The Information Society, 24: 1–17, 2008

ISSN: 0197-2243 print / 1087-6537 online
DOI: 10.1080/01972240701771606

Routledge
Taylor & Francis Group

Consumer Benefits of Public Services Over FTTH in Japan: Comparative Analysis of Provincial and Urban Areas by Using Discrete Choice Experiment

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As the rapid development of broadband Internet access services continues, particularly fiber to the home (FTTH) services, the digital divide between provincial and urban areas is becoming a big social issue in Japan. We classify the issue into two problems: access to high-speed Internet, and service utilization of high-speed Internet access. We focus on the latter problem by quantitatively and qualitatively investigating whether a digital divide problem exists based on Internet service utilization. Consequently, we discover that willingness to pay (WTP) for public services over FTTH is almost identical between provincial and urban areas. Furthermore, territorial digital broadcasting over FTTH accounts for a large part of WTP in provincial areas, while tele-working and tele-education are also important as public services over FTTH in urban areas.

Keywords conjoint analysis, digital divide, mixed logit model, tele-education, tele-working

Broadband Internet access services in Japan have developed rapidly. As of March 2005, the penetration rate of broadband services reached about 50% of Japanese households, broken down as follows: (1) asymmetric digital subscriber line (ADSL) 70%, (2) cable television (CATV) Internet 15%, and (3) fiber to the home (FTTH) 15%.[1] Considering the explosion of the FTTH market, Japan's broadband is reportedly the fastest and cheapest in the world.[2] However, digital divide remains a major concern in Japan.

Digital divide is defined as the inequality between the information haves and information have-nots: in other words, the gap between individuals, households, businesses, and geographic areas at different socioeconomic levels with regard to both opportunities to access information technologies and their Internet use for a wide variety of activities (OECD, 2001). Norris (2001) pointed out that the global digital divide is substantial and impedes the economic development of developing countries. Wong (2002) also discussed the significant digital divide that exists between advanced (Japan and the four Asian newly industrializing economies [NIEs]) and developing Asian countries.

However, there is little consensus with regard to digital divide, especially in the case of broadband.[3] According to Firth and Mellor (2005), the aggregation of expected revenues from broadband-related enterprises is not an adequate measure of broadband benefits; they must be measured in terms of the increase not only in private but also public surplus, including external effects. Selwyn (2002) and Mariscal (2005) argued that the social capital concept provides a useful analytical lens that identifies potential broadband benefits and offers a useful guideline for the design of a digital divide policy that integrates the needs and restraints of users. Horrigan (2002) and Oxendine et al. (2003) provided evidence of the importance of broadband access not only as a means for acquiring information but also as a catalyst for cooperation within a community and thus as an instrument for building social capital. Gillett, Lehr, and Osorio (2004) argued that since a growing number of communities are adopting policies to

Received 26 September 2006; accepted 15 September 2007.

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promote advanced telecommunications services, including broadband access, governments should be considered broadband users, rulemakers, financiers, and infrastructure developers.

Strover (2003) approached the digital divide problem from various angles in a special issue of *The Information Society* entitled "Remapping the Digital Divide." Wilhelm (2003) suggested that everybody should have access to essential information and communication technologies, and, more importantly, all people should be able to use them to achieve their goals; therefore, policymakers should leverage the utility of existing infrastructures to expand human capital development. Van Dijk and Hacker (2003) separated digital divide into two large categories:

1. Material digital divide: lack of elementary digital experiences (mental access) and no computers or network connections (material access).
2. Usage digital divide: lack of digital skills (skills access) and lack of significant usage opportunities (usage access).

They argue that public policies have been preoccupied with the material digital divide; however, the problem has shifted from the material to the usage digital divide.

In case of Japan's digital divide, the Ministry of Internal Affairs and Communications (MIC) has reported that, as of October 2004, although FTTH is now becoming available in cities and towns with populations over 50,000, there is hardly any provision for starting FTTH in towns or villages with smaller populations. For ADSL, on the other hand, critical mass is a population of 5,000.[4] Therefore, the digital divide in FTTH service remains a big social issue. We call this problem *access-based* digital divide. At present, the Japanese government is addressing this digital divide by creating e-Japan and u-Japan strategies.

Another problem is called *usage-based* digital divide (though a positive relation usually exists between the access-based and usage-based digital divides). Even if high-speed Internet infrastructure is established in provincial areas, residents whose information literacy is low cannot effectively exploit broadband access. It is true that the usage rate of personal computers by elderly people living in provincial areas is very low, but they would greatly benefit from such remote provisions of public services as tele-medicine and tele-care. Moreover, it is important to clearly distinguish the *quantitive* aspects from the *qualitative* aspects of the remote provision of public services over FTTH.[5]

The purpose of this article is to investigate the usage-based digital divide from both *qualitative* and *quantitive* standpoints.[6] We compare two regions in which FTTH services have already been started: Yawata in Yamagata Prefecture (a typical depopulated area) and the Tokyo Metropolitan Area. We use the same survey questionnaire in both regions and analyze the data by using a mixed logit model, and we measure willingness-to-pay (WTP) values for various public services over FTTH.

The first finding in this article is that from the quantitative standpoint, there is no usage-based digital divide between the two FTTH available areas, provincial and urban. We consider three categories and nine services provided over FTTH, as shown in Table 1: telecommunication and broadcasting services (Internet Protocol [IP] phone, television [TV] phone, terrestrial digital broadcasting), health and security services (tele-care, tele-medicine, disaster alarm), and society and life services (tele-working, electronic government, tele-education). Measuring the total WTP for those services over FTTH, the figures are ¥8,733 (US$79.40, given US$1 = ¥110) for the provincial area (Yawata) and ¥8,620 (US$78.36) for the urban area (Tokyo), respectively. Thus, the former is slightly higher than the latter, meaning that there is sufficient need for public services over FTTH even in the provincial area.

The second conclusion is that from the qualitative standpoint, a usage-based digital divide certainly does exist. Although total WTP values are almost identical between the provincial and urban areas, the compositions of the values are largely different. For the provincial area (Yawata), expenditures for terrestrial digital broadcasting are extremely large, while interest in tele-working and tele-education is quite small. On the other hand, for the urban area (Tokyo), interest ranges broadly from terrestrial digital broadcasting to tele-working and tele-education.

The discussion is organized as follows. We first explain why FTTH takes precedence over other broadband services in Japan. We then explain the usage situation with regard to FTTH service in Yawata and Tokyo. Thereafter we explain the conjoint analysis and the econometric model we employ, and demonstrate the estimation results and measures WTP values for public services over FTTH. Finally, we offer our concluding remarks.

WHY FTTH TAKES PRECEDENCE IN JAPAN

Before moving to the detailed analysis, we need to briefly explain why FTTH takes precedence over other broadband services, especially ADSL, in Japan. NTT has declared its target of implementing an FTTH service environment with 30 million users by 2010. There are currently 60 million households with subscriber telephone contracts, so the figure of 30 million represents half of these. This is a commendable move, because NTT now has a concrete target to aim for and is striving to achieve that level of penetration. With regard to charges, the differential between ADSL and FTTH has almost disappeared. To use ADSL, subscribers must pay a monthly phone subscription charge of over $14 and an ADSL usage charge of about $20. On top of that, they also have to pay for their phone calls. On the other

TABLE 1
Public services over FTTH

Service	Explanations
	(a) Telecommunication and broadcasting services
IP phone	IP phone is also called Voice over Internet Protocol (VoIP) and the routing of voice conversations over the Internet or through any other IP-based network. In general, it is free or costs less than traditional public switched telephone network (PSTN) services.
TV phone	TV phone can send and receive VGA-equivalent video data, and users can connect TV phones to home video devices to transmit recorded video to the other end, which will record the received video data on a connected recorder, in part, over FTTH.
Terrestrial digital broadcasting	Terrestrial digital broadcasting systems, which embrace television in high quality, started in Tokyo, Osaka, and Nagoya in December 2003, and by 2011 every TV program in Japan will be digitalized.
	(b) Health and security services
Tele-care	Tele-care offers remote care for the elderly and the vulnerable, providing care and reassurance to allow them to remain in their own homes. Using sensors offers risk management as part of a package that can support people with dementia or at risk of falling.
Tele-medicine	Tele-medicine delivers medicine at a distance, which may be as simple as health professionals or patients discussing a case by telephone, or as complex as using video conferencing equipment to conduct a real-time consultation.
Disaster alarm	The disaster alarm features short rings of an alarm bell and other advanced functions such as automatic switching and sending audio or video data in cases of disasters or emergencies.
	(c) Society and life services
Tele-working	Tele-working (also tele-commuting) is the ability to work from home, a satellite office, or a tele-work center instead of commuting.
Electronic government	Electronic government applies information and communications technology (ICT) to enhance the effectiveness of government or the judiciary, improving efficiency, changing the relationship between citizens and government, or both.
Tele-education	Tele-education conducts conferences between two or more participants at different sites by using computer networks to transmit audio and video data. It also connects teachers and students at remote sites in real time.

hand, FTTH users have to pay a FTTH usage charge of about $40. Since they can use optical IP phone services, they are able to dispense with a subscriber phone line, and hence it is often the case that FTTH works out to be the cheaper of the two. Accordingly, in terms of cost there are no financial obstacles to prevent current ADSL users from migrating to FTTH.

Furthermore, NTT is now planning to deploy FTTH on a national scale, taking the same line as the development of the Next Generation Network (NGN), in which one network transports all services. Because the current Internet standard (Internet Protocol v. 4) is only able to support best-effort quality services and will soon run out of IP addresses, the NGN will be based on the next-generation Internet standard (Internet Protocol v. 6) and will support cost-effective, high-quality services. The NGN will also readily provide interactive videophone services and delivery of high-definition quality contents. The NGN also provides much more robust network control and management of illegal traffic, and is thus able to avoid network congestion and prevent fraudulent transactions, invasion of people's privacy, and other kinds of cyber crime. The NTT Group plans to begin full-scale deployment of NGN services during 2007. In general there is a sense of impending crisis that the full potential of broadband services will not be realized because the current Internet only supports best-effort services and security is inadequate.

FTTH USAGE IN YAWATA AND TOKYO

Since Tokyo is Japan's capital, all main administrative and legislative functions are centralized there. As of March 2006, by prefecture, Tokyo had both the highest diffusion rate of FTTH (11.5%) and the most subscribers (665,801). On the other hand, Yamagata Prefecture, located along the Japan Sea, is a typical depopulated area. It ranks around the mid 30s in prefectural income and around 40th in FTTH

diffusion rate (2.1%) or in FTTH subscribers (8,091). The town of Yawata in Yamagata Prefecture is special because one-third of its households subscribe to FTTH services. On this point, there is no access-based digital divide between Yawata and Tokyo. However, in Yawata the ratio of senior citizens 65 years old or more exceeds 27.5%, and most of these are informationally deprived. In this sense, a usage-based digital divide may exist between Yawata and Tokyo. We compared FTTH usages in both areas by using the same questionnaire.

FTTH Usage in Yawata

As of March 2003, Yawata in Yamagata Prefecture had 1,926 households and was becoming an area with one of the oldest populations in Japan. In terms of high-speed Internet access, there are two digital divides: between Yawata and other towns, and between its central plain and surrounding mountain zones. According to an investigation of Internet access by the Yawata town offices, as of March 2003, the rate of personal computer ownership was 50.4% and the diffusion rate of Internet access was 32.4%, both of which were almost the same as national averages in 2000.

The same local government survey also asked whether residents were willing to subscribe to FTTH for ¥5,000 (US$45.45) per month. As a result, among 1,224 families (whose recovery rate was 66%), 187 families (15.3%) replied "promptly" and 282 families (23.0%) replied "in a few years"; in total, 469 families (38.3%) were seriously considering subscribing to FTTH.

Then the office proposed a plan entitled *The Basic Plan for the Development of Information and Communication Technology in Yawata*, which was selected by the Ministry of Internal Affairs and Communications as the *Development Project of Optical-Fiber Access Line*. This project subsidized about 30% of the total construction cost of ¥315 million (US$2.9 million) for Yawata. As such, FTTH service in Yawata called *E-Naka Net* started in April 2004. At the start of FTTH service, 610 families subscribed,[7] exceeding survey expectations. Two FTTH services were available: the basic for ¥4,400 (US$40) and the advanced (making it possible to use high-quality IP phone and TV phone) for ¥5,300 (US$48). More than 90% chose the former, revealing that introductory pricing is important for FTTH diffusion.

We jointly carried out a FTTH usage survey in January 2006 with the Yawata Town Office. The 163 respondents correspond to one fourth of the total FTTH subscribers in Yawata. We summarize the demographics of respondents in Table 2, current Internet usage in Table 3, and the actual or expected utilization of public services over FTTH in Table 4, respectively.

FTTH Usage in Tokyo

In the Tokyo Metropolitan Area, such Internet access line companies as NTT East, Tokyo Electricity Power Company, KDDI, and USEN are providing FTTH services and fiercely competing with each other. We carried out a survey regarding FTTH usage in January 2006 with 182 respondents. As with Yawata, we summarize the demographics of the respondents in Table 2, current Internet usage in Table 3, and the expected utilization of public services over FTTH in Table 4.

Comparison of FTTH Usage Between Yawata and Tokyo

We investigate the differences in FTTH utilization between Yawata and Tokyo.[8] First, we examine Table 2, in which the demographics of respondents are indicated. As for age, many respondents in Yawata are in their 50s, while those in Tokyo are in their 30s. There are more male respondents in Yawata than in Tokyo. Regarding residence, detached houses are common in Yawata, while apartments are more common in Tokyo. For family composition, even three-generation families are quite common in Yawata, while singles or couples are common in Tokyo. For occupations, more people are without regular occupations, such as housewives and students, in Tokyo than in Yawata. It is interesting that all the preceding findings precisely reflect the general differences between provincial and urban areas.

Next we turn to Table 3, which demonstrates the current Internet usage of FTTH subscribers in Yawata and Tokyo. The most common monthly Internet connection fee ranges from ¥4,000 (US$36.40) to ¥5,000 (US$45.80) in both areas, but the figures are more scattered in Tokyo than in Yawata because there are many FTTH providers in Tokyo.[9] Remarkably for frequently used services, current utilizations are more progressive in Tokyo than in Yawata for all terms.[10] For example, for downloading a large volume of data such as video, the usage rate in Tokyo (33.5%) is much higher than Yawata (17.8%). In this respect, the disparity of information literacy between Yawata and Tokyo results in a utilization gap. However, note that there is higher demand for the provision of public services over FTTH in Yawata (38.0%) than in Tokyo (24.2%), which probably reflects the higher ratio of senior citizens in Yawata. The elderly expect to use public services more effectively.

Last, we examine Table 4, which describes the expected utilization of public services over FTTH. To examine willingness to use each service, we attribute 1 point to *currently using*, 2 points to *strongly want to use*, 3 points to *want to use*, 4 points to *no opinion*, 5 points to *do not want to use too much*, 6 points to *never want to use*, and then calculate averages by weighing choice ratios. Thus, the lower the score is, the more people want to use the service.

TABLE 2
Demographics of respondents

		Yawata (Yamagata) Respondents = 163		Tokyo Respondents = 182	
		No.	Ratio	No.	Ratio
Age	1. 10s	0	0.0%	7	3.8%
	2. 20s	13	8.0%	31	17.0%
	3. 30s	27	16.6%	61	33.5%
	4. 40s	49	30.1%	57	31.3%
	5. 50s	61	37.4%	21	11.5%
	6. 60s	10	6.1%	5	2.7%
	7. 70s	3	1.8%	0	0.0%
Gender	1. Male	138	84.7%	85	46.7%
	2. Female	25	15.3%	97	53.3%
Residence	1. Detached house	161	98.8%	53	29.1%
	2. Apartment	2	1.2%	118	64.8%
	3. Others	0	0.0%	11	6.0%
Family	1. Single	2	1.2%	36	19.8%
	2. Living with only wife	14	8.6%	34	18.7%
	3. Living with wife, child	89	54.6%	74	40.7%
	4. Living with parent, wife, and child	58	35.6%	38	20.9%
Occupation	1. Office worker	76	46.6%	83	45.6%
	2. Public official	33	20.2%	3	1.6%
	3. Self-employed	30	18.4%	10	5.5%
	4. No occupation on pension	10	6.1%	0	0.0%
	5. No occupation and no pension	3	1.8%	9	4.9%
	6. Others (housewife, student, etc.)	11	6.7%	77	42.3%

For the utilization of public services over FTTH in Yawata, the order from the top is as follows: (1) disaster alarm (2.344), (2) terrestrial digital broadcasting (2.571), (3) electronic government (2.712), (4) tele-medicine (2.926), (5) IP phone (2.945), (6) tele-care (3.129), (7) tele-education (3.245), (8) TV phone (3.325), and (9) tele-working (3.589). On the other hand, in Tokyo, the order is as follows: (1) disaster alarm (2.445), (2) electronic government (2.588), (3) IP phone (2.780), (4) terrestrial digital broadcasting (2.813), (5) tele-working (3.033), (6) tele-medicine (3.088), (7) tele-education (3.181), (8) tele-care (3.253), and (9) TV phone (3.676). Both Yawata and Tokyo rank disaster alarm first and TV phone at or near the bottom, while tele-working is evaluated low in Yawata but high in Tokyo.

Comparing average scores, TV phone, terrestrial digital broadcasting, tele-care, tele-medicine, and disaster alarm are ranked higher in Yawata, while IP phone, tele-working, electronic government, and tele-education are highly evaluated in Tokyo. We thus conclude that health and security services are preferred in Yawata, whereas society and life services are highly evaluated in Tokyo.[11]

ECONOMETRIC ANALYSIS

This section analyzes the data explained in the previous section. First, we explain conjoint analysis and a mixed logit model, which is a generalization of a conditional logit model.

Conjoint Analysis

Since Japanese FTTH service is now rapidly growing, it is quite difficult to collect sufficient actual market data for analysis based on revealed preference method (RPM).[12] As such, we use conjoint analysis, or, more generally, a stated preference method (SPM) that seems more suited for projecting such an emerging market as FTTH.[13]

Conjoint analysis, or discrete choice experiment (DCM), assumes that a service is a profile composed of

TABLE 3
Current Internet usages

		Yawata (Yamagata) Respondents = 163		Tokyo Respondents = 182	
		No.	Ratio	No.	Ratio
Internet use	1. Use	163	100.0%	182	100.0%
	2. Do not use	0	0.0%	0	0.0%
Internet access type	1. Dial up	0	0.0%	0	0.0%
	2. Always-on ISDN	0	0.0%	0	0.0%
	3. ADSL	0	0.0%	0	0.0%
	4. CATV Internet	0	0.0%	0	0.0%
	5. FTTH	163	100.0%	182	100.0%
	6. Others	0	0.0%	0	0.0%
Monthly expenditure	1. Less than Y2,000	1	0.6%	11	6.0%
	2. Y2,000 through Y3,000	6	3.7%	21	11.5%
	3. Y3,000 through Y4,000	6	3.7%	32	17.6%
	4. Y4,000 through Y5,000	82	50.3%	35	19.2%
	5. Y5,000 through Y6,000	48	29.4%	27	14.8%
	6. Y6,000 through Y7,000	15	9.2%	22	12.1%
	7. Y7,000 through Y8,000	3	1.8%	15	8.2%
	8. Y8,000 through Y9,000	0	0.0%	2	1.1%
	9. More than Y9,000	0	0.0%	3	1.6%
	10. No idea	1	0.6%	14	7.7%
	11. No response	1	0.6%	0	0.0%
Frequently used service	1. Mail service	116	71.2%	176	96.7%
	2. Home page browsing	138	84.7%	169	92.9%
	3. IP phone	17	10.4%	41	22.5%
	4. TV phone	3	1.8%	7	3.8%
	5. On-line games	24	14.7%	45	24.7%
	6. On-line shopping	99	60.7%	127	69.8%
	7. On-line banking	27	16.6%	104	57.1%
	8. Music download	34	20.9%	46	25.3%
	9. Movie download	29	17.8%	61	33.5%
	10. Other pay services	8	4.9%	10	5.5%
Satisfaction	1. Very satisfied	20	12.3%	28	15.4%
	2. Satisfied	77	47.2%	83	45.6%
	3. Average	56	34.4%	44	24.2%
	4. Dissatisfied	10	6.1%	27	14.8%
	5. Very dissatisfied	0	0.0%	0	0.0%
Public service over FTTH	1. Strongly want to use	62	38.0%	44	24.2%
	2. Want to use	79	48.5%	103	56.6%
	3. No opinion	22	13.5%	33	18.1%
	4. Do not want to use	0	0.0%	2	1.1%
	5. Never want to use	0	0.0%	0	0.0%

attributes.[14] In an FTTH service context, for example, basic monthly charges and available functions are considered attributes. The purpose of the analysis is to construct a profile composed of a palette of the introduced attributes. If we include too many attributes, respondents have difficulty answering the questions. On the other hand, if we include too few, the description of alternatives becomes inadequate. After carrying out several pretests, we determined

TABLE 4
Utilization of public services over FTTH

		Yawata (Yamagata) Respondents = 163		Tokyo Respondents = 182	
		No.	Ratio	No.	Ratio
	(a) Telecommunication and broadcasting services				
IP phone	1. Currently using	24	14.7%	50	27.5%
	2. Strongly want to use	42	25.8%	32	17.6%
	3. Want to use	38	23.3%	42	23.1%
	4. No opinion	45	27.6%	31	17.0%
	5. Do not want to use too much	6	3.7%	20	11.0%
	6. Never want to use	8	4.9%	7	3.8%
	Average score	2.945		2.780	
TV phone	1. Currently using	4	2.5%	8	4.4%
	2. Strongly want to use	33	20.2%	21	11.5%
	3. Want to use	59	36.2%	56	30.8%
	4. No opinion	48	29.4%	47	25.8%
	5. Do not want to use too much	11	6.7%	37	20.3%
	6. Never want to use	8	4.9%	13	7.1%
	Average score	3.325		3.676	
Terrestrial digital broadcasting	1. Currently using	0	0.0%	0	0.0%
	2. Strongly want to use	110	67.5%	76	41.8%
	3. Want to use	21	12.9%	69	37.9%
	4. No opinion	27	16.6%	33	18.1%
	5. Do not want to use too much	2	1.2%	3	1.6%
	6. Never want to use	3	1.8%	1	0.5%
	Average score	2.571		2.813	

		Yawata (Yamagata) Respondents = 163		Tokyo Respondents = 182	
		No.	Ratio	No.	Ratio
	(b) Health and security services				
Tele-care	1. Currently using	1	0.6%	1	0.5%
	2. Strongly want to use	50	30.7%	45	24.7%
	3. Want to use	51	31.3%	69	37.9%
	4. No opinion	52	31.9%	48	26.4%
	5. Do not want to use too much	6	3.7%	12	6.6%
	6. Never want to use	3	1.8%	7	3.8%
	Average score	3.129		3.253	
Tele-medicine	1. Currently using	0	0.0%	1	0.5%
	2. Strongly want to use	62	38.0%	52	28.6%
	3. Want to use	61	37.4%	81	44.5%
	4. No opinion	31	19.0%	32	17.6%
	5. Do not want to use too much	8	4.9%	10	5.5%
	6. Never want to use	1	0.6%	6	3.3%
	Average score	2.926		3.088	

(Continued on next page)

TABLE 4
Utilization of public services over FTTH *(Continued)*

		No.	Ratio	No.	Ratio
Disaster alarm	1. Currently using	0	0.0%	1	0.5%
	2. Strongly want to use	126	77.3%	118	64.8%
	3. Want to use	25	15.3%	47	25.8%
	4. No opinion	7	4.3%	14	7.7%
	5. Do not want to use too much	3	1.8%	1	0.5%
	6. Never want to use	2	1.2%	1	0.5%
	Average score	2.344		2.445	
		Yawata (Yamagata) Respondents = 163		Tokyo Respondents = 182	
		No.	Ratio	No.	Ratio
	(c) Society and life services				
Tele-working	1. Currently using	0	0.0%	4	2.2%
	2. Strongly want to use	40	24.5%	77	42.3%
	3. Want to use	39	23.9%	47	25.8%
	4. No opinion	51	31.3%	30	16.5%
	5. Do not want to use too much	14	8.6%	11	6.0%
	6. Never want to use	19	11.7%	13	7.1%
	Average score	3.589		3.033	
Electronic-government	1. Currently using	1	0.6%	3	1.6%
	2. Strongly want to use	95	58.3%	104	57.1%
	3. Want to use	38	23.3%	49	26.9%
	4. No opinion	15	9.2%	19	10.4%
	5. Do not want to use too much	7	4.3%	5	2.7%
	6. Never want to use	7	4.3%	2	1.1%
	Average score	2.712		2.588	
Tele-education	1. Currently using	1	0.6%	2	1.1%
	2. Strongly want to use	52	31.9%	58	31.9%
	3. Want to use	54	33.1%	62	34.1%
	4. No opinion	32	19.6%	31	17.0%
	5. Do not want to use too much	10	6.1%	23	12.6%
	6. Never want to use	14	8.6%	6	3.3%
	Average score	3.245		3.181	

the attributes indicated in Table 1 and their levels. Since the number of profiles becomes unwieldy if we consider all possible combinations, we adopt an orthogonal planning method to avoid this problem (see Louviere et al., 2000, Chap. 4, for details).

Concretely, basic monthly charges are set from ¥3,000 (US$27.27) to ¥8,000 (US$72.72). Functions available for that charge are represented as dummy variables with an index of 1 (available) or 0 (unavailable). Figure 1 depicts the scope of the representative questionnaire covering profiles and attributes. We asked eight questions per respondent and used a stratified random sampling method on a data set, totaling 1,304 (163 × 8) samples for Yawata and 1,456 (182 × 8) samples for Tokyo.

Mixed Logit (ML) Model

This section describes our econometric model. Conditional logit (CL) models that assume independent and identical distribution (IID) of random terms have been widely used in past studies. However, independence from the irrelevant alternatives (IIA) property derived from the IID assumption of the CL model is too strict to allow for flexible substitution patterns. A nested logit (NL) model

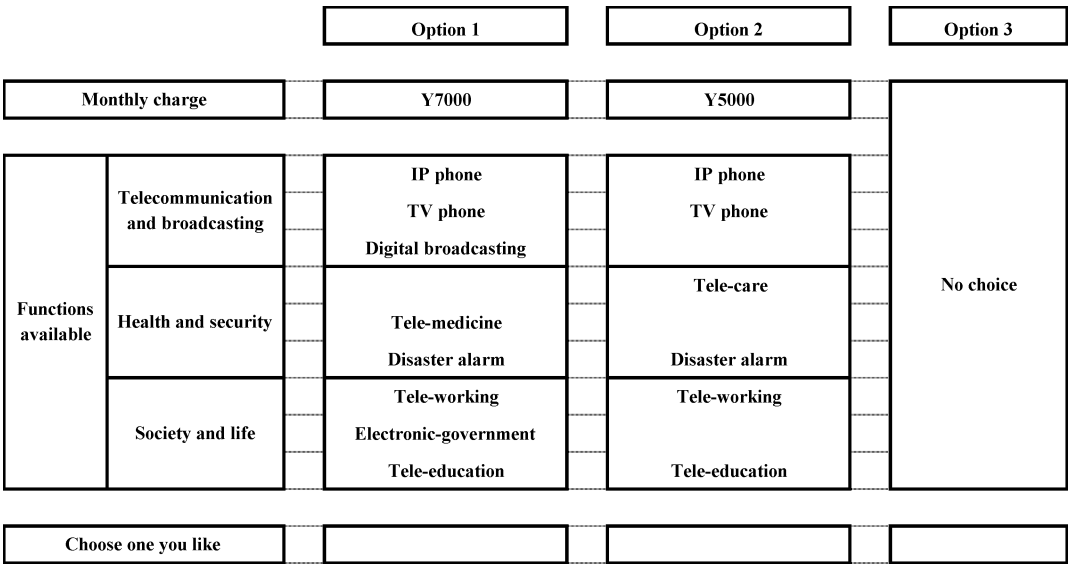


FIG. 1. Questionnaire sample.

partitions the choice set, allowing alternatives to have common unobserved components compared with nonnested alternatives by partially relaxing strong IID assumptions. However, even the NL model is not suited for our analysis because it cannot deal with the distribution of parameters (Ben-Akiva, Bolduc, & Walker, 2001).

Consequently, the most prominent model is a mixed logit (ML) that accommodates differences in variance of random components (or unobserved heterogeneity).[15] They are flexible enough to overcome the limitations of CL models by allowing for random taste variation, unrestricted substitution patterns, and the correlation of random terms over time (McFadden & Train, 2000). See APPENDIX for details of the ML model.[16]

In what follows, we assume that parameters for nine function dummy variables, except for constant term and basic monthly fee parameters, follow normal distribution. Accordingly, we can demonstrate variety in individual-level parameters.

ESTIMATION RESULTS AND ANALYSIS

This section shows estimation results and analyzes various outputs including willingness to pay and individual level parameters. While it is dangerous to infer too much from the analysis of two survey panels with fewer than 200 respondents each, such a quantitative analysis of FTTH demand can provide a first example for further studies.

Estimation Results

We used an ML model for estimating the data, as explained earlier. Table 5 indicates the estimation results for Yawata on the left and Tokyo on the right. McFadden's pseudo R^2 exceeds .3, corresponding to over .6 for ordinary least squares (OLS) R^2, which indicates quite a good fit for a discrete choice model (Domenich & McFadden, 1975). The parameters signs are all correct except for Yawata tele-working. Turning to t values, the results show conclusive evidence, as estimates are almost all statistically significant at the 5% level, except the means of TV phone parameter in both areas and tele-working and tele-education parameters in Yawata.[17]

Since differences exist in estimates and t values between Yawata and Tokyo, we investigated whether consumer preferences, expressed as parameters, are equal between Yawata and Tokyo by using a likelihood ratio (LR) test. More concretely, we use the following procedure. Let $L(\text{Yawata})$ and $L(\text{Tokyo})$ be the estimated log likelihood function values for the Yawata and Tokyo areas; furthermore, let $L(\text{Yawata} + \text{Tokyo})$ be the value of the estimated log likelihood function for the pooled data; then we obtain the test statistic of $-2[L(\text{Yawata} + \text{Tokyo}) - (L(\text{Yawata}) + L(\text{Tokyo}))]$, which is chi-squared ($\chi^2$) distributed (see Louviere et al., 2000, p. 244). As a result, the test statistic is 148.3, and the critical value of $\chi^2(df. = 20, p = .05)$is 31.4. Thus, we conclude that the preferences are not equal between Yawata and Tokyo.

Willingness to Pay

We calculate the average willingness to pay (WTP) for public services over FTTH,[18] as indicated in Table 5.[19] Also, a graphical presentation of WTP is given in Figure 2. At first, WTP values of Yawata are arranged in order as follows: (1) terrestrial digital broadcasting (¥3,144; US$28.58), (2) IP phone (¥1,441; US$13.10), (3) disaster

TABLE 5
Estimation results

		Yawata (Yamagata)					Tokyo				
Respondent No.		163					182				
Sample No.		1304					1456				
LL Max		−990.6					−1093.1				
LL (0)		−1432.6					−1599.6				
Pseudo R2		0.30851					0.31661				
		Estimates	S.E.	t value	p value	WTP	Estimates	S.E.	t value	p value	WTP
Non random parameter											
Constant of Option 3		−0.85304	0.38489	2.216	0.027		−1.85045	0.39409	4.696	0.000	
Monthly charge		−0.00089	0.00079	−11.242	0.000		−0.00111	0.00009	−12.943	0.000	
Random parameter											
IP phone	Mean	1.28652	0.19637	6.552	0.000	¥1,441	1.60337	0.21998	7.289	0.000	¥1,438
	S.D.	0.74074	0.32298	2.293	0.022		1.45168	0.21925	6.621	0.000	
TV phone	Mean	0.09207	0.23955	0.384	0.701	¥103	0.32455	0.22925	1.416	0.157	¥291
	S.D.	1.67340	0.21591	7.751	0.000		1.64202	0.19764	8.308	0.000	
Digital	Mean	2.80616	0.23636	11.872	0.000	¥3,144	2.66761	0.24357	10.952	0.000	¥2,393
broadcasting	S.D.	1.41369	0.27478	5.145	0.000		1.69451	0.22538	7.518	0.000	
Tele-care	Mean	0.61539	0.15905	3.869	0.000	¥689	0.39688	0.15845	2.505	0.012	¥356
	S.D.	0.81417	0.22107	3.683	0.000		0.80911	0.20555	3.936	0.000	
Tele-medicine	Mean	0.70193	0.21530	3.260	0.001	¥786	0.79245	0.16980	4.667	0.000	¥711
	S.D.	1.73468	0.23015	7.537	0.000		1.23446	0.17891	6.900	0.000	
Disaster alarm	Mean	1.19331	0.19881	6.002	0.000	¥1,337	1.50674	0.20984	7.180	0.000	¥1,351
	S.D.	1.10868	0.20292	5.464	0.000		1.61002	0.19786	8.137	0.000	
Tele-working	Mean	−0.17044	0.19411	−0.878	0.380	¥−191	0.56963	0.21270	2.678	0.007	¥511
	S.D.	1.06846	0.30790	3.470	0.001		1.52078	0.25553	5.951	0.000	
E government	Mean	1.11920	0.18917	5.916	0.000	¥1,254	1.13364	0.16530	6.858	0.000	¥1,017
	S.D.	1.32175	0.25424	5.199	0.000		0.91489	0.19597	4.669	0.000	
Tele-education	Mean	0.18608	0.19706	0.944	0.345	¥208	0.61578	0.20405	3.018	0.003	¥552
	S.D.	0.98654	0.25242	3.908	0.000		1.35399	0.20293	6.672	0.000	
$\chi 2$(d· f = 20, p = 5%)		31.4			Total WTP	¥8,773				Total WTP	¥8,620
Test statistic		148.3									

alarm (¥1,337; US$12.15), (4) electronic government (¥1,254; US$11.40), (5) tele-medicine (¥786; US$7.15), (6) tele-care (¥689; US$6.26), (7) tele-education (¥208; US$1.89), (8) TV phone (¥103; US$0.94), and (9) tele-working (¥-191; US$-1.74).

Next, WTP values of Tokyo are as follows: (1) terrestrial digital broadcasting (¥2,393; US$21.75), (2) IP phone (¥1,438; US$13.07), (3) disaster alarm (¥1,351; US$12.28), (4) electronic government (¥1,017; US$9.25), (5) tele-medicine (¥711; US$6.46), (6) tele-education (¥552; US$5.02), (7) tele-working (¥511; US$4.65), (8) tele-care (¥356; US$3.24), and (9) TV phone (¥291; US$2.65).

Comparing the total WTP values that comprise individual WTP values, the figures are almost identical: ¥8,773 (US$79.75) for Yawata and ¥8,620 (US$78.36) for Tokyo. Interestingly, the total WTP value of FTTH users is higher in Yawata, even though their information literacy seems lower than in Tokyo. This result contradicts the common view that effective utilization of FTTH services does not exist in provincial areas, which is consistent with our finding that there is greater potential demand for public services, in particular for digital broadcasting, over FTTH in Yawata than in Tokyo. In summary, there is not a *service-based* digital divide, at least, from a *quantitive* view of point, which is here defined as the level of total WTP for public services over FTTH.

However, a large difference can be observed regarding individual WTP values between Yawata and Tokyo. In Yawata, the WTP value for terrestrial digital broadcasting is much more prominent than the others, while the WTP values for tele-working and tele-education are

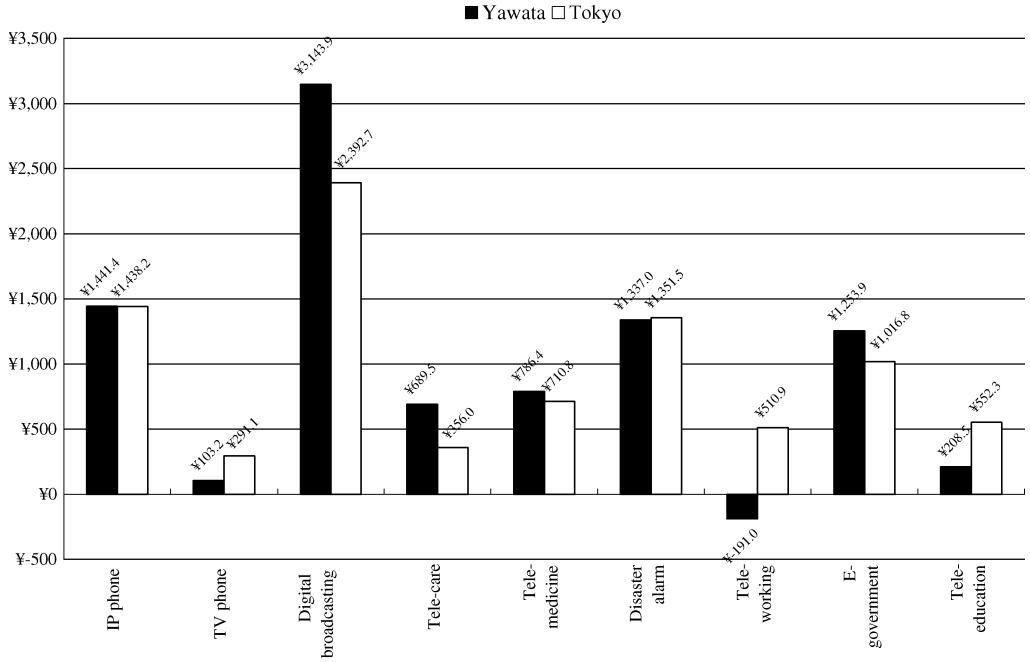


FIG. 2. Comparison of WTP values.

very low. On the other hand, in Tokyo, WTP values are statistically significant, except TV phone, and, in particular, tele-working and tele-education are highly evaluated compared to Yawata. We observe, consequently, a contrast between the provincial area, in which FTTH is mainly considered a measure to counter poor reception, and the urban area, in which FTTH is expected to improve social lives, including work and school.[20] Also, we should not ignore demographic differences between Yawata and Tokyo; there are more elderly people of lower information literacy in provincial areas, while there are more young people of higher information literacy in urban areas. For this point, there is a *service-based* digital divide based on a *qualitative* point of view, which is here defined as the contents of individual WTP for public services over FTTH.

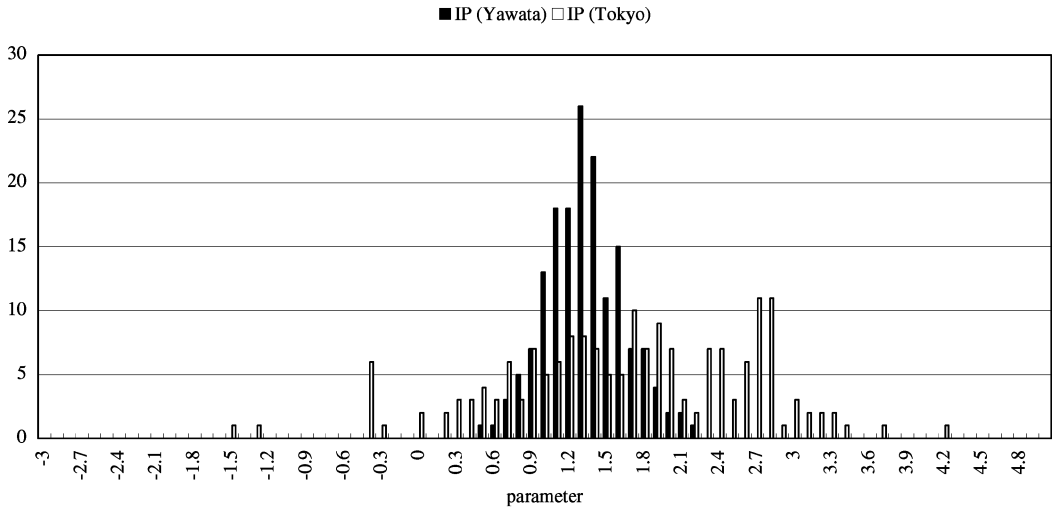
Conditional Distributions of Random Parameters

In an ML model, we can indicate varieties in individual preferences by standard deviations of random parameters. For example, in Yawata, although the mean estimates are close between the tele-care (0.61539) and tele-medicine parameters (0.70193), the standard-deviation estimates greatly differ between the tele-care (0.81417) and tele-medicine parameters (1.73468). We thus see that in Yawata evaluation for tele-medicine varies more than for tele-care. One reason may be that FTTH subscribers lack agreement regarding tele-medicine because they still believe that directly receiving outpatient treatment is important, while sharing the close preferences for tele-care as home-based care that is now becoming quite common.

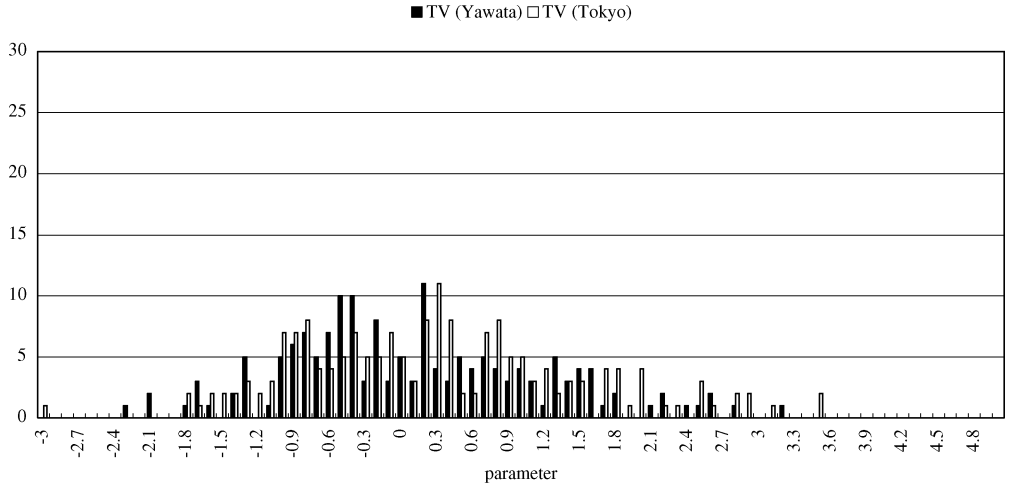
Figure 3 displays the conditional parameter distributions, which are based on the Bayes theorem; in other words, we can calculate the estimator of the conditional mean of the random parameters, conditioned on individually specific choice profiles (see Appendix for details). First, comparing the conditional parameters of IP phone between Yawata and Tokyo, the mean values are almost identical, but those parameters are more widely scattered in Tokyo than in Yawata. This is consistent with the observation in Table 4, which demonstrates that in Tokyo FTTH users who want to use IP phone service coexist with those who do not. Next, turning to the conditional parameters of tele-working between Yawata and Tokyo, the mean value in Tokyo is clearly higher than in Yawata. This also corresponds to Table 4, suggesting that FTTH users living in Tokyo have much higher evaluation for tele-working than in Yawata.

CONCLUSION

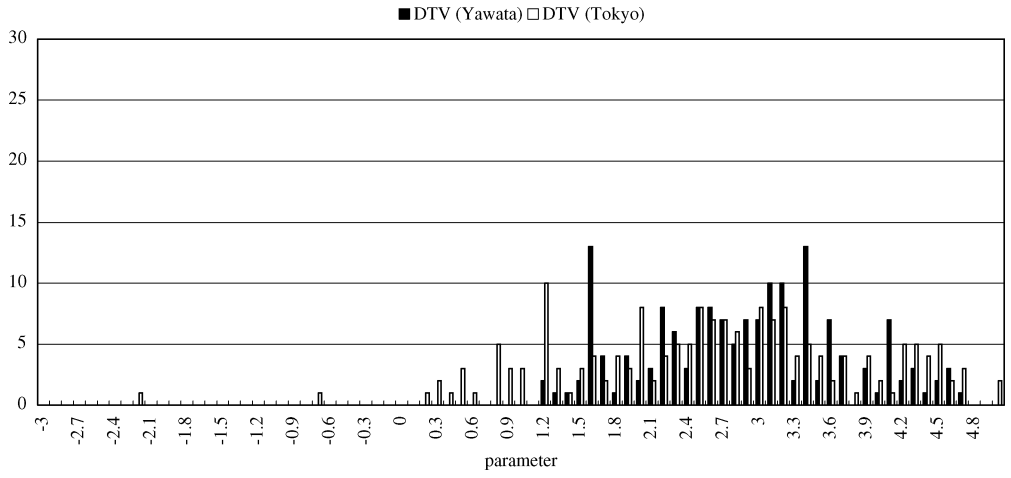
Digital divide is the shadow of brilliant broadband services. We get a clear idea of the problem from two different angles: access-based digital divide and usage-based digital divide. Since most research so far has concentrated on the former, we focus on the latter problem by using conjoint analysis and a mixed logit model. We reach two main conclusions. First, we did not quantitatively observe



(a) IP phone

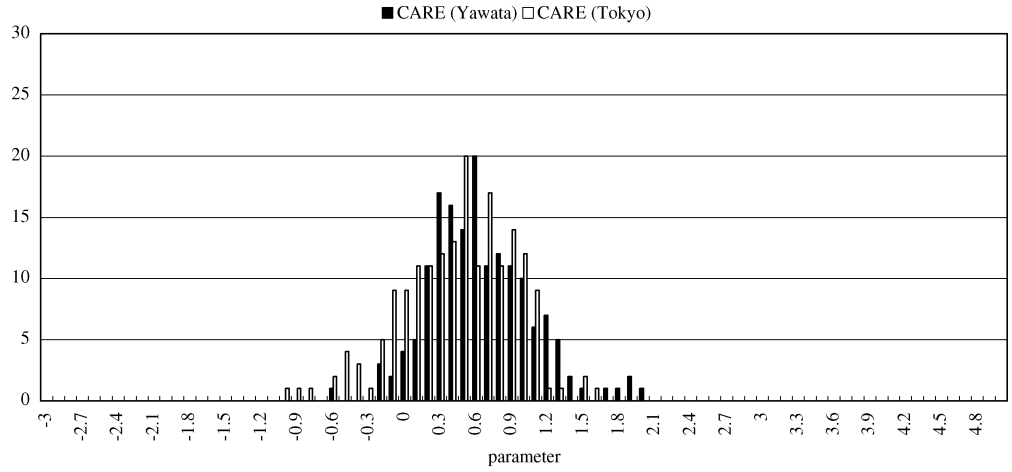


(b) TV phone

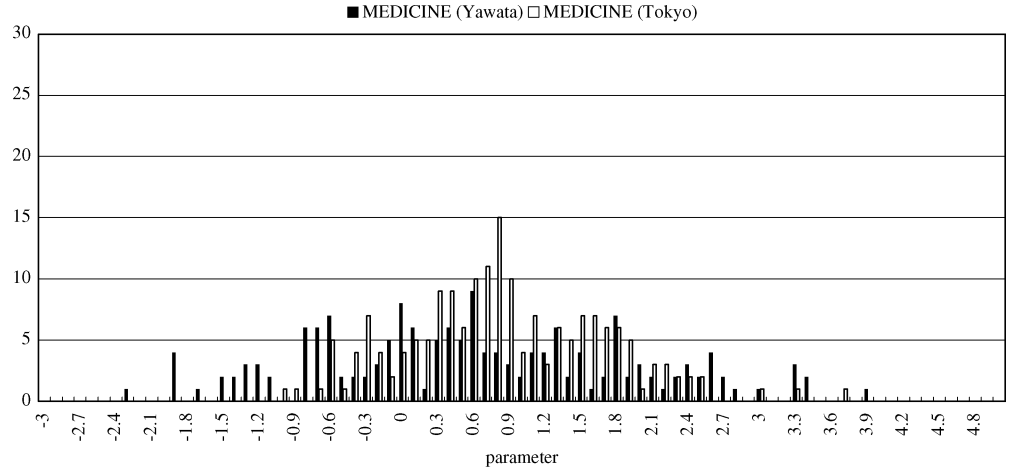


(c) Terrestrial digital broadcasting

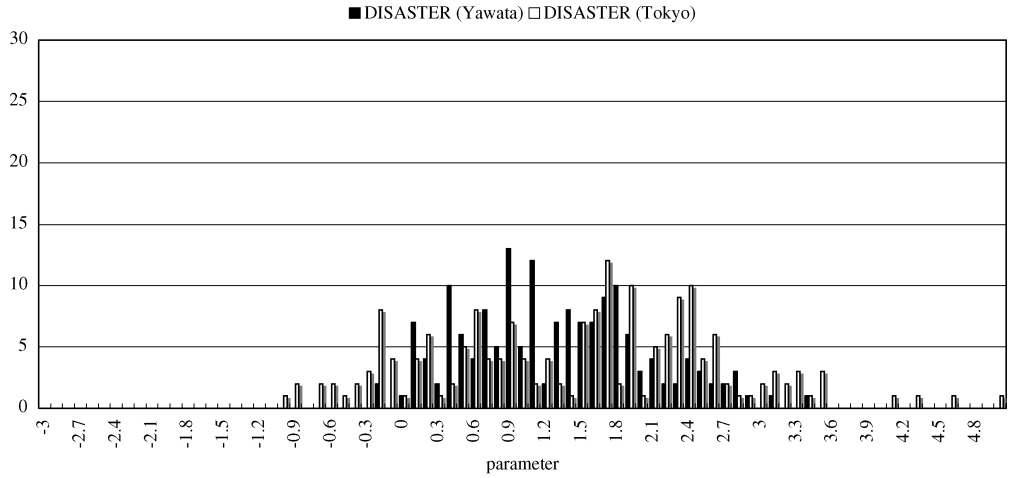
FIG. 3. Conditional parameters: (a) IP phone; (b) TV phone; (c) terrestrial digital broadcasting; (d) tele-care; (e) tele-medicine; (f) disaster alarm; (g) tele-working; (h) electronic government; (i) tele-education. (*Continued*)



(d) Tele-care

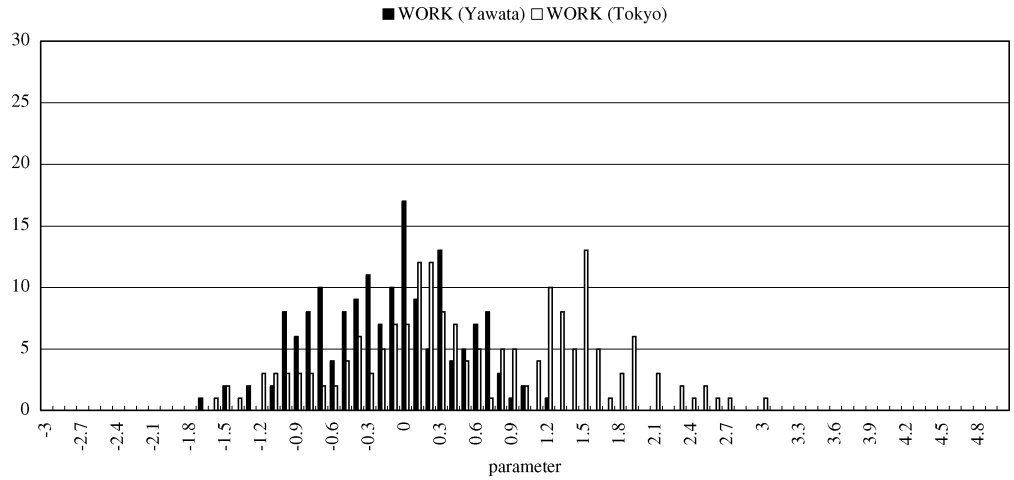


(e) Tele-medicine

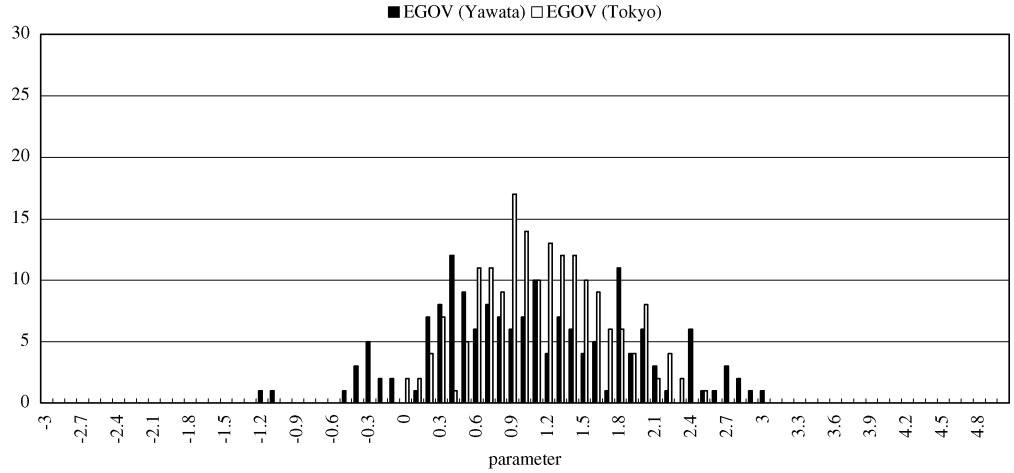


(f) Disaster alarm

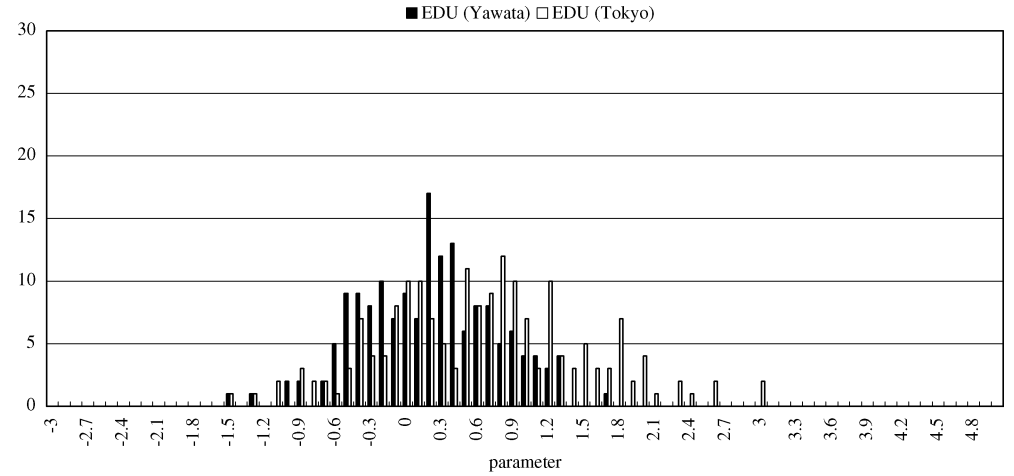
FIG. 3. (Continued)



(g) Tele-working



(h) Electronic government



(i) Tele-education

FIG. 3. Continued

the usage-based digital divide between provincial and urban areas because total willingness to pay for using public services over FTTH is almost identical between Yawata and Tokyo. Therefore we conclude that potential demand exists for public services over FTTH even in provincial areas. Second, there is a usage-based digital divide in a qualitative sense. In the provincial area, terrestrial digital broadcasting overwhelms other services in WTP values. On the other hand, in the urban area, tele-working and tele-education are also highly evaluated, as well as terrestrial digital broadcasting. Therefore, simply securing access to FTTH nationwide is insufficient, and measures are necessary to solve the qualitative digital-divide problem in provincial areas, such as improving information literacy among elderly people. Since innovation is rapidly changing the landscape of telecommunication infrastructure and architecture, this research will have broad implications concerning the industrial policies of telecommunication services that need careful consideration in the future.

APPENDIX: THE MIXED LOGIT (ML) MODEL

Here we explain an ML model assuming that parameter β is distributed with density function $f(\beta)$(Train, 2003; Louviere et al., 2000). The logit probability of decision maker n choosing alternative i is expressed as

$$L_{ni}(\beta) = \exp(V_{ni}(\beta))/\sum_{j=1}^{J} \exp(V_{nj}(\beta))$$

which is the normal logit form, given parameter β, the observable portion of utility function V_{ni}, and alternatives $j = 1, \ldots, J$. Therefore, the ML choice probability is a weighted average of logit probability $L_{ni}(\beta)$ evaluated at parameter β with density function $f(\beta)$, which can be written as

$$P_{ni} = \int L_{ni}(\beta) f(\beta) d\beta$$

In a form that is linear in parameters, the utility function can be written as

$$U_{ni} = \alpha' x_{ni} + \beta' z_{ni} + \varepsilon_{ni}$$

where x_{ni} and z_{ni} respectively denote observable variables, α denotes a fixed parameters vector, β denotes a random parameter vector, and ε_{ni} denotes an independently and identically distributed extreme value (IIDEV) term.

Since ML choice probability is not expressed in closed form, simulations need to be performed for the ML model estimation. Let θ be a deep parameter of parameterβ, in other words, the mean and variance of parameter density function $f(\beta|\theta)$. ML choice probability is approximated through the simulation method. More specifically, the simulation is carried out as follows (see Train, 2003, p. 148 for details): First, draw a value of β from $f(\beta|\theta)$ for any given value of θ, and repeat this process R times (labeled β^r, $r = 1 \ldots R$); second, calculate the logit formula probability $L_{ni}(\beta)$ with each draw; and third, averaging $L_{ni}(\beta)$, the simulated choice probability is obtained as

$$\hat{P}_{ni} = (1/R) \sum_{r=1}^{R} L_{ni}(\beta^r)$$

We can also calculate the estimator of the conditional mean of the distribution of the random parameters, conditioned on individual specific choice profile y_n (see Revelt & Train, 2000, for details), which is given as

$$h(\beta|y_n) = \frac{P(y_n|\beta) f(\beta)}{\int P(y_n|\beta) f(\beta) d\beta}$$

We here use a simulation method for estimation by setting 100 Halton draws.[21] Furthermore, since a respondent repeatedly completes eight questionnaires, we consider the data a kind of panel data. Thus, we apply a standard random effect method in which random draws are repeatedly reused for the same respondent.

NOTES

1. ITU (2003) compared rates per 100 kbps among various countries: (1) Japan ($0.09), (2) Korea ($0.25), (3) Belgium ($1.15), (4) Hong Kong, China ($1.27), (5) Singapore ($2.21), (10) USA ($3.53), (19) UK ($6.37), and so on.

2. This article focuses on FTTH, the most advanced broadband service, because both NTT and the Japanese government have aggressively pursued the deployment of optical fiber networks since the 1990s, and most recently (as of December 2006) 30% of broadband users in Japan subscribe to FTTH. However, in other countries, FTTH is still not commonly used and other alternatives, including xDSL, cable modem Internet, or power line communications services, satisfy many needs. Therefore, we must exercise caution when applying the results of this article to other nations.

3. Most recently, the indices used to measure the digital divide were critically evaluated (see Barzilai-Nahon, 2006; Vehovar et al., 2006).

4. The details are given as follows: (1) 50,000 or more (478 cases): FTTH (93.9%), ADSL (100%); (2) 10,000 through 50,000 (1,186 cases): FTTH (33.8%), ADSL (99.2%); (3) 5,000 through 10,000 (783 cases): FTTH (10.6%), ADSL (89.9%); (4) 5,000 or less (676 cases): FTTH (2.1%), ADSL (48.8%) (note: numbers represent the percentage of communities where the service is at least partially available; source: http://www.soumu.go.jp/s-news/2005/050201_1.html (in Japanese).

5. The term *public service* is repeatedly used in this article. However, we do not precisely define it because the academic definition of public goods does not always correspond to the popular image of public services. We tentatively use the term with following meanings: first,

services for which public interventions are more or less necessary although pure private provision may be possible, such as telephone, broadcasting; second, merit goods considered necessities to civic lives and that should be supplied based on public initiatives, including medicine, care; and third, services whose social effects are so large that the government should assist or even subsidize the startups for their diffusions, including tele-working and tele-education.

6. This article provides insight into the nature of demand for FTTH, which has obvious relevance to the digital divide debate, but it can also contribute to much broader discussions of public initiatives to promote the diffusion of broadband Internet services and the deployment of the next generation Internet networks.

7. Note that since 700 households living in the mountain zone of Yawata suffered from poor reception, they expect FTTH to be an effective transmission system for terrestrial digital broadcasting. This is one reason why many households in Yawata joined the FTTH service.

8. In our survey, a representative responds from each family, but his/her opinion may not correctly reflect the preference of the family.

9. FTTH subscribers in Tokyo pay less because facility-based competition as well as service-based competition by multiple providers exists and various discount campaigns are also available to consumers.

10. The reason why current Internet utilizations are more progressive in Tokyo than in Yawata for all terms can in part be attributed to the maturity of broadband markets; broadband services, including FTTH, became available much earlier in Tokyo than in Yawata. For example, FTTH started in 2001 in Tokyo and in 2004 in Yawata.

11. The reason why health and security services are preferred in Yawata, whereas society and life services are highly valued in Tokyo, partly reflects population demographics: Many respondents in Yawata are in their 50s, while those in Tokyo are in their 30s.

12. Examples that have analyzed broadband services by using RPM include Madden et al. (1999), Eisner and Waldon (2001), Kridel et al. (2001), Dufy-Deno (2003), and Ida and Kuroda (2006).

13. Examples that have analyzed broadband services by using SPM include Madden and Simpson (1997), Savage and Waldman (2005), Ida and Sato (2004), and Ida, Kinoshita, and Sato (2007).

14. Our findings are based on a DCE in which the effects of attributes are evaluated based on answers from hypothetical scenarios. Thus, there is no guarantee that respondents who answer that they are willing to pay will actually pay. For example, the potential defects of SPM (including DCE) have been indicated, since they only model current consumer attitudes for market forecasting. Their current intentions will become accurate reflections of future choices only if the current environment represents a future in which their choices are realized (Fields & Kumar, 2002).

15. ML models are also called random parameter models if focusing on the distribution of parameters, or as error component models if focusing on the flexible substitution pattern (Revelt & Train, 1998; Brownstone & Train, 1999).

16. This article only deals with discrete choice of services, and future research will consider the continuous aspects of choice variables. We then assume that the attributes are orthogonal based on a main effects model. Although Dawes and Corrigan (1974) showed that alienating interaction effects with main effects might be justified since main effects typically account for 70% to 90% of explained variance, we believe that trying an interaction effects model is still important.

17. These results were expected because those utilizations were very low in the questionnaire survey.

18. The willingness to pay for an attribute is calculated by substituting a monetary attribute estimate for another attribute estimate. There are two problems concerning WTP measurements. First, since WTP is the sum of the demand of high-speed Internet connection itself and derived demands (e.g., public services) over FTTH, the sum of WTP values is necessarily greater than each WTP. Second, since Internet access-line and service providers cannot completely extract the consumer surplus that includes the derived demands (e.g., public services) over FTTH, they are often in conflict with content/application providers.

19. Here WTP means values for adding a function over FTTH, and it does not include usage fees necessary for actual use. For example, WTP for IP phone includes no call charge but a basic monthly charge.

20. FTTH is expected to improve social lives including tele-working and tele-education in urban areas because substitutes are differentially available between urban and rural markets. For example, most people employed in Tokyo are white-collar workers who suffer from hellish commutes, while many in Yawata are engaged in agriculture and are unconcerned with commuting, which results in different evaluations of tele-working.

21. Louviere et al. (2000, p. 201) suggest that 100 replications are normally sufficient for a typical problem involving five alternatives, 1,000 observations, and up to 10 attributes (also see Revelt & Train, 1998). The adoption of Halton sequence draw is an important problem to be examined (Halton, 1960). Bhat (2001) found that 100 Halton sequence draws are more efficient than 1,000 random draws for simulating an ML model. However, an anomaly may arise in this analysis, and therefore the properties of Halton sequence draws in simulation-based estimation need to be investigated further (Train, 2003).

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