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Factors of FTTH Deployment in Japan: A Panel Data Analysis

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Abstract

In accordance with the development of broadband services, interests are focused on the deployment of optical fiber and various reports and researches are published, including “Next Generation Connectivity” by the Berkman Center, Harvard University, and “Indicators of Broadband Coverage” by OECD. These analyze the international comparison of broadband penetration or how U.S. and EU lag behind. Less analysis was, however, spent how Japan constructed the most successful FTTH networks all over the country. The objective of this paper is to identify factors promoting deployment of Japanese FTTH in the competitive environments utilizing the panel data analysis and the prefectural panel data of subscribers. Major deregulations including unbundling, openness of facilities, connection charges and collocations were already implemented. The problem occurred in this process, however, is that the share of NTT locals in the FTTH market locals has been increasing and reached more than 70%. Moreover, the NTT locals’ share in the total four broadband markets including FTTH, cable modem, ADSL and FWA becomes also more than 50%. This paper attempts to explain this reason. Recently, however, the situation has been changing, namely competition has been more severe in the metropolitan and populated areas, which is promoted by power companies and KDDI. This paper also focuses on current changes in the FTTH market, and explains how these are different from the previous period. Lessons learned from Japanese experiences will provide good reference to other economies to deploy FTTH.

Keywords: FTTH; broadband connectivity; panel data analysis; unbundling; migration; HHI.

1. Introduction

FTTH (Fiber To The Home) has already covered residential areas by nearly 100% in the main part of metropolitan areas in Japan, and no other countries all over the world can be found that have such diffusion. FTTH can not only transmit large amount of data instantly, but also provide voice and video services with one single line (Triple-play). Therefore, it will be expected to contribute various industries other than telecommunications. Heavy users of the Internet have already migrated from ADSL to FTTH, and the former subscribers are declining. In addition, NTT East and West announced to start new broadband services based on their NGN (Next Generation Network) in April 2008, which make it possible to transmit high speed and large volume of images with guaranteed quality (NGN is not of best effort). This is the one we waiting for in the age of broadband, and NGN becomes possible in the existence of FTTH.

1.1. Objectives of the paper

Japan has taken a worldwide lead in FTTH, with 17.8 million subscribers as of March 2010. Japan has been the first country to experience this transformation. Based on this development, NGN services started in 2008. This paper analyzes factors promoting Japanese FTTH. Tsuji and Tomizuka [2006], Akematsu [2008a], [2008b], and Tsuji and Akematsu [2010] summarized factors promoting Japanese broadband as follows: (1) deregulations by the government; (2) competition among carriers; and (3) technological development. The paper identifies exactly which factors facilitating Japanese FTTH development, especially focuses on how subscribers migrate from ADSL to FTTH. In so doing, this paper utilizes the panel data analysis, and due to the availability of related data, instead of subscribers of carriers, the prefectural panel data of subscribers are used. In estimation, explanatory variables which promote FTTH development are the number of cable modem and ADSL subscribers as competing broadband technology, and the number of FTTH carriers operating particular prefecture. Since Tsuji and Akematsu [2010] analyzed FTTH diffusion using prefectural panel data models (pooled data model), this paper separates the nation into two parts, the Eastern and Western Japan and attempts to identify factors promoting Japanese FTTH. This paper thus aims at explaining how Japan takes lead in FTTH services.

1.2. Literature review

With respect to studies on the broadband diffusion factors, there have been

various opinions and discussions on the government policies such as deregulations for broadband diffusion and competition, business strategies of operators, and attributes of each country, in the scope of one single country or region, or multiple countries.

For studies on broadband in a single country, one example can be found in the analysis on broadband markets conducted by the US Federal Communications Commission (FCC [2010]), which focuses on the level of education, income, and other attributes found in multiple areas throughout the US. Similarly, Tsuji and Akematsu [2010] attempted to identify factors promoting Japanese FTTH using panel data analysis based on prefectural data by focusing how subscribers migrate from ADSL to FTTH. Other studies on the Japanese ADSL market include Tsuji and Tomizuka [2006] and Akematsu [2008a] and [2008b] made positive analyses of ADSL diffusion factors, suggesting that the driving force of ADSL diffusion throughout Japan is the open-access policy for metal subscriber lines.

For studies on broadband, within a region as shown by FCC [2010] and Commission of the European Communities [2009], or among several countries, as shown by Kushida [2006] and [2009], Fiona [2009], and Scott [2009], one of the most prominent works is the research conducted by the Berkman Center for Internet and Society, Harvard University (Berkman Center [2010]). The research analyzes a wide range of broadband diffusion factors, including competition-related issues such as diffusion rates, access speeds, costs, etc. as well as government policies for broadband diffusion and competition, operators' investments, attributes of the country and other factors. The Center examines a broadband diffusion policy including state aid in each country, while studying broadband competition policies and suggesting a correlation between countries with the open-access policy (unbundling, etc.) for subscriber lines that are irreproducible and high broadband diffusion rates.

This paper consists of four sections: Section 2 describes the FTTH market in general. In Section 3, data for estimation is summarized and also this section formulates our methodology of estimation and presents the results. Discussions and brief conclusions including some prospects of this research are provided in Section 4 and 5.

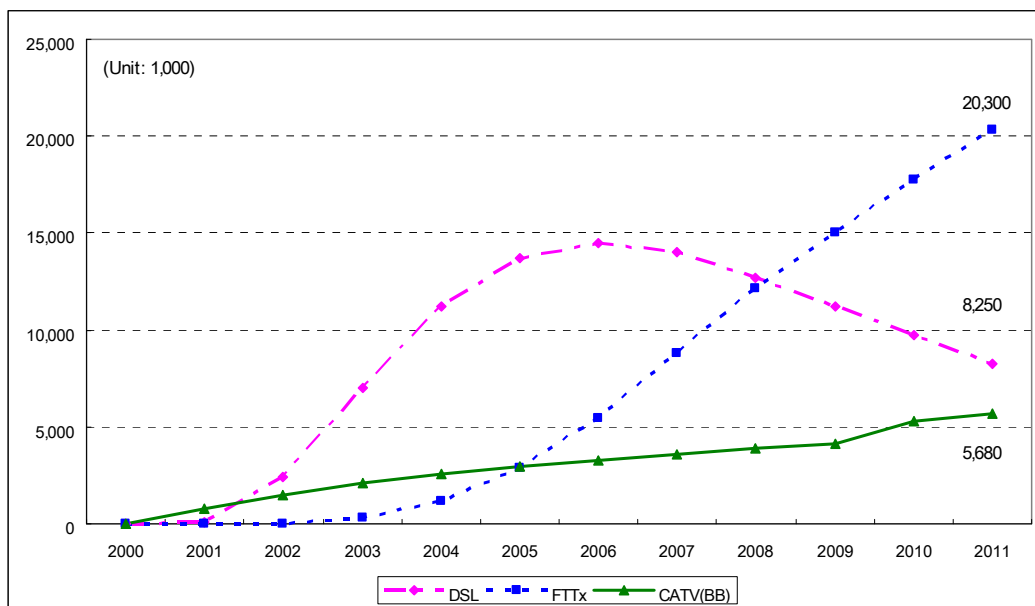
2. FTTH MARKET

Here the current situation of Japanese FTTH market is present as a premise to the analysis.

2.1. Broadband market in Japan

One of the defining characteristics of broadband services in Japan is its sequential development, which began with PSTN (analog telephone network) and ISDN before the launch of broadband services, then moved to broadband systems such as cable modem and DSL, and later on to FTTH, as Figure 1 shows.

The trend of subscribers of broadband is summarized in Figure 1. The first transformation of broadband was right after year 2000, when ADSL services was introduced. Due to the deregulations such as unbundling, collocations, market competition promoted sharply an increase in ADSL. In the middle of 2000s, the number of subscribers of FTTH was increasing rapidly, while that of ADSL showed peak out and started declining, which was termed by “migration from ADSL to FTTH.” The number of FTTH subscribers exceeded those of ADSL at the end of June 2008, that is, FTTH comes to be major in Japanese broadband, which was the second transformation of broadband. The number of subscribers of CATV is slightly increasing.



(Unit: 1,000)

Figure 1: The number of broadband subscribers in Japan

Source: Ministry of Internal Affairs and Communications, and various company publications

2. 2. FTTH market

Different from the ADSL market, one of the issues related to Japanese FTTH is dominance of NTT locals in the market. There are two sub-markets of FTTH; condominiums and single house. Among approximate 17.8 million subscribers of the whole market, the former amounts to 10.1 million subscribers (59.4%), while the latter to 7.2 million (40.6%). As for the FTTH market as a whole, the share is as follows: NTT locals (74.42%), power companies (9.2%), KDDI (8.0%), and USEN (3.0%) as of March 2010. The market share of condominiums is NTT locals (70.1%), KDDI (8.0%), USEN (6.7%), power companies (5.8%), while in the market of single house, NTT locals (77.56%), Power companies (11.5%) and KDDI (8.0%) as of March 2010. NTT's share has been gradually increasing, and it is expected that NTT dominates the market.

A big difference regarding competition in the FTTH market in comparison with ADSL is that carriers have to deploy optical fiber to single houses or condominiums by themselves, since there can be no line sharing which is popular in the ADSL market. In 2005, the "shared access system" was introduced, in which carriers could borrow NTT locals' optical fiber network. This system, however, does not work as well as the line sharing of ADSL. Thus, more deregulation is required to promote competition in the FTTH market. The Japanese success of ADSL development is due largely in part to a good cycle of deregulation and effective market competition: deregulation caused competition, while competition demanded further deregulation. After all, subscribers (consumers) can obtain economic benefits. This is a lesson well learned from the Japanese ADSL experience, but one not yet fully applicable to this market.

Deregulation was almost completed in the early stage of ADSL. Openness of copper lines was also applied to FTTH subscriber lines, and Japan is an only country to admit this, while other countries do not since it harms for carriers to invest in FTTH subscriber lines. The owners of FTTH networks such as telecommunication carriers, power companies, CATV, water subways, etc. are obliged to open their networks to other competitors. The openness is aimed at introducing service-based competition in the FTTH market. The competitors' use of NTT's FTTH subscriber line remains only 0.5 percent, which is not similar to ADSL case. Power companies and KDDI, for example, entered the market by constructing their own FTTH subscriber networks, and thus even in Japan, service-based competition is not fully promoted.

The Implementation and events of the FTTH market which contributed to diffusion is summarized in Table 1. Most of implementations and events are related not only FTTH, but also ADSL, or other broadband technology. Therefore, many

deregulations have implemented before FTTH services started, and thus it may be difficult to extract factors related to deregulation which promote FTTH.

Table 1 Implementation and Events of FTTH Market

| Time | Events |
|-----------|---|
| Apr. 2001 | Revision and enforcement of Telecommunications Business Law Enforcement Rule and connection fee rule (Unbundling of dark fiber) |
| Jun. 2001 | Enactment of notification (Stipulation of information on collocation be disclosed free of charge) |
| Nov. 2001 | Inauguration of the Telecommunications Business Dispute Settlement Commission (Mediation and arbitration became possible) |
| Sep. 2005 | NTT started optical IP telephony service (“ <i>Hikari-Denwa</i> ”). |
| Mar. 2008 | Revision of connection fee rule of dark fiber. |

Source: MIC and NTT

The factors which effect FTTH diffusion are represented by migration, competition among broadband technology, and charges. The other factors and the data for estimation will be summarized in the next section.

3. ESTIMATION

In the previous paper, Tsuji and Akematsu [2010] extensively analyzed the FTTH market such as market as a whole, single house and condominium sub-markets using prefectural data by focusing the migration from ADSL to FTTH. This paper, on the other hand, attempts to examine the difference between the Eastern and Western Japan in the same framework.

3.1. Model specification and data

As mentioned, this paper attempts to estimate factors promoting FTTH in two geographical markets, the Eastern and Western Japan. The motivation of the analysis is that FTTH market is quite different in two part of Japan. In Eastern Japan, there is no strong competitor, and accordingly the share of NTT East has been increasing, while in Western Japan, power companies have been challenging NTT West which share is relatively lower than NTT East. Thus, we hypothesize the latter is more competitive than the latter. By estimating two models separately, this paper clarifies the factors promoting Japanese FTTH.

In addition, the FTTH market can be divided into two sub-markets such as single house and condominium and in terms of competition these two markets have different characteristics. These two markets are examined separately. As already mentioned, NTT locals have the majority of market share, not only whole FTTH market but also two sub-markets. This paper also examines separately subscribers of NTT locals. Accordingly, we estimate the following estimations: (i) Eastern Japan (whole, single house and condominium markets); (ii) Western Japan (whole, single house and condominium markets); (iii) NTT East (whole market); and (iv) NTT West (whole market).

The method we use here is panel data models using prefectural data, after estimating fixed effect model and random effect model, the best model is selected according the F test, the Lagrange Multiplier test, and the Hausman test. The general model for estimation in common for these markets is formulated as follows.

$$\begin{aligned} \ln(FTTH_{it}) &= \alpha_0 + \alpha_1 \ln(price_{it}) + \alpha_2 \ln(GDP_t) + \alpha_3 \ln(CATV_{it}) + \alpha_4 \ln(ADSL_{it}) \\ &\quad + \alpha_5 \ln(HHI_{it}^{Intra}) + \alpha_6 \ln(HHI_{it}^{Inter}) + u_{it} \\ u_{it} &= \lambda_i + v_{it} \quad (v_{it} \sim iid(0, \sigma_v^2)) \end{aligned}$$

where $FTTH_{it}$, $ADSL_{it}$, and $CATV_{it}$ denotes the number of subscribers of each broadband technology (per 100 people), $price_{it}$ monthly subscription charges (per 1Mbps and normalized by Consumer Price Index of each prefecture), GDP_t real GDP (also normalized by CPI), $Intra-HHI_{it}$ and $Inter-HHI$ Herfindahl-Hirschman Index of the FTTH and broadband market, respectively. An error term is assumed to consist of one-way fixed effect where λ_i is a fixed effect and $v_{it} \sim iid(0, \sigma_v^2)$. Finally, i denotes prefecture and t quarter. Related to HHIs, there are only 4 biennial data for each region, and these data are transformed to annual then to quarter data by approximating them linearly. The sample period is from the third quarter of 2005 to the last quarter of 2011.

The explanatory variables are the number of cable modem subscribers as alternative technology, and the sign of cable modem coefficient is assumed to be negative. $Intra-HHI$ and $Inter-HHI$ present the degree of competition in the market. The more carriers enter the market, the more subscribers grow due to intense market competition. But one carrier dominates the market, and the number of subscriber would not increase. The signs of HHIs are expected to be negative. On the variable of ADSL,

the more subscribers one region has, the more people migrate to FTTH in that region naturally.

The sources of data and summary statistics are summarized in Table 2 and Table 3 and 4, respectively.

Table 2 Sources of Data

| Variables | Source |
|--------------------------------------|---|
| FTTH ADSL CATV | Ministry of Internal Affairs and Communications (http://www.johotsusintokei.soumu.go.jp/) |
| Price | Reports of MIC |
| GDP | Data from National Accounts of Japan (SNA) (http://www.esri.cao.go.jp/jp/sna/) |
| <i>Intra</i> -HHI, <i>Inter</i> -HHI | Reports of MIC |
| Population | Data from Statistics Bureau and the Director-General for Policy Planning (http://www.stat.go.jp/data/jinsui/) |
| CPI | Data from Statistics Bureau and the Director-General for Policy Planning (http://www.stat.go.jp/data/cpi/) |

Source: Author

3.2. Result of Estimation I: whole market

First, the estimation of the whole FTTH market (single house and condominium markets together) is conducted, and the result is shown in Table 4. Let us summarize the results as follows:

- FTTH Price: West Japan ($p < 0.1$) only satisfies the sign condition, and its price elasticity is -1.79.
- GDP: All Japan ($p < 0.01$) and West Japan ($p < 0.01$) satisfy the sign condition.
- ADSL: This is positively significant in all cases ($p < 0.01$), which shows the general trend of migration from ADSL to FTTH.
- CATV: All Japan satisfies the sign condition ($p < 0.05$) indicating that FTTH is substitute to CATV.
- Intra-platform HHI: All Japan ($p < 0.01$), East Japan ($p < 0.05$), and West Japan ($p < 0.1$) are negatively significant. Competition among FTTH carriers promotes diffusion.
- Inter-platform HHI: All Japan ($p < 0.01$), East Japan ($p < 0.01$), and West Japan ($p < 0.01$) are negatively significant. The coefficient of East Japan Inter-HHI is the

largest. FTTH diffusion has been enhancing by competition among broadband technologies such as ADSL and CATV.

Table 3 Summary Statistics (Eastern Japan)

| | Obs. | Mean | S.D. | Min | Max |
|---|------|--------|-------|--------|--------|
| All Japan | | | | | |
| No. of subscribers: FTTH (Condominium+Single house) | 1222 | 11.840 | 1.169 | 9.076 | 15.011 |
| No. of subscribers: FTTH (Single house) | 1222 | 11.506 | 1.041 | 8.821 | 14.003 |
| No. of subscribers: FTTH (Condominium) | 1222 | 10.449 | 1.488 | 6.242 | 14.556 |
| Price (FTTH) | 1222 | 8.589 | 0.056 | 8.393 | 8.742 |
| Price (FTTH: Single house) | 1222 | 13.307 | 0.022 | 13.250 | 13.395 |
| Price (FTTH: Condominium) | 1222 | 12.819 | 0.020 | 12.774 | 12.897 |
| GDP | 1222 | 17.760 | 0.030 | 17.695 | 17.827 |
| No. of subscribers: ADSL | 1222 | 11.954 | 0.885 | 10.217 | 14.564 |
| No. of subscribers: Cable modem | 1222 | 10.678 | 1.243 | 6.545 | 13.744 |
| Intra-Platform HHI (FTTH) | 1034 | 8.708 | 0.271 | 8.136 | 9.152 |
| Intra-Platform HHI (FTTH: Single house) | 1034 | 8.838 | 0.217 | 8.461 | 9.180 |
| Intra-Platform HHI (FTTH: Condominium) | 1034 | 8.519 | 0.348 | 7.689 | 9.158 |
| Inter-Platform HHI | 1222 | 8.380 | 0.152 | 8.115 | 8.899 |
| East Japan | | | | | |
| No. of subscribers: FTTH (Condominium+Single house) | 442 | 12.168 | 1.257 | 9.226 | 15.011 |
| No. of subscribers: FTTH (Single house) | 442 | 11.755 | 1.097 | 8.936 | 14.003 |
| No. of subscribers: FTTH (Condominium) | 442 | 10.948 | 1.570 | 7.530 | 14.556 |
| Price (FTTH) | 442 | 8.576 | 0.067 | 8.393 | 8.712 |
| Price (FTTH: Single house) | 442 | 13.321 | 0.020 | 13.283 | 13.395 |
| Price (FTTH: Condominium) | 442 | 12.812 | 0.020 | 12.774 | 12.886 |
| GDP | 442 | 17.761 | 0.031 | 17.701 | 17.827 |
| No. of subscribers: ADSL | 442 | 12.373 | 0.873 | 10.764 | 14.564 |
| No. of subscribers: Cable modem | 442 | 10.641 | 1.571 | 6.545 | 13.744 |
| Intra-Platform HHI (FTTH) | 374 | 8.812 | 0.285 | 8.162 | 9.122 |
| Intra-Platform HHI (FTTH: Single house) | 374 | 8.977 | 0.179 | 8.658 | 9.180 |
| Intra-Platform HHI (FTTH: Condominium) | 374 | 8.602 | 0.346 | 7.756 | 8.993 |
| Inter-Platform HHI | 442 | 8.440 | 0.147 | 8.182 | 8.899 |
| West Japan | | | | | |
| No. of subscribers: FTTH (Condominium+Single house) | 780 | 11.655 | 1.073 | 9.076 | 14.443 |
| No. of subscribers: FTTH (Single house) | 780 | 11.365 | 0.982 | 8.821 | 13.765 |
| No. of subscribers: FTTH (Condominium) | 780 | 10.166 | 1.361 | 6.242 | 13.734 |
| Price (FTTH) | 780 | 8.596 | 0.047 | 8.462 | 8.742 |
| Price (FTTH: Single house) | 780 | 13.299 | 0.019 | 13.250 | 13.373 |
| Price (FTTH: Condominium) | 780 | 12.823 | 0.019 | 12.774 | 12.897 |
| GDP | 780 | 17.759 | 0.030 | 17.695 | 17.825 |
| No. of subscribers: ADSL | 780 | 11.717 | 0.801 | 10.217 | 13.901 |
| No. of subscribers: Cable modem | 780 | 10.699 | 1.012 | 8.275 | 13.541 |
| Intra-Platform HHI (FTTH) | 660 | 8.649 | 0.244 | 8.136 | 9.152 |
| Intra-Platform HHI (FTTH: Single house) | 660 | 8.760 | 0.197 | 8.461 | 9.163 |
| Intra-Platform HHI (FTTH: Condominium) | 660 | 8.471 | 0.340 | 7.689 | 9.158 |
| Inter-Platform HHI | 780 | 8.346 | 0.145 | 8.115 | 8.794 |

Source: Author

Table 4 Result of estimation (Whole market)

| Dependent variable: No. of subscriber (FTTH): 2005Q3~2011Q4 | All Japan | East Japan | West Japan |
|--|------------------------------------|------------------------------------|------------------------------------|
| Price (FTTH) | -1.066 [0.684] | -1.307 [1.179] | -1.789* [0.925] |
| GDP | 1.783*** [0.345] | 0.477 [0.581] | 2.409*** [0.424] |
| No. of subscribers (ADSL) | 0.369*** [0.068] | 0.801*** [0.133] | 0.275*** [0.083] |
| No. of subscribers (CATV) | -0.018** [0.009] | -0.014 [0.016] | -0.011 [0.010] |
| Intra-Platform HHI | -0.347*** [0.103] | -0.314** [0.157] | -0.253* [0.147] |
| Inter-Platform HHI | -1.028*** [0.105] | -1.348*** [0.147] | -0.690*** [0.163] |
| Constant | -14.889* [8.590] | 13.543 [14.805] | -23.605** [11.215] |
| Observations | 843 | 312 | 531 |
| Number of ID (Prefecture) | 47 | 17 | 30 |
| R-squared | 0.195 | 0.416 | 0.241 |

Standard errors in brackets

*** p<0.01, ** p<0.05, * p<0.1

3.3. Result of Estimation II: Single house market

Here the result of estimation on the market of single house, which is shown in Table 6. The following variables are significant.

- FTTH Price: East Japan only satisfies the sign condition ($p<0.01$), and its price elasticity is -5.36.
- GDP: All Japan ($p<0.01$) and West Japan ($p<0.01$) satisfy the sign condition.
- ADSL: All Japan ($p<0.01$), East Japan ($p<0.01$), and West Japan ($p<0.1$) satisfy the sign condition and they are positively significant. In particular, East Japan shows larger migration from ADSL to FTTH.
- CATV: All Japan ($p<0.05$) and West Japan ($p<0.05$) satisfy the sign condition indicating that FTTH is competing more severely with CATV in West Japan. This is consistent with the fact such that Western Japan contains prefectures with high CATV diffusion rate such as Mie and Ohita.

- Intra-platform HHI: All Japan ($p < 0.01$) and East Japan ($p < 0.01$) are negatively significant. Since the Eastern Japan has larger share of single house in broadband than the Western Japan, this fact causes the result.
- Inter-platform HHI: All Japan ($p < 0.01$), East Japan ($p < 0.01$), and West Japan ($p < 0.01$) are negatively significant. The coefficient of East Japan Inter-HHI is the largest. FTTH in the Eastern Japan, diffusion has been enhancing by competition with other broadband technologies.

Table 5 Result of estimation (Single house)

| Dependent variable: No. of subscriber (FTTH): 2005Q3~2011Q4 | All Japan | East Japan | West Japan |
|--|-----------------------------|-----------------------------|-----------------------------|
| Price (FTTH) | -1.223 [1.050] | -5.364*** [1.997] | 0.315 [1.207] |
| GDP | 1.337*** [0.363] | 0.828 [0.646] | 1.497*** [0.427] |
| No. of subscriber (ADSL) | 0.354*** [0.078] | 0.860*** [0.157] | 0.167* [0.094] |
| No. of subscriber (CATV) | -0.020** [0.009] | -0.003 [0.018] | -0.022** [0.010] |
| Intra-Platform HHI | -0.462*** [0.140] | -0.698*** [0.248] | -0.212 [0.173] |
| Inter-Platform HHI | -0.905*** [0.118] | -1.131*** [0.194] | -0.686*** [0.157] |
| Constant | -0.197 [15.395] | 68.994** [29.256] | -27.87 [17.865] |
| Observations | 843 | 312 | 531 |
| Number of ID (Prefecture) | 47 | 17 | 30 |
| R-squared | 0.185 | 0.308 | 0.13 |

Standard errors in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

3.4. Result of Estimation III: Condominium

Finally, the result of estimation of the condominium market is shown in Table 6, which can be summarized as follows:

- FTTH Price: West Japan ($p < 0.01$) only satisfies the sign condition, and its price elasticity is -7.80, which is quite high. This is opposite result to the single house market, in which East Japan shows higher price elasticity.
- GDP: All Japan ($p < 0.05$) and West Japan ($p < 0.01$) satisfy the sign condition.

- ADSL: All Japan ($p < 0.01$), East Japan ($p < 0.01$), and West Japan ($p < 0.01$) satisfy the sign condition and they are positively significant. In particular, East Japan shows larger migration from ADSL to FTTH. No difference can be found between East and West Japan.
- CATV: All three variables are not significant.
- Intra-platform HHI: All Japan ($p < 0.01$), East Japan ($p < 0.01$), and West Japan ($p < 0.01$) are negatively significant. There is no difference among three variables. In the condominium market, competition among FTTH carriers is severe.
- Inter-platform HHI: All Japan ($p < 0.05$) and East Japan ($p < 0.01$) are negatively significant, while West Japan is not.

Table 6 Result of estimation (Condominium)

| Dependent variable: No. of subscriber (FTTH): 2005Q3~2011Q4 | All Japan | East Japan | West Japan |
|---|-----------------------------|-----------------------------|----------------------------|
| Price (FTTH) | -6.786*** [2.507] | -1.485 [3.980] | -7.798** [3.469] |
| GDP | 2.556** [1.009] | -0.472 [1.325] | 4.396*** [1.397] |
| No. of subscriber (ADSL) | 0.868*** [0.165] | 0.828*** [0.312] | 0.752*** [0.223] |
| No. of subscriber (CATV) | -0.003 [0.025] | -0.027 [0.037] | 0.003 [0.033] |
| Intra-Platform HHI | -0.341*** [0.132] | -0.465* [0.248] | -0.316* [0.168] |
| Inter-Platform HHI | -0.695** [0.272] | -1.009*** [0.385] | -0.623 [0.415] |
| Constant | 45.762 [34.362] | 35.255 [54.934] | 24.995 [46.673] |
| Observations | 814 | 298 | 516 |
| Number of ID (Prefecture) | 47 | 17 | 30 |
| R-squared | 0.156 | 0.202 | 0.125 |

Standard errors in brackets
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

3.5. Summary of analysis

The above three analyses show that Japanese FTTH as a whole promoted by competition with other technologies such as ADSL and CATV, which can be seen as migration to FTTH. In addition, completion among carriers in the FTTH market as well as in the three broadband markets is high so that diffusion of FTTH is enhanced. In

comparison with East and West Japan, It seems that East Japan is more competitive than West Japan. This is not consistent with the reality, and more elaborate estimation is required. Table 7 shows the summary of the above estimations.

Table 7 Summary of estimations

| | Total | | | Single House | | | Condominium | | |
|---------------------------|-----------|------|------|--------------|------|------|-------------|------|------|
| | All Japan | East | West | All Japan | East | West | All Japan | East | West |
| Price (FTTH) | | | - | | - | | - | | - |
| GDP | + | | + | + | | + | + | | + |
| No. of subscribers (ADSL) | + | + | + | + | + | + | + | + | + |
| No. of subscribers (CATV) | - | | | - | | - | | | |
| Intra-Platform HHI | - | - | - | - | - | | - | - | - |
| Inter-Platform HHI | - | - | - | - | - | - | - | - | |

4. DISCUSSION

In this section, we will compare the results of estimation with our previous papers such as Tsuji and Akematsu [2010], Shinohara, Akematsu and Tsuji [2011] and [2012] which analyzed in the same framework as this paper. In addition to this, other factors which are not discussed in the empirical studies such as carriers' managerial objectives are discussed here.

4.1. Government policies and market conditions on FTTH

Unlike ADSL that use pre-laid metal subscriber lines, FTTH requires fiber-optic subscriber lines. The Japanese government has started to work on a series of FTTH diffusion policies which are the same as ADSL, namely openness of the fiber networks such as unbundling and connection charges. Japan is only country which implemented the open network policy, while other countries did not implement yet. According to Shinohara, Akematsu, Tsuji [2012], the effect of unbundling to FTTH diffusion is found to be negatively significant for OECD 30 counties, while unbundling to ADSL is positively significant. Japan is thus an exceptional case.

One note, however, should be added in this context. NTT East and West, the dominant operators, are obligated to open fiber-optic subscriber lines, just as it was with

ADSL service metal subscriber lines. This requirement, like the ADSL requirement, is intended to establish unbundling, collocation, and connection fees so that other operators are able to offer services that can compete with NTT East and West's FTTH services. However, as the technical attributes of fiber-optic technology limit unbundling to a certain level, competitors that make use of NTT East and West's fiber-optic infrastructures cannot actually offer services that are completely competitive with those of NTT East and West.

Since there are opposite opinions, it is difficult to decide whether Japanese competition policy in the FTTH market promote its diffusion. Another factor will be discussed later.

4.2. Business conditions and strategies of operators

The growing diffusion of FTTH and the phasing out of ADSL have become prominent after NTT East and West, the owner of the metal lines, announced in November 2004 its intentions to make a complete transition to the optical network and the possibility of removing metal subscriber lines.

This move has created three major problems for competitors that had previously focused on ADSL services. First, NTT's announcement on the possibility of removing metal subscriber lines made it increasingly difficult to concentrate primarily on DSL and forced the providers to be more cautious about continued investment in management resources. Second, NTT East and West's full transition to FTTH would mean a smaller ADSL market and higher speed broadband services in the entire market, thereby putting pressure on competitors, as well, to move from ADSL to FTTH. Third, competitors were unable to offer FTTH services which are sufficiently competitive with NTT East and West, thus it was difficult to develop its broadband service operations. In fact, Softbank, which had secured a share comparable to that of NTT East and West in the ADSL market, abandoned its plans to make a full-scale entry into the FTTH market (deciding not to provide FTTH as a Softbank service), and now sells NTT East and West's FTTH services as a wholesaler.

On the other hand, NTT East and West, the dominant operators, had the following five major reasons that influenced their move:

- (1) Since they are a strictly fixed (not mobile) operator, they intended to concentrate on the enhancement of management resources including capital investments in order to set FTTH as a mainstay business;

- (2) They wanted to pool resources toward optical subscriber lines only, and avoid the double burden of having both metal subscriber lines and fiber-optic subscriber lines;
- (3) They were locked in a battle with Softbank for ADSL share supremacy, with both tied at roughly 35% (NTT East and West had provided all domestic telecommunications services prior to the 1985 liberalization);
- (4) They have suggested the possibility of removing metal subscriber lines, which are vital to ADSL services. They had no intention to reinforce the permanency of ADSL; and,

As described above, we could assume that the fierce competition between operators in the ADSL arena, fueled by the provisions of broadband competition policies that opened metal subscriber line infrastructures, prompted NTT East and West to shift to FTTH. Then, having concentrated on management resources for FTTH and made aggressive capital investment moves, NTT East and West has widened its lead over competitors. It seems apparent that the decision of the dominant operator, who owns the metal lines, on the transition of its business entirely toward the FTTH subscriber network and the possibility of removing metal subscriber lines has caused rapid FTTH diffusion in Japan and ADSL peak-out to a certain degree. Thus in the stage of FTTH, NTT East and West, facing with heated competitor opposition that pulled its share of the ADSL market down to a tie for the lead (35%), decided to make capital investments in the FTTH subscriber lines, prompting the shift from ADSL to FTTH.

It should be noted carrier's attitude toward FTTH businesses. In the development of the DSL business, the amount of new investment is limited because the metal subscriber line that had already been laid for telephones can be used without additional modification. In contrast, the development of the FTTx business requires a vast investment for laying optical fiber subscriber lines, which are indispensable for the business. Furthermore, dominant carriers are generally considered to be negative toward the provision of any new service that absorbs the profits of existing services. Such a management attitude is called "cannibalism" (Falch [2007], Cambini and Jiang [2009]). Thus, since DSL takes away the profits of existing services, such as from telephones and dedicated lines, and FTTx does so with regard to DSL by providing a higher-speed service, dominant carriers are said to be reluctant to provide these new services. It can reasonably be said that the remarkable diffusion of FTTx in Japan is the result of dominant carriers' management strategy to dare to accept cannibalism and the massive

capital investment mentioned above. In this way, they took a great risk. In contrast, dominant carriers in Europe and the United States appear to have avoided such risk. Such management strategies can be regarded as having affected the diffusion of FTTx.

5. CONCLUSION

In order to conclude this paper, we attempt to summarize policy frameworks under discussions for FTTH. The issues to be addressed in this framework are as follows:

(1) Connection charges

Currently interconnection charges of fixed telephone are based on LRIC (Long-run Incremental Costs), while charges of dark fiber on expected future demand and dry copper on historical costs. NCCs insist on the charges of optical subscriber network should be based on LRIC. In addition to access charges, there are other issues to be solved such as unbundling of facility and the openness of platform of the security and charging systems of providing application services via FTTH.

Under the current accounting system of NTT, costs attributed to FTTH are not clearly itemized from the total costs, while the costs of interconnection of PSTN are restrictedly calculated based on LRIC. Revenues related to FTTH are grasped by the NTT branch offices, but FTTH costs are separated from the legacy network yet.

(2) Other regulation policy

The NGN network consists of different layers such as the access, platform and application. In the access layer, the equal access to all subscriber lines such as CATV, ADSL and FTTH. NTT's NGN is based on openness to all possible networks which can access to NGN. The platform function such as charging application services and guaranteeing security must be separated from NGN, since NTN can manipulate this function in order to exploit from application services. NGN also should be open to all service providers. An example of the closed network is mobile telephone, which is a vertical integrated business model in which all layers are owned by a mobile phone company. Policy is required to how to secure the open NGN.

(3) Development of FTTH networks through competition

The development of ADSL in Japan was promoted by the following three factors:

namely, (i) deregulation such as collocation before June 2001; (ii) competition among ADSL carriers from September 2001 to January 2002; and (iii) development of ADSL technology which enabled high speed access such as 12 or 24 Mbps from October 2002 to January 2003 (Tsuji and Tomizuka, 2006; Akematsu, 2008a). These factors made Japan as one of the most advanced broadband economy. This paper compared development of FTTH with that of ADSL and clarifies the issues of the FTTH market.

Among these carriers, competition is based on “facility based.” In addition to this, there is another type of competition, namely “service competition.” NCCs such as KDDI and Soft Bank utilize NTT’s FTTH networks for providing their own broadband services through the framework of “shared access.” The development of Japanese FTTH has been promoted through these two types of competition. There are, however, still problems to be solved. Even though the NTT’ share of total broadband services including cable modem, ADSL, and FTTH is less than 50%, in the FTTH market their shares are more than two-third. Japan needs delicate competition policy to make good balance of two type competition. In order to promote more diffusion of FTTH, facility competition is recommended, while in order to reduce NTT’s share service competition is required.

(4) How to promote FTTH use

Recently one idea came out in order to raising ICT usage, being termed by Broadband Super Highway Initiatives. Now 90% of Japanese can access to FTTH, but only 30% actually utilize it. This initiative attempts to raise 90% to 100% and to use this FTTH as a basis for various applications such as medicine, education, business, and so on. In the area of medicine, for example, the Medical Law, established more than 100 years ago, prohibits telemedicine, since diagnosis or medical treatment must be provided by face-to-face basis. In addition, telemedicine is not admitted by reimbursement from public medical insurance. The attitude of Japanese people toward privacy and security is another example. They refuse any national identify system being afraid of government’s abuse. The unified ID system is a key to e-government as well as e-commerce. The Japanese global ranking of e-government is rated quite low among OECD counties.

Another alternative to enhance FTTH usage is the termination of PSTN, that is, if the termination of PSTN is achieved, then the costs of its maintenances are transferred to those of FTTH, and accordingly all subscribers will enable to use FTTH at 1,400 yen (about US\$ 15.00) per month and NCCs can use this network as their access network to

the Internet at low charges. With low charges, all people can enjoy FTTH. This idea seems to be similar so-called “functional superstation” implemented in UK. The MIC plans to achieve this in 2015. It is still the level of an idea, but the share of NTT locals in the FTTH market, this kind idea becomes one possible alternative of competition policy to utilize FTTH network.

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