Consumer Preferences for Mobile Broadband Quality in Japan : Implications for the Discussion on Network Neutrality

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Consumer Preferences for Mobile Broadband Quality in Japan: Implications for the Discussion on Network Neutrality

Toshiya Jitsuzumi

Abstract

The rapid development of information and communication technology has facilitated significantly expanded use of the Internet and made it an indispensable infrastructure element for socio-economic activities. With the boom in bit-intensive and live-streaming content over broadband Internet, the phenomenon of increasing and persisting Internet congestion and an abuse of market power by dominant Internet service providers (ISPs) is no longer a mere engineering possibility but a grave and imminent reality. As a means of dealing with these problems, "network neutrality" has become the focus of discussion among operators, academics, telecom regulators, and consumer groups in recent years. With the current rapid traffic increase not only in fixed broadband but also in mobile broadband, U.S. stakeholders have started discussing whether both mobile and fixed Internet access should comply with similar network neutrality standards. Considering the global trend in broadband usage, other countries will soon have to follow suit. Unfortunately, the discussions related to network neutrality thus far have mainly considered operators' viewpoints and have failed to give proper attention to consumers' perspectives; therefore, arriving at an optimal conclusion is difficult for them. In order to overcome this shortcoming, this study uses a Web-based questionnaire and empirically shows that users' preferences for the communication quality of fixed broadband may differ significantly from their preferences for its mobile counterpart. Accordingly, this paper recommends that each broadband medium be treated differently, for optimal resource allocation.

Keywords: Mobile Internet, Mobile Broadband, Quality of Service, Network Neutrality, Willingness to Pay

1. Introduction

The rapid development of information and communication technology has significantly facilitated expanded Internet use, leading to an improvement in social welfare. Consumers have benefited from an ever-increasing number of applications that enable various activities. Consequently, the amount of IP traffic over network infrastructure has increased. According to Cisco (2012, p. 1), "Global IP traffic has increased eightfold over the past 5 years, and will increase threefold over the next 5 years. Overall, IP traffic will grow at a compound annual growth rate (CAGR) of 29 percent from 2011 to 2016."

Simultaneously, owing to the boom in bit-intensive and live-streaming content, the phenomenon of increasing and persisting congestion on the Internet is no longer a mere engineering possibility, but a grave and imminent reality that may negatively influence user experience. Because of the "first come, first served" feature of TCP/IP, such congestion clogs the system during peak times and negatively influences the Internet experiences, not only of heavy users, but of all users. In addition, if some Internet service providers (ISPs) attempt to control the traffic flow and optimize the network, an anti-competitive concern may arise, particularly when these ISPs control bottleneck facilities and have strong market power.

As a means of addressing these unfavorable situations or the possibility of their occurrence, "network neutrality," which is a term coined by Wu (2003) to connote the equal and fair treatment of Internet packets by ISPs, has recently become the focus of discussion among operators, academics, telecom regulators, and consumer groups. This term has multiple aspects, such as economic vs. non-economic, long term vs. short term, and fixed broadband vs. mobile broadband; thus, stakeholders' discussions have so far covered a wide range of issues, including freedom of speech, end-user privacy, the fight against piracy, access charges for content/application providers, and motivations for ISP investment (Jitsuzumi 2010). Each of these issues is significant in its own way with regard to policymaking in the future; however, their economic aspects are all related, in varying degrees, to the supply constraints in ISPs' networks.

Accordingly, related issues can be classified into two groups: those related to packet congestion over Internet infrastructure and those related to the possibility of anti-competitive behaviors by a dominant ISP that controls network bottlenecks. In order to resolve the issues of the first group, economic theory suggests demand control in the short term[1)] and capacity expansion in the long term based on theoretical developments concerning road traffic congestion. With regard to the second group, it is desirable, for example, to introduce a significant market power (SMP) regulation or to apply anti-trust rules. Nevertheless, in the real world, actual policy development in individual nations may vary based on industrial organization and legal frameworks. For example, in Japan, the Ministry of International Affairs and Communications (MIC) has focused its efforts on the optimization of network management.[2)] On September 19, 2007, the MIC's Work-

1) Since the location and intensity of packet congestion is more ephemeral and unpredictable than car congestion, some modifications are required. One such modification is a real-time auction of bottleneck capacity, or the "smart market" proposed by MacKie-Mason and Varian (1994).

2) It is assumed, although implicitly, that Japan does not have to be overly concerned about anti-competitive ISPs, because the MIC has regulated Nippon Telegraph and Telephone (NTT) East and NTT West as SMPs and has successfully maintained the competitiveness of the broadband ISP market to some extent.

ing Group on Network Neutrality issued a final report (MIC 2007) that suggested a co-regulatory approach wherein the MIC would provide legal oversight to the private sector's collaborative efforts for reasonable network management. In response, ISPs and network operators organized a committee and released a guideline in May 2008 that established voluntary standards for proper packet shaping (JAIPA, TCA, TELESA, & JCTA, 2008; revised in JAIPA, TCA, TELESA, JCTA, & MVNO Committee, 2010 and 2012).

However, MIC's proposal failed to achieve sufficient stakeholder participation.[3] Active stakeholder participation is essential for establishing the appropriate authority of a co-regulatory framework (for example, see Werbach 2009). End users' participation is especially important for establishing an economically efficient standard for packet shaping, because packet priority must be determined from not only a technological perspective but also a socioeconomic one. Currently, traffic is rapidly increasing in both fixed broadband and mobile broadband. Cisco (2012) stated, "Globally, mobile data traffic will increase 18-fold between 2011 and 2016" (p. 2) and concluded that in 2016, 61% of IP traffic will come from wireless devices.[4] Since an increasing number of people have begun connecting to the Internet via mobile broadband, and because users' preferences for mobile quality of service (QoS) are not identical to those for fixed QoS, it is critical to incorporate such differences when preparing a guideline.

Recently, stakeholders have started focusing on whether both mobile and fixed Internet access should comply with similar network neutrality requirements. In the United States, major ISPs that are vertically integrated with mobile network operators have opposed strong regulations on mobile broadband. They argue that since mobile broadband must deal with several difficulties that its fixed counterpart does not (e.g., extreme difficulty in acquiring additional spectrum, technological features of the allocated spectrum, collective consumption of last miles, mobility of terminal equipment, and interference with and from neighboring bands), greater discretion in network management is required for mobile broadband than for fixed broadband. In contrast, considering the increasing pervasiveness of mobile Internet, a similar-fixed-Internet rule is required to guarantee a sound Internet experience for end users who consume both types of broadband, occasionally without knowing the type of network to which they are connected. However, neither of the arguments was supported with empirical data regarding consumers' perspectives on their Internet experience. Even the Federal Communications Commission (FCC) (2010a) admitted that "we do not know, for example, how end users will value the trade-offs between the benefits of wireless service (e.g., mobility) and the benefits of fixed wireline service (e.g., higher download and upload speeds)" (para. 33, p. 20).

In this context, the author's primary research interest in this paper is to investigate users' perspectives

3) MIC's proposal has another drawback: the lack of an enforcement mechanism. For further discussion concerning this drawback, please refer to Jitsuzumi (2011).

4) This increase can be at least partially explained by the usage of smartphone users. For example, Nielsen's monthly analyses of cellphone bills clearly display an explosive increase of data communication by smartphone users. See http://blog.nielsen.com/nielsenwire/online_mobile/average-u-s-smartphone-data-usage-up-89-as-cost-per-mb-goes-down-46/ and http://blog.nielsen.com/nielsenwire/online_mobile/quantifying-the-mobile-data-tsunami-and-its-implications/.

on mobile broadband in Japan. The remainder of this paper is organized as follows. Section 2 explains why the users' perspective has to be considered, and Section 3 summarizes the responses to a Web-based questionnaire to discuss the Japanese network neutrality problem and the empirical findings of the status quo of the Japanese mobile Internet. Section 4 conducts econometric analyses and presents the differences among users' perspectives on QoS between fixed and mobile broadband. Finally, Section 5 summarizes this study's findings, discusses implications for the network neutrality debate, and presents the remaining research questions for future analysis.

2. Users' perspective and optimal rule-making

When facing an exaflood (Swanson 2007), a strict network management policy can reduce the network capacity and, therefore, achieve a price reduction; however, under this policy, some end users will have to accept certain constraints such as being disallowed from accessing certain types of applications or from consuming network capacity during peak hours. On the other hand, users can enjoy broader discretion under a less-strict management policy. However, under such a policy, network operators will need greater capacity to cope with peak demand, and will, therefore, require higher usage fees; otherwise, end users will have to endure poor Internet performance. These constraints are a trade-off for market players and thus autonomously generate an optimal network management policy as long as competition dynamics are active.

The same principles can be applied when determining whether mobile networks require a network management policy that is different from the one being employed for fixed networks. If users would like similar usage discretion in both environments, mobile operators will have to apply a management policy consistent with that of a fixed counterpart and charge a higher fee. Alternatively, if users prefer paying a lower fee to broader usage discretion, then they can comply with a stricter management policy when connecting to mobile broadband. In a competitive market, differences in the technological specifications of both networks are reflected in the position and shape of the supply curve, whereas the demand curve describes users' preferences of usage discretion, communication quality, and price level. The intersection of this demand and supply curves will determine the optimal network management policy and optimum price level.

The problem is that thus far, a market for dealing with ISP's network management policy has not been developed effectively. If such a policy does exist, it is extremely difficult to achieve a competitive equilibrium that satisfies a Pareto optimum owing to externalities and information asymmetries. To avoid the risk of network congestion and to protect consumers' interest from excessive network management, some non-market mechanisms such as a government-led rule setting have to be introduced as a second-best solution. The FCC's network neutrality rule is an output example of such a mechanism.

The optimality of such a non-market mechanism depends on how closely it can imitate market dynamism. At a minimum, it is desirable to reflect the interests of as many stakeholders as possible. A network management rule that reflects suppliers' conditions and fails to consider the differences between mobile and fixed broadband users cannot generate a Pareto optimum. Such a situation is depicted in the following charts (Fig. 1), which show a mechanism for determining a certain minimum quality that must be guaranteed by an approved network management policy. CASE 1 is a situation in which regulators fail to consider user differences and generate a level *M* for mobile broadband and *F* for fixed broadband, whereas CASE 2 and CASE 3 are situations in which regulators appropriately consider the differences between users' preferences for quality levels and successfully obtain an optimal rule. Depending on whether mobile users have a higher valuation of broadband quality, a rule generated in CASE 1 either overshoots or undershoots the truly optimal one.

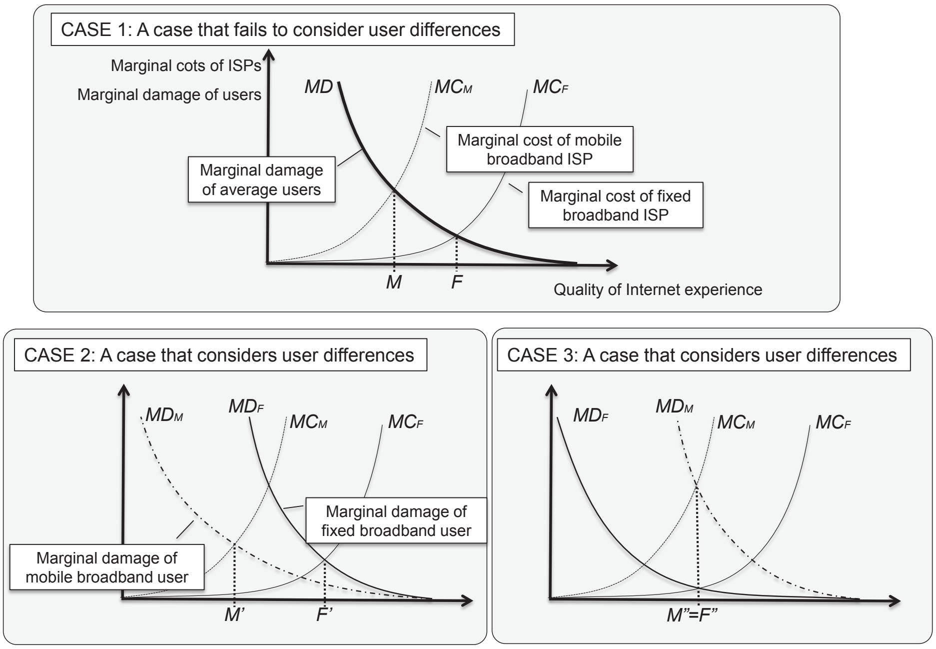

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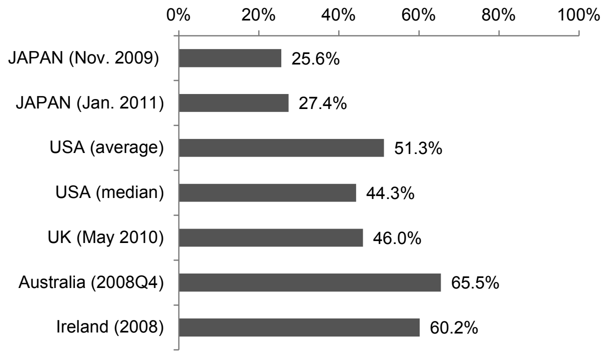
Fig. 1. Optimal and sub-optimal rule settings

3. Japan's approach and the QoS status quo

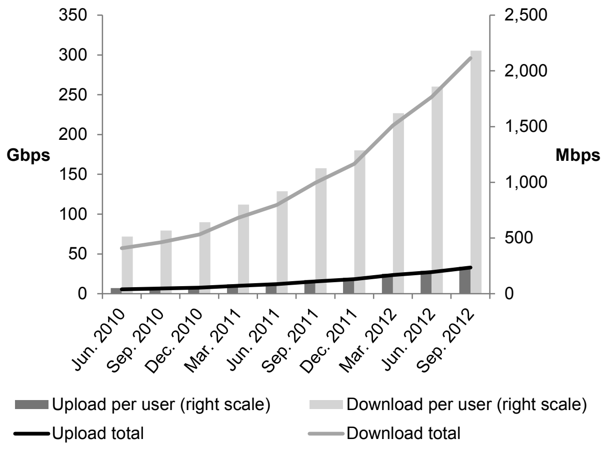
Japan is not an exception to the global IP traffic explosion. The total volume of download packets required by Japanese broadband users has increased dramatically. According to the MIC (2012a), downloads reached 1.7 terabits per second (Tbps) in May 2012, exceeding the previous year's downloads by 116.2%. Owing to massive investments by network operators and ISPs, thus far, we have not experienced an IP traffic blackout; however, as shown in Fig. 2, Japanese users have already been experiencing poorer fixed broadband QoS than that of the United States, the United Kingdom, Australia, and Ireland.



Source: The data for Japan (Nov. 2009) is from Jitsuzumi (2011) and that for Japan (Jan. 2011) is from the survey conducted in this study. The data for the USA (average) and USA (median) are calculated by the author using the FCC data (2010b, p.21). The data for the UK (May 2010) is from Ofcom (2010, p.7), that for Australia is from Epitiro (2009a, p.11), and that for Ireland is from Epitiro (2009b, p.11).

Fig. 2. Advertised vs. actual download speeds in fixed broadband

Besides a considerable rise in IP traffic, Japan is also experiencing a dramatic increase in mobile network traffic (Fig. 3). There were 76.03 million (79.1% of the total Internet users) mobile users (MIC 2012b) by the end of 2011 and this huge figure, accompanied by increasing smartphone penetration,[5)] is making "mobile traffic congestion" an imminent possibility. Therefore, owing to more severe capacity constraints, mobile operators will be required to introduce various congestion control measures that are more intense than those for fixed operators, such as packet shaping or setting a monthly cap.



Source: Created on the basis of MIC data
(http://www.soumu.go.jp/johotsusintokei/field/tsuushin06.html)

Fig. 3. Monthly mobile data traffic in Japan

5) Nikkei BP Consulting, Inc. conducted a Web-based survey in June 2011 and estimated that 9.5% of the population owns smartphones, which is about twice as high as the previous year's estimate. See http://consult.nikkeibp.co.jp/consult/news/2011/0801mobile/.

To identify whether mobile users have a higher valuation of broadband quality and what factors influence users' preferences for mobile network quality, the author conducted a Web-based questionnaire survey. The survey period was from January 24 to 27, 2011, and 768 valid responses were collected from 8,992 contracted monitors of Rakuten Research, Inc. The average age of the respondents was 44.5 years and the average household income was 5.947 million yen per annum. At the time of the survey, respondents had, on average, 129.5 months (10.8 years) of Internet experience; they spent 22.1 hours per week on the Internet and paid 4,668.7 yen per month for Internet access. Among them, 472 respondents (61.5%) were FTTH users, 176 (22.9%) were ADSL users, and 100 (13.0%) were cable users.[6)]

The following analyses focus on "mobile computing," which is defined in the analyses as a service that enables users to enjoy the Internet outside their homes and whose best-effort QoS is usually not as high as home-based fixed broadband. Internet usage over 3G/4G mobile phones is not included in the research scope of this study. Questionnaire respondents were asked to compare their mobile QoS with home-based fixed QoS. The survey revealed that 28.5% of the respondents (219 out of 768) had used such "mobile computing" before and 19.0% (146 out of 768) had used it within the last 12 months. The majority of experienced users (81 out of 219) accessed free-of-charge services only, 78 (70 + 8) respondents paid all or part of their mobile computing charges themselves, and for the rest of the respondents, these charges were fully covered by their companies or institutions (Table 1).

Table 1. Usage of mobile computing

Frequency of use	Daily	Within the previous year	Not within the previous year	Never	Total
Total	49 (6.4%)	97 (12.6%)	73 (9.5%)	549 (71.5%)	768 (100.0%)
Payer					
Respondents	17	39	14		70
Respondents + Employer or School	3	3	2		8
Employer or School	2	7	6		15
No one (Free service only)	20	36	25		81
Unknown	7	12	26		45

Source: Created by the author.

The three most-cited issues that led daily users of mobile computing to be unsatisfied were insufficient coverage, insufficient QoS, and high fee for wireless services; the first two issues reflects that users found the quality of wireless services to be poor (Fig. 4). Fig. 5 indicates that although poor wireless quality is not a dominant reason for discouraging people from using mobile computing, the complaints regarding poor QoS

6) Compared to the national average as of December 2010 (MIC 2011), the share of FTTH users was 3.8 percentage points higher and that of ADSL users was 1.9 percentage points lower.

have been increasing with the increasing use of mobile computing. The difference between the attitudes of users and non-users is also evident in the places where they would most like to experience mobile computing (Fig. 6). Experienced users would like to use mobile computing in a fixed location probably due to the intolerably low QoS when they are on the move, whereas inexperienced users prefer a nomadic style. This clearly indicates that the status quo of mobile QoS is not well understood by general consumers unless they actually experience mobile computing. Therefore, users' revealed preference (RP) data is ideal for analyzing users' attitudes toward mobile QoS; however, since RP data were not available, the stated preferences (SP) data were used.

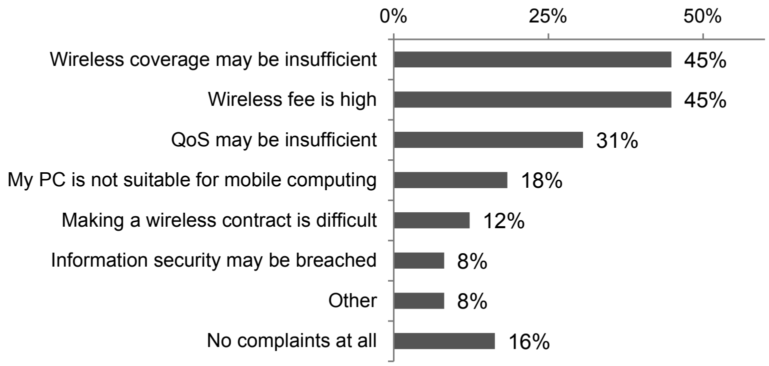


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Fig. 4. Complaints of daily users (multiple choice; N = 49)

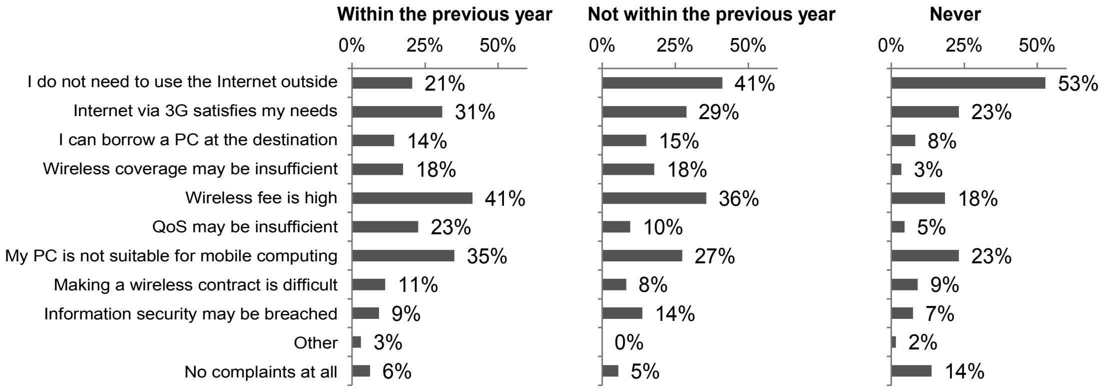

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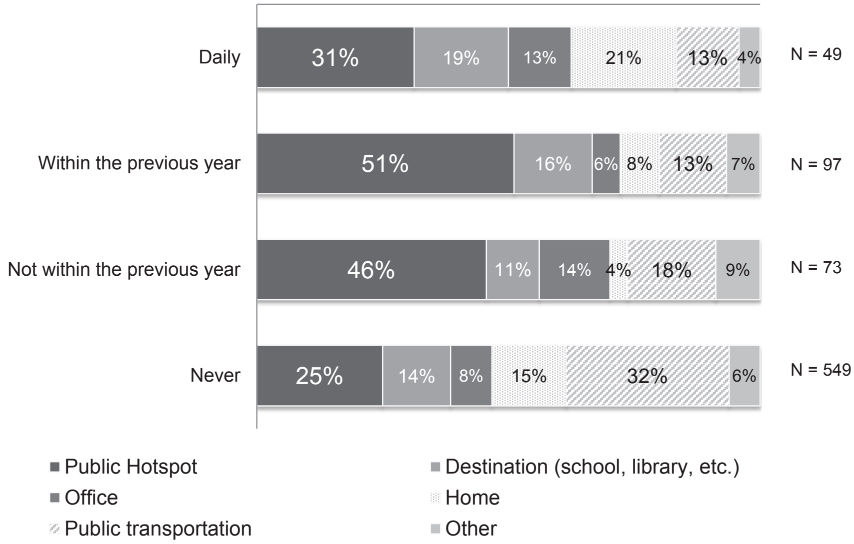
Fig. 5. Reasons for infrequent or no use of mobile computing (multiple choice; N = 97, 73, 549)



Source: Created by the author.

Fig. 6. Preferred places for mobile computing

4. Consumers' attitudes toward fixed QoS and mobile QoS

Using a contingency valuation method (CVM), the questionnaire asked the following two hypothetical questions:

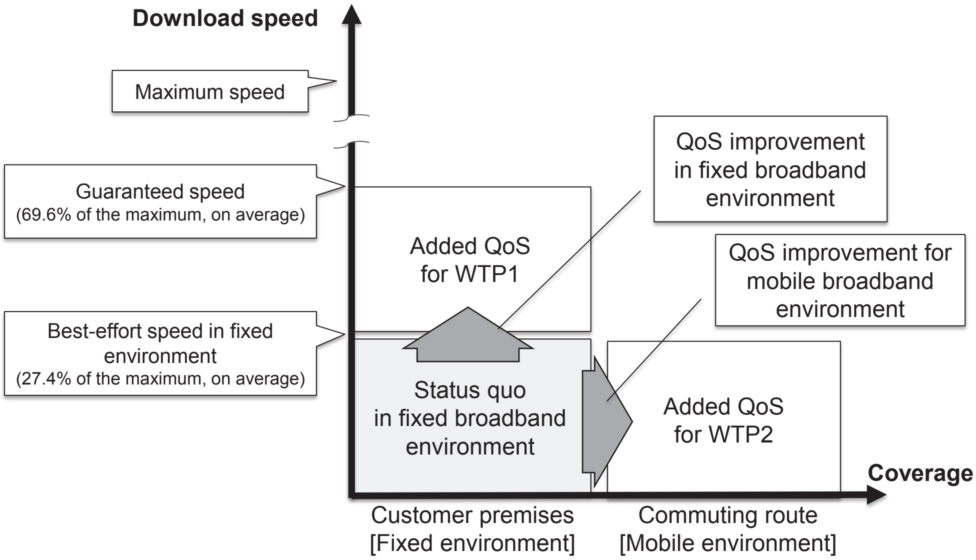
Q1: Would you agree to spend an additional "X"[7] yen per month if your ISP could guarantee a certain bandwidth (guaranteed-level speed) in your current fixed environment?

Q2: Would you agree to spend an additional "Y"[8] yen per month if your ISP could guarantee the same download speed along your commuting route as you are currently enjoying at home under best-effort QoS?

"Guaranteed-level speed" was the download speed that respondents demanded as a minimum under the current ISP contract. The proportion of guaranteed-level speed to maximum download speed varied among individual respondents; however, on average, it was 69.6%, which is, on average, 2.5 times higher than the proportion of the actual speed to maximum download speed (27.4%) that is currently observed in users' premises (Fig. 7). The answers to each of the above questions were statistically analyzed to calculate willingness to pay (WTP) for the respective improvements; regression analysis using various demographic

7) "X" was randomly assigned from 100, 500, 1,000, 1,500, 2,000, 4,000, and 7,000.
8) "Y" was randomly assigned from 100, 500, 1,000, 1,500, 2,000, 4,000, and 7,000.

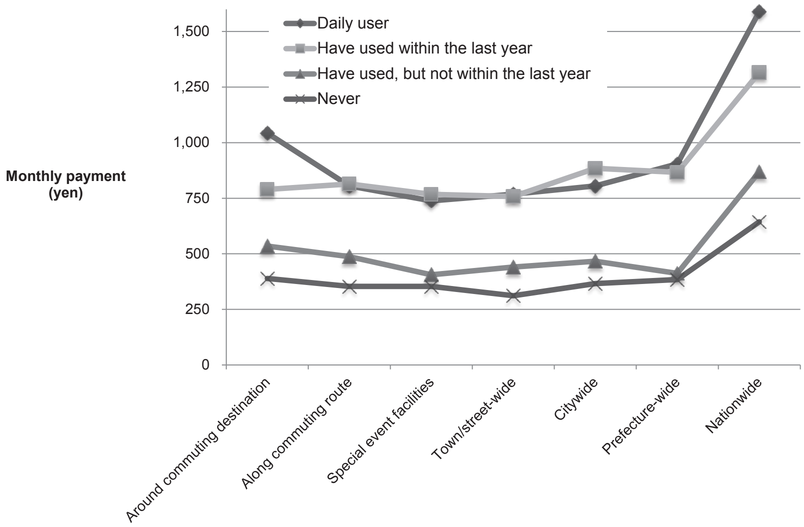
variables was also conducted to identify the factors that had a significant influence on WTP. The relationship between the two types of WTP, “WTP1” for Q1 and “WTP2” for Q2, is also shown in Fig. 7.



Source: Created by the author.

Fig. 7. Relationship between WTP1 and WTP2

However, before proceeding, it is important to elucidate how the amount of mobile computing experience influences WTP2 estimates. If there is a significant discrepancy between experienced and less-experienced mobile computing users, it is not appropriate to pool both types of respondents and conduct an estimation for WTP2. Moreover, if the size of the coverage area affects WTP2, then again, it is inappropriate to pool all the respondents into a single WTP estimation, because the commuting route varies for each respondent. To clarify these points, respondents were asked how much they would be willing to additionally pay if the same level of QoS that they get at home currently could be extended to (1) around their commuting destination, (2) along the commuting route, (3) special event facilities, (4) the town/street where they live, (5) the city where they live, (6) the prefecture where they live, or (7) nationwide. The results are summarized in Fig. 8, which indicates a clear gap depending on the mobile computing experience; however, it fails to show any relationship between coverage area and WTP2, except when the coverage area is nationwide. Therefore, in the remainder of this paper, the estimations have been conducted by considering all the respondents, including those who used mobile broadband daily or within the previous year (hereafter called “active mobile users”).



Source: Created by the author.

Fig. 8. Relationship between WTP, mobile computing experience, and coverage

WTPs were estimated using a Weibull survival model. In particular, the following two equations were employed:

$$S(T) = \exp\left(-\exp\left(\frac{\ln T - \mu}{\sigma}\right)\right) \quad (1)$$

$$S(T) = \exp\left(-\exp\left(\frac{\ln T - \boldsymbol{\beta}'\mathbf{X}}{\sigma}\right)\right) \quad (2)$$

In equation 1, the survival function $S(T)$ can be interpreted as a reduced-form description of the probability that an individual's WTP is at least as high as T, where μ and σ are the estimated parameters. When incorporating the samples' demographic features, the survival function (equation 2) is employed where $\mathbf{X}$ and $\boldsymbol{\beta}$ indicate a vector of demographic variables and a vector of parameters to be estimated, respectively.[9)]

The demographic variables employed for equation 2 and the expected parameters are as follows: age of the respondent (indeterminable), monthly ISP fee (positive), dissatisfaction with actual download speed (positive), experience with packet congestion (positive), experience with the speed test (positive), payment for mobile computing (positive), and ratio of actual download speed over advertised download speed (negative).

Tables 2 and 3 show the estimated results for equations 1 and 2, respectively. Table 1 shows that WTP2

9) For technical details of the estimation process, please refer to Hidano (1999).

is larger for active mobile users. In Table 3, although only some of the parameters were statistically significant, almost all the results indicated in this table matched previous expectations. Exceptions included “experiences with packet congestion” and “experiences with the speed test,” which require further investigation. However, this may be explainable under the following scenario: once users realize that they can actually enjoy the Internet without major issues, even with poor network quality, they come to understand that Internet experience cannot be determined solely by their ISP’s QoS, thus, lowering their WTP accordingly.

Because targeted QoS improvement is not the same, it is not beneficial to compare WTP1 and WTP2; instead, it is possible to compare the median value of WTP2 for “QoS improvement for mobile broadband environment” in all samples with a monthly fee for fixed broadband service since both targeted services aim to achieve the same level of QoS. Currently, monthly expenditure for fixed broadband service is 500 to 1,500 yen; the level of WTP2 is much smaller than that in both sample groups. Even if perfect price discrimination is possible, the WTP (truncated mean) is lower for the QoS improvement in mobile environment. This indicates that broadband users value the QoS for mobile broadband much lesser than that for the fixed broadband service, suggesting that CASE 2 in Figure 2 describes the market reality.

Another finding is that the set of the factors affecting WTP1 is different from those affecting WTP2. For example, parameters on monthly ISP fees suggest that users who pay a higher fee to an ISP ascribe a significantly higher value to enhanced QoS for mobile broadband; however, the same logic does not hold for the fixed broadband service. In addition, parameters on packet congestion experience indicate that the more frequently users face congestion, the lesser the premium that they would like to pay for fixed broadband; however, the same result is not seen with sufficient significance for mobile broadband. This suggests the existence of different mechanisms behind user preferences for fixed and mobile QoS or different utility functions behind the improvement of fixed and mobile QoS, reflecting that it is not economically efficient to treat fixed broadband QoS and mobile broadband QoS in the same manner.

Table 2. WTP estimation using Weibull survival model 1

	All samples				Active mobile users			
	WTP1		WTP2		WTP1		WTP2	
N	564		700		102		133	
Fitness of the model								
Log likelihood	-233.29		-225.4		-48.92		-55.91	
AIC	470.57		454.8		101.84		115.81	
Estimated parameters								
σ	2.53	***	2.53	***	2.03	***	1.80	***
μ	5.77	***	5.03	***	6.69	***	6.31	***
Estimated WTP								
Truncated mean	¥831.6		¥470.7		¥1,286.8		¥863.9	
Median	¥126.6		¥60.7		¥381.3		¥284.1	

Source: Created by the author.
Note 1: *** indicates statistical significance at the 1% level.
Note 2: Truncated points for Weibull mean estimation are 0 and 7,000 yen.

Table 3. WTP estimation using Weibull survival model 2

	All samples				Active mobile users			
	WTP1		WTP2		WTP1		WTP2	
N	511		639		92		122	
Fitness of the model								
Log likelihood	-200.94		-197.46		-34.05		-42.03	
AIC	419.88		412.92		86.1		102.07	
Estimated parameters								
σ	2.39	***	2.26	***	1.65	***	1.44	***
Age of the respondent	0.193		-0.125		0.168		-0.411	
LN of monthly ISP fee	0.110		0.110		0.0265		0.595	**
Dissatisfaction with actual speed in fixed BB (1: not satisfied, 0: otherwise)	1.20	***	0.199		1.97	***	0.566	
Experience with packet congestion (1: experienced, 0: otherwise)	-0.502		0.167		-3.26	**	-1.35	*
Experience of speed test (1: more than once a year, 0: otherwise)	0.298		0.478		-1.23	**	0.0579	
Payment for mobile computing (1: paid by the respondent, 0: otherwise)	0.744		1.23	***	1.24	*	1.40	***
Actual speed / advertised speed of fixed BB(%)	-0.538	***	-0.156		-0.313		-0.0713	
μ	5.67	***	4.68	***	9.13	***	6.61	***

Source: Created by the author.
Note: *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

5. Implications for the discussion on network neutrality and remaining Issues

The empirical results of this paper show that QoS preference in mobile environments differs from that in fixed environments in terms of the levels of QoS as well as its underlying functions, which suggests the importance of considering consumers' conditions when setting the rules for minimum network quality or for network management practices. As the JAIPA et al.'s guidelines (2010 and 2012) suggest, although the technological difference between mobile and fixed broadband is not significant enough to require a different treatment, variability in user preferences may justify a special treatment for mobile broadband. If this is the case, the MIC or ISPs should start considering the possibility of not treating fixed and mobile QoS in the same manner. Moreover, it should be noted that the cost for such a solution, that is, adopting a different treatment for each broadband service, must be considered. One such cost is the introduction of special treatment for mobile packets by ISPs. Moreover, disseminating information regarding mobile best-effort service and educating consumers about congestion management will be formidable challenges for ISPs. Recently, many network operators have begun working on providing a seamless broadband experience under the name "Fixed Mobile Convergence," which is designed to relieve end users from being concerned about whether they are using a mobile or fixed network. Additionally, to address explosive traffic growth, mobile operators now actively offload data traffic to fixed networks. Thus, it is becoming increasingly difficult for ordinary users to determine whether they are on a fixed network or a mobile network. If different rules are applied to fixed and mobile broadband, end users will face increased uncertainty when using broadband, which increases a transaction cost and negatively affects user experience.

There is potential for further elaboration of this analysis. First, if possible, an analysis using "hypothetical" SP data should be replaced by an analysis using "actual" RP data. It is widely agreed that estimations based on SP data are not as accurate as parameters based on RP data; therefore, conducting an economic experiment is a possible solution. Second, to check the robustness of these findings, similar tests should be conducted in other hypothetical scenarios. Third, it may be necessary to consider variations among mobile applications or contents. For example, the required QoS for live-video applications may not be the same as that for social networking service applications. Each application has its own QoS requirements; therefore, users' preferences for mobile QoS will be affected accordingly.

Before concluding this paper, it is important to note that users' QoS preferences may change overtime, with changes in the technological difference between fixed and mobile broadband. Therefore, policymakers who are in charge of the network neutrality problem should conduct such empirical research regularly to guarantee that the present rule satisfies the optimal standard.

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