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日本市場における携帯電話と固定電話との代替・競争効果と普及プロセス

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1. Introduction

While the process of diffusion of ICT has been attracting much attention, revolution occurred in the telephony sector is of our research interest. While the fixed telephone (so-called "mainline") has been one of the most widely used technologies in the advanced industrial economies, typically achieving a household penetration rate in excess of 90%, widespread of mobile phone technology in recent years has made this late-comer catch up with the long-existing fixed phone system. The trend of going from the fixed to mobility and from voice-only to voice-and-data has driven the number of mobile phone subscribers worldwide to surge. **Fig. 1** shows the trends in number of fixed phone and mobile phone users per 1000 in the world.

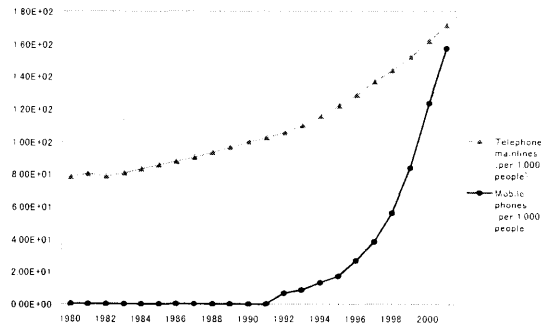


Fig. 1. Trends in number of fixed phone and mobile phone users per 1000 worldwide (1980-2001).

Source: World Development Indicator, (World Bank, 2003).

As the situation in other countries, fixed line phone service had been continuing its steady progress in Japan until 1996. With the empirical data before 1996 offered by MPHPT, Japan, the Simple Logistic Model shows that the potential of fixed line subscription should be 61.8 million as demonstrated in **Fig. 2**.

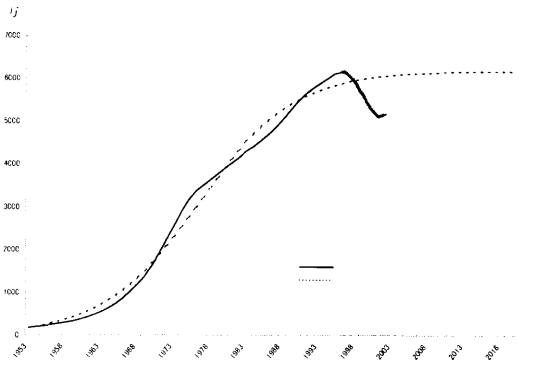


Fig. 2. Observations (1953-2002) and estimates (1953-2020) of mobile subscribers in Japan by Simple Logistic Model (formulated with data before 1996).

In this study, we tried to elucidate the substitution and competition effect between the fixed line phone and the mobile phone market. Besides, how different factors affect the demand of the market is also estimated.

2. Methodology

2.1 Choice-based Substitution Diffusion Model

Define the utility that the i-th potential customer (i.e. non-subscriber) would obtain by choosing not to subscribe or by subscribing to service at time t as:

$$U_{it}^{(0,k)} = V_t^{(0,k)} + \varepsilon_t^{(0,k)} \quad , k = 0, 1, 2 \qquad (1)$$

where $k = 0$, $k = 1$ and $k = 2$ indicate non-subscription, 1st generation (fixed line) and 2nd generation (mobile phone) service subscription, respectively. In the superscript, the first term represents the subscription status of the individual just before the choice, and the second term represents the choice made at time t. Thus, the superscript (0,0) means that the i-th non-subscriber remains a non-subscriber. The superscripts (0,1) and (0,2) mean that the i-th non-subscriber chooses fixed-line service and mobile

service at time t, respectively. In the equation, V and ε denote the deterministic term and the error term of the utility. Assume V is independent of the individual customer and is related only to the attributes (e.g. price, advertising, design, etc.) of each service; the error term, ε, is stochastic and captures both random taste variation across the population and model specification error. These assumptions make it possible to aggregate across individuals. In the second choice situation, the i-th fixed-line subscriber at time t must decide whether to subscriber at time t must decide whether to upgrade. The utility that the i-th fixed-line subscriber would obtain by choosing a specific alternative at time t is defined as follows:

$$U_{it}^{(1,k)} = V_t^{(1,k)} + \varepsilon_t^{(1,k)}, \ k=1, 2 \tag{2}$$

The superscript (1,1) means that the i-th fixed-line subscriber remains an fixed-line subscriber and (1,2) that he upgrades to mobile service.

Based on the model Jun and Park (1999, [2]) proposed, the model for the mobile market in Japan is set up. In order to capture the diffusion and substitution dynamics for successive generations of products as well as for a single generation, the deterministic terms of the utility is specified as follows:

$$\text{When } t < \tau_2, V_t^{(0,0)} = C^{(0,0)} = C, V_t^{(0,1)} = M \times r_1 \tag{3}$$

where r_1 denotes the penetration rate. It shows that the more the penetration rate is, the more consumers' utility is.

When

$$t \geq \tau_2 \quad , \quad V_t^{(0,0)} = C_1^{(0,0)} = C_1 \quad , \quad V_t^{(0,1)} = Q_{01} \times (t - \tau_1 + 1) \quad ,$$

$$V_t^{(1,1)} = Q_{11} \times (t - \tau_1 + 1),$$

$$V_t^{(0,2)} = Q_{02} \times (t - \tau_2 + 1) + \beta_{f02} \times f^2$$

$$V_t^{(1,2)} = Q_{12} \times (t - \tau_2 + 1) + \beta_{f12} \times f^2 + Q_p \times p \tag{4}$$

Equations (2) and (3) indicate that the deterministic part of the non-subscription utility is constant. f means the function index of mobile phone service and p means the monthly price index for subscribing mobile phone service. The time variables account for the diffusion effects related to multiple generations of products. As time passes, a consumer's valuation of a product's attributes usually increases when the product succeeds in the market. When a new product is introduced into the market, information about the product is uncertain and insufficient. However, as more information becomes available to consumers, they can achieve higher levels of utility. For example, with time, more advertising, sales promotion, word-of-mouth, etc., result in an increase in product recognition. Furthermore, the time variables may capture most of the effects of the unavailable attributes (or exogenous variables). While some attributes, such as price, are easily available, others are not easy to quantify or to observe even if they have a significant influence on the decision process of consumers. In such situations, the time variables may explain the effect of factors such as design, sales promotion.

When the error terms ε is assumed to follow independent Gumbel distribution, the probability that a customer, i, subscribes to fixed-line or mobile service at time t is:

$$P_t^{(0,k)} = \frac{\exp(V_t^{(0,k)})}{\exp(V_t^{(0,0)}) + \exp(V_t^{(0,1)}) + \exp(V_t^{(0,2)})}, \ k = 1, 2 \tag{5}$$

where the subscript, i, is omitted because the choice probability choice probability individuals under the assumption that the deterministic terms are independent of the individual.

Similarly, the probability that a fixed-line subscriber upgrades to mobile service at time t is the same for all individuals:

$$P_t^{(1,2)} = \frac{\exp(V_t^{(1,2)})}{\exp(V_t^{(1,1)}) + \exp(V_t^{(1,2)})} \tag{6}$$

Define the total market potential of the choice based model at time t, N_t, as:

$$N_t = N_k, \ \tau_k \leq t < \tau_{k+1} \tag{7}$$

It is possible that the market potential may be unchanged throughout the time period. The total number of subscribers to fixed-line and mobile services at time t-1 is denoted as Y_{t-1}. Then the total number of non-subscribers at time t is ($N_t - Y_{t-1}$). Before the introduction of mobile service ($t < \tau_2$), the expected net number of subscribers at time t for fixed-line service can be defined as:

$$\Delta Y_t^1 = (N_1 - Y_{t-1}) \frac{\exp(V_t^{(0,1)})}{\exp(V_t^{(0,0)}) + \exp(V_t^{(0,1)})} \tag{8}$$

After the introduction of mobile service ($t \geq \tau_2$), the expected net number of subscribers at time t for each service can be defined as:

$$\Delta Y_t^1 = (N_2 - Y_{t-1}) \frac{\exp(I_t^{(0,1)})}{\exp(I_t^{(0,0)}) + \exp(I_t^{(0,1)}) + \exp(I_t^{(0,2)})} - Y_{t-1}^{(1)} \frac{\exp(I_t^{(1,2)})}{\exp(I_t^{(1,1)}) + \exp(I_t^{(1,2)})}$$

$$\Delta Y_t^2 = (N_2 - Y_{t-1}) \frac{\exp(I_t^{(0,2)})}{\exp(I_t^{(0,0)}) + \exp(I_t^{(0,1)}) + \exp(I_t^{(0,2)})} + Y_{t-1}^{(1)} \frac{\exp(I_t^{(1,2)})}{\exp(I_t^{(1,1)}) + \exp(I_t^{(1,2)})}$$

where $Y_t^k = Y_{t-1}^k + \Delta Y_t^k$, $k = 1, 2$ and $Y_t = Y_t^{(1)} + Y_t^{(2)}$ (9)

The first item of each equation in (8) denotes the increase of subscribers who were previous non-subscribers. The second item denotes the upgraders who switch from fixed-line to mobile service.

2.2 Data and software

Data for subscriber base of mobile phone service in Japan, including NonIP and IP mobile phone, is published by Telecommunications Carriers Association (TCA) Japan (2004). Further data about ICT in Japan is retrieved from IT White Book published by Japan Information Processing Development Corporation and from annual survey result of ICT usage style (2003). The empirical analysis, including multi-factor analysis, nonlinear regression and correlation analysis is conducted with the statistical software, SPSS.

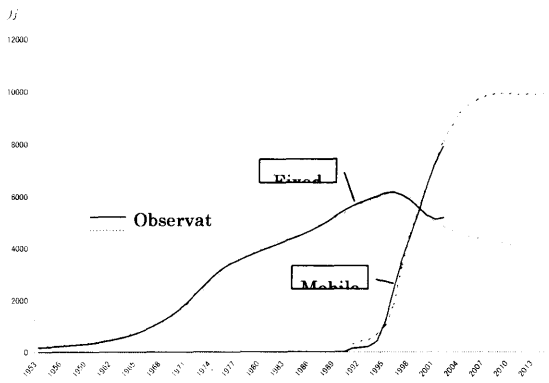
3. Result of analysis and discussion

(1) Empirical result

Since 1996, the diffusion curve of fixed phone line turned down and reached its the peak in 1996, claiming that fixed phone line is no longer an isolated telecommunication industry that could spread out as it had. The possible reason for such dramatic inflection point followed by decline is assumed to be the mobile phone service. As mentioned in the literature review in Chapter 2, mobile phone and fixed phone may be both complements and substitutes to each other. In this section, the markets of both services are integrated by analyzing with the Choice-based Substitution Diffusion Model.

The difficulty in taking mobile phone and fixed phone line subscriber base into a single model lies in the double counting. First, it is quite possible that people who have been using the mainline also sign up to mobile service and become "double subscribers." It is difficult to determine how much percent of the population is constituted of such double users. A solution can be obtained by depending on the annual survey conducted by MPHPT.

The estimated model is illustrated in **Fig. 3**.



$Adj.\ R^2 = 0.994$, $N_1 = 5738.00\,(5.76)$, $N_2 = 10350.02\,(3.22)$,

$C_0 = 121.5\,(1.86)$, $C_1 = 6.50 \times 10^{-1}\,(1.97)$,

$C_2 = 1.67 \times 10^{0}\,(2.67)$, $M = -1.00 \times 10^{1}\,(3.12)$,

$Q_{pm02} = -4.72 \times 10^{-1}\,(2.43)$, $Q_{pm12} = -1.06 \times 10^{0}\ (1.98)$,

$Q_{pm13} = -3.02 \times 10^{0}\,(2.43)$, $Q_t = 1.35 \times 10^{-1}\,(2.37)$

Fig. 3. Observations (1953-2002) and estimates (1953-2015) of mobile subscribers in Japan by Choice-based Substitution Diffusion Model.

[a] Original statistics based on monthly reports by MPHPT, Japan.

[b] Figures in parentheses indicate t-value.

(2) From fixed to mobile telephony, and from voice to data

With such understanding, by compiling the data offered by MPHPT, Japan on the trends in number of fixed mainline, mobile phone, PHS and ISDN subscribers in Japan as illustrated in **Fig. 4**, the trends in "portable" and "non-portable" telephony subscription as well as "voice-only" and "data and voice" telephony subscription can be compared as illustrated in Fig. 4. "Portable" category contains mobile phone and PHS services while

"non-portable" represents fixed phone and ISDN. "Voice-only" category contains "fixed mainline" while "data-and-voice" consists of "ISDN," "mobile phone" and "PHS."

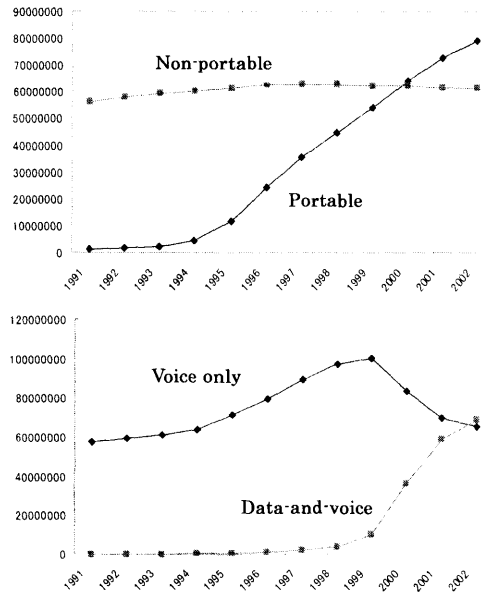


Fig. 4. Trends in number of "portable" and "non-portable" telephony subscription and number of "voice-only" and "data-and-voice" telephony subscription in Japan (1991-2002).

Source: Compiled base on data from MPHPT, Japan.

4. Conclusion

(i) The subscription of fixed line phone has started to decline after reaching the peak in 1996. It is considered that the complementary feature between mobile and fixed line telephone is the reason for such decrease in a matured fixed phone line market.

(ii) By taking mobile and fixed line telephony as two generations of telephony with substitutability and analyzing with the Choice-based Substitution Diffusion Model, it is demonstrated that the potential of the overall telephony can be about 100 million, consisting of double-subscribers who sign up to both mobile phone and fixed line phone.

(iii) Consumers' utility to adopt fixed line phone increase as time goes by before mobile phone is introduced but deceases with time after mobile phone appeared in the market. The price of monthly subscription fee of mobile phone is a negative factor for users to adopt or switch to mobile phone; moreover, the double- subscribers reveal the highest price elasticity and non subscribers seem to consider price less than those who have already subscribed to either one service. The result is attributed to that fact that for people who have not yet adopted any telephony service, they have higher need to subscribe than those who just consider to switch.

(iv) Moreover, even after mobile phone is introduced into the market, existing subscribers of fixed line phone still tend to continue such subscription as long as the price of mobile phone does not drop too much.

(v) In both mobile and fixed line telephony cases, it is observed that voice-only service is occupying less and less share of communication market while data-and-voice service is still growing. With only mobile and fixed line telephony taken into consideration, the substitution effect lead the subscription of fixed line phone to decrease; however, including the impact by the Internet access demand, the fixed line phone demand will decrease less than analyzed with this model.

References

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