c* denote statistical significance at the 1%, 5%, and 10% levels, respectively. For more details, please refer to the text.

Table 8: Price Elasticity and Traffic Speed Semi-Elasticity Matrices

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| *Price* | | | | | | | | |
| 1 FTTH (DH) | -3.4796 | 0.0000 | 0.2349 | 0.2047 | 0.1984 | 0.2089 | 0.2344 | 0.1715 |
| 2 FTTH (CH) | 0.0000 | -2.8764 | 0.1563 | 0.1741 | 0.1983 | 0.1618 | 0.1795 | 0.2411 |
| 3 ADSL (H) | 0.3386 | 0.3252 | -3.1570 | 0.4874 | 0.4802 | 0.2996 | 0.3998 | 0.4073 |
| 4 ADSL (M) | 0.2610 | 0.3247 | 0.4363 | -3.0322 | 0.4470 | 0.2636 | 0.3690 | 0.3991 |
| 5 ADSL (L) | 0.2391 | 0.3420 | 0.4096 | 0.4257 | -2.8296 | 0.2589 | 0.3384 | 0.3802 |
| 6 CATV | 0.1529 | 0.1721 | 0.1499 | 0.1474 | 0.1546 | -2.6846 | 0.1605 | 0.1758 |
| 7 ISDN | 0.6434 | 0.7248 | 0.7644 | 0.7920 | 0.7678 | 0.6266 | -2.7251 | 0.9094 |
| 8 Dial-up | 0.2841 | 0.6067 | 0.4806 | 0.5294 | 0.5364 | 0.4217 | 0.5554 | -1.4167 |
| *Speed* | | | | | | | | |
| 1 FTTH (DH) | 0.0111 | 0.0000 | -0.0008 | -0.0007 | -0.0006 | -0.0007 | -0.0008 | -0.0005 |
| 2 FTTH (CH) | 0.0000 | 0.0070 | -0.0004 | -0.0004 | -0.0005 | -0.0004 | -0.0005 | -0.0005 |
| 3 ADSL (H) | -0.0018 | -0.0008 | 0.0098 | -0.0015 | -0.0015 | -0.0010 | -0.0013 | -0.0011 |
| 4 ADSL (M) | -0.0015 | -0.0008 | -0.0015 | 0.0096 | -0.0014 | -0.0009 | -0.0012 | -0.0011 |
| 5 ADSL (L) | -0.0014 | -0.0010 | -0.0015 | -0.0014 | 0.0094 | -0.0009 | -0.0012 | -0.0011 |
| 6 CATV | -0.0008 | -0.0004 | -0.0005 | -0.0004 | -0.0004 | 0.0080 | -0.0005 | -0.0004 |
| 7 ISDN | -0.0036 | -0.0019 | -0.0027 | -0.0026 | -0.0024 | -0.0021 | 0.0085 | -0.0024 |
| 8 Dial-up | -0.0027 | -0.0026 | -0.0027 | -0.0027 | -0.0027 | -0.0023 | -0.0030 | 0.0077 |

Note: These were calculated based on the estimated parameters of Model 3. Cell entries ($i$, $j$), where $i$ indexes the rows and $j$ indexes the columns, provide the percent change in the market share of access line $j$ with respect to a 1% change in the price or a 1 Mbps change in the download traffic speed of $i$, respectively. For more details, please refer to the text.

Table 9: FTTH Coverage Area Expansion: Basic Simulation Results

| | Noncovered Households (obs = 547) | | | |
|---|---|---|---|---|
| | (1) obs | (2) % | (3) FTTH unavailable (status quo) | (4) if FTTH becomes available |
| 1 FTTH for Detached Housing | 0 | 0.00% | 0.00% | 8.28% |
| 2 FTTH for Complex Housing | 0 | 0.00% | 0.00% | 2.48% |
| 3 ADSL (High) | 82 | 14.99% | 21.69% | 19.68% |
| 4 ADSL (Medium) | 128 | 23.40% | 21.05% | 19.07% |
| 5 ADSL (Low) | 83 | 15.17% | 12.07% | 11.01% |
| 6 CATV | 60 | 10.97% | 3.57% | 3.17% |
| 7 ISDN | 135 | 24.68% | 30.48% | 26.45% |
| 8 Dial-up | 59 | 10.79% | 11.13% | 9.86% |
| FTTH Total | 0 | 0.00% | 0.00% | **10.76%** |
| ADSL Total | 293 | 53.56% | 54.82% | 49.77% |
| Others | 254 | 46.44% | 45.18% | 39.48% |

Note: For more details, please refer to the text. The first four columns (1) to (4) correspond to the noncovered households. Column (1) is the number of households for every access mode in our dataset. Column (2) denotes the corresponding share, and column (3) presents the estimated share distribution based on the demand system. Column (4) shows the simulated share distribution with regard to FTTH coverage expansion. The simulation results for the covered households are similarly presented in columns (5) to (8). Column (5) is the number of households for every access mode in our dataset. Column (6) denotes the corresponding share, and column (7) shows the simulated share distribution with regard to FTTH coverage expansion. Column (8) presents the estimated share distribution based on the demand system. $\Delta CS$ denotes the estimated welfare change in JPY (per household per month) induced by the expansion of the FTTH coverage. For more details, please refer to the text.

Table 10: Simulation of the FTTH Coverage Area Expansion: Subsample Results

| | Noncovered Households (Obs. = 547) | |
|---|---|---|
| | (1) FTTH unavailable (status quo) | (2) if FTTH becomes available (simulated) |
| 1. Single Female:Households | 0.00% | 10.72% |
| Others: | 0.00% | 10.79% |
| 2. Large Household: | 0.00% | 12.00% |
| Small Household: | 0.00% | 9.67% |
| 3. With a Student: | 0.00% | **17.83%** |
| Without a Student: | 0.00% | **9.33%** |
| 4. Rent Housing | 0.00% | 13.02% |
| Non–rent:ed Housing | 0.00% | 10.17% |
| 5. Big & Medium Cities | 0.00% | 10.04% |
| Small City: | 0.00% | 10.97% |
| 6. Long History: | 0.00% | 10.85% |
| Short History: | 0.00% | 10.62% |
| 7. Heavy Users: | 0.00% | **14.04%** |
| Nonheavy Users: | 0.00% | **6.97%** |

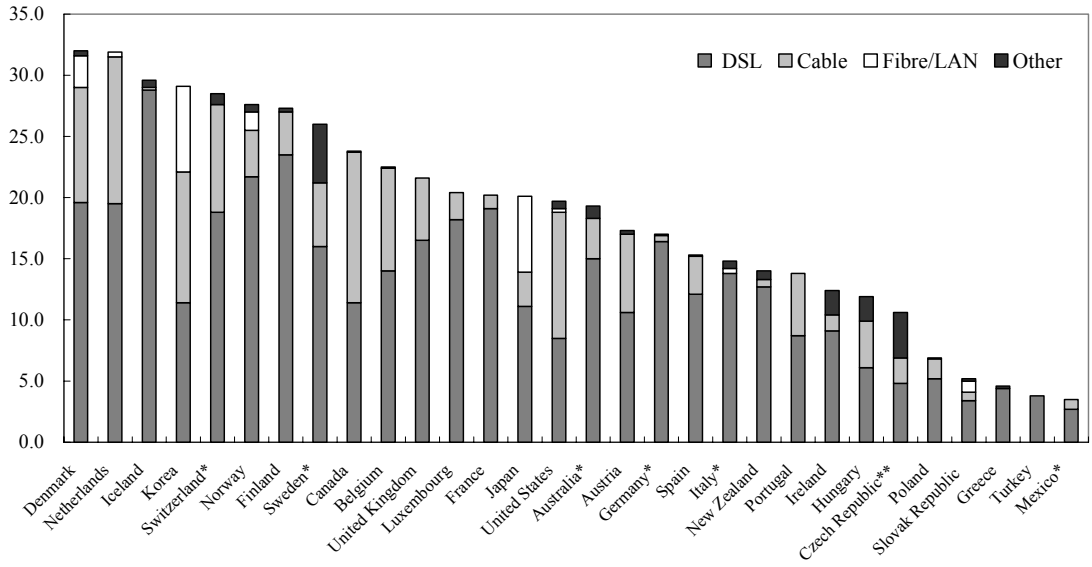
Note: The data has been divided into seven pairs of subsamples based on the following household characteristics: (i) whether or not it is a single female household, (ii) households with more or less than 3 members, (iii) household with or without students, (iv) rented or non-rented housing, (v) households in cities or towns/villages, (vi) usage history more or less than 5 years, and (vii) usage time is more or less than 10 hours per week.

Table 11: Welfare Change due to FTTH Coverage Area Expansion

| | Noncovered household | Covered household |
|---|---|---|
| ΔCS: per capita (in JPY): | | |
| Mean | 417.92 | 478.44 |
| Standard Deviation | 2,916.95 | 3,302.39 |
| Minimum | 6.29 | 1.47 |
| First Quartile | 49.70 | 67.67 |
| Median | **91.57** | **144.64** |
| Third Quartile | 207.26 | 303.41 |
| Maximum | 42,903.19 | 129,426.10 |

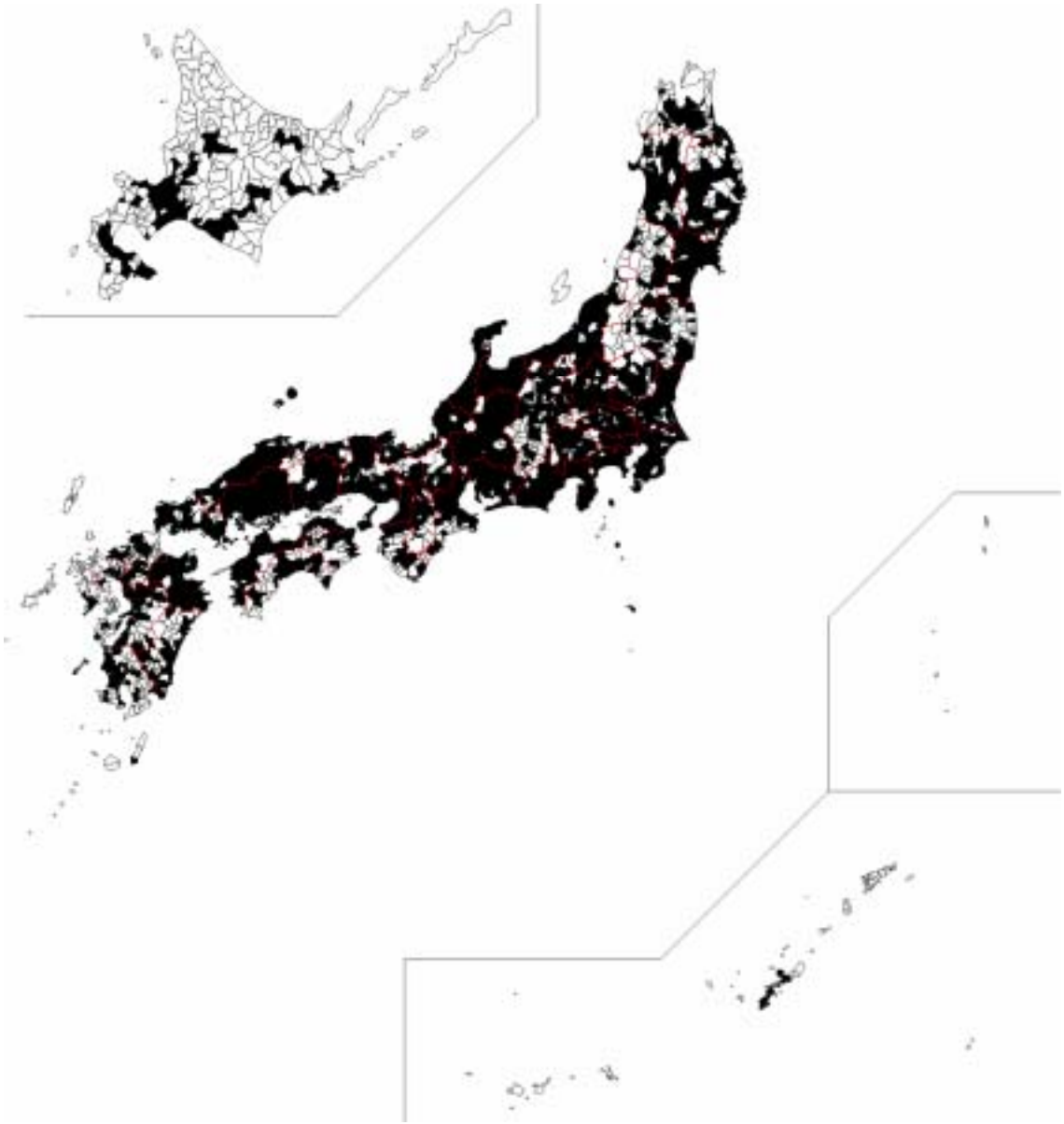
Note: ΔCS denotes the estimated welfare change in the Japanese yen (per household per month) induced by the expansion of FTTH coverage. For more details, please refer to the text.

Figure 4: OECD Broadband Subscribers per 100 inhabitants by technology



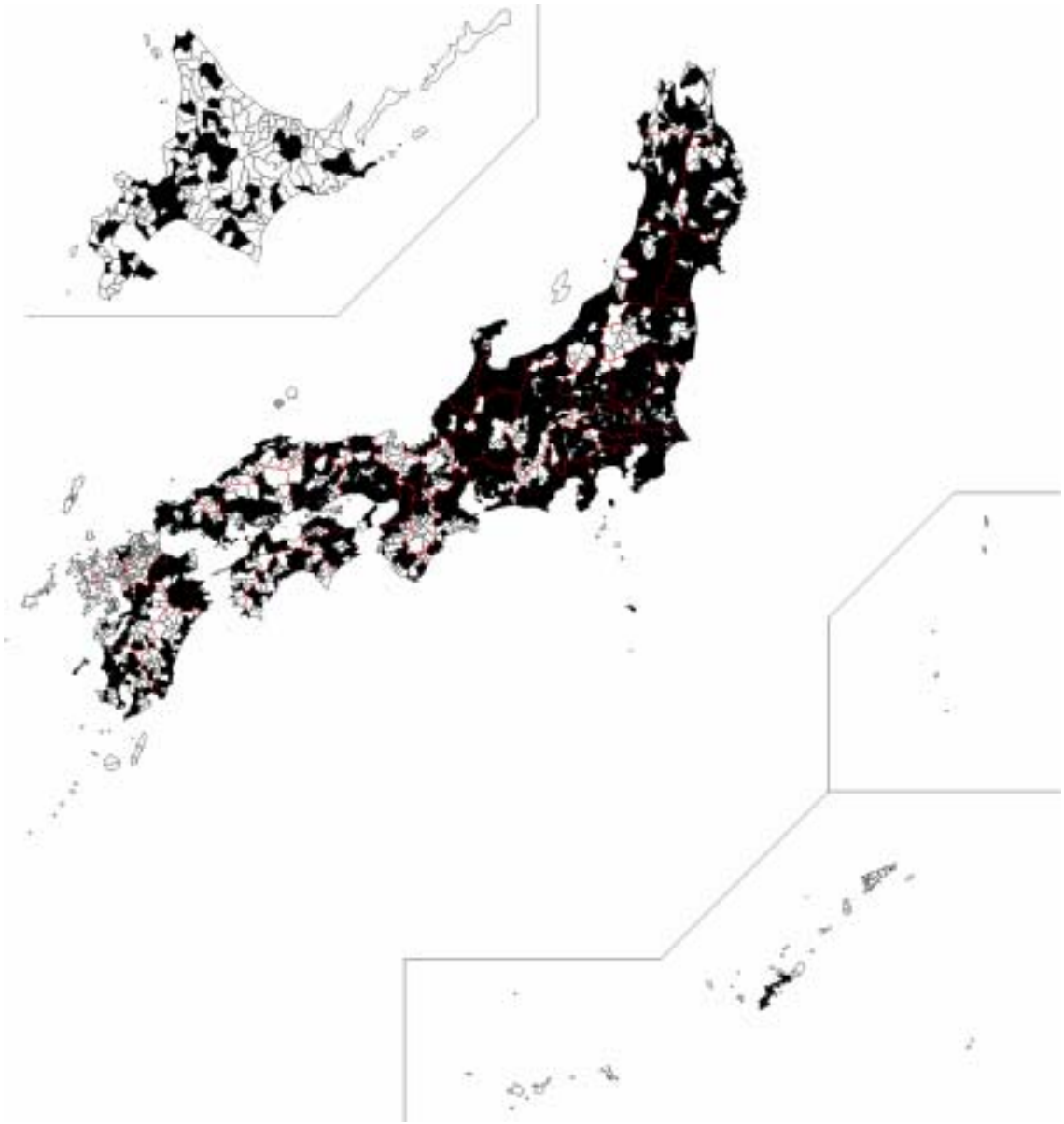

Note: This data has been sourced from the OECD broadband statistics (December 2006).

Figure 5: Service Areas of ADSL (47 Mbps), Provided by NTT



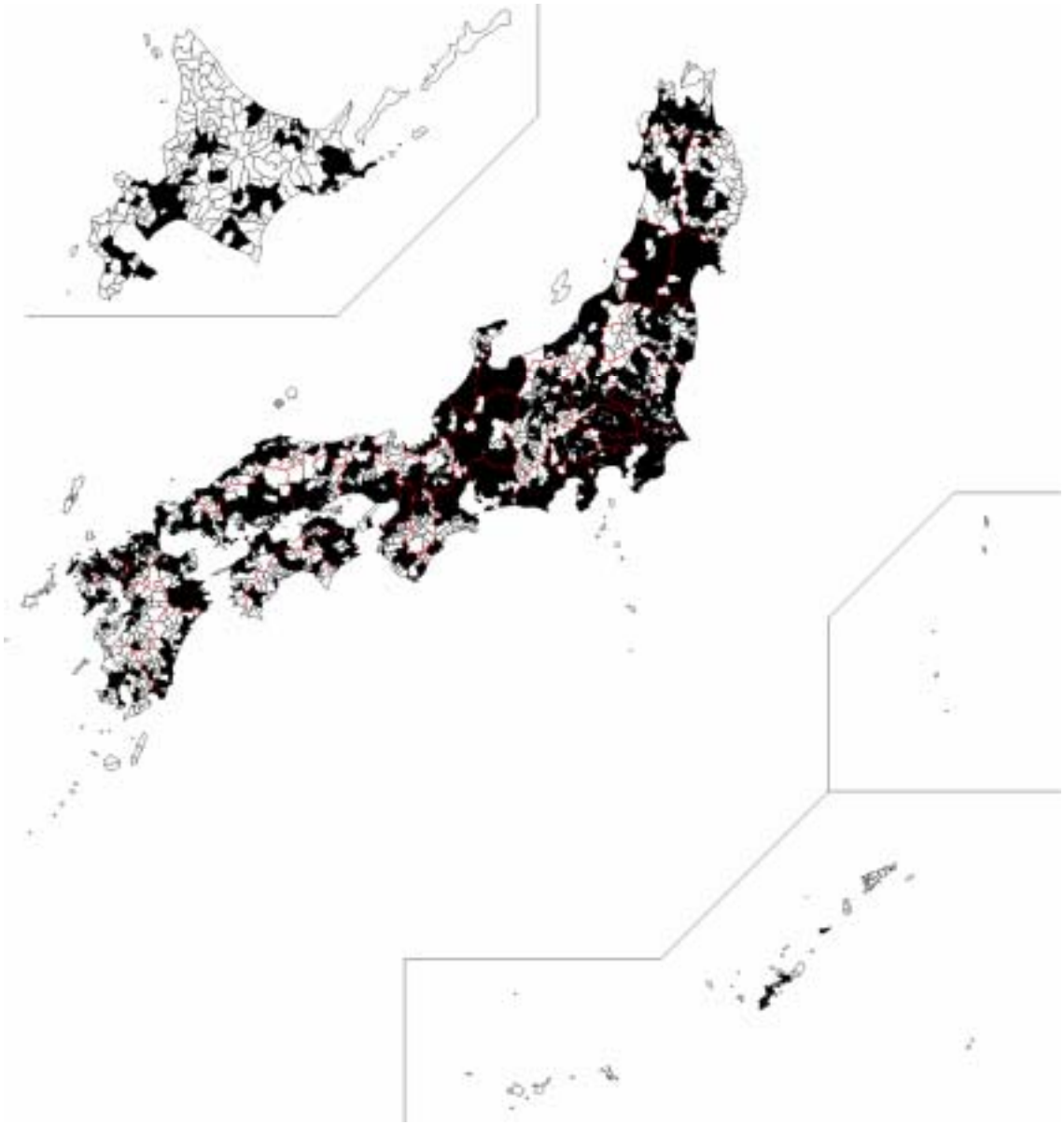
Note: The municipalities where NTT East/West provided “FLETS ADSL” (47 Mbps) services in June 2005 are marked in black. The information was obtained from the NTT East/West website. The map image has been produced by using the GeoLinkXL software.

Figure 6: Service Areas of ADSL (40 Mbps), Provided by NTT



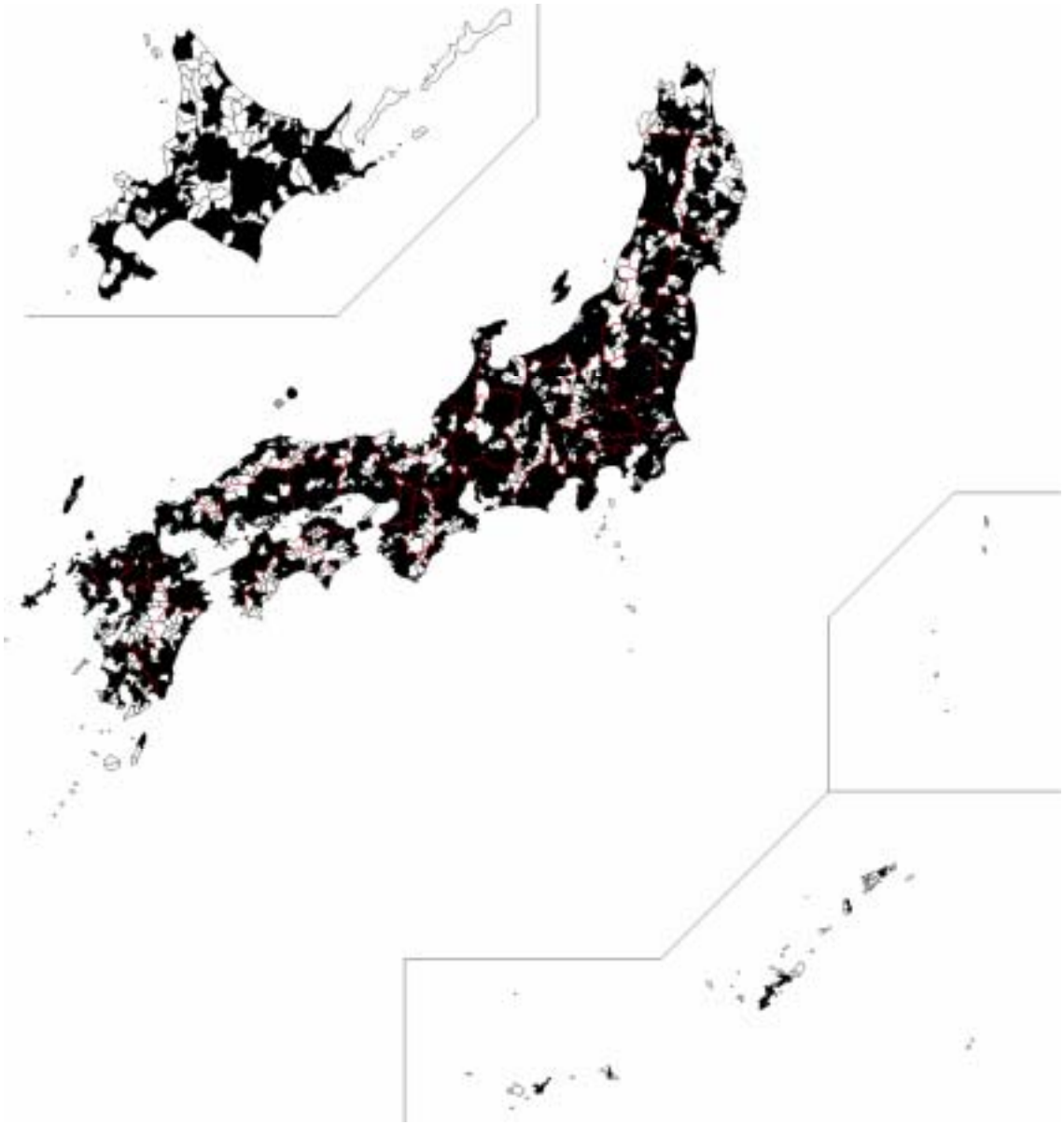
Note: The municipalities where NTT East/West provided “FLETS ADSL” (40 Mbps) services in June 2005 are marked in black. The information was obtained from the NTT East/West website. The map image has been produced by using the GeoLinkXL software.

Figure 7: Service Areas of ADSL (24 Mbps), Provided by NTT



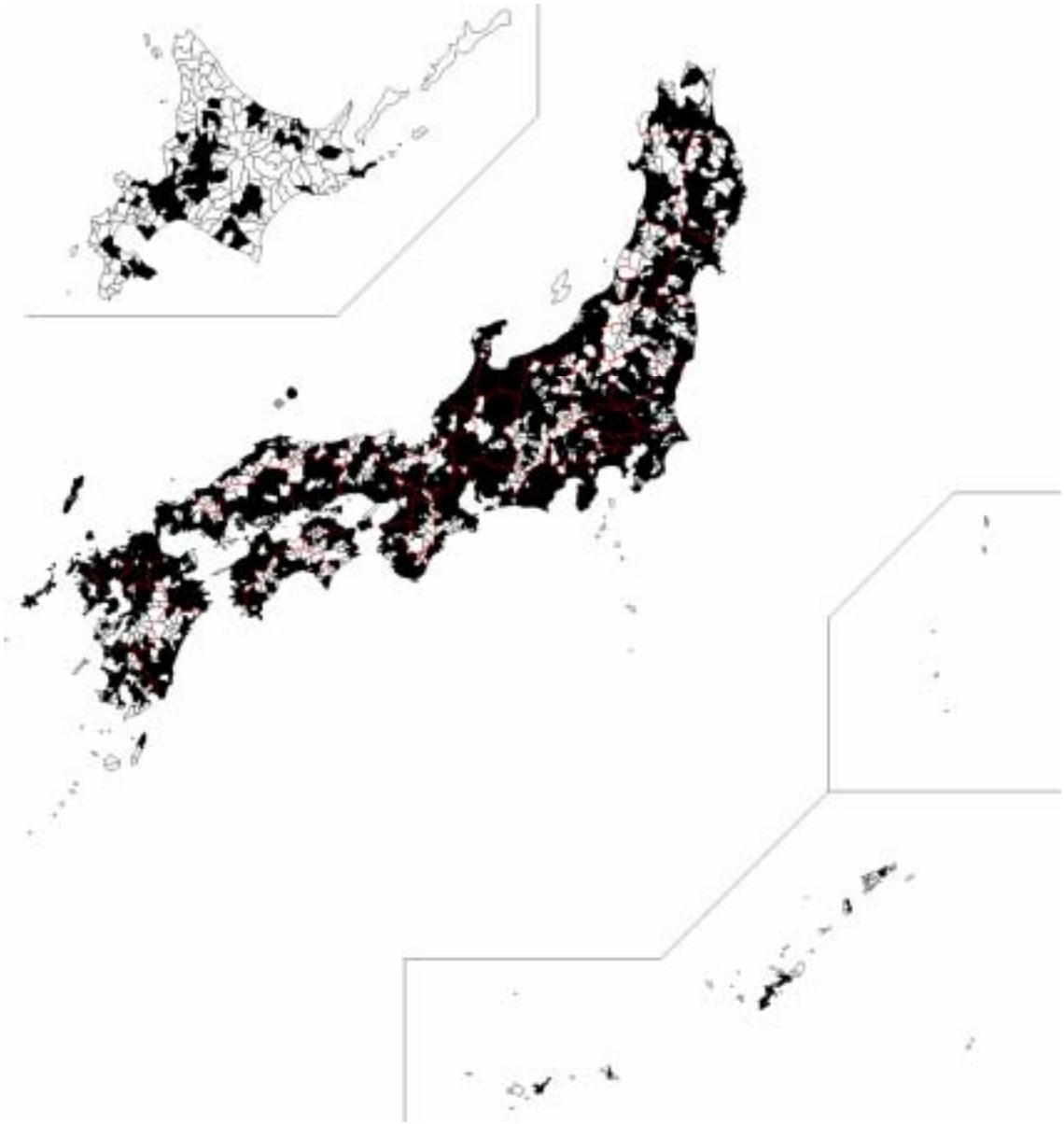
Note: The municipalities where NTT East/West provided “FLETS ADSL” (24 Mbps) services in June 2005 are marked in black. The information was obtained from the NTT East/West website. The map image has been produced by using the GeoLinkXL software.

Figure 8: Service Areas of ADSL (12 Mbps), Provided by NTT



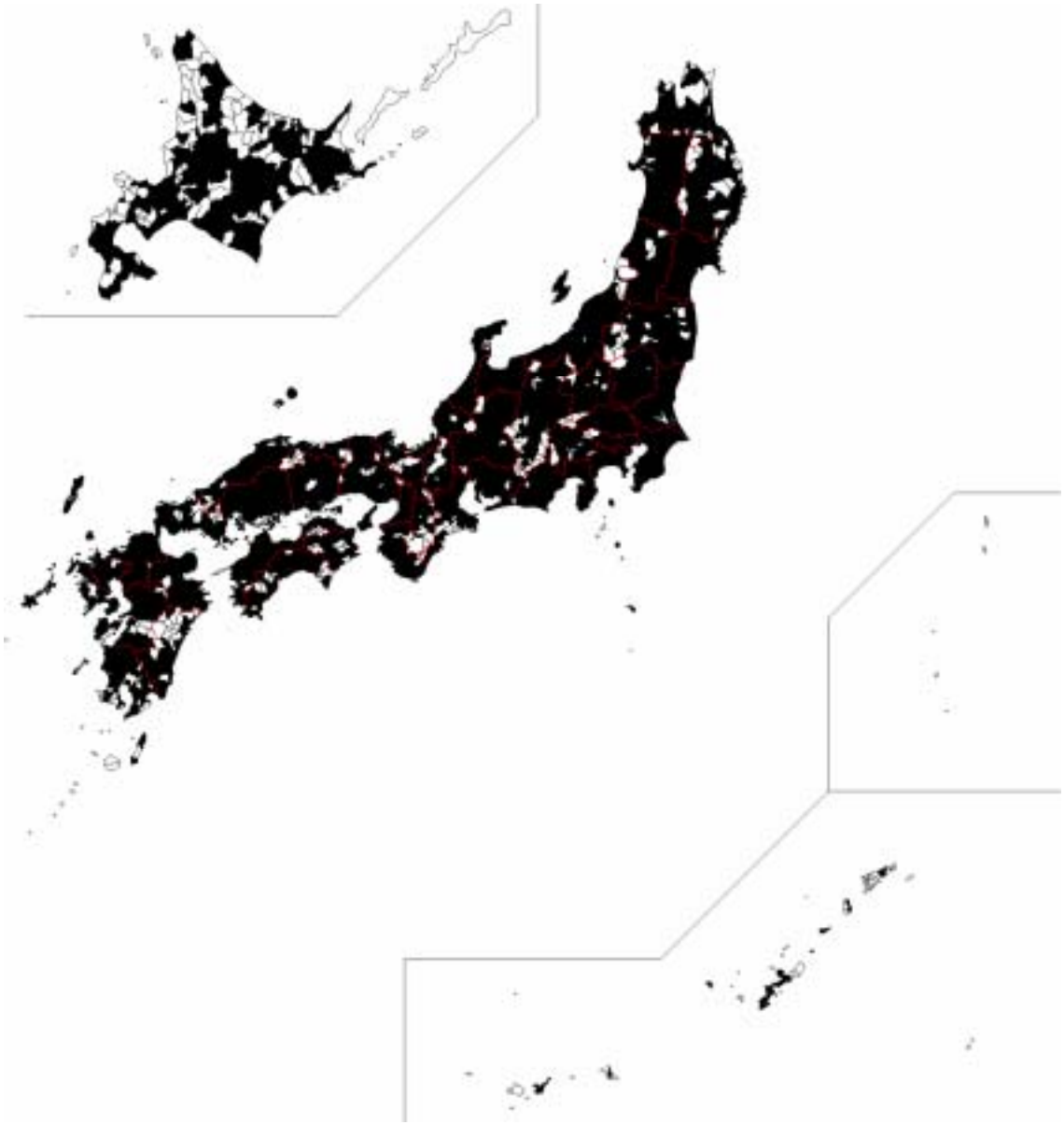
Note: The municipalities where NTT East/West provided "FLETS ADSL" (12 Mbps) services in June 2005 are marked in black. The information was obtained from the NTT East/West website. The map image has been produced by using the GeoLinkXL software.

Figure 9: Service Areas of ADSL (8 Mbps), Provided by NTT



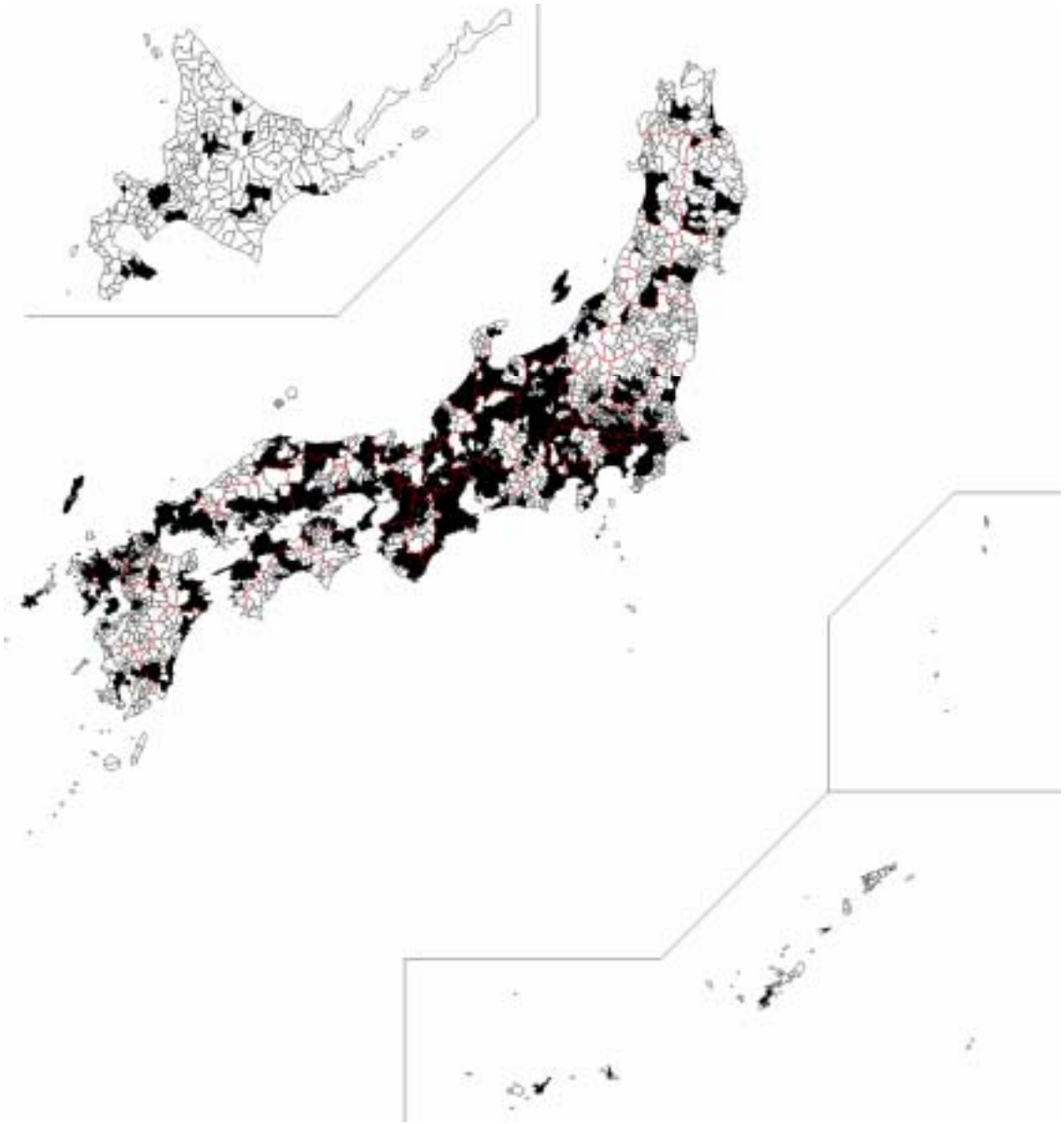
Note: The municipalities where NTT East/West provided “FLETS ADSL” (8 Mbps) services in June 2005 are marked in black. The information was obtained from the NTT East/West website. The map image has been produced by using the GeoLinkXL software.

Figure 10: Service Areas of ADSL (1.5 Mbps), Provided by NTT



Note: The municipalities where NTT East/West provided “FLETS ADSL” (1.5 Mbps) services in June 2005 are marked in black. The information was obtained from the NTT East/West website. The map image has been produced by using the GeoLinkXL software.

Figure 11: Service Areas of CATV service



Note: The municipalities where CATV services were available in June 2005 are marked in black. The information was obtained from Satemaga B.I., Inc. (2005). The map image has been produced by using the GeoLinkXL software.

Table 12: Price Elasticity and Traffic Speed Semi-Elasticity Matrices based on Models 1 and 2

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| | | | | Model 1 | | | | |
| *Price* | | | | | | | | |
| 1 FTTH | -1.2958 | 0.0000 | 0.1026 | 0.1002 | 0.1044 | 0.1214 | 0.1125 | 0.1130 |
| 2 FTTH (CH) | 0.0000 | -0.6959 | 0.0705 | 0.0683 | 0.0723 | 0.0859 | 0.0734 | 0.0735 |
| 3 ADSL (H) | 0.1401 | 0.1270 | -0.8828 | 0.1707 | 0.1722 | 0.1343 | 0.1455 | 0.1456 |
| 4 ADSL (M) | 0.1085 | 0.0981 | 0.1362 | -0.8562 | 0.1382 | 0.1035 | 0.1176 | 0.1176 |
| 5 ADSL (L) | 0.0990 | 0.0892 | 0.1208 | 0.1216 | -0.8356 | 0.0940 | 0.1000 | 0.1000 |
| 6 CATV | 0.0850 | 0.0805 | 0.0691 | 0.0669 | 0.0696 | -0.9354 | 0.0746 | 0.0750 |
| 7 ISDN | 0.2882 | 0.2499 | 0.2711 | 0.2755 | 0.2675 | 0.2745 | -0.7829 | 0.3135 |
| 8 Dial-up | 0.0784 | 0.0679 | 0.0737 | 0.0749 | 0.0727 | 0.0746 | 0.0847 | -0.5255 |
| *Speed* | | | | | | | | |
| 1 FTTH | 0.0081 | 0.0000 | -0.0006 | -0.0006 | -0.0007 | -0.0008 | -0.0007 | -0.0007 |
| 2 FTTH (CH) | 0.0000 | 0.0073 | -0.0007 | -0.0007 | -0.0008 | -0.0009 | -0.0008 | -0.0008 |
| 3 ADSL (H) | -0.0013 | -0.0012 | 0.0083 | -0.0016 | -0.0016 | -0.0013 | -0.0014 | -0.0014 |
| 4 ADSL (M) | -0.0011 | -0.0010 | -0.0013 | 0.0086 | -0.0014 | -0.0010 | -0.0012 | -0.0012 |
| 5 ADSL (L) | -0.0010 | -0.0010 | -0.0012 | -0.0012 | 0.0087 | -0.0010 | -0.0010 | -0.0010 |
| 6 CATV | -0.0008 | -0.0007 | -0.0006 | -0.0006 | -0.0006 | 0.0087 | -0.0007 | -0.0007 |
| 7 ISDN | -0.0026 | -0.0023 | -0.0025 | -0.0025 | -0.0024 | -0.0025 | 0.0071 | -0.0028 |
| 8 Dial-up | -0.0013 | -0.0011 | -0.0012 | -0.0012 | -0.0012 | -0.0012 | -0.0014 | 0.0086 |
| | | | | Model 2 | | | | |
| *Price* | | | | | | | | |
| 1 FTTH | -2.1918 | 0.0000 | 0.2029 | 0.1904 | 0.1934 | 0.2362 | 0.2150 | 0.1954 |
| 2 FTTH (CH) | 0.0000 | -1.5424 | 0.1391 | 0.1402 | 0.1522 | 0.1690 | 0.1462 | 0.1738 |
| 3 ADSL (H) | 0.2431 | 0.2628 | -1.7647 | 0.3350 | 0.3363 | 0.2592 | 0.2796 | 0.2890 |
| 4 ADSL (M) | 0.1825 | 0.2128 | 0.2697 | -1.7276 | 0.2758 | 0.2038 | 0.2309 | 0.2431 |
| 5 ADSL (L) | 0.1644 | 0.2001 | 0.2406 | 0.2451 | -1.6804 | 0.1872 | 0.1978 | 0.2113 |
| 6 CATV | 0.1435 | 0.1637 | 0.1315 | 0.1286 | 0.1341 | -1.8713 | 0.1416 | 0.1499 |
| 7 ISDN | 0.4921 | 0.5305 | 0.5308 | 0.5460 | 0.5289 | 0.5389 | -1.5577 | 0.6353 |
| 8 Dial-up | 0.1303 | 0.1845 | 0.1603 | 0.1681 | 0.1658 | 0.1656 | 0.1846 | -1.0731 |
| *Speed* | | | | | | | | |
| 1 FTTH | 0.0071 | 0.0000 | -0.0007 | -0.0006 | -0.0006 | -0.0008 | -0.0007 | -0.0006 |
| 2 FTTH (CH) | 0.0000 | 0.0055 | -0.0005 | -0.0005 | -0.0005 | -0.0006 | -0.0005 | -0.0006 |
| 3 ADSL (H) | -0.0012 | -0.0009 | 0.0067 | -0.0012 | -0.0012 | -0.0010 | -0.0011 | -0.0010 |
| 4 ADSL (M) | -0.0009 | -0.0007 | -0.0011 | 0.0067 | -0.0010 | -0.0008 | -0.0009 | -0.0009 |
| 5 ADSL (L) | -0.0009 | -0.0007 | -0.0010 | -0.0010 | 0.0068 | -0.0008 | -0.0008 | -0.0008 |
| 6 CATV | -0.0007 | -0.0005 | -0.0005 | -0.0005 | -0.0005 | 0.0070 | -0.0005 | -0.0005 |
| 7 ISDN | -0.0023 | -0.0017 | -0.0020 | -0.0020 | -0.0019 | -0.0020 | 0.0057 | -0.0021 |
| 8 Dial-up | -0.0011 | -0.0010 | -0.0010 | -0.0010 | -0.0010 | -0.0010 | -0.0011 | 0.0065 |

Note: These have been calculated based on the estimated parameters of Models 1 and 2. Cell entries ($i$, $j$), where $i$ indexes the rows and $j$ indexes the columns, provide the percent change in the market share of access line $j$ with respect to a 1% change in the price or a 1 Mbps change in the download traffic speed of $i$, respectively. For more details, please refer to the text.