

Broadband Diffusion and Public Policy: A Panel Data Analysis

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Abstract

Broadband service showed a remarkable increase in Japan after 2000, with ADSL representing more than 14.5 million subscribers in 2006. Recently, Japan has taken a worldwide lead in FTTH, with 11.3 million subscribers at the end of December 2007. Japan has been the first country to experience this transformation, which is referred to as migration, from ADSL to FTTH. However, the environment of the Japanese ADSL market was not initially favorable; ADSL service in Japan was introduced later than in Korea, the U.S., and other countries, causing Japanese ADSL penetration to lag behind. This was considered a symbol of Japan's delay in embracing the so-called IT Revolution. Since then, a lot of effort has been made in both the public and private sectors to catch up.

The purpose of this paper is to estimate the effect of deregulation as such on ADSL carriers, and specify the factors promoting Japanese ADSL which is the major technology of Japanese broadband. Tsuji and Tomizuka [2006], for instance, analyzed factors promoting ADSL by the AHP analysis, but there are no other analyses which focus on the market and subscribers data of ADSL rigorously. This paper utilizes the panel data analysis and this is the first attempt in this field so far. One result we obtain is that the revision and enforcement of Telecommunications Business Law contributed greatly to the promotion of Japanese ADSL. This research can be applied to the analysis of FTTH, which shows rapid growth in the broadband market.

1. INTRODUCTION

Broadband access has shown a remarkable increase in Japan after 2000, representing some 28.3 million subscribers, including 13.1 million ADSL subscribers (46.3%), and 11.3 FTTH subscribers (33.9%) as of December 2007. More than 90% of households are equipped to use ADSL service, and subscription charges have become very low. Therefore, Japan can be said to be the most developed nation in the world when it comes to broadband infrastructures. Factors promoting Japanese broadband lie in deregulation by the government, competition among carriers, and technical development. However, there are few studies rigorously evaluating these effects in this field. Also, an evaluation of the deregulation policies is not enough. The regulators need much more information on market trends with respect to the change of policies or innovations. The importance of studies in this field will only rise with the diffusion of FTTH, which is expected to be the next major technology of broadband.

This paper focuses on the ADSL market, and heuristically analyzes the factors promoting it by using the data of its subscribers. There are few previous studies empirically analyzing the demands of broadband services. This is because it's difficult to obtain such important data as traffic or subscriber numbers, because the broadband market is growing at such a rapid rate. Therefore recent research is represented by individual data based on a questionnaire, and applying a discrete choice model such as a logit or probit model. We utilized a panel data analysis on the four carriers which dominate over 80% of the market. This is so far the first attempt in this field.

This paper consists of six sections: Section 2 introduces the previous studies and characteristics of our research. In Section 3, a general description of the ADSL market is presented. Section 4 formulates our methodology of estimation and presents the results. The contribution of factors promoting ADSL development such as deregulation, market competition, and technological development is also analyzed. Another important purpose this paper serves is to analyze effects of these factors on individual carriers. We can then identify which carriers benefitted most from particular factors. These are presented in Section 5. In Section 6, we discuss how to apply this analysis to the FTTH market, whose number of subscribers has been approaching those of ADSL due to the recent migration. Brief conclusions are also provided in this section.

2. PREVIOUS STUDIES

Though there have been many previous studies on broadband technology, we have few empirical studies of its development. Eisner and Waldon [2001], Kridel, Rappoport and Taylor [2001], Sidak, Crandall and Singer [2002] all utilized discrete choice methods to analyze competition in the broadband market in the U.S. Also, Ida and Kuroda [2006] applied a nested-logit model to analyze the Japanese market, while Tsuji [2003], and Tsuji and Tomizuka [2006] analyzed Japanese ADSL. Some cases which utilized subscriber data can be found in the calculation of supply function by Tanaka, Yazaki, and Murakami [2004], and in the calculation of demand function by Tsuji and Tomizuka [2006]. One of the reasons there isn't much research utilizing subscriber data is due to how difficult it is to actually get. Broadband was developed so rapidly that it is difficult to obtain enough data for estimation calculations, and its market would be a monopoly or duopoly, so it is also difficult to obtain even cross-sectional data. In addition, discrete choice methods applied in the studies above required filling out a questionnaire to obtain the data, thus there are some problems for bias or reliability of data for estimation.

Tsuji and Tomizuka [2006] analyzed factors promoting Japanese ADSL by AHP (Analytical Hierarchical Process) analysis. They divided these factors into three types: deregulation, competition, and technology, then calculated degrees of importance. Finally, they monetarily evaluated the factors, in which competition mostly contributed to the development of ADSL. AHP is applicable if factors are very complicated and the data is small. However, data for the estimation was obtained from a questionnaire, so there may still be some problems of bias.

This paper utilizes panel data of monthly subscribers of four ADSL carriers to overcome the problem of shortage of data. As was noted earlier, the ADSL market has been an oligopoly, and research with the Tele-communication Working Group [2005] mentioned difficulty in utilizing the panel data analysis. Many studies which utilize panel data use yearly data. It has only been 5 years since ADSL service started, so the sample would be small even with the yearly panel data.

Instead, we can utilize monthly data for estimation, as development of ADSL was very rapid; then we can estimate its effects rigorously and significantly.

This paper utilizes the data of subscribers, but the traffic of connection is also important when we analyze its diffusion. This implication would be more serious if subscription charges were based on the traffic generated (pay-as-you-go plan), but ADSL carriers charge fixed monthly rates, so we can apply the number of subscribers as an index of the ADSL diffusion.

3. ADSL MARKET

Deregulations of the ADSL market began with the revision and enforcement of Telecommunication Law on September 2000, which included some political adjustment of unbundling subscriber lines and collocation rules.¹⁾ In December 2000, interconnection charges of line-sharing and dry-copper were admitted, which enabled a substantial number of competitors to enter the ADSL market.²⁾ In addition, Telecommunication Law and the admission of interconnection charges were revised and enforced again, which mainly included the unbundling of dark-fiber.³⁾ However, NTT did not disclose information on collocation related to dry-copper or dark fiber, and intended to delay the competitors' installation of ADSL devices in NTT's telephone offices. NTT was thus forced to disclose all information on collocation for free (enactment of notification) in June 2001, and a committee of arbitration on this problem was set up in November 2001. In July 2000, NTT was advised at the administrative level to install competitors' equipment within one week. In addition, NTT was ordered again to keep the period of installation, which enabled NTT to delay it deliberately. These market developments of ADSL are summarized in Table 1.

As shown below, NTT, e-Access, ACCA networks, and Yahoo!BB all launched ADSL service one after another, and these four carriers have been dominating over 80% of the ADSL market ever since.

Table 1: Implementations and Events of Factors

Time	Events
Dec. 1999	Experimental connection in MDF started.
Sep. 2000	Revision of Telecommunications Business Law enforcement rule (Introduction of regulations concerning unbundling in the subscriber's line) (Establishment of regulations regarding collocation)
Oct. 2000	e-Access started its services.
Dec. 2000	Admission of line sharing and dry copper connection charges NTT East and West started its services.
Jan. 2001	ACCA networks started its services.
Feb. 2001	NTT East and West started making the ADSL modem terminal.
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)
Sep. 2001	Yahoo!BB started its services.
Nov. 2001	Inauguration of the Telecommunications Business Dispute Settlement Commission (Mediation and arbitration became possible)
Aug. 2002	Yahoo!BB started the two-month free trial campaign.
Oct. 2002	Yahoo!BB formed a business tie-up with Edion and Joshin Denki. (Tie-up with the general merchandising store)

Source: Ministry of Internal Affairs and Communications (MIC)

The trend of subscribers is summarized in Figure 1. There are three big jumps of subscribers: in mid-2001, at the end of 2001, and at the end of 2002. This paper aims to clarify factors which explain these jumps.

One of the most significant factors promoting Japanese ADSL has been the continuous decline of its subscription charges as shown in Figure 2. Regarding the definition of subscription charges, we normalize those per 1Mbps. It should be noted that this construction of charges removes the effect of connection speed from charges. Subscribers' connection speed was about 1.5Mbps when ADSL started, and is currently over 50Mbps. The trend of connection speed is described in Table 2, which shows speeds almost double every year. This makes ADSL charges per 1Mbps low substantially.

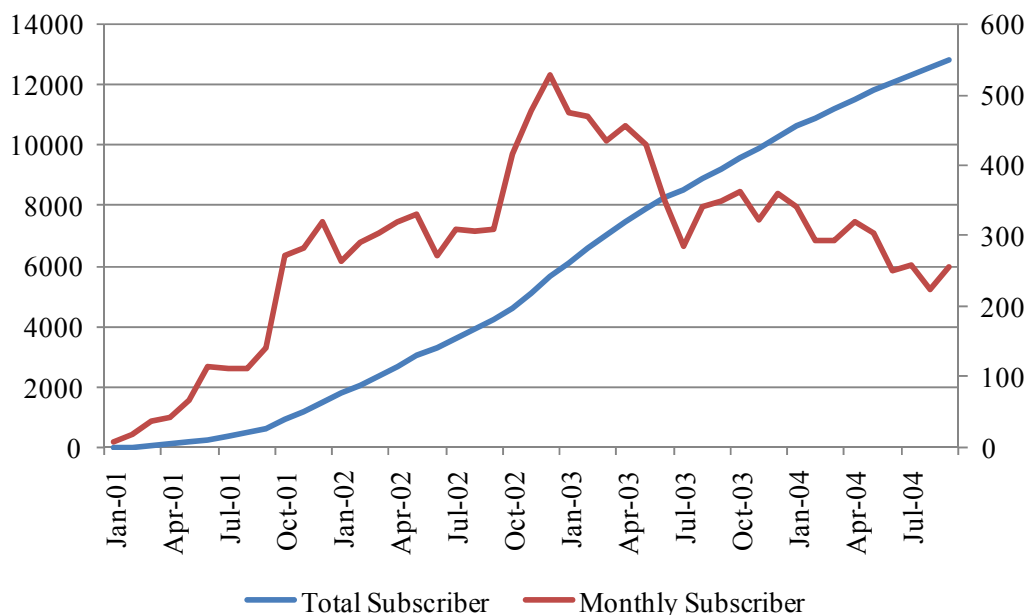


Figure 1: Transition in number of ADSL subscriber (thousand)

Source: MIC

Table 2: Speed of ADSL connection

	NTT	Yahoo!BB	e-Access	ACCA
8Mbps	December-01	September-01	November-01	September-01
12Mbps	November-02	August-02	October-02	October-02
24~26Mbps	July-03	August-03	July-03	August-03
40Mbps	December-03	January-04	November-03	February-04
47~50Mbps	August-04	September-04	February-04	July-04

Source: MIC

Figure 2 presents the trend of charges of each carrier, and it is obvious from looking at this that competition among ADSL carriers in the market lowers charges. In addition, pricing strategies of each carrier also affect the service charges of the market as a whole. According to Figure 2, NTT charged the highest among the carriers, while Yahoo!BB the lowest. This is because NTT has a brand image due not only to its being a member of the very prominent NTT (or Nippon Telephone and Telegraph Corporation) before its privatization, but also due to its

reputation for high quality service. On the other hand, Yahoo!BB is based on the unique business model such as vertical integration management which provides all services from the network to the provision of various contents. In addition to this, Yahoo!BB was the late comer to the market, and this made it adopt the above pricing strategy.^{4,5)} Price elasticity is considered to be different for each carrier.

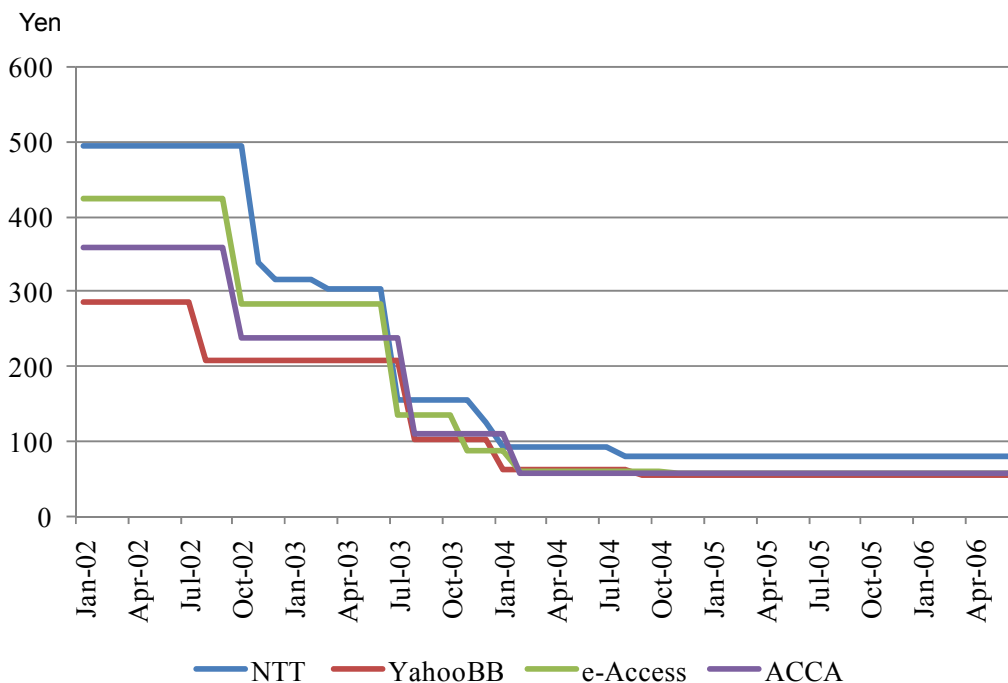


Figure 2: Transition of Subscription Charges of Four Carriers (JPY per 1Mbps)
Source: MIC

4. ESTIMATION I: PANEL DATA ESTIMATION

A model for estimation is formulated as follows:

$$\ln S_{it} = \beta_0 + \beta_1 \ln P_{it} + \beta_2 \ln G_t + \sum_j \beta_3^j D_{it}^j + u_{it} \quad (1)$$

$$u_{it} = \lambda_i + v_{it}$$

where S_{it} denotes the number of subscribers, P_{it} the monthly subscription charge (per 1Mbps), G_t real GDP converted into monthly data by moving average method of 3 quarters, and D_{it} dummy variables attached to factors which take 0 before the events started and 1 after they started. In case of the latter, the effects of the events do not last forever, and they take 0 if their effect is terminated. Let us take, for example, the 26Mbps connection service. This service started being offered in July 2003 according to Table 2, and so dummy variables before this time take 0, and after it take 1. The new service of 40Mbps started in December 2003, and it is reasonable to consider that subscribers started upgrading from 26Mbps to 40Mbps, and thus the effect of the former disappeared at that time. The dummy variables attached to 26Mbps take 0 again thereafter. An error term is assumed to consist of one-way fixed effect where λ_i is a fixed effect and $v_{it} \sim iid(0, \sigma_v^2)$.

Table 3: Factors (dummy variables) used for estimation

Time	Dummy	Events
Dec. 2000	d1	Admission of line sharing and dry copper connection charges NTT East and West started its services.
Jan. 2001	d2	ACCA networks started its services.
Feb. 2001	d3	NTT East and West started making the ADSL modem terminal.
Apr. 2001	d4	Revision and enforcement of Telecommunications Business Law Enforcement Rule and connection fee rule
Jun. 2001	d5	Enactment of notification
Sep. 2001	d6	Yahoo!BB started its services.
Nov. 2001	d7	Inauguration of the Telecommunications Business Dispute Settlement Commission
Aug. 2002	d8	Yahoo!BB started the two-month free trial campaign.
Oct. 2002	d9	Yahoo!BB formed a business tie-up with Edion and Joshin Denki.

Source: Author

Data for estimation is an unbalanced panel in which i indicates the four carriers of ADSL, and uses monthly data from the end of 2000 to mid-2006. At that time MIC changed the publication of data and monthly data was not published thereafter. The model is based on a log-linear model, where β_1 shows the elasticity of price. It should be noted that the price data in this equation is that of the highest-speed plan for subscribers, which is normalized into per 1Mbps as explained earlier.⁶⁾ Based on the formulation of the demand function, we add a monthly smoothed real GDP, and apply constant dummy variables of factors that are the most important variables of this estimation. The dummy variable shows 0 before the event started, 1 after it started, and 0 if the effects cease.

Table 4: Factors of Innovations used for Estimation

	Dummy	NTT	Yahoo!BB	e-Access	ACCA
8Mbps	d10	December-01	September-01	November-01	September-01
12Mbps	d11	November-02	August-02	October-02	October-02
24~26Mbps	d12	July-03	August-03	July-03	August-03
40Mbps	d13	December-03	January-04	November-03	February-04
47~50Mbps	d14	August-04	September-04	February-04	July-04

Source: Author

One of main objectives of this paper is to utilize this panel data analysis, and we assume that carriers and times have slope parameters in common. But the elasticity of price may be different from carrier to carrier, as noted in the last chapter. In this case, we can adjust for this, for instance, by adding cross effect terms of price and individual dummy to the model. This is the same as for dummy variables of factors. In this case, however, a serious multicollinearity problem can potentially arise when using all the factors as the cross effect terms. The panel data analysis ordinarily uses hundreds or thousands of data, and it is impossible to estimate the effects on each individual sample. In this paper, however, since there are only four carriers for the estimation, we can estimate the effects of factors to individual carriers. We thus estimate with the panel data analysis at first, and then estimate the effects on each carrier. The summary statistics for this estimation is provided by Table 5.

Table 5: Summary Statistics

Variable		Mean	Std.Dev.	Min	Max	Observations
Subscriber	overall	13.7025	1.8898	4.3694	15.5569	N=236
	between		0.9642	12.9437	14.6626	n=4
	within		1.6952	5.1283	15.1997	T-bar=59
price	overall	5.2318	1.3372	4.0082	9.2904	N=260
	between		0.4185	4.6667	5.5777	n=4
	within		1.2893	3.7875	9.0244	T-bar=65
GDP	overall	12.0610	0.0281	12.0220	12.1142	N=276
	between		0	12.0610	12.0610	n=4
	within		0.0281	12.0220	12.1142	T=69
d1	overall	0.9710	0.1681	0	1	N=276
	between		0	0.9710	0.9710	n=4
	within		0.1681	0	1	T=69
d2	overall	0.9565	0.2043	0	1	N=276
	between		0	0.9565	0.9565	n=4
	within		0.2043	0	1	T=69
d3	overall	0.2355	0.4251	0	1	N=276
	between		0.4710	0	0.9420	n=4
	within		0.1171	-0.7065	0.2935	T=69
d4	overall	0.9130	0.2823	0	1	N=276
	between		0	0.9130	0.9130	n=4
	within		0.2823	0	1	T=69
d5	overall	0.8841	0.3207	0	1	N=276
	between		0	0.8841	0.8841	n=4
	within		0.3207	0	1	T=69
d6	overall	0.8406	0.3667	0	1	N=276
	between		0	0.8406	0.8406	n=4
	within		0.3667	0	1	T=69
d7	overall	0.8116	0.3917	0	1	N=276
	between		0	0.8116	0.8116	n=4
	within		0.3917	0	1	T=69
d8	overall	0.1703	0.3766	0	1	N=276
	between		0.3406	0	0.6812	n=4
	within		0.2334	-0.5109	0.4891	T=69
d9	overall	0.1630	0.3701	0	1	N=276
	between		0.3261	0	0.6522	n=4
	within		0.2386	-0.4891	0.5109	T=69
d10	overall	0.1667	0.3734	0	1	N=276
	between		0.0145	0.1594	0.1884	n=4
	within		0.3731	-0.0217	1.0072	T=69
d11	overall	0.1413	0.3490	0	1	N=276
	between		0.0248	0.1159	0.1739	n=4
	within		0.3483	-0.0326	1.0254	T=69
d12	overall	0.0725	0.2597	0	1	N=276
	between		0.0118	0.0580	0.0870	n=4
	within		0.2595	-0.0145	1.0145	T=69
d13	overall	0.0688	0.2536	0	1	N=276
	between		0.0572	0	0.1159	n=4
	within		0.2487	-0.0471	1.0254	T=69
d14	overall	0.3732	0.4845	0	1	N=276
	between		0.0547	0.3188	0.4203	n=4
	within		0.4822	-0.0471	1.0543	T=69

The equation (1) for estimation is based on the “reduced form,” in which factors of both demand and supply are mixed. All the variables are then assumed to be exogenous, except charges. If charges are lowered, then this leads to an increase in the number of subscribers, and this leads to still lower charges simultaneously, since an increase in the number of subscribers reduces costs, and this makes charges lower. Charges are thus considered to be an endogenous variable. To control this, we utilize the instrumental variables method in such a way that charges from one period earlier are taken to be an instrumental variable. Since there are many dummy variables and multicollinearity might occur in the estimation, we omit variables from the estimation with correlation coefficient over 0.8. Considering these discussions, the results of estimation are shown in Table 6.

Table 6: Result of Estimation (Panel Data Estimation)

dependent variable: Subscriber of ADSL											
Fixed Effect IV Model						EC2SLS Random Effect IV Model					
	Coef.	Std. Err.	z-value	p-value		Coef.	Std. Err.	z-value	p-value		
price	-0.4635	0.1021	-4.54	0.000	***	price	-0.3673	0.1097	-3.35	0.001	***
GDP	14.4544	4.0703	3.55	0.000	***	GDP	14.6454	4.4626	3.28	0.001	***
d1	0.6867	0.5442	1.26	0.207		d1	0.5570	0.5986	0.93	0.352	
d3	(deleted)					d3	1.4122	0.0950	14.86	0.000	***
d4	1.5998	0.2954	5.42	0.000	***	d4	1.5507	0.3250	4.77	0.000	***
d5	1.1704	0.2669	4.38	0.000	***	d5	1.1906	0.2936	4.05	0.000	***
d6	1.2913	0.2914	4.43	0.000	***	d6	1.6238	0.3133	5.18	0.000	***
d8	0.6919	0.2414	2.87	0.004	***	d8	1.0784	0.1136	9.49	0.000	***
d10	0.0914	0.1812	0.50	0.614		d10	-0.0289	0.1947	-0.15	0.882	
d11	0.6720	0.1549	4.34	0.000	***	d11	0.5369	0.1693	3.17	0.002	***
d12	0.5412	0.1584	3.42	0.001	***	d12	0.4524	0.1740	2.60	0.009	***
d13	0.1651	0.1297	1.27	0.203		d13	0.1287	0.1427	0.90	0.367	
constant	-162.9671	49.7249	-3.28	0.001	***	constant	-166.2991	54.5022	-3.05	0.002	***
R-sq			within	0.9091		R-sq			within	0.9081	
			between	0.4140					between	0.9363	
			overall	0.7922					overall	0.9122	
F test that all $u_i=0$			F(3,219)	17.11		Hausman Test			chi2(11)	24.63	
			Prob>F	0.000					Prob>chi2	0.010	
Number of obs			234			Number of obs			234		
Number of groups			4			Number of groups			4		

Instrumented: price, Instruments: GDP, d1, d3-d6, d8, d10-d13, price[t-1]

***, **, and * indicate the 1%, 5%, and 10% significant level, respectively.

Source: Author

In the random effect model, we utilized the error component two-stage least squares (EC2SLS) method followed by Baltagi [2005], but it was rejected at 10% level by the Hausman test, and thus the fixed effect model was adopted. The elasticity of charges is significant at a 1% level, satisfying the sign condition. The estimated coefficient of charges is -0.46, and this is not elastic.⁷⁾ The factor of “NTT’s manufacturing modem terminal” is omitted from the list of variables used, because it is completely correlated with its individual effect. In what follows, we discuss the results of identifying factors promoting ADSL according to points such as deregulation, competition, and technology, followed by Tsuji and Tomizuka [2006].

(i) Deregulation

“d1: admission of line sharing and dry copper connection charges (December 2000),” “d4: revision and enforcement of Telecommunications Business Law (April 2001),” and “d5: enactment of notification (June 2001)” are categorized into the factors of deregulation. Except the dummy variable d1, all variables of deregulation are significant. The coefficient of d4 (Revision and enforcement of Telecommunications Business Law) is the largest in comparison with all other factors. It can be said, therefore, that deregulation actually promoted the ADSL

diffusion by increasing subscribers.

(ii) Competition

Three carriers (NTT locals, e-Access, and ACCA, but not Yahoo!BB) provide network services to ISPs, such as @nifty, Biglobe, and So-net. Instead of these carriers competing, ISPs compete with each other for obtaining subscribers. Business strategies achieving subscribers are related to ISPs, not the three carriers. In this sense, it is not desirable for the estimation to include factors of each ISP's marketing strategies. Only Yahoo!BB owns its own ISP services, and it is for this reason that the marketing strategies of Yahoo!BB are included among dummy variables. Excepting factors of the carriers launching new services, all dummy variables related to the above three carriers take 0.

The factors of competition extracted by the estimation are as follows: "d1: new service launch of NTT east and west," "d6: new service launch of Yahoo!BB," and "d8: two-month free trial campaign by Yahoo!BB". Generally speaking, any new service launched by one carrier causes negative effects towards subscribers of other carriers. The estimation result, however, shows that the sign of factor d6 (new service launched by Yahoo!BB) is significantly positive. This can be interpreted as follows: the elasticity of charges is low in the ADSL market, and this implies that users rarely change their carriers. The entrance of Yahoo!BB into the market expanded and vitalized the whole market, and this led to other carriers obtaining new subscribers. "d8: two-month free trial campaign by Yahoo!BB" is also positive at a 1% significance level, and it can be said that the campaign was successful. In spite of fact that this dummy variable is attached to only Yahoo!BB, the estimated coefficient is rather large, and this shows the strong power of Yahoo!BB at that time.

(iii) Technology

Technological development of ADSL has been occurring continuously, especially in those areas related to connection speed, as shown in Table 2. According to the results, 12Mbps service (d11) has the largest coefficient 0.6920 with the 1% significance level. 24Mbps service (d12) is also large 0.5412 with the 1% significance level, and follows just behind 12Mbps. 40Mbps service (d13) is not significant. The results related to different connection speeds are interesting. Generally speaking, when a faster connection speed service is launched, the number of subscribers to this particular speed increases. The results we obtained, however, suggest the opposite. One possible interpretation is that many users are not concerned with such high speed connection; since most data can be transmitted smoothly with around 1Mbps.⁸⁾

5. ESTIMATION II: INDIVIDUAL EFFECTS TO EACH CARRIER

One problem of estimation in this paper is related to multicollinearity, or correlation of independent variables. As our data covers from its beginning, the effect of trends tends to be dominant. Adopting the panel data analysis is one solution to this problem, but it is very much only an estimation of each carrier, due to the shortage of samples. Following the panel estimation, we omitted variables with a correlation coefficient over 0.8, and tested whether multicollinearity existed by using VIF (Variance Inflation Factor). Generally speaking, multicollinearity is said to exist if VIF indicates over 10. We omitted variables to an extent that their mean of VIF became less than 10, and then calculated this for each carrier. The results of estimation are summarized as follows:

Every carrier satisfies the sign condition of their prices significantly, and they are around -0.6 to -0.7. This estimation shows an interesting result. Carrier A provides only network connection services, which is the least elastic in its price. As shown in Figure 2, its subscription charges are the highest among four. Carrier B, on the other hand, which provides all-around service has the highest elasticity of price. This is because it serves the lowest subscription charges in contrast with carrier A, since it is of vertical integration.

The number of dummy variables is reduced due to multicollinearity. Almost all variables of the factors of deregulation are significant at a level under 1%, which shows that deregulation promoted Japanese ADSL development. In the panel data estimation, "Revision and enforcement of Telecommunications Business Law (April 2001)," has the largest coefficient, and this policy resulted in Carrier C's and D's number of subscribers increasing, though they did not

possess their own ADSL network. This estimation clarifies again that the revision of Telecommunications Business Law, including how the political settlement of unbundling contributed the most to the diffusion of Japanese ADSL.

Regarding factors of innovation, all carriers except Carrier B have quite large, positive coefficients with respect to 12Mbps service. Again, it can be seen that connection speed and the number of subscribers are not correlated with each other. Now let us examine the results of each carrier in more detail.

(i) Carrier A

As noted earlier, Carrier A provides only line connection services and is independent of ISPs, which leads to its subscription charges being the highest; it has the least elasticity of price among the four carriers. “d6: new service launched by Yahoo!BB” served to raise the number of its subscribers, although Yahoo!BB was a new entrant to the market and consequently a new competitor to this carrier. This can be interpreted by the fact that its entry into the market promoted the growth of the market as a whole, creating a strong synergy effect. Innovation of connection speed seems to have no effect to Carrier A, with only 12Mbps service being affected significantly. All these indicated that Carrier A might have a strong brand image and this brought the stability of the number of subscribers.

Table 7: Result of Estimation (Carrier A)

dependent variable: Subscriber of ADSL				
	Coef.	Std. Err.	t-value	p-value
price	-0.5635	0.0839	-6.72	0.000 ***
GDP	6.3754	3.7196	1.71	0.092 *
d6	1.1146	0.2007	5.55	0.000 ***
d10	-0.0864	0.1526	-0.57	0.574
d11	0.3382	0.1498	2.26	0.028 **
d12	0.1946	0.1664	1.17	0.247
d13	-0.0176	0.1218	-0.14	0.885
constant	-60.2601	45.3545	-1.33	0.189
Number of obs			63	
Adj R-sq			0.9440	
Durbin-Watson			0.8125	
Mean VIF			4.61	

***, **, and * indicate the 1%, 5%, and 10% significant level, respectively.

Source: Author

(ii) Carrier B

Carrier B has the most elastic charges, and this is because it was a latecomer to the market and entered with far lower charges than other carriers; that is, low fees were its strategy to obtain subscribers. Another reason for its high elasticity is its achieving high efficiency of management due to vertical integration. The factor, “d7: inauguration of Telecommunications Business Dispute Settlement Commission” is strongly significant for carrier B. The aim of the commission at that time was related to interconnection charges of ADSL, which is important when serving low subscription charges. Factors of technological innovation such as connection speed were not significant to Carrier B, which implies that subscribers chose Carrier B mainly for its low charges.

Table 8: Result of Estimation (Carrier B)
dependent variable: Subscriber of ADSL

	Coef.	Std. Err.	t-value	p-value	
price	-0.7728	0.1268	-6.09	0.000	***
d7	2.0973	0.1828	11.47	0.000	***
d9	0.8012	0.1692	4.73	0.000	***
d11	0.2113	0.1481	1.43	0.162	
d12	0.1491	0.1298	1.15	0.258	
d13	-0.0491	0.1015	-0.48	0.631	
constant	15.5709	0.7333	21.23	0.000	***
Number of obs			42		
Adj R-sq			0.9561		
Durbin-Watson			1.3642		
Mean VIF			3.11		

***, **, and * indicate the 1%, 5%, and 10% significant level, respectively.

Source: Author

(iii) Carriers C and D

Carriers C and D are referred to as “wholesale type,” and they wholesale their lines to ISPs which actually engage in marketing to subscribers. In this sense, they are different from Carrier A and B. Another difference can be found in factors of innovation. 12Mbps and 24Mbps services are estimated to be significant to Carrier C and D. The factors of deregulations such as “d4: revision of Telecommunication Business Law,” or “d5: enactment of notification” particularly affected both carriers. The main objectives of deregulation were to promote market competition and encourage new entrants, and in this sense, deregulation in the ADSL market is considered to be successful from our estimations.

Table 9: Result of Estimation (Carrier C)
dependent variable: Subscriber of ADSL

	Coef.	Std. Err.	t-value	p-value	
price	-0.6854	0.1003	-6.83	0.000	***
GDP	10.6795	4.9282	2.17	0.035	**
d1	2.2211	0.2845	7.81	0.000	***
d4	1.2891	0.2890	4.46	0.000	***
d5	0.5980	0.3000	1.99	0.051	*
d6	0.1624	0.3209	0.51	0.615	
d10	0.1564	0.2041	0.77	0.447	
d11	0.8729	0.1822	4.79	0.000	***
d12	0.5296	0.2143	2.47	0.017	**
d13	0.1832	0.2144	0.85	0.397	
constant	-116.1690	60.0477	-1.93	0.058	
Number of obs			66		
Adj R-sq			0.9755		
Durbin-Watson			1.3576		
Mean VIF			5.71		

***, **, and * indicate the 1%, 5%, and 10% significant level, respectively.

Source: Author

Table 10: Result of Estimation (Carrier D)

dependent variable: Subscriber of ADSL					
	Coef.	Std. Err.	t-value	p-value	
price	-0.7017	0.1151	-6.10	0.000	***
GDP	7.4192	4.0630	1.83	0.073	*
d4	2.2869	0.3413	6.70	0.000	***
d5	1.3849	0.3344	4.14	0.000	***
d7	2.1145	0.2518	8.40	0.000	***
d10	0.4155	0.2288	1.82	0.075	*
d11	0.9179	0.2149	4.27	0.000	***
d12	0.5446	0.1863	2.92	0.005	***
constant	-78.6117	49.3710	-1.59	0.117	
Number of obs			65		
Adj R-sq			0.9727		
Durbin-Watson			1.8016		
Mean VIF			4.52		

***, **, and * indicate the 1%, 5%, and 10% significant level, respectively.

Source: Author

6. CONCLUSION

By utilizing the rigorous Panel Data Analysis, we heuristically identified factors promoting Japanese ADSL. We will now briefly describe the conclusions of the analysis. The paper shows that the deregulation of the “Revision and enforcement of Telecommunications Business Law (April 2001),” whose coefficient is 1.5998 with a 1% significance level, mainly promoted Japanese ADSL. As for factors related to competition, “Entrance of Yahoo!BB into the market” had an important effect with coefficient of 1.2913 at a 1% significance level. Regarding technological factors, “12Mbps services started” was the most effective at diffusing ADSL (0.6720 with a 1% significant level), as high-speed services are not necessarily demanded by users. From these discussions, we can now interpret Figure 1, where we see there are three big jumps in its growth: before June 2001, from September 2001 to January 2002, and from October 2002 to January 2003. From the results of our analysis, three factors contributed to these jumps: “Revision and enforcement of Telecommunications Business Law” in April 2001, “Entrance of Yahoo!BB into the market” in September 2001, and “12Mbps services started” in October/November 2002. These factors coincide with the three big jumps in the number of ADSL subscribers. It follows thus that the first sharp increase was due to deregulation, the second jump was caused by an increase in market competition inspired by previous deregulations, and the third one by technological development.⁹⁾

Another result is related to the elasticity of prices of the carriers, which are different from one to another. Carrier A has the smallest elasticity (-0.5635) with a 1% significance level, while Carrier B the largest (-0.7728) with a 1% significance level. This difference might come from their pricing, or perhaps from their marketing strategies, or the managerial organization, such as whether they provide ISP services or not. Although these results are reliable because they are based on the data of actual subscribers, this analysis does include all factors related to the ADSL diffusion in the model mainly due to multicollinearity. In addition, ADSL developed quite rapidly in a short period of time, so the effect of trends seems be strong and might affect our results. Some new ideas such as utilizing time difference data might be required. As mentioned earlier, FTTH and CATV affect ADSL development, and the estimation of all broadband subscribers is needed, which is one aim of future studies.¹⁰⁾

One of the issues related to Japanese FTTH is dominance of NTT in the market. There are two sub-markets of FTTH: namely, that of condominiums and that of the single house. In the former market, the share is as follows: NTT locals (52%), Power companies (20%), KDDI (5%), and USEN (7%), as of December 2006, while for the latter market the shares are apportioned to NTT locals (76%), Power companies (22%) and KDDI (4%). NTT’s share is gradually increasing, and there is anxiety that NTT holds market control. 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 as there was with ADSL. This is the main reason why carriers other than NTT locals target mainly condominiums. In 2005, the “shared access system” was in effect, in which carriers could borrow NTT locals’ optical fiber. This system, however, does not work as well as the line sharing of ADSL did. 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 healthy 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.

Finally, when we consider an application of this analysis of ADSL with respect to FTTH, the number of major FTTH carriers is four: NTT locals, Power Companies, USEN, and KDDI, which is not so different from that of ADSL. But NTT’s share is much larger, and the same estimation might not apply. In this case, one alternative method is to estimate the broadband market as a whole, as Tanaka, Yazaki, Murakami [2004] did. All related carriers and operators in telecommunications market such as ADSL, FTTH, and CATV must be included. Actually they are substitutive with each other, but the number of subscriber of FTTH was extremely low through the time our data covered, and the data was not monthly, but quarterly. So this time we excluded these. On CATV, the number of carrier amounts over 300 in Japan, thus the average charges of it do not exist or it is very difficult to make it newly. In addition, the charges of CATV have not changed since its service started. For this reason, we considered that the effects of other technologies might be weak, thus excluded the variables on CATV or FTTH. However, the primary significance of this study can be emphasized by that we utilized the panel data analysis and rigorously estimated the factors promoting ADSL at the first time in the world. Also, this estimation, which statistically revealed the factors, can be guiding principles for other developed and developing countries, as Japan is most exceeding in broadband. On the economic view of this estimation, the results are consistent with the economic theory. Deregulations, as well as competitions and innovations, these three factors promoted Japanese ADSL one after another. We apprehended this process econometrically, and testified. No other previous researches studied an obvious model interpreting this process, especially in particular services on telecommunication field.

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NOTES

- 1) ADSL is required to connect to a local subscriber's line, which is owned by NTT locals. ISPs have to install ADSL equipment at NTT's telephone offices. The NTT locals thus have advantages as incumbent operators. Moreover, NTT had a strategy to promote ISDN instead of ADSL, and claimed that the latter disturbed the former. Thus, it took some time to settle this technological problem, and it is said that this made for a delay in starting Japanese ADSL services. Almost all deregulation regarding ADSL were related to restrict NTT locals and enforce fair competition.
- 2) The charge of dry copper is calculated by historical costs, not by long-run incremental costs. NTT locals claim that those are set too low to cover actual costs. But it is true that ADSL development became possible because of this, as we can analyze in this paper (see Tsuji [2005] in more detail)
- 3) The charge of dark fiber is based on the long-run pricing; that is, the time period of pricing is set to be for several years, and future demand for optical fibers will be increasing. Again, NTT locals claim that the charge is too low to cover actual costs.
- 4) Regarding the business strategy of Yahoo!BB, extensive analysis can be found in Tsuji [2003], for example. ADSL services were the company's first business in the telecommunications market.
- 5) Even Yahoo!BB has been suffering negative profit from the beginning. Only recently has it begun to turn a profit.
- 6) There are always problems regarding charges for empirical studies, since telecommunications carriers tend to have various service plans to cover customers. The weighted average of different charges is theoretically desirable, but pricing plans are so complicated and no data for the share of different services are published. Due to these reasons, we assume that subscribers choose the highest speed services.
- 7) MIC [2007] obtains elasticity of price based on the discrete choice model with 0.289 in 2003, 0.439 in 2005, and 0.763 in 2006. The average of these three is 0.497, which is similar to our result (0.464).
- 8) This result reveals one of the weak points of ADSL: transmission loss. The farther one's home is from the telephone office, the weaker transmission signals become, which thus causes decline in connection speed. Therefore, such high-speed services benefit only users near the base station. Another reason for this result is that when we need high speed connection, we had better select FTTH, which is more stable in connection speed than ADSL.
- 9) See Tsuji and Tomizuka [2007].
- 10) In Japan, the number of FTTH subscribers has been increasing rapidly. In this section, we will discuss issues related to its diffusion and the Next Generation Network (NGN). The number of FTTH subscribers of NTT locals, which is referred to as "B Flet's," exceeded that of their ADSL in December 2006. The number of their ADSL subscribers, on the other hand, has been decreasing since it reached its peak in June 2006, and this indicates that a so-called migration from ADSL to FTTH has been occurring. A migration analysis by MIC [2005] revealed that most of subscribers of narrowband such as ISDN as well as the most of ADSL heavy users have a strong intention to change to FTTH and actually had migrated. Since FTTH can transmit and receive a large volume of data at one time, it is suitable to the NGN.

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