A Panel Data Analysis of Diffusion of Japanese FTTH

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Abstract

Japan has taken a worldwide lead in FTTH, with 15 million subscribers at the end of 2008. Japan has been the first country to experience this transformation. This paper analyzes the factors facilitating Japanese FTTH. Factors promoting Japanese broadband can be summarized as follows: (1) deregulations by the government; (2) competition among carriers; and (3) technical development. In the previous research, we already analyzed how these factors effected Japanese ADSL promotion, with the panel data of subscribers on four major carriers (Tsuji and Tomizuka [2006], Akematsu [2008]). Different from the case of ADSL, however, FTTH has its own scopes and issues. A big difference is regarding competition in the FTTH market, that is, basically carriers have to deploy optical fiber to single houses or condominiums by themselves, since there was no line sharing like ADSL. Therefore, NTT locals, which have own networks and facilities of FTTH, have competitive advantages and are gradually increasing their shares. Due to the number of related data, this paper adopt the prefectural panel data of subscribers, and analyzes the factors facilitating Japanese FTTH development, especially focuses on how subscribers migrate from ADSL to FTTH.

By utilizing the prefectural panel data of broadband subscribers, we found some interesting results. The charges and GDP satisfies the sign condition significantly. FTTH and CATV were competitive with each other, and FTTH has been diffused more in the prefecture in which the number of FTTH carriers is large and the intensity of the market competition indicated by Herfindahl-Hirschman Index is low. The number of ADSL subscribers is strongly significant to FTTH diffusion, which shows that the effect of migration is large. These results are important for policy for the broadband diffusion and in particular for competitive assessment with respect to the comparison between facility-based and service-based competitions.

Keywords: FTTH, migration, ADSL, Herfindahl-Hirschman Index, panel data analysis

1. Introduction

FTTH (Fiber To The Home), which is ultrahigh-speed internet access technology, has covered residential areas by nearly 100% at the main part of the city since the end of 2007, which is shown as in Figure 1. No other countries all over the world can be found that have such infrastructures. FTTH can not only send and receive 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. [1] The current number of Japanese broadband subscribers reaches almost 30 million, including 15 million FTTH, 1.2 million ADSL, and 4.1 million CATV (as of the end of 2008). Heavy users of the Internet have been migrating 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. In accordance with this, MIC (Ministry of Internal Affairs and Communications) has been preparing and studying policy frameworks for the NGN in the Telecommunications Council, which includes Research Committee of the Future of Universal Service System, the Evaluation Committee of Competition Policy, and Interconnection Committee, for instance.

Among factors of successful FTTH diffusion, deregulations or competitive policies by the government are of primary importance. In case of ADSL (Asymmetric Digital Subscriber Line), which is the main technology before FTTH, as shown by Tsuji [2005a], Tsuji and Tomizuka [2006], Akematsu [2008a] and [2008b], deregulations such as unbundling and collocation rules enabled other new carriers supported other carriers other than NTT East and West to start providing ADSL services, and the intense competition among carriers caused its diffusion.

This paper focuses on FTTH market, and heuristically analyzes the factors promoting it. Our interests lie in whether factors promoting broadband is different between ADSL and FTTH. One big difference can be found in the nature of their infrastructures, that is, NCC (New Common Carrier) ADSL carriers use the same

cupper line owned by NTT locals, and accordingly the market is referred to as the "service-based" competition. In case of FTTH, on the other hand, NCC has to deploy their own optical fiber networks by themselves, which makes the market to be the "facility-based" competition. The two different types of competition require different policy scheme such as deregulation and competition policy for the promotion.[2, 3]

Table 1 NTT's Coverage of Optical Fiber

		12 major cities and other large prefectural capital cities		Cities with more than 0.1 million population		Others	Total
		Main Area	All Area	Main Area	All Area		
1999	West Japan	90 %	50 %	78 %	25 %	10 %	29 %
	East Japan	95 %	60 %	70 %	36 %	19 %	41 %
2000	West Japan	92 %	56 %	82 %	37 %	17 %	37 %
	East Japan	95 %	65 %	70 %	43 %	29 %	48 %
2001	West Japan	94 %	68 %	82 %	43 %	36 %	50 %
	East Japan	96 %	84 %	76 %	62 %	41 %	66 %
2002	West Japan	96 %	84 %	85 %	66 %	50 %	56 %
	East Japan	97 %	92 %	86 %	78 %	49 %	76 %
2003	West Japan	97 %	92 %	88 %	86 %	63 %	80 %
	East Japan	98 %	95 %	86 %	86 %	55 %	81 %
2004	West Japan	97 %	93 %	91 %	88 %	69 %	83 %
	East Japan	98 %	96 %	88 %	89 %	61 %	84 %
2005	West Japan	97 %	94 %	91 %	89 %	74 %	86 %
	East Japan	98 %	96 %	89 %	91 %	65 %	86 %
2006	West Japan	97 %	94 %	91 %	90 %	76 %	87 %
	East Japan	98 %	97 %	91 %	94 %	73 %	89 %
2007	West Japan	97~99 %	94~96 %	93~95 %	90~92 %	77~79 %	87 %
	East Japan	99~100 %	98~99 %	94~96 %	94~96 %	74~76 %	90 %

Source: NTT's annual reports

According to Tsuji [2005a], Tsuji and Tomizuka [2006], Akematsu [2008a] and [2008b] which studied factors promoting Japanese ADSL development by the panel data analysis of major four carriers, they divided the factors into three; "deregulation," "competition," and "technology". FTTH is also considered to be diffused by these factors. In addition, we have to consider the effects of subscribers switching from ADSL to FTTH, which is referred to as "migration". FTTH services started after the certain

level of ADSL diffusion. The methodology adopted here is the panel data analysis, in which data consists of those of Prefecture, which are published quarterly by Ministry of Internal Affairs and Communications (MIC) since September 2005.

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

Different from the ADSL market, one of the issues related to Japanese FTTH is dominance of NTT in the market. There are two sub-markets of FTTH; condominiums and single house. Among approximate 15 million subscribers of the whole market, the former amounts to 8.4 million subscribers, while the latter to 6.0 million. As for the FTTH market as a whole, the share is as follows: NTT locals (49.2%), power companies (10.4%), KDDI (5.4%), and USEN (3.9%), as of December 2008. The market share of condominiums is NTT locals (67.1%), USEN (8.7%), KDDI (6.3%), power companies (5.3%), while in the market of single house, NTT locals (78.6%), Power companies (14.0%) and KDDI (4.8%) as of December 2008. NTT's share has been gradually increasing, and it is expected that NTT dominates the market. There is one big difference regarding competition in the FTTH market in comparison with ADSL: basically carriers have to deploy optical fiber to single houses or condominiums by themselves, since there can be no line sharing which is quite popular in the ADSL market. This is the main reason why carriers other than NTT locals target mainly condominiums. In 2005, the "shared access system" was introduced, in which carriers could borrow NTT locals' optical fiber. This system, however, does not work as well as the line sharing of ADSL.[4] 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.

The Implementation and events of FTTH market is summarized below. Most of implementations and events are related not only FTTH, but also ADSL, or other broadband technology. Therefore, many deregulations have implemented before FTTH started to grow, so it may be difficult to extract factors related to deregulation which promote FTTH.[5]

The trend of subscribers of broadband is summarized in Figure 1 and 2. The number of subscribers of FTTH is increasing rapidly in these days, while that of DSL is declining, which shows obviously migration from ADSL to FTTH. And total subscribers of FTTH first exceeded those of ADSL at the end of June 2008, that is, FTTH comes to be major in Japanese broadband. The number of subscribers of CATV is slightly increasing.

Figure 1 shows the quarterly increase of broadband subscribers, in which the number of subscribers of FTTH and CATV indicates a flat or positive slope, while that of ADSL has been decreasing greatly since mid-2006. As the quality of CATV such as connection speed and variety of services becomes similar to those of FTTH, weak negative correlation between these two can be found from the figure.

One of the most important factors of broadband diffusion is found in its charges, which is shown in Figure 2, that is, charges of FTTH do not change a lot for years; the NTT's charges of condominium indicate 3,700 yen monthly, and those of single house 6,400 yen.[6]

Table 2 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 ("Hikari-Denwa").
Mar. 2008	Revision of connection fee rule of dark fiber.

Source: MIC and NTT
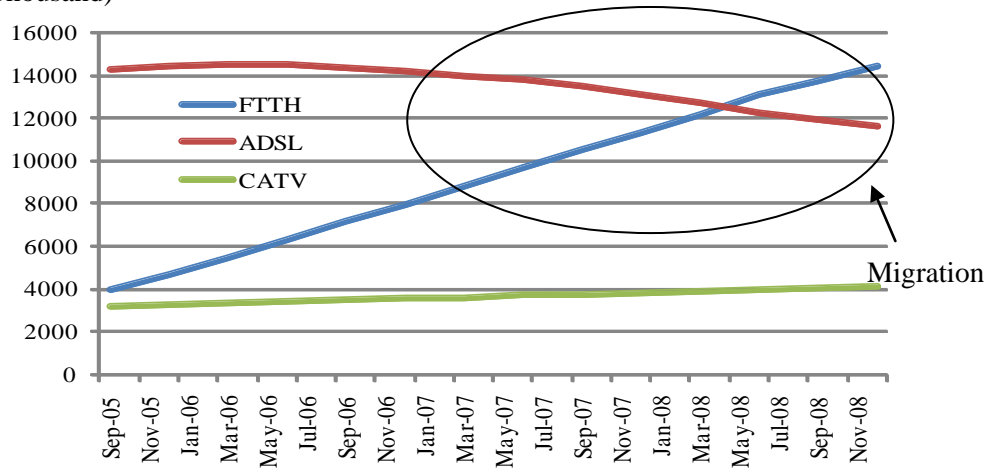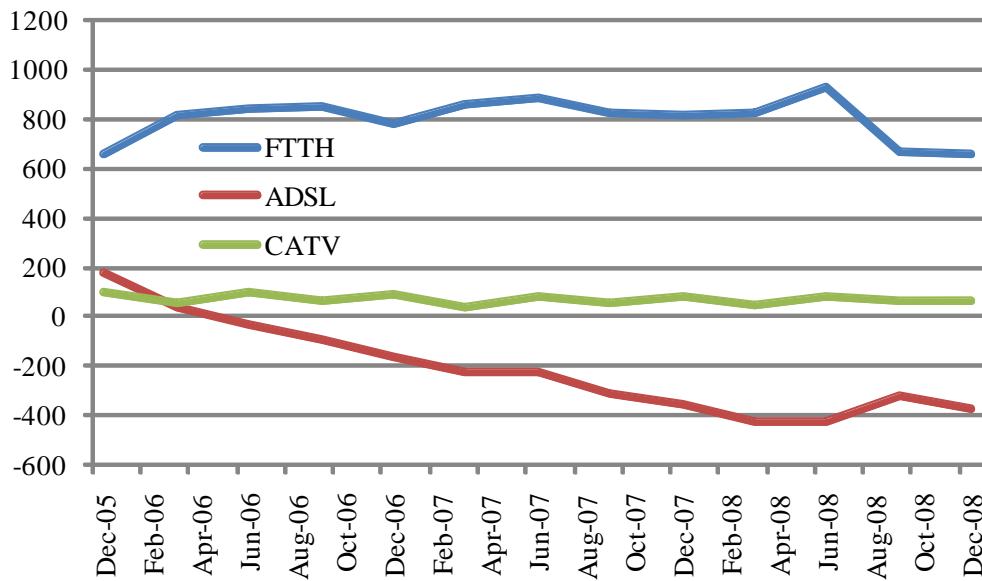
(Unit: Thousand)

Figure 1 Transition of Broadband Subscribers (Migration)

Source: MIC

(Unit: Thousand)

Source: MIC

Figure 2 Increases of Broadband Subscribers (Quarterly)

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

3.1. Model Specification and Data

The model for estimation is formulated as follows.

$$\ln(FTTH_{it}) = \ln(price_{it}) + \ln(GDP_t) + \ln(CATV_{it}) + \ln(ADSL_{it}) + Carrier_{it} + \ln(HHI_{it}) + u_{it}$$

$$u_{it} = \lambda_i + v_{it} \quad (v_{it} \sim iid(0, \sigma_v^2))$$

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), $Carrier_{it}$ the number of FTTH carriers in prefecture i, and HHI_{it} Herfindahl-Hirschman Index of the FTTH market. An error term is assumed to consist of one-way fixed effect where λ_t is a fixed effect and $v_{it} \sim iid$ (0, σ_v^2). Finally, i denotes prefecture and t quarter. Related to the number of carriers operating in the particular prefecture and HHI (Herfindahl-Hirschman Index), there are only 4 biennial data for each region, and these data are transformed to anural then to quarter data by approximating them linearly.

The independent variables are the number of CATV subscribers as alternative technology, the number of carriers of FTTH, and HHI which present competition in the market. The sign of CATV coefficient is assumed to be negative, that of the number of carriers operating in the particular prefecture positive and HHI negative. On the variable of ADSL, the more subscribers one region has, the more people migrate to FTTH in that region naturally. On the other hand, if there are a large number of ADSL subscribers of NTT's in one region, a high leverage effect to lead to increase FTTH subscribers exists. So we examine two models in which total subscribers of ADSL and that of NTT's are included, and compare their coefficients.

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

Table 3 Sources of Data

Variables	Source
FTTH ADSL CATV	Ministry of Internal Affairs and Communications (http://www.johotsusintokei.soumu.go.jp/)
ADSL (NTT)	Data from NTT East and West
Price	Reports of MIC
GDP	Data from National Accounts of Japan (SNA) (http://www.esri.cao.go.jp/jp/sna/)
No. of Carrier	Reports of MIC
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

Table 4 Summary Statistics

Variable		Mean	Std. Dev.	Min	Max	Observations
FTTH	overall	-0.7122	0.3501	-1.8043	0.2228	N=470
	between		0.2923	-1.2783	0.0539	n=47
	within		0.1970	-1.3929	0.0360	T=10
price	overall	8.5778	0.0539	8.4271	8.6641	N=517
	between		0.0538	8.4408	8.6526	n=47
	within		0.0083	8.5457	8.6024	T=11
GDP	overall	17.8328	0.0188	17.8012	17.8767	N=517
	between		0.0030	17.8263	17.8381	n=47
	within		0.0185	17.7973	17.8734	T=11
CATV	overall	-3.2863	1.1975	-8.8410	-1.0901	N=400
	between		1.0745	-7.4989	-1.6365	n=47
	within		0.6336	-6.6164	-1.2880	T-bar=8.5
ADSL (NTT)	overall	1.4748	0.2087	1.0046	2.0236	N=517
	between		0.2021	1.1620	1.9584	n=47
	within		0.0593	1.2494	1.6306	T=11
ADSL (total)	overall	2.2418	0.2029	1.8147	2.8204	N=517
	between		0.2013	1.8615	2.7259	n=47
	within		0.0381	2.0938	2.3363	T=11
No. of carrier	overall	28.8375	8.0959	6.0000	48.0000	N=517
	between		7.4605	8.2727	39.0909	n=47
	within		3.3111	19.7466	37.7466	T=11
HHI	overall	8.6552	0.3058	8.1197	9.1559	N=517
	between		0.2997	8.2394	9.1522	n=47
	within		0.0738	8.3991	8.8772	T=11

Source: Author

3.2. Result of Estimation I: Whole Market

We estimate two models according to the total number of ADSL subscribers or those of NTT. The former is referred to as the Migration model, while the latter to Leverage. The former is aimed to examine the general trend of migration from ADSL to FTTH. In addition to this, we are interested in how FTTH operators have been competing each other to obtain more subscribers by marketing to their own ADSL subscribers. Since available data of ADSL subscribers is only NTT's which is dominant in the market. As a result, the Leverage Model examines how NTT utilizes its ADSL subscribers for promotion of its sales. This is why this model is referred to as the Leverage Model. These estimations are summarized in Table 5 and Table 6, respectively.

In the actual estimation, we estimated the fixed effect model as the best unbiased model according to the Hausman test, the F test, and the Lagrange Multiplier test. However, the fixed effect model, or LSDV (Least Squares Dummy Variables) requires 46 dummy variables of each prefecture, which might cause multicollinearity with the time invariant variables such as charges which are normalized by CPI and GDP. In addition, the degree of freedom seriously becomes low, due to the 46 dummy variables. In fact, the coefficient of determination of the fixed effect model is very low. The Hausman test and the Lagrange Multiplier test chose the fixed effect model against the random effect model, and the F test selected the fixed effect model against Pooled OLS.

Table 5 Result of Estimation (Migration)

	Coefficient	Std. Err.	t-value	p-value	
Price	0.98610	1.26480	0.78	0.436	
GDP	5.23031	0.92066	5.68	0.000	***
CATV	-0.03323	0.01438	-2.31	0.021	**
ADSL (total)	2.41786	0.30022	8.05	0.000	***
No. of carrier	0.02489	0.00566	4.40	0.000	***
HHI	-0.00011	0.00005	2.15	0.033	**
Constant	-108.07770	17.89746	-6.04	0.000	***

*** , **, *, and + indicate the 1%, 5%, 10%, and 15% significance level, respectively

Source: Author

Table 6 Result of Estimation (Leverage)

	Coefficient	Std. Err.	t-value	p-value	
Price	0.92595	1.30125	0.71	0.477	
GDP	6.60973	1.02345	6.46	0.000	***
CATV	-0.03635	0.01476	-2.46	0.014	**
ADSL (NTT)	1.66014	0.25221	6.58	0.000	***
No. of carrier	0.02369	0.00584	4.06	0.000	***
HHI	-0.00008	0.00005	-1.64	0.102	+
Constant	-129.27540	20.01435	-6.46	0.000	***

***, **, *, and + indicate the 1%, 5%, 10%, and 15% significance level, respectively

Source: Author

To begin with, the estimation of the whole market is analyzed, and let us discusses the results by checking the significant variables one by one.

(i) Charges and GDP

As the charges of FTTH have not changed greatly since our data started, the difference of them relies on CPI used for normalization. Similarly, GDP does not move widely. As noted before, there might be a problem of multicollinearity among independent variables. According to the results, GDP satisfied the sign condition significantly, and the estimates seemed to be stable among the models. Charges, however, was not significant in this estimation.

(ii) CATV

In both models, CATV's coefficients were significant at the 5% significance level, and these results strongly showed that CATV is competitive with FTTH. Coefficients are almost similar in both models.

(iii) ADSL

The coefficients of ADSL represent the effects of the leverage and the migration in each model. Also, we can examine which effect is more for shifting ADSL service to FTTH, by the comparison with their coefficients.

As a result, their coefficients were positively significant in all of the models, so both effected the diffusion of FTTH. The comparison of two effects revealed that

migration was more effective, as its coefficient was higher than that of leverage.

(iv) Number of Carrier and HHI

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. We examined these effects by adding variables such as the number of carriers and HHI, which were expected to be positive and negative, respectively. As mentioned before, we used the estimated data in case the data do not exist. In addition, the variable of the number of carrier is non-logarithmic, because it rarely changes.[7]

According to the results for the migration model, the number of carrier was positively significant with coefficient 0.02489 for migration, and HHI was negatively significant with coefficient -0.00011, which coincide with the realty and are the results we expected. The former is much larger than the latter, which indicates that competition is important for the diffusion of FTTH.

3.2. Result of Estimation II: Submarkets

The FTTH market consists of two submarket; single and condominium, and here we examine these submarkets one by one. In so doing the same estimation method already discussed in the previous section is also utilized. Let begin with the single house market.

(a) Single house market

The estimation results are shown in Table 7 and Table 8, and the former is the migration model, while the latter the leverage model. In both models, all variables except HHI are found to be significant. Among them, charges and GDP satisfy sign conditions significantly, and in particular, the price elasticity of single house amounts to approximately 5 in the migration model, while nearly 6 in the leverage mode. This means that a decrease in charges will promote further the diffusion of FTTH. Thus in the single house market, price competition promotes the diffusion. The sign of CATV is negatively significant with coefficient -0.03638, which indicates that FTTH for single house competes with CATV. The number of carriers is positively significant with coefficient 0.01918, while HHI is not. These coincide with the reality of competition among FTTH carriers. Regarding the leverage of NTT though capturing its ADSL

subscribers, the ratio of coefficients of ADSL (total) /ADSL (NTT) is slightly larger than that of the whole market shown in the previous section, which implies that NTT tends to make more effort in the single market.

Table 7 Estimation Result of Single House Market (Migration)

	Coefficient	Std. Err.	t-value	p-value	
Price	-4.63058	2.62965	-1.76	0.079	*
GDP	6.76809	1.02093	6.63	0.000	***
CATV	-0.03638	0.01646	-2.21	0.028	**
ADSL (total)	2.02356	0.34004	5.95	0.000	***
No. of carrier	0.01918	0.00667	2.88	0.004	***
HHI	-0.00003	0.00004	-0.66	0.511	
Constant	-86.28970	20.50556	-4.21	0.000	***

***, **, *, and + indicate the 1%, 5%, 10%, and 15% significance level, respectively

Source: Author

Table 8 Estimation result of Sing House Market (Leverage)

	Coefficient	Std. Err.	t-value	p-value	
Price	-5.97900	2.69934	-2.21	0.027	**
GDP	8.13216	1.19818	6.79	0.000	***
CATV	-0.03881	0.01676	-2.32	0.021	**
ADSL (NTT)	1.31244	0.28504	4.60	0.000	***
No. of carrier	0.01859	0.00688	2.70	0.007	***
HHI	-0.00002	0.00004	-0.56	0.577	
Constant	-96.29865	22.19054	-4.34	0.000	***

***, **, *, and + indicate the 1%, 5%, 10%, and 15% significance level, respectively

Source: Author

(b) Condominium market

The results of estimating the condominium submarket are summarized in Table 9 for the migration model and Table 10 for the leverage model. The significant variables are GDP, ADSL and HHI in the both models. As for the migration model, charges become insignificant again, which indicates that operators complete each other rather than prices. GDP is positively significant. ADSL shows the largest coefficients such as 2.26285 in the migration model, while 3.02237 in the leverage model. This indicates

that residents in condominium pay more attention to merits of the FTTH and thus have been switching to it. Regarding competition in this market, HHI is significant, while the number of carriers not. The interpretation of this is such that it is users, not carriers, that take initiatives to switch to FTTH. In the leverage model, NTT's ADSL subscribers have the largest coefficient, which seems to show that NTT targets their subscribers by marketing to switch to FTTH.

Table 9 Estimation Result of Condominium (Migration)

	Coefficient	Std. Err.	t-value	p-value	
Price	1.86128	5.60141	0.33	0.740	
GDP	7.34997	2.40641	3.05	0.002	***
CATV	-0.00124	0.03253	-0.04	0.970	
ADSL (total)	2.26285	0.34840	6.49	0.000	***
No. of carrier	0.00565	0.01074	0.53	0.599	
HHI	-0.00010	0.00004	-2.83	0.005	***
Constant	-153.18820	40.13802	-3.82	0.000	***

***, **, *, and + indicate the 1%, 5%, 10%, and 15% significance level, respectively

Source: Author

Table 10 Estimation Result of Condominium (Leverage)

	Coefficient	Std. Err.	t-value	p-value	
Price	-2.42585	5.98464	-0.41	0.685	
GDP	11.43514	2.81896	4.06	0.000	***
CATV	0.00829	0.03629	0.23	0.820	
ADSL (NTT)	3.02237	0.61553	4.91	0.000	***
No. of carrier	0.03250	0.01451	2.24	0.026	**
HHI	-0.00009	0.00006	-1.62	0.106	+
Constant	-190.77360	47.60975	-4.01	0.000	***

***, **, *, and + indicate the 1%, 5%, 10%, and 15% significance level, respectively

Source: Author

4. DISCUSSION AND COMPARATIVE STUDIES: FTTH AND ADSL

By utilizing the prefectural panel data of broadband subscribers, we found some interesting results regarding the diffusion of FTTH. We will now discuss about the results of the analysis. The significant variables are shown in Table 11.

(i) Charges and GDP satisfies the sign condition significantly, although charges are not significant in some case. Charges are stale over the sample period.

(ii) FTTH and CATV are competitive each other except condominium submarket.

(iii) ADSL are significant in all models and the coefficients show that the effect of migration was larger than that of leverage by NTT except condominium submarket.

(iii) FTTH was diffused more in the prefectures where the number of carrier is large and HHI is low.

From Table 11, the result of estimation on the condominium submarket seems to be different from other two markets, although the whole and the single house markets coincide with the realty. As explained in introduction, NTT has less market share in the condominium market for both of ADSL and FTTH services, which implies that NTT can use less leverage. There are two reasons for this, that is, FTTH carriers do not compete with each other in charges, while in the single house market NTT is dominated, and accordingly NTT can spends more resources in the condominium market. In addition, since CATV is not significant in this submarket, it shows less competitive power in this market. These results are important for competitive policy to promote more competition in the condominium as well as the single house market.

Table 11 Summary of Results

	Whole market		Single house		Condominium	
	Migration	Leverage	Migration	Leverage	Migration	Leverage
price			-4.63	-5.98		
GDP	5.23	6.61	6.77	8.13	7.35	11.43
CATV	-0.03	-0.04	-0.04	-0.04		
ADSL (total)	2.42		2.02		2.26	
ADSL (NTT)		1.66		1.31		3.02
No. of carrier	0.02	0.02	0.02	0.02		0.03
HHI	-0.0001	-0.0001			-0.0001	-0.0001

Source: Author

Finally, let us compare these results with the previous researches on the ADSL market. In this analysis, we could not calculate the factors "deregulation" and "technology" due to the lack of data related to these, but the number of carriers which is the same meaning of "competition" is positively significant. In case of ADSL, since a

new entrant Yahoo!BB which entered the market with far low charges increased ADSL subscriber to great extent (Tsuji and Tomizuka [2006] and Akematsu [2007]). The ADSL market is a good example such that a new entrant contributed the diffusion of broadband. Another specific feature of the ADSL market is that in its early developing period, its market was independent or not affected by the other broadband technology such as CATV. The variables of ADSL and CATV were, however, significant in our results of FTTH, which is different from the ADSL diffusion. An evidence of this result can be found in questionnaires in Tanaka, et al. [2004], in which the FTTH carriers answered that they regarded the ADSL carriers as competitors.[8]

Some problems can be found in our data, however, that the data started from September 2005, when many significant factors, such as deregulation (unbundling, or collocation) and competitive strategies of FTTH carriers, had already completed. We thus could not add these factors into our model.

5. CONCLUSIONS: FOR FURTHER DIFFUSION OF FTTH

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

(1) Access charges of NGN

Now MIC has been preparing the access charges prior to NGN, since NTT's NGN is only one and other carriers have to use it. 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 cupper on historical costs. NCCs insist on the charges of NGN should be based on LRIC (Long Run Incremental Costs), but NTT's proposed scheme is "bill and keep". "Bill and keep" is only applicable in case of networks with equal size and the number of subscribers, but since NTT's is only one NGN, a system of access charges will be required. The current level of Access charges of NGN was determined to be based on expected demand for NGN, which is calculated expected total costs divided by expected demand. 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 NGN.

Under the current accounting system of NTT, costs attributed to NGN are not clearly itemized from the total costs, while the costs of interconnection of PSTN (Public Switched Telephone Network) 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 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. 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.

The share of FTTH subscribers are as follows: (i) NTT locals 6 million; (ii) carriers established power companies 1.3 million; and (iii) others, as of September 2007. 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) Killer contents

So far this paper discusses about NGN from the viewpoint of the supplied side, namely, the openness of the network, access charges, and so on. In order to promote FTTH further, attention should be paid to the demand side. In order for many users to access to NGN, contents are essential. NTT's NGN provides the Internet services which quality is guaranteed, while usual Intern services are of best effort type. Because of this characteristic, NGN is said to be suitable for services such as medicine, education, or digital broadcasting. More than one year passed since the services started, there are no such sophisticated services yet. NGN without such services is just the same as the regular Internet, and in this case NGN is rather too expensive for general users to access. From the cost-benefit comparison, NGN might end up with just a network.

Notes

1) Such areas are medicine, education, entertainments such as moves, and e-commerce.

2) Some theoretical approaches of service-based competitions and facility-based competitions can be found in Ida [2007]. They concluded that service-based competitions were not as favorable as facility-based competitions from the social view.

3) In order to compare the results of two cases, ADSL and FTTH, basically we have to use the panel data of FTTH carriers. However, the market share of NTT is high, which might cause biased estimations. In addition, its share is greatly different according to the regions, so some regional factors have to be added. Therefore, utilizing the prefectural panel data could be better.

4) Competitive carriers other than NTT are allowed to borrow NTT's optical fiber. A single line can cover eight houses. However, unit of renting is not single line, but four lines. So carriers have to find around thirty of customers, which is tough to great extent. Therefore, other carriers are unwilling to participate in the market.

5) It is significant to estimate the effect of these deregulations, and some theoretical approach might be valid for this resolution. However, theoretical approaches might kill the strengths of the panel data analysis because of many constraints causing problems such as the reduction of samples.

6) For those of other competitive carriers, their average charges of condominium indicate 3,612 yen monthly, and those of single house 5,525 yen.

7) The number of carriers of each region is summarized as follows.

Table 3-8 Number of Carriers of FTTH

		Hokkaido	Tohoku	Kanto	Hokuriku	Tokai
Total	Dec. 2006	23	26	39	16	37
	Dec. 2007	23	25	46	21	42
Single Houses	Dec. 2006	12	15	22	10	24
	Dec. 2007	11	14	26	13	26
Condominiums	Dec. 2006	17	16	33	10	19
	Dec. 2007	18	16	36	12	21
		Kinki	Chugoku	Shikoku	Kyushu	Okinawa
Total	Dec. 2006	29	32	24	23	8
	Dec. 2007	31	38	23	22	10
Single Houses	Dec. 2006	10	21	17	10	6
	Dec. 2007	14	26	15	9	7
Condominiums	Dec. 2006	24	18	12	18	7
	Dec. 2007	22	18	13	18	8

Source: MIC

8) See Tanaka, et al. [2004] in more detail.

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