

Impact of Fixed Mobile Convergence in Japan

Estimation of Market Size Using Empirical Welfare Analysis

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Abstract

The purposes of this article are twofold. One is to propose a method for the unbiased estimation of calling elasticity, and the other is to gauge the impact of the introduction of fixed mobile convergence (FMC) services on the Tokyo metropolitan market, by applying our estimation method. Since FMC is an emerging service, its definition and service specifications have not yet been well established. At present, FMC can mean anything from a one-stop-billing service to the use of a single handset for both indoor wireless LAN as well as a nationwide mobile network. However, subscribers who do not require high mobility may not be motivated to use FMC services, because indoor FMC telephony may still be more expensive than plain old telephone service (POTS). Thus, it is important for FMC providers to ascertain the characteristics and size of their potential users. The authors have not yet come across any empirical analysis that quantitatively analyzes the impact of FMC on providers as well as subscribers. The second objective of this research is to fill this gap and to gain some instructive insight into the future of the telephone market in Japan.

To achieve the abovementioned research objectives, the authors first estimate the fixed as well as mobile telephone demand function of households, using micro data obtained from households in the Tokyo Metropolitan area between 1997 and 2000. They propose a two-step, three-stage least squares estimation of household telephone demand, which explicitly considers subscription decision-making to obtain an unbiased estimation of the own- and cross-price elasticities. Our results show that the selectivity bias is indeed relevant.

Then, by introducing a few additional assumptions, we can determine the types of households that are likely to subscribe to FMC services and estimate its share and market volume in the Tokyo metropolitan area. Our results show that approximately half of the households pay a surcharge of about \$10 for subscribing to FMC services, if the subscription can reduce their averaged mobile calling fee by 10%.

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Estimation of Market Size Using Empirical Welfare Analysis[†]

Akihiro Nakamura* and Toshiya Jitsuzumi**

1. INTRODUCTION

The purposes of this article are twofold. One is to propose a method for unbiased estimation of calling elasticity, and the other is to calculate an impact of the introduction of fixed mobile convergence (FMC) services into the Tokyo metropolitan market, as an application of our estimation method.

In 1985, the Japanese telecommunications market was opened to competition. Thereafter, the number of telecommunications carriers has risen steadily, reaching at more than 14,000 today. Meanwhile, local and long-distance calling rates have dropped by 15%–25% and 80%–96%, respectively. New services have been aggressively introduced and subscription for mobile phone service now exceeds that for plain old telephone service (POTS). It can be concluded that the Japanese telecommunications policies over the past several decades have been remarkably successful (Jitsuzumi, 2006) and have also been highly evaluated from the viewpoint of economic efficiency (e.g., Cabinet Office [2007]). However, the impact of these policies on income distribution has not been fully analyzed; thus, whether every subscriber has been better off has yet to be known. In order to evaluate the income distribution effect, accurate price elasticity for neighboring telephone services is needed. As previous studies on telephone demand (see Table 1) fail to consider “the calling demands inter-relationship” between mobile phone and fixed telephone services and/or do not consider consumers’ subscription behavior, the authors have been proposing a two-step simultaneous equations household telephone demand system that explicitly considers subscription decision-making of each household, employing a Heckman-Lee two-step approach..

Table 1 Previous Studies on Telephone Demand¹

FMC service is one of the most recent members of telecommunications services. As it is an

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¹ All of these studies—with the exception of Okada and Hatta (1999), Kawamura et al. (2000), Nakamura (2004), Nakamura and Jitsuzumi (2006), and Nakamura et al. (2007)—fail to consider “the calling demands inter-relationship” between mobile phone and fixed telephone services; thus, their estimations are not applicable to the current situation in Japan, where the number of mobile phone subscribers is surpassing that of fixed telephone users, and some consumers (especially the younger generation) tend to subscribe only to mobile phone services. Conversely, Okada and Hatta (1999), Kawamura et al. (2000), Nakamura (2004), and Nakamura and Jitsuzumi (2006) explicitly take neighboring services into consideration, thereby rendering their estimated elasticities a much wider applicability. However, they do not consider consumers’ subscription behavior; that is, their estimates assume that subscription to each telephone service is exogenously fixed. If consumers’ subscription behavior and their telephone usage behavior were mutually related, then without considering their subscription choices, the estimated parameters in telephone usage demand functions would be biased.

emerging service, its definition and service specifications have not yet been well established. Thus, FMC can mean anything from a one-stop-billing service to the use of a single handset under the next generation networks (NGN) that can support any telecommunications services by an IP-based technology. At present, a one-stop-billing service has already been introduced, and Japanese mobile operators now start offering a single handset service that uses WiFi technology indoors and mobile phone technology outdoors in order to realize seamless, inexpensive, and always-on mobile phone connectivity. In 2004, NTT announced that it will start an NGN-based service experimentation in FY2007 and offer an NGN-based FMC service in the near future. As FMC makes the previous market boundary meaningless and opens a wide margin for collaboration between fixed and mobile operators, it may have a grave impact on fair competition in the telecom market, especially concerning regulations for significant market powers. For example, dominant operators in the fixed and mobile markets can work together in the emerging FMC market, or a dominant operator in the fixed market can leverage its monopolistic power in the neighboring mobile market by means of FMC.

Whether such concerns require policy attentions depends on the market size of FMC services. From the viewpoint of subscribers, a currently available WiFi-based FMC service is nothing but a mobile phone service which becomes inexpensive when it is used in subscriber's premises. Although the overall calling fee of FMC may not become as cheap as fixed counterparts and extra monthly charge may be levied, subscribers who highly value mobility will have a reason to subscribe to FMC services. Once consumers start using FMC, those who highly value mobility may stop using the fixed phone services and choose to use their mobile handsets exclusively; therefore, the introduction of FMC could have a negative impact on fixed phone providers. Of course, it is also important from the viewpoint of FMC providers to find out who their users will be and how many of them.

By using the above-mentioned two-step simultaneous equations system, the authors can estimate who will move to this new telecom services and their welfare impact. In addition, by introducing a few additional assumptions for demographic distribution, we can determine what kinds of households will subscribe to FMC and estimate its share and market volume in the Tokyo metropolitan area.

This paper is organized as follows. In the next section, we present our econometric framework for estimating the household telephone demand system. The data description is presented in Section 3; the estimated parameters and their significance levels are presented in Section 4. The simulation result for the impact of introducing FMC service is presented in Section 5. Section 6 concludes this article by providing a brief summary of our findings, issues pertaining to the limitations of this paper and future research directions will be discussed in this section.

2. MODEL

2.1. Two-step model

First, we assumed that all households had already subscribed to POTS, and then each household

faces the decision for subscribing to a mobile phone service (First stage). Thereafter, they determine their budget allocation for the selected telephone services (Second stage), as illustrated in Figure 1.

Figure 1: Assumed decision-making mechanism

Our econometric model is proposed in accordance with a sample selection model in Heckman(1979) and Lee(1982).

2.2. First Stage: Selection Equations

As mentioned earlier, we assumed that all households had already subscribed to POTS before the beginning of the first stage². Then, at the beginning of the first stage, a rational individual household i is faced with the decision of whether or not to subscribe to a mobile phone service in addition to POTS. With regard to the subscription decision for a mobile phone service, we assumed that the decision is made based on the linear indirect utility function expressed below.

$$I_i = Z_i \alpha' + \varepsilon_i$$

where I_i is calculated by subtracting the utility when not subscribing to a mobile phone service from the utility when subscribing to it. ε_i is a normally distributed error term with mean 0. Z_i is a vector of household i 's socio-demographic variables.

To estimate the mobile phone subscription decision, we can employ the probit model.

2.3. Second Stage: Expenditure Function

In the second step, we estimated the telecommunications expenditure function by following the Almost Ideal Demand System (AIDS)³. We express the model for the expenditures of a household that subscribes to a mobile phone service as follows:

$$\ln E(P_1, P_2, P_3; u) = a_0 + \sum_i a_i \ln P_i + \frac{1}{2} \sum_{i,j} b_{ij} \ln P_i \ln P_j + u c_0 P_1^{c_1} P_2^{c_2} P_3^{c_3}$$

where E is the total expenditure amount. $u = \ln(E/P) / c_0 P_1^{c_1} P_2^{c_2} P_3^{c_3}$ is an indirect utility function. P_i denotes a price index of service i .

$i, j \in \{1: POTS \quad 2: mobile\ phone \quad 3: \text{the aggregate consumption of all other goods}\}$

From the perspective of economic theory, an expenditure function requires the following conditions:

² In our sample data, approximately 96% of households subscribed to POTS.

³ For more details of AIDS, see Deaton and Muellbauer (1980).

additivity, symmetry, homogeneity, and concavity. We can impose all these conditions, with the exception of the concavity condition, into the estimation equations as linear constraints. The concavity condition can be examined after the estimation. We can derive the share equations for each telephone service using Shepherd's lemma as follows:

$$S_{POTS} = a_1 + b_{11} \ln \frac{P_1}{P_2} + b_{13} \ln \frac{P_1}{P_2} + c_1 \ln \frac{E}{P} + v_{POTS}$$

$$S_{mobile} = a_3 + b_{13} \ln \frac{P_1}{P_2} + b_{33} \ln \frac{P_3}{P_2} + c_3 \ln \frac{E}{P} + v_{mobile}$$

where S is the budget share of each service. P is an aggregate price index. v is a normally distributed error term with mean 0.

However, the dependent variable in the above mobile phone budget share equation can be observed only when household subscribes to the mobile phone service. Therefore, we use a subsample set of mobile phone subscribers to estimate the expenditure function. In the case limited to the subsample set of mobile phone subscribers, the means of the error terms are generally not equal to 0. This difference represents a self-selection bias. Therefore, following an idea from Heckman-Lee's two-step method, we insert into the share equations the inverse Mill's ratio calculated from the estimation result of the mobile phone subscription function. For the subsample set of mobile phone subscribers, we obtain the unbiased parameter by estimating the following equation:

$$S_{POTS} = a_1 + b_{11} \ln \frac{P_1}{P_2} + b_{13} \ln \frac{P_1}{P_2} + c_1 \ln \frac{E}{P} + \sigma_{SUBmob,SPOTS} \frac{\phi(Z_i \alpha')}{\Phi(Z_i \alpha')} + \omega_{POTS} \quad (1)$$

$$S_{mobile} = a_3 + b_{13} \ln \frac{P_1}{P_2} + b_{33} \ln \frac{P_3}{P_2} + c_3 \ln \frac{E}{P} + \sigma_{SUBmob,Smob} \frac{\phi(Z_i \alpha')}{\Phi(Z_i \alpha')} + \omega_{mobile} \quad (2)$$

where ϕ is a standard normal density function, Φ is a standard normal CDF, $\sigma_{SUBmob,SPOTS}$ and $\sigma_{SUBmob,Smob}$ are the correlation coefficients of ε and each v , respectively, and ω s are normally distributed error terms with mean 0.

In order to confirm whether this sequential estimation is needed, we can statistically test the significance of σ s after the estimation.

Incidentally, the following price index function is consistent with that of an AIDS model. Apart from this price index function, the above share equations system is linear with the same variables appearing in the r.h.s.

$$\ln P = a_0 + \sum_i a_i \ln P_i + \frac{1}{2} \sum_{i,j} b_{ij} \ln P_i \ln P_j$$

This conditional linearity equation system⁴ can be estimated by the Iterated linear least squares estimation method (ILLE) proposed by Blundell and Robin (1999). However, the price index function includes the parameter a_0 , which does not appear in the share equations. This implies that the parameter a_0 does not improve in the iterated processes. Therefore, we simultaneously estimate the price index function with the share equations. We can impose the additivity, symmetry, and homogeneity constraints on the price index function and add the last term for bias adjustment, as in the case of the share equations.

$$\ln \frac{P}{P_2} = a_0 + a_1 \ln \frac{P_1}{P_2} + a_3 \ln \frac{P_3}{P_2} + \frac{1}{2} b_{11} \left(\ln \frac{P_1}{P_2} \right)^2 + \frac{1}{2} b_{13} \left(\ln \frac{P_1}{P_2} \right) \left(\ln \frac{P_3}{P_2} \right) + \frac{1}{2} b_{33} \left(\ln \frac{P_3}{P_2} \right)^2 + \sigma_{SUBmob,p} \frac{\phi(Z_i \alpha')}{\Phi(Z_i \alpha')} \quad (3)$$

The starting value of the aggregated price index number P is calculated by Stone's linear approximated price index. For each iteration process, we precede the three-stage least squares estimation (3SLS)^{5,6} to estimate the two share equations with the price index function. After the estimation, in order to confirm whether it will be justified to incorporate the subscription behavior in determining the demand behavior for telecom services, we can statistically test the significance of the estimated σ s.

3. DATA DESCRIPTION

In this article, we use a data set constructed from the telecom expenditure surveys conducted by the Institute for Posts and Telecommunications Policy (IPTP)⁷ between 1998 and 2001, combined with the telephone traffic data gathered by the Ministry of Posts and Telecommunications (MPT)⁸ for the corresponding periods.

3.1. Questionnaire Data

The IPTP's telecom expenditure survey was designed to collect telephone usage data from individual

⁴ The characteristic of conditional linearity is that the systems are linear in all the parameters of interest conditional on very general functions of explanatory variables and parameters of interest themselves. For more detail, see Blundell and Robin (1999).

⁵ Blundell and Robin proved that ILLE can be applied to three stage least square estimator.

⁶ Constant, population, the number of POTS subscribers, the number of mobile phone subscribers, CPI, and inverse Mill's ratio are used as instrumental variables.

⁷ Currently reorganized as the Institute for Information and Communications Policy (IICP) of MIC.

⁸ In January 2001, MPT was reorganized and combined with three other governmental sectors to form the Ministry of Internal Affairs and Communications (MIC).

households. This survey was conducted at approximately the same time over four consecutive years. The survey target was 15.6 million households in the Tokyo Metropolitan Area, which includes 7 prefectures (Tokyo, Kanagawa, Chiba, Saitama, Gunma, Tochigi, and Ibaraki) and covers 33.8% of the national population. Questionnaire sheets were mailed to addressees who were selected using a stratified multistage random sampling method. In these surveys, respondents were requested to answer questions on several socio-demographic features as well as those on average monthly expenditures for POTS and mobile phone service. The details of the survey's results for each year are summarized in Table 2⁹. The total number of valid responses is 5,268 and the overall collection rate was 13.8%.

Table 2 Survey Specifications

Table 3 Descriptive Statistics of Respondents

3.2. Telephone Traffic Data

The Telecommunications Business Law—more specifically, the Telecommunications Business Report Rule (MPT ordinance No. 46 of 1988)—authorized MPT, and later its successor MIC, to collect telephone traffic data from facility-based telecommunication operators. In this article, the authors constructed a calling price index using these traffic data and used them in estimating calling expenditure functions.

With regard to fixed telephone services, we first calculated the average per-minute calling rate for each talking range bracket by using the revenue/call-duration/talking-range table. Then, by combining these rates with the Origin-Destination (OD) traffic data among the local calling areas, or message areas (MAs), we obtained an average unit calling rate of household subscribers in each MA. These unit rates were obtained for each destination media and were then aggregated into a Theil-Törnqvist calling price index. In order to guarantee transitive consistency across each year and MA, we modified the aggregation procedure by following the Elteto, Koves, and Szulc (EKS) method¹⁰, as proposed by Nakamura (2001).

With regard to mobile services, their traffic data is compiled on the basis of prefecture areas, and not MAs; therefore, we employed the OD traffic data between prefectures and followed the same procedures used for fixed telephone services.

4. ESTIMATION

4.1. Estimation Parameters

First, we estimate the mobile phone subscription function considering the sampling weight¹¹. This

⁹ Please refer to Oishi (1998), Jitsuzumi and Ando (1999, 2000), and Nakamura and Yoshida (2001) for more detailed information on the demographics of mobile phone users.

¹⁰ For details on the EKS method, see Kloek and Theil (1965).

¹¹ In estimating the AIDS model, we also take the respective sampling weights into consideration.

probit equation includes the following independent variables.

SelfEmp: 1 if the householder is self-employed, 0 otherwise

Family: The number of household members

TotalEx: The total household consumption expenditure

U&H_Stu: 1 if the household includes a university or high school student, 0 otherwise

Single: 1 if the household is a bachelor's establishment, 0 otherwise

Male: 1 if the householder comprises a male, 0 otherwise

Table 4 presents the estimated results for the mobile phone subscription function. Most of the estimated parameters, with the exception of *Male*, are statistically significant.

Table 4 Estimated Parameters for the Mobile Phone Subscription Function

After the mobile phone subscription function estimation, we proceed to the estimation of the expenditure function. Although there are two alternative subscription patterns, our interest lies in the cross-price elasticities between POTS and mobile phone services. Therefore, we will proceed to evaluate the mobile phone subscribers. Table 5 shows the estimated results for the households that subscribe to mobile phone services. The parameters in Table 5 are identical to those of equations (1), (2), and (3) in Section 2. By using our estimated parameters, we examined the concavity condition. Our estimation results satisfy this condition at the sample mean.

Table 5 Estimated Parameters of the Expenditure Function

The most noteworthy finding in Table 5 is that the parameters $\sigma_{SUBmob,POTS}$ and $\sigma_{SUBmob,mob}$ are statistically significant. This suggests that the error terms of the mobile phone subscription function and those of the share equations are significantly correlated; further, this finding indicates the necessity of inserting the bias-adjusted terms into the estimation functions in the second stage. In other words, as in the case of the above mobile phone subscription function estimate, it would be impossible to obtain the “unbiased” expenditure function parameters without the bias-adjusted terms.

4.2. Measurement of Price Elasticity

Tables 6, 7, and 8 present the estimated expenditure elasticity, the uncompensated price elasticity, and the compensated price elasticity pertaining to the demand for each good. These figures are evaluated at each variable sample's mean value.

The expenditure elasticity for POTS and mobile phone services takes a negative sign; this implies that these services are inferior goods.

As compared to the own-price elasticity recorded from previous studies that used Japanese data, our

estimation result regarding the uncompensated own-price elasticity for POTS almost assumes a similar level. However, our estimated elasticity level (in absolute value) is considerably larger than that of the other countries. The reason for this difference partly appears to be the difference in the time of sample collection in our study and the previous studies. It is commonly believed that telephone services constitute a necessary commodity. At the time when the previous studies were conducted, there were no phone services other than POTS. Conversely, we now have mobile phones that can be considered as substitutes to POTS. Thus, it is possible that the presence of substitutes increases the own-price elasticity for POTS usage.

Table 6 Estimated Expenditure Elasticity

Table 7 Estimated Uncompensated Price Elasticity

Table 8 Estimated Compensated Price Elasticity

Of particular importance is the large absolute value of the own-price elasticity for mobile phone services. During this period, the mobile phone calling rates were considerably higher than at present and mobile phone services were considered to be one of the additional phone services. Therefore, the higher own-price elasticity for mobile phone services seems acceptable in this period.

For uncompensated cross-price elasticity, it is shown that the uncompensated cross price elasticities for POTS and mobile phone service assumes a positive sign. Thus, the relationship between POTS demand and mobile phone service demand is gross substitutive.

If we observe the compensated cross-price elasticity, we note that all the estimated values are positive. This implies that all services and goods are mutually substitutive.

5. ANALYSIS

In the preceding chapter, we estimate the expenditure function using the household data of the Tokyo Metropolitan Area. In this section, in order to obtain the implications of our empirical demand analysis, we evaluate the welfare impact of declining telephone calling rates and simulate the market size of a fixed mobile roaming service by using our estimation results.

5.1. Simulation of the Equivalent Variation of Unequal Price Decline

First, by using the above estimation results, we can simulate the impact of declining telephone calling rates on households through a policy impact analysis. As mentioned in section 1, the Japanese government has been promoting competitive policies since 1985. We can evaluate these competitive policies by simulating the equivalent variation of the declining phone rates. Table 9 shows the impact of declining telephone calling rates on households. The farthest column on the right-hand side of the second

row presents the estimated change in the monthly equivalent variation of each household when mobile phone calling rates are reduced by 20%, with POTS and the price index of other goods unchanged (i.e., 100%)¹². Among the reduced rates, the predominant effect on households appears to arise from the reduction in the POTS rates.

Table 9 Simulation Results of the Equivalent Variation of Unequal Price Decline

Following the same approach, we can evaluate the impact of declining phone rates on each household's welfare by different income groups. Figure 2 shows a distribution of household's equivalent variations in the various income levels, assuming that the mobile phone rates has declined by 20%. The curve in the figure is fitted with a log-linear function. From this curve, we may infer that the impact of declining mobile phone calling rates on households' welfare becomes stronger as their incomes increase.

Figure 2 The impact of declining phone rates on each household

5.2. Simulation for Fixed Mobile Roaming

In the preceding section, we calculated the changes in the monthly equivalent variation of each household when the prices of certain services are changed. We may infer that each household's monthly equivalent variation of declining phone rates can be equated with the maximum amount of the monthly fixed surcharge for availing a discount in calling rates.

As mentioned in section 1, an NGN-based FMC service might offer, on average, a lower mobile phone rate with extra monthly charge. Assuming that the equivalent variation calculated above is the maximum amount of the monthly fixed surcharge for the lower calling rate service, we can simulate which households subscribe to this type of FMC service under each pair of the monthly fixed surcharge and the discount rate. Undoubtedly, the discount rate probably differs among households because the lower rate may apply to only in-house mobile phone usage. In this case, the more a household uses mobile phones at home, the further does its phone rate decline. Currently, the mobile phone calling rate as per the standard plan is approximately 10 times higher than the inner city fixed phone rate. Under the assumption that the mobile phone rate for in-house usage is the same as the fixed phone, people who use mobile phones about 33% at home would get a 30% discount on the mobile phone rate by subscribing to the FMC service. Unfortunately, our available data set cannot recognize where each subscribing households make mobile phone callings. Therefore, we decided to simulate the transition rate under the assumption that every household avails of the same discount rate offered by the FMC service.

Figure 3 illustrates the simulated transition rates for each surcharge with three different discount rates. First, we simulated each household's equivalent variation of three different discount rates on mobile phone

¹² We calculate dollar-based figures by \$1=114.9yen as the exchange rate of Japanese yen to US\$. It's the spot rate at the end of year 2000.

calling rates. Subsequently, we calculate the transition rates corresponding to each surcharge under the assumption that only the household whose equivalent variation is more than each monthly surcharge will switch to the FMC service. For example, when half the households subscribe to the FMC service, the surcharge is \$39.90/month under the assumption that the FMC service on average decreases the mobile phone calling rate to 70% of the current rate. From Figure 3, we can infer that approximately half the households pay a surcharge of approximately \$10 for subscribing to the FMC service, if this subscription can reduce their average mobile calling fee by 10%.

Figure 3 The transition rates for each pair of monthly fixed fees and discounted calling rates

6. CONCLUSIONS AND ISSUES FOR FURTHER RESEARCH

The purpose of this article is to propose a method for the unbiased estimation of calling elasticity and to gauge the impact of the introduction of FMC services in the Tokyo Metropolitan Area, as an application of our demand analysis

In order to deal with the selectivity bias, we proposed the application of Heckman-Lee's two-step method to the simultaneous demand equation system. Our estimation results reveal that there exists a statistically significant correlation between the error terms of the subscription function and those of the share equations in the AIDS model. This result implies that the selectivity bias is indeed relevant. Therefore, it is reasonable to conclude that our two-step estimation procedure is required for obtaining the unbiased price elasticity.

For the application of our empirical analysis, we simulated the welfare impact of declining phone rates and the transition rate to FMC services by using our estimation results. The following are the main results obtained from our simulation results: the welfare impact of declining mobile phone calling rates on households becomes stronger as their income increases, and approximately half the household subscribe to FMC services, provided the subscription yields a 10% discount at a surcharge of \$10.

Before concluding this article, it is necessary to briefly mention the remaining issues and possible directions for future research. The limitation of our estimated results from the AIDS model is that some of the parameters are not statistically significant. It is crucial to note that the estimation results could be improved by incorporating household attributes—for instance, the number of household members, family savings, etc.—as independent variables in the share equations. In this manner, we could conduct a more detailed welfare analysis from the fairness aspect.

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Tables & Figures

Table 1 Previous Studies on Telephone Demand

Articles	Period	Model	Area/Service	Price	Elasticity Cross Price	Income
Nakamura & Jitsuzumi (2007)	1997-1999	AIDS, 3SLS, 2step	Tokyo Metropolitan Area/Fixed phone Tokyo Metropolitan Area/Mobile phone	-0.8031 -2.5108	Fixed-Mob: 1.5-1.91	-0.4289 -0.1735
Nakamura, Jitsuzumi, & Kawamura (2007)	1997-1999	AIDS, SUR, 2step	Tokyo Metropolitan Area/NTT Tokyo Metropolitan Area/NCC Tokyo Metropolitan Area/Mobile	-1.0978 -1.4794 -0.4253	NTT-NCC: 0.30, 0.48 NTT-Mob: -0.19, -0.18 NCC-Mob: -0.01, -0.004	N/A
Nakamura & Jitsuzumi (2006)	1997-1999	AIDS, SUR	Tokyo Metropolitan Area/NTT Tokyo Metropolitan Area/NCC Tokyo Metropolitan Area/Mobile	-0.89 -4.08 -0.18	NTT-NCC: 0.66, 4.26 NTT-Mob: 0.23, 0.33 NCC-Mob: -0.18, -0.29	1.04 0.71 1.00
Nakamura (2004)	1998-1999	AIDS, 3SLS	Japan/Fixed-Fixed [FF] Japan/Fixed-Mobile [FM] Japan/Mobile-Mobile [MM]	-0.69 -0.03 -1.87	FF-FM: -0.006, -0.004 FF-MM: 1.81, 0.70 MM-FM: 0.03, 0.06	1.02 0.98 1.03
Nakamura (2002)	1996-1998	Fixed & Random Effect	Japan/NTT inter-prefecture Japan/NCC inter-prefecture	-0.19 ~ -0.66 -0.22 ~ -1.40	NTT-NCC: 0.25 ~ 1.05 NTT-NCC: 0.36 ~ 0.56	0.26 ~ 0.85 0.62 ~ 0.63
Kawamura, Jitsuzumi, & Ando (2000)	1998-1999	AIDS, SUR	Tokyo Metropolitan Area/NTT Tokyo Metropolitan Area/NCC Tokyo Metropolitan Area/Mobile	-0.73 ~ -0.75 -0.98 ~ -0.99 -1.34 ~ -1.37	NTT-NCC: 0.10 ~ 0.49 NTT-Mob: 0.50 ~ 0.53 NCC-Mob: 1.39 ~ 1.89	1.05 ~ 1.06 0.60 ~ 0.72 1.0041 ~ 1.0044
Okada & Hatta (1999)	1992-1996	Maximum Likelihood	Japan/Fixed phone Japan/Mobile Phone	-1.41 -3.96	0.87 0.28	0.59 0.67
Rappoport & Taylor (1997)	1994.4-1994.5	OLS	U.S./Inter LATA U.S./Inter LATA Inter State U.S./Total Inter LATA	-0.44 ~ -0.70 -0.42 ~ -0.70 -0.35 ~ -0.50	N/A	N/A
Kawamura (1996)	1989-1994	Fixed & Random Effect, Weighted LS, Censored Regression	Japan/NTT inter-prefecture Japan/NCC inter-prefecture	-1.67 ~ -1.81 -1.16 ~ -1.17	N/A	1.29 ~ 2.99 1.19 ~ 1.30
Munoz (1996)	1985-1989	Fixed & Random Effect	Spain	-0.13	N/A	0.46
Mitomo & Ota (1994)	1990	OLS	Tokyo Metropolitan Area/NTT inter-MA	-1.87 or -0.88	N/A	0.1994
Yamazaki, Imagawa, & Mitomo (1993)	1990	2step OLS	Japan/NTT inter-MA	-1.56 (Tokyo MA)	N/A	N/A
Shiba & Nakatsuma (1993)	1953-1990	OLS, ML, Cocran Orchit	Japan/ NTT	approx. -1.0 ~ approx. -0.2	N/A	approx. 0.55 ~ approx. 0.85
Appelbe et al. (1992)	1979Q1-1988Q4	AR1, Fixed & Random Effect	Canada/Domestic Long Distance/Peak-hours Canada/Domestic Long Distance/Non-peak	-0.26 ~ -0.65 -0.40 ~ -0.83	N/A	N/A N/A
Lang & Lundgren (1991)	1988	Nonlinear Leased Square	Sweden	-0.013 ~ -0.016	N/A	
Appelbe et al. (1990)	1975Q1-1983Q3	AR1, Fixed & Random Effect	Canada/Domestic Long Distance/Peak-hours Canada/Domestic Long Distance/Non-peak	-0.24 ~ -0.54 -0.45 ~ -0.89	N/A	0.56 ~ 1.38 0.72 ~ 1.29
Larson et al. (1990)	1983	AR1, 2step LS	U.S./Domestic Inter-City	-0.75	N/A	0.54
Appelbe et al. (1988)	1977Q1-1986Q4	AR1, Fixed & Random Effect	Canada/Domestic Long Distance/Peak-hours Canada/Domestic Long Distance/Non-peak Canada/Canada-US Long Distance/Peak-hours Canada/Canada-US Long Distance/Non-Peak	-0.21 ~ -0.73 -0.39 ~ -0.75 -0.43 ~ -0.49 -0.45 ~ -0.53	N/A	0.33 ~ 0.95 0.23 ~ 0.79 0.12 ~ 0.74 0.17 ~ 0.54

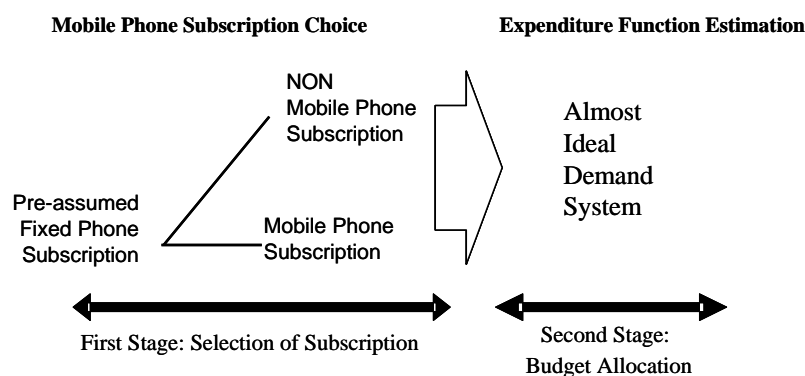


Figure 1: Assumed decision-making mechanism

Table 2 Survey Specifications

Survey	No. 1	No. 2	No. 3	No. 4
Timing	Feb. 1998	Jan. 1999	Jan. 2000	Jan. 2001
Survey area	Tokyo, Kanagawa, Chiba, Saitama, Gunma, Tochigi, and Ibaraki. Isolated islands are not included.			
Dispatch and recovery	Mailing			
Sampling method	Stratified multistage random sampling method using the basic register of residents			
# of sheets dispatched	2,300	11,800	12,000	12,000
# of sheets recovered	1,006	2,061	1,168*	1,033
Collection rate	43.7%	17.5%	9.73%	8.61%

Note*: Monitoring research was simultaneously conducted due to an extremely low initial collection rate.

Table 3 Descriptive Statistics of Respondents

Survey (Year)	Total	No. 1 (1998)	No. 2 (1999)	No. 3 (2000)	No. 4 (2001)
# of Respondents	5,367	1,006 19.1%	2,060 39.1%	1,168 22.2%	1,033 19.6%
Spending (yen)					
Total Expenditures for Telephone Service	14,635.71	12,380.63	14,819.52	14,816.12	16,251.09
S.D.	22,116.43	10,562.31	26,991.62	18,166.26	20,980.28
N	4,375	774	1,949	893	759
(for I-POTS)	7,464.84	7,213.05	7,542.43	7,798.67	7,170.80
(for NCC-POTS)	1,562.68	1,326.78	1,914.70	1,225.46	1,322.20
(for mobile phone service)	5,914.59	4,073.27	5,349.93	6,534.32	8,286.30
Ownership/Subscription Ratio of IT					
Personal Computer	55.4%	37.2%	56.8%	57.5%	67.4%
Word Processor	44.2%	49.6%	43.8%	44.4%	39.3%
Facsimile	48.1%	35.9%	51.2%	47.9%	54.0%
PC network	35.2%	16.0%	34.6%	39.4%	47.2%
Internet	50.5%	20.0%	52.6%	52.6%	67.7%
Other Features					
Annual Income before Tax (in thousand yen)	8,448.18	9,040.04	8,502.92	8,059.54	8,266.35
S.D.	7,531.94	10,184.87	7,042.92	5,947.02	7,331.07
N	4,946	865	1,957	1,126	998
Annual Income after Tax (,000yen)	6,349.73	6,672.39	6,424.09	6,094.46	6,224.50
S.D.	4,979.83	6,178.81	4,741.13	4,518.94	4,799.28
N	4,689	795	1,863	1,082	949
Annual Savings (,000yen)	1,154.90	1,276.11	1,147.47	1,099.62	1,130.64
S.D.	1,695.12	2,457.62	1,555.45	1,486.67	1,362.24
N	4,705	799	1,872	1,083	951
# of Household Members	2.92	3.15	2.93	2.81	2.79
S.D.	1.43	1.49	1.38	1.45	1.40
N	5,267	1,006	2,060	1,168	1,033
(male)	1.46	1.59	1.43	1.42	1.42
(female)	1.46	1.56	1.50	1.39	1.37
(self-employed)	0.22	0.25	0.19	0.21	0.22
(employed, full-time)	1.03	1.09	1.05	0.98	0.96
(employed, part-time)	0.16	0.16	0.16	0.16	0.17
(unemployed, excluding students)	0.73	0.77	0.70	0.74	0.72
(elementary school age or younger children)	0.43	0.42	0.47	0.39	0.38
(junior high school students)	0.10	0.11	0.10	0.11	0.08
(senior high school students)	0.10	0.10	0.09	0.12	0.10
(college, university students)	0.13	0.14	0.14	0.10	0.13
Average Age of Household Members	38.79	39.92	37.29	39.70	39.67
S.D.	15.11	14.86	14.55	15.28	15.99
N	5,151	945	2,029	1,157	1,020
# of Family Members who Live Remotely	0.23	0.14	0.17	1.57	0.22
S.D.	0.67	0.47	0.60	0.95	0.71
N	3,913	880	1,953	130	950
Prefectures					
Tokyo	1,644	287	712	364	330
Share	32.2%	28.5%	34.6%	31.2%	31.9%
Kanagawa	1,133	219	501	245	209
Share	22.2%	21.8%	24.3%	21.0%	20.2%
Saitama	862	179	337	192	176
Share	16.9%	17.8%	16.4%	16.4%	17.0%
Chiba	755	151	288	181	159
Share	14.8%	15.0%	14.0%	15.5%	15.4%
Ibaraki	303	55	89	90	79

Table 4 Estimated Parameters for Mobile Phone Subscription Function

	<i>Coef.</i>	<i>S.D.</i>	<i>P-Value</i>
<i>Constant</i>	-0.6548602	0.06889	(0.000)
<i>SelfEmp</i>	0.2620246	0.06091	(0.000)
<i>Family</i>	0.1883786	0.02792	(0.000)
<i>TotalEx</i>	0.0000003	0.00000	(0.000)
<i>U&H_Stu</i>	0.3379020	0.06586	(0.000)
<i>Single</i>	0.4759892	0.06883	(0.000)
<i>Male</i>	-0.0074848	0.03733	(0.841)
<i>Log of Likelihood at convergence</i>	-2449.454		
<i>Log of Likelihood Index</i>	0.04		

Table 5 Estimated Parameters for the Expenditure Function

	<i>Coef.</i>	<i>S.D.</i>	<i>P-Value</i>
a_0	0.95471	0.26390	(0.000)
a_1	0.27212	0.04798	(0.000)
a_2	0.14243	0.02708	(0.000)
a_3	0.58545	0.19458	(0.001)
b_{11}	-0.00155	0.01990	(0.938)
b_{12}	0.00029	0.01053	(0.978)
b_{13}	0.00126	0.07069	(0.493)
b_{23}	0.02395	0.00873	(0.003)
b_{22}	-0.02424	0.00688	(0.000)
b_{33}	-0.02521	0.06671	(0.353)
c_1	-0.02724	0.00176	(0.000)
c_2	-0.01855	0.00131	(0.000)
c_3	0.04580	0.00249	(0.000)
$\sigma_{SUBmob,POTS}$	0.02968	0.00576	(0.000)
$\sigma_{SUBmob,mob}$	0.01527	0.00421	(0.000)
$\sigma_{SUBmob,P}$	0.12309	0.18046	(0.495)

Table 6 Estimated Expenditure Elasticity

<i>POTS</i>	-0.44682
<i>MobilePhone</i>	-0.37654
<i>Others</i>	1.04733

Table 7 Estimated Uncompensated Price Elasticity

	<i>quantity</i>		
	<i>POTS</i>	<i>MobilePhone</i>	<i>Others</i>
<i>POTS</i>	-0.68340	0.39460	-0.01166
<i>MobilePhone</i>	0.28339	-2.54356	0.01589
<i>Others</i>	0.84683	2.51871	-1.05156

Table 8 Estimated Compensated Price Elasticity

	<i>quantity</i>		
	<i>POTS</i>	<i>MobilePhone</i>	<i>Others</i>
<i>POTS</i>	-0.69181	0.38751	0.00806
<i>MobilePhone</i>	0.27737	-2.54863	0.03001
<i>Others</i>	0.41444	2.15434	-0.03807

Table 9 Simulation Results for Equivalent Variation of Unequal Price Declines

Fixed Phone Price	Mobile Phone Price	Other Goods Price	Monthly Equivalent Variation	Rate of change
100%	100%	100%	US\$0.00 ¥0	0.00%
100%	80%	100%	US\$20.96 ¥2,408	0.68%
80%	100%	100%	US\$29.44 ¥3,383	0.98%
80%	80%	100%	US\$49.41 ¥5,678	1.65%

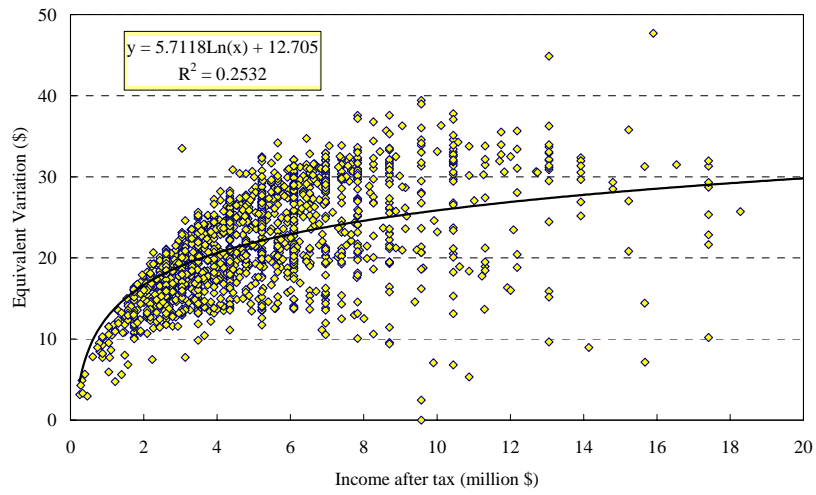


Figure 2 The impact of phone rate declines on each household

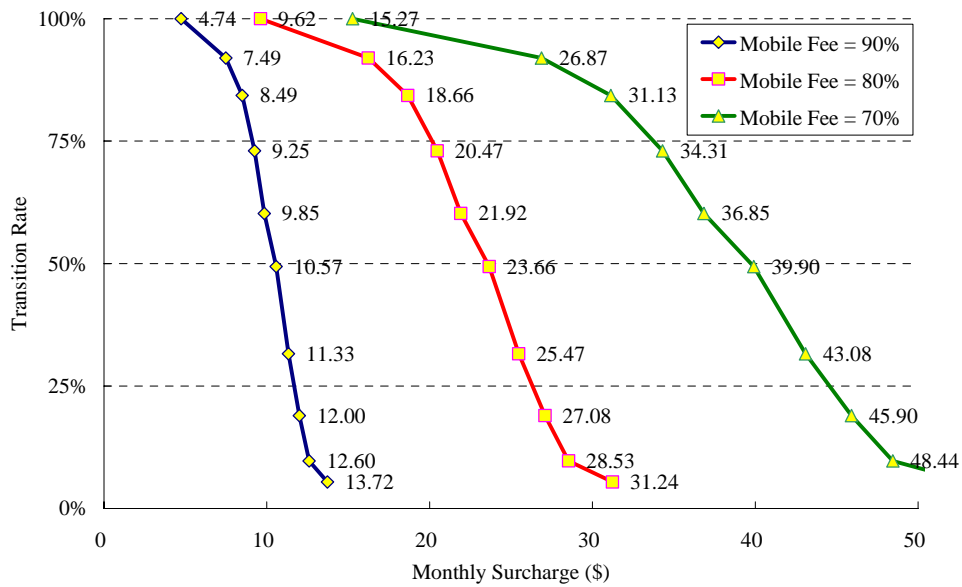


Figure 3 The transition rates for each pair of monthly fixed fee and discounted calling rate