Broadband Economics

Lessons from Japan

Takanori Ida

Routledge Studies in Global Competition

Broadband Economics

Japan's high-speed Internet access services such as ADSL, CATV Internet and FTTH are considered the cheapest and fastest state-of-the-art services drawing international attention. In this book the author introduces the current status of broadband services in Japan and their recent development in competition policy. An econometric model is proposed and discussed to analyze access demand. The purpose of the analysis is to understand quantitatively the current status of the rapidly developing Japanese broadband services while providing an academic and practical basis for conceiving prospective competition policies.

The book is composed of three parts. The first part introduces the diffusion of current broadband services, the economics of network industries and related econometric model analysis. The second part elucidates in detail the development of fixed-line broadband services, IP phone services as well as mobile phone services. The third part consequently investigates the migration among broadband services, the fixed and mobile convergence and the digital divide problem.

This book is oriented towards researchers focusing on issues of technology and international economics, business competition and econometric analysis, and those with an interest in Japanese industry.

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Abbreviations

0ABJ	0-ABCDE-FGHJ (10 digits) (so-called “ 0ABJ ” numbers)
1G	first generation
2G	second generation
3G	third generation
ADSL	asymmetric digital subscriber line
AIC	Akaike’s Information Criterion
ARPU	average revenue per user
BB	broadband
CATV	cable TV
CL	conditional logit
DCM	discrete choice experiment
ECPR	efficient component pricing rule
FEE	fulfilled expectations equilibrium
FIML	full information maximum likelihood
FMC	fixed-mobile convergence
FTTH	fiber to the home
GDP	gross domestic product
HEV	heteroscedastic extreme value
IBP	Internet backbone provider
ICT	information and communications technology
IIA	independence of irrelevant alternative
IID	independently and identically distributed
IID-EV	independently and identically distributed extreme value
IIN	independence of irrelevant nests
IP	Internet protocol
ISDN	Integrated Services Digital Network
ISP	Internet service provider
IT	information technology
ITU	International Telecommunication Union
IV	inclusive value
Kbps	kilobits per second
LIML	limited-information maximum likelihood
LLU	local loop unbundling

LR	likelihood ratio
LRIC	long-run incremental costs
MIC	Ministry of Internal Affairs and Communications
ML	mixed logit
MLE	maximum likelihood estimation
MNP	multinomial probit
MPT	Ministry of Posts and Telecommunications (former)
MSL	maximum simulated likelihood
NCC	new common carrier
NGN	next-generation network
NIEs	newly industrializing economies
NL	nested logit
NRI	Nomura Research Institute
OECD	Organization for Economic Cooperation and Development
OFTEL	Office of Telecommunications (UK)
P2P	peer-to-peer
PDC	Personal Digital Cellular
PHS	Personal Handyphone System
POTS	plain old telephone service
PSTN	public switched telephone network
QoS	quality of service
RP	revealed preference
RPM	revealed preference method
RT	remote terminal
RUM	random utility model
RUT	random utility theory
SD	standard deviation
SLL	simulated log-likelihood
SP	stated preference
SPM	stated preference method
SSNIP	small but significant and nontransitory increase in price
telco	telecommunications company
TFP	total factor productivity
UIBN	ultra-high-speed interactive broadband network
UK	United Kingdom (U.K., if adj)
US	United States (U.S., if adj)
VCR	video cassette recorder
VoIP	Voice over Internet Protocol
WTP	willingness to pay

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Introduction

The idea for this research came to me at Cambridge. I spent one year at the University of Cambridge in 2001–2002 and the verdant park-like atmosphere with stately old campus buildings was the ideal setting for serious scholarly pursuit. Steeped in a tradition of discipline coupled with originality, I could see why so many first-rate scholars had come from this small college town. I finished up the project I had brought with me from Japan, then I was at a loss as to what to pursue next. Long dreary English winter days and walks along the banks of the river Cam did nothing to lift my spirits. I did not see much chance at this point of me making a ground-breaking contribution in the theoretical sphere. That led me to experimental research. And in network industries—my area of expertise—Japan lagged far behind the West in reform and restructuring of the power industry, and there didn't seem to be room for new research in that area. That led me to the telecommunications industry. It was thought then that Japan's regulatory reform of its telecommunications industry lagged about ten years behind the West, yet Japan was making steady progress in upgrading the infrastructure of both its fixed and mobile networks. It seemed likely that at some point there would be a reversal between the US and Japan, with Japan taking over the lead in high-speed data communications. Though I arrived at my primary research interest through a negative process of elimination, I did have one thing going for me: I decided to pursue *broadband experimental research*, knowing that if this theme really took off in Japan then it would be equally significant the whole world over. It was the beginning of summer that I returned to Japan. This was the year that the whole country was so excited about the 2002 World Cup that was jointly hosted by Japan and South Korea.

Coincidences do happen, and right about the time I came back to Japan, Softbank stunned the industry with its offering of ADSL service and NTT DoCoMo rolled out its FOMA service. This was the spark that ignited the broadband revolution. Right around this same time, Mr Hideyuki Ohashi of the Ministry of Internal Affairs and Communications (MIC) paid me a visit at my office. The MIC was planning a comprehensive review of competition in the telecommunications field the next year in

2003, but the analysis of broadband demand, which was the basis of market demarcation for the review, had not yet been completed. I had the impression that Mr Ohashi had already made the rounds of a number of other economists before he finally arrived to my door. Anyway, we had a very candid discussion. I laid out my ideas, and this was the beginning of a fruitful collaboration on broadband between Kyoto University and the MIC.

Trying to link individual ideas to policy is a gamble, and I have always been skeptical of overly simplistic applications of academic research to policy-making. Indeed, there was a question in my mind as to whether economics was really mature enough as an empirical science to support this kind of application. The University of Cambridge's own famed economist Joan Robinson once observed that "the primary reason for studying economics is to avoid getting duped by economists." I also worried that to chase after both academics and policy might result in me succeeding at neither. If your policy work is successful, then you achieve very different goals as an economist than you envisioned, but if your policy work fails, then you become an economist that did not achieve much of anything. As to which category I eventually fall into, I will leave that to the verdict of you and of history.

Now to the subject matter at hand—broadband economics. Broadband has developed in Japan at a much faster pace than I ever would have predicted. A fairly evenly matched contest emerged with Softbank's ADSL service, K-Opticom's FTTH service, and Au's 3G service, squarely challenging the giant incumbent NTT. In this context, Japan is moving to develop its own competition policy that draws out the originality and ingenuity of the new common carriers while continuing to draw upon all the latent strengths of NTT. Now, apparently thanks to this winning triangle of stakeholders with NTT and the new common carriers and the government occupying the three corners of the triangle, Japan's broadband environment has evolved to become the most advanced in the world in both fixed and mobile networks. But no matter how ample the capacity, this will not mean much without a substantial improvement in the content that flows over those fiber lines. The Internet launched this revolution, but we are now stuck at a plateau and it's not at all certain whether these technological advances will be reflected in genuinely improved community services. To my mind, the real goal of this revolution is to enable public services—medical, welfare, education, and government—at lower than prevailing rates to information-disadvantaged communities in rural areas. But broadband is not a gift conferred from on high by the government, but rather is a common resource nurtured and developed by the people. This book will look back over these past five years of the broadband revolution, and look ahead to consider what prospects lie in store over the next five years. The leading role in this unfolding drama is you, the public at large.

Many will recognize their contributions in the pages of this book. Here I express special thanks to Hideyuki Ohashi and Takuro Imagawa of the Ministry of Internal Affairs and Communications; Toshihumi Kuroda, Masayuki Sato, Shin Kinoshita, Kai Sakahira, and Yuki Horiguchi of Kyoto University.

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1 Competition policy in the broadband era

By the beginning of 2007, growth in demand for broadband services in Japan had leveled off and gave way to a period of maturation. It was generally held some years ago that regulatory reform of Japan's telecommunications industry lagged ten years behind that of the West, but now the advanced precedents of Europe and the US have been completely absorbed, and quite unexpectedly Japan has emerged as the definitive global leader in the realm of broadband.¹ There is no earlier precedent or experience in other countries that Japan can study, and indeed the world is closely watching to see the direction Japan will take. In the history of regulatory reform in Japan, this is something that has never occurred before. Will the current growth trend be sustained or will it falter? Steering the proper course in formulating a beneficial competition policy, or antitrust policy, in Japan's telecommunications industry is a difficult prospect indeed.

Here I will address three fundamental challenges for competition policy in the broadband era:

- Market dominance and leverage,
- Next-generation network (NGN) and network neutrality,
- Digital divide and investment incentive.

Let us consider these challenges in a bit more detail. First, amid ongoing developments in Japan's telecom sector—migration from ADSL (asymmetric digital subscriber line) to FTTH (fiber to the home) coupled with convergence of fixed and mobile communications—the presence of the NTT Group is very much on the ascendancy. This raises the issue of the dominance or leverage that the NTT Group is able to exert across markets, and considering the degree of potential leverage, how market dominance should be restrained or not restrained.

The second challenge of an effective viable competition policy is how to ensure network neutrality of the next-generation IP (Internet protocol) network when it is built. The current IP network is a best-effort network with no guarantee of bandwidth, so traffic inevitably becomes congested when there is not enough capacity. The next-generation IP network guarantees

bandwidth, so the congestion problem is resolved by controlling charges and services. At the same time, careful vigilance is called for considering the enormous network management power wielded by the NTT Group.

The third challenge of competition policy is the widening disparity between the information haves and have-nots with the implementation of NTT's mid-term strategic plan that calls for 30 million subscribers—roughly half the country's users—to migrate from today's public switched telephone network (PSTN) to FTTH by the year 2010. This will create a serious gap between the half of the population that migrates to FTTH and the other half that does not. Some argue that it is not necessary to extend optical fiber to the countryside, while others contend that this kind of *digital divide* should not be tolerated. Can society turn a blind eye to the emergence of such a digital divide?

In this chapter I will address these issues and provide a general introduction to broadband economics. I will not offer any solutions. Rather, in the following chapters I will repeatedly examine these competition policy-related issues from a range of academic and policy-oriented perspectives.

How we approach these three competition policy challenges is largely affected by how Japan's telecommunications industry evolves by the year 2010. In addition to the NTT Group, the telecommunications industry has become increasingly concentrated in the hands of a small number of mega telecom groups, and today a three-way oligopolistic structure has emerged consisting of the NTT Group, the KDDI group, and the SoftBank Group. Certainly there are many smaller operators specializing in fixed services, mobile services, or content applications, but it will become increasingly difficult for these smaller operators to survive as all-out competitive war continues to escalate among the giants. Even among the three giants there are significant differences in corporate scale, infrastructure support, and brand strength, so how long this three-way oligopolistic structure will persist is not at all clear. The fact that Japan's competition policies over these past two decades have led to the reemergence of an oligopolistic or monopolistic industry is historical irony, but also inevitable.

Japan's current broadband infrastructure not only supports a full range of fixed and mobile services; it is also the most robust, high-quality infrastructure environment in the world. Most important as the main objective of competition policy is whether Japan's consumers enjoy a sufficiently diverse range of genuine service options. Quality is important here, not just quantity. As basic infrastructure there is little point in the telecommunications industry offering a multitude of service options if they are all on the same mediocre level as junk food. In order to meet the general needs of consumers, a minimum of three basic options should be provided: a high-quality expensive service, a low-quality affordable service, and a medium-quality moderately priced service. And to meet the needs of more advanced users, it would also be desirable to offer an environment that allows users to build systems based on their own specifications tailored to their own needs and preferences.

Whether Japan's telecommunications industry must undergo major structural reform in the year 2010 will depend on these points I have outlined: the outcome of talks regarding how the NTT Group should evolve, the ability of ordinary end-users to freely choose from among three basic one-stop services, and whether an environment can be put in place that enables advanced users to develop customized systems tailored to their own needs.² As far as consumers are concerned, the provisioning of three basic service options plus extra features and capabilities is the litmus test for defining how Japan's broadband infrastructure should evolve by the year 2010. However, rather than trying to envision some future image that is still unclear, here we focus on the here and now and start by describing the upward trend of Japan's broadband. This will require a good understanding of the broadband industry, backed by ample data and detailed analysis. This book was written precisely to provide such a base.³

Dilemma of competition policy

The term *competition policy* has come up. If broadband is the main theme of this book, then competition policy is the subtheme. However, if the main theme is a clear melody, the harmony has some discordant elements. First off, we should consider just what we mean by competition policy. Motta (2004, p. 30) defines competition policy as "a series of policies and laws aimed at ensuring that competition in the marketplace is not restricted in a way that is detrimental to economic welfare." Competition policy is considered desirable because it is generally held that competition enhanced economic welfare in terms of efficiency. There are three concepts of economic efficiency: allocative efficiency, technological efficiency, and dynamic efficiency. In a word, allocative efficiency is obtained when prices and costs coincide. For example, if NTT DoCoMo was a monopoly, the firm could leverage its market dominance to set prices at a level higher than costs, which could be detrimental to consumer surplus. Technological efficiency occurs when it is not possible to increase output without increasing inputs. For example, if NTT East and West were monopolies, business efficiency would be neglected,⁴ goods and services would be produced at higher than minimum costs, prices would hover at a high level, and consumer interests would suffer. Dynamic efficiency entails technological innovation. For example, if the NTT Group was a monopoly, profits from NTT equity shares would be spent on lobbying activity in support of vested interests and not plowed back into research and development, so introducing new technologies and products is substantially delayed.⁵ Competition is believed to help in all these monopolistic situations by suppressing the tendency to leverage market dominance and lack of managerial effort, while providing a good incentive to innovate new technologies. The presence of competitors such as KDDI and SoftBank causes NTT to behave so as to improve allocative efficiency, technological efficiency, and dynamic efficiency.

However, the real world is more complicated than textbook models. As I consider in detail in Chapter 3, the telecommunications industry is characterized by economies of scale and scope, and by increasing returns called network externalities. A laissez-fair policy in this industry results in market failure where the market is unable to reach a competitive equilibrium and optimum economic welfare is not guaranteed. Although we have a clear instance of market failure in this case, a quasi-market structure is introduced to reap the benefits of competition, so we can see just how complicated competition policy can be.

Here I will highlight two potential pitfalls of competition policy noted by Motta (2004). First, competition policy does not mean increasing the number of (inefficient) operators or giving new entrants preferential treatment. However, in reality, increasing the number of operators and successfully bringing in new entrants is considered important in terms of promoting competition. Second, even when competition policy ensures *ex ante* fairness with equal access to the market at the outset, this is no guarantee that the market will end up the same way with *ex post* fairness later on. Motta's (2004) observations are especially apt with regard to the telecommunications industry characterized by increasing returns to scale. This is because competition is a natural selection mechanism, in which efficiently run enterprises have a higher probability of surviving while inefficiently run enterprises have a higher probability of being driven from the market. When this survival-of-the-fittest competitive mechanism functions properly, firms naturally tend to become enormously large and markets highly concentrated. While competition policy is not necessarily hostile toward the giant firms that naturally result from competition, some regulation must nevertheless be imposed on corporate acquisitions, price discrimination, and other unfettered practices of megacorporations. In other words, in order for competition policy to succeed in the telecommunications industry, regulation is required because of the effects of increasing returns to scale and increasing monopolization at bottleneck facilities. This is referred to as the *dilemma of competition policy*.

Competition policy is by no means a panacea. History attests that at the beginning of the twentieth century the telephone and power industries went through a long contentious period during which countless smaller firms were taken over in a succession of hostile acquisitions and mergers to create enormous firms, and rather than accept monopolistic business rights from government, most were brought in under the umbrella of public regulation. In Chapter 3, I describe how, after the Second World War, critics began to loudly contend that excessive regulation actually impaired economic welfare, and this ushered in the current regime of privatization and liberalization. If there is any truth to the adage that history repeats itself, we may see another reversal with people clamoring again for stronger regulation.

Let us consider for a moment whether competition is actually detrimental. Perhaps there is no need for competition policy at all. This is clearly not the

case, but perhaps not for the obvious reasons stressed in economic textbooks. In the world of simple economic theory, it is claimed that if competition works like it is supposed to, efficiency is guaranteed but fairness cannot necessarily be guaranteed. However, in the telecommunications industry, characterized by increasing returns to scale, the inevitable result of competition is the giant megacorporations emergence, which absolutely must be subject to regulation. The importance of competition lies in the fact that, in contrast to the non-transparent selection mechanism of regulation, competition is a totally transparent selection mechanism. Kotaro Suzumura (2003), the authoritative welfare economist, has noted that the true value of competition is to be found in its procedural aspect, which facilitates equality of opportunity, which allows people to freely pursue whatever opportunities they choose.

Though it sounds somewhat paradoxical, the value of competition policy is not that it leads to efficiency (I am not denying that it does), but rather that competition lays the groundwork for procedural fairness and equality of opportunity. It is generally held in the telecommunications industry that allocative inefficiency and technological inefficiency should be ameliorated by bottleneck monopoly regulations, access regulations, and other appropriate regulations (these measures do not always succeed however). In a sense, competition guarantees fairness while regulations guarantee efficiency. This is a reversal of the conventional wisdom that competition guarantees efficiency and (economic or social) regulations guarantee fairness. This mixed structure of regulations and competition has at least continued to function fairly well up to now in supporting Japan's rollout of broadband, but will it continue to serve us well in the years ahead? Nobody knows the answer to that question, but at least we are not currently in such a crisis situation that the telecom policy paradigm has to be totally overhauled. At the same time, we cannot afford to be caught off guard. We summarize the main points as follows:

Dilemma of competition policy

The purpose of competition policy is to enhance economic welfare through market competition. However, in the telecommunications industry, which is characterized by increasing returns to scale, the result of competition is an increasing tendency to monopolization, so regulation of monopoly bottlenecks is essential.

The year 2010: Respective visions of NTT and the MIC

The first years of the twenty-first century witnessed a decisive rollout of broadband in Japan, but the transition from the growth period associated

with rapid take-up of ADSL to the mature period involving migration to FTTH is still very much in flux. The number of broadband users now exceeds 25 million, and the number of FTTH users has reached 10 million. There is widespread agreement among knowledgeable observers that the year 2010 will mark a critical milestone. It is estimated that by the year 2010, about 30 million users—roughly half the current 60 million subscribers to landline services—will have switched over to fast broadband FTTH and using communications, broadcasting, remote medical and government services, and a range of other advanced services. By the same token, the information-disadvantaged, such as the elderly in rural areas, will be left behind still using legacy landline services, and could paradoxically end up paying even higher rates than the high-speed broadband users. So the picture of broadband evolution over the next few years up to 2010 is a mixed one with both positive and negative aspects. Let us next consider how the NTT Group and the Ministry of Internal Affairs and Communications (MIC)—the two entities most responsible for the future of broadband in Japan—envision broadband in the year 2010.

The NTT Group's Mid-Term Management Strategy

In November 2004, the NTT Group unveiled a *Mid-Term Management Strategy* committing the firm to provide “broadband ubiquitous network services that are safe and secure,” and announced concrete steps toward achieving a broadband society by the year 2010. Citing specific and audacious numerical targets such as the migration of 30 million fixed wireline subscribers to optical access services by the year 2010, NTT's announcement has generated much discussion. The key objectives of the NTT Group Strategy are:

- Fixed-mobile convergence (FMC),
- Deployment of a high-quality, flexible, secure NGN,
- Smooth migration from fixed wireline to IP-based telephony, and from copper to optical fiber access,
- Expansion of business opportunities,
- Strengthening of competitiveness, and establishment of a solid financial base.

Let us consider these objectives in closer detail. The first objective is FMC. This involves the integration of optical FTTH services and third-generation (3G) wireless services to provide high-speed, interactive data services supporting distribution of massive video content, anywhere, anytime (discussed in Chapter 9). In other words, FMC will enable a broadband ubiquitous network society with practically unlimited telecom capabilities such as the ability to monitor and control your home from a remote location, the ability to provide immediate crisis management support by linking an onsite remote

location and a central desk, and a host of other advanced capabilities. Eliminating the separation between wireline and wireless services is what the broadband user community has been waiting for. The only concern is that only the big three—the NTT Group, the KDDI Group, and the SoftBank Group—will be able to implement this technology, and the business opportunities for other operators will be limited. Especially regarding the market dominance of the NTT Group, which has such a substantial share of both wireline and wireless networks, there is a pervasive sense of wariness.

The second objective of NTT's Mid-Term Management Strategy is deployment of an NGN. 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 video-phone services and delivery of high-definition quality content. 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 peoples' privacy, and other kinds of cyber crime. The NTT Group has started the full-scale deployment of NGN services since March of 2008. In the background 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. The current Internet has also shown remarkable development, based on the pervasively liberal temperament especially prevalent on the West coast of the US, and some operators are extremely wary of enforcing tighter control over networks.

The third objective of the NTT Group's Mid-Term Management Strategy is to migrate 30 million users, equivalent to half the country's fixed wireline subscribers, to optical access by the year 2010, and come up with a concrete strategy for moving the remaining 30 million subscribers to fiber as well. The NTT Group's fourth objective is to raise earnings from non-traffic sources at the platform layer, such as advanced authentication and billing options, to ¥500 billion by the year 2010 by exploiting all the firm's collective resources: wireline, wireless, and system integration. NTT's fifth objective is to cut back dramatically on equipment investment so that the firm's total investment in fixed network operations will be trimmed to ¥5 trillion, and optical access and NGN services will be operating in the black. While this aggressive program to deploy broadband ubiquitous network services will give Japan the most advanced telecommunication infrastructure environment in the world, it will also create a serious digital divide between those with access to broadband and those without. The public and private sectors are working together to address this issue, but it remains a challenging problem (this is discussed at length in Chapter 10). We summarize the main points as follows:

The NTT Group's Mid-Term Management Strategy

Based on an aggressive strategy to deploy FMC and NGN, the NTT Group aims to migrate half its current fixed wireline subscribers to FTTH by the year 2010. This is raising concerns about the NTT Group's growing market dominance and growing digital divide between broadband haves and have-nots.

MIC's Competition Promotion Program 2010

To address changes in the competitive environment with the transition to IP, the Ministry of Internal Affairs and Communications (MIC) announced a *New Competition Promotion Program 2010* in September 2006, citing the beginning of the 2010 decade as a critical milestone for assessing competition rules. This initiative was triggered by fundamental changes in the structure of the telecommunications industry as traditional service categories (voice, data, video; wireline versus wireless; local, long distance, international) are disappearing, and the traditional layers (physical network, telecommunications service, platform, and content/application layers) are being spanned by vertical integration (see Figure 1.1). To develop solid support for the new competition rules, the MIC is promoting discussions from three new perspectives: competition neutrality, technology neutrality, and network neutrality. Key points of this discussion are summarized as follows:

- Appropriate balance between facility-based competition and service-based competition,
- Assurance of fair competition regarding cooperation with the NTT Group,
- How NGN should be constructed and connectivity supported,
- Assurance of network neutrality,
- Assurance of universal access.

Here, I will briefly consider these issues. First, facility-based competition and service-based competition are the two primary factors in promoting competition in broadband services (see Chapter 3). *Facility-based competition* refers to the ability of an operator to construct his/her own network and compete in the market, and *service-based competition* refers to the ability of a competing operator to utilize the network of the dominant carrier possessing bottleneck facilities and competing in the market. In case of new services such as FTTH requiring new deployment, facility-based competition would be more effective in built-up urban areas where demand density is high, while service-based competition would be more effective in regional cities where demand

Figure 1.1 Network layered competition model.

density is moderate. However, in sparsely populated areas where demand density is low, NTT East and West have been extremely cautious in committing investment for deployment of optical fiber, and the problem of inadequate investment incentives has been pointed out. Thus, the current FTTH market cuts across different kinds of regions—areas where facility-based competition will develop, areas where there is potential for service-based competition to develop, and areas where investment in facilities is unlikely, based on market principles alone—and it would be difficult to impose a connection policy obligating NTT East and West to provide open access to their fiber access lines.

The second issue involves how cooperation with the NTT Group, the dominant operator in the market, should be set up and regulated as the market becomes increasingly integrated. For example, offering FMC services through cooperation with NTT East's or West's wireline network or NTT DoCoMo's wireless network would be beneficial for end-users. However, NTT operators own designated telecommunications facilities subject to bottlenecks, so it will be necessary to establish fair competition conditions to ensure an equal footing for all carriers seeking to offer services using NTT Group facilities (see Chapter 9). Thus, while the primary emphasis of telecommunications regulation in the past was to restrain leverage of market dominance over a single market, the emphasis now will shift to restraining leverage of market dominance laterally across markets. Unfortunately, we have very little theoretical or regulatory knowledge regarding leveraging of market dominance across adjacent markets, so careful and deliberate

investigation is called for. The MIC has begun work on a safeguard system that will unify the current dominance regulations, and plans to conduct a comprehensive assessment of the designated telecommunications system before 2010.

The third key point of MIC current discussions revolves around the NGN that will be constructed by NTT East and West. While it is commonly assumed that NGN is new facilities, it is actually based on legacy infrastructure subject to bottlenecks, an issue that must be addressed so competing operators can interconnect to NTT East's and West's NGN and offer flexible services. On this point, the NTT Group too has given assurances that the NGN will be open, but a neutral forum must nevertheless be established to discuss NGN interconnection rules including rules to ensure an open video distribution platform that is expected to see significant growth in the years ahead.

The fourth key point of MIC discussions addresses network neutrality emphasizing the ability of users to freely access the content/application layer, the ability of users to freely access the network with any standards-compliant terminal equipment, and the ability of users to utilize the telecommunications layer and platform layer at reasonable cost. Two points are particularly important: the neutrality of the telecommunications layer vis-à-vis the other layers, and developing fair rules for allocating the costs of upgrading the network.

The fifth point of MIC discussions involves a system currently operated by the MIC to collect costs from operators commensurate to the benefit they receive from maintaining universal services; but now with the disappearance of barriers between services and distance-related categories, the rationale for maintaining the universal service system confined to subscriber telephone service has been diluted. For accessing broadband services, the MIC has thus begun exploring a new concept of universal access that would ensure access to anyone without disparities between different regions and at reasonably low cost.

Within the framework of the *New Competition Promotion Program 2010*, steps will be taken to promote infrastructure investment, deploy competitive environment facilities, conduct a comprehensive assessment of competition rules by the beginning of the 2010 decade, address NTT organizational issues, and quickly reach a conclusion regarding telecom-broadcasting convergence. We summarize the main points as follows:

MIC's Competition Promotion Program 2010

The MIC has drafted competition policy guidelines specifying the year 2010 as a critical milestone. Concerning the two basic concerns of facility-based competition and service-based competition, the guidelines deal with restraint of NTT Group market dominance, ensuring universal access, and other basic issues. Certainly new competition

policy-related issues that are wholly different than in the past will arise with the deployment of the NGN, so figuring out ways to safeguard network neutrality are critically important.

Moving toward the future of broadband in Japan

In this section I consider three fundamental issues pertaining to broadband in Japan. First I will address the issue of market dominance and leverage. If services can be provided in collaboration with the NTT Group, this implies that only certain competing operators will have access to favorable business opportunities. This requires that lateral market dominance be defined, and continuously monitored. The second issue I address is the NGN and network neutrality. The proliferation of peer-to-peer (P2P) file-sharing services on the Internet has exacerbated the problem of network congestion. However, now the bandwidth control and guaranteed quality (quality of service (QoS)) supported by NGN will enable the distribution of interactive rich content. It is thus desirable that an equal access environment be put in place, making the NGN accessible to all. Finally, the third issue concerns the digital divide and investment incentives. It is commonly held that extending FTTH to rural areas would be extremely costly and only serve a very modest demand. Yet it would be an enormous waste of resources to deploy both fixed wireline and optical access networks, and it is likely that the main beneficiaries of FTTH to rural areas would be the elderly, who would use fiber to access public services. Most important is to develop a clear consensual vision of how FTTH is to be used.

Market dominance and leverage

Regarding Japan's telecommunications policies, we are currently faced with four main issues:

- Examination of the appropriateness of access charge regulations based on long-run incremental costs (LRIC) currently charged for accessing the public switched telephone network (PSTN) owned by Type I designated telecommunications businesses (NTT East and West).
- Examination of the appropriateness of access obligations to provide access to subscriber optical fiber networks owned by Type I designated telecommunication businesses (NTT East and West).
- When Type I designated telecommunications businesses (NTT East and West) deploy an NGN, examination of whether platform functions such as bandwidth control, authentication, charge assessment, database function, etc. should be covered by regulations.

- Establish fair competition conditions for competing operators to provide FMC services using the networks of Type I and Type II designated telecommunications businesses (NTT East, NTT West, and NTT DoCoMo).

The *New Competition Promotion Program 2010* has been applauded for working out an approach to address these issues. Dealing with NGN and FMC was especially challenging, considering that these services are not currently available but are expected to see extensive deployment in the future. Once these services do become available, it will be necessary to develop a system that restrains the leveraging of market dominance over closely related adjacent markets.

Let us consider these issues in economic terms. The four issues raised above can all be analyzed using the common framework of a vertically integrated bottleneck monopoly structure. Let us assume two firms, Firm A and Firm B. Firm A provides wholesale services. Both Firm A and Firm B provide retail services to consumers using Firm A's wholesale service. Thus, Firm A is a vertically integrated firm providing both wholesale and retail services, while Firm B is a non-vertically integrated firm that provides only retail services. Considering that neither Firm A nor Firm B could offer actual services to consumers without using Firm A's wholesale service, this wholesale service owned by Firm A is essential to Firm B (see Figure 1.2).

In the realm of network economics, the capital equipment needed to provide Firm A's wholesale service is called *bottleneck monopoly facilities* or *essential facilities*, and discussions have been held to determine what the access obligation should be and what the appropriate interconnection charges should be to gain access to these essential facilities (see Chapter 3). Now let us consider some potential cases. In Case 1, interconnection to NTT East's or West's local exchange network corresponds to a wholesale service, while a competing operator using NTT's network to offer long-distance telephone

Figure 1.2 Vertically integrated bottleneck monopoly structure.

service is a retail service. In Case 2, interconnection to NTT East's or West's subscriber optical fiber network constitutes a wholesale service, and a competing operator using NTT's network to offer FTTH service is a retail service. In Case 3, interconnection to NTT East's or West's NGN constitutes a wholesale service, while a content/application provider using the NGN to offer a value-added service represents a retail service. In Case 4, interconnection to NTT DoCoMo's mobile phone network constitutes a wholesale service, while a competing operator using DoCoMo's network to offer FMC service is a retail service.

Here I will comment on the idea of examining competition impairment by vertically integrated firms that possess bottleneck monopoly facilities. Section 251(d)(2) of the United States' Telecommunications Act of 1996 defines the standard for network unbundling obligations of incumbent telecommunications operators as follows:

- Interconnection to the network is "necessary" for the entrant.
- Refusal to allow interconnection to the network would "impair" competition.

Unbundling "necessity" and "impairment" of bottleneck monopoly facilities is determined, based on demand substitutability and supply substitutability. Generally, demand substitutability is primarily determined from the price elasticity of demand, while supply substitutability is determined from the price elasticity of supply (Werden, 1993, 1998).

More specifically, the following five conditions must be considered to determine the necessity of unbundling bottleneck monopoly facilities such as local exchange networks (Hausman and Sidak, 1999).

- 1 It is technically feasible for Firm A to provide Firm B with access to the unbundled network.
- 2 Firm A denied Firm B use of the network at a competitive (or regulated) price.
- 3 It is impractical and unreasonable for Firm B to construct the network beforehand.
- 4 In providing services to end-users, Firm A exercises monopoly control over the network.
- 5 In providing services to end-users, Firm A can leverage market dominance by refusing access to the network.

Generally, the so-called *essential facilities doctrine* covers conditions (1) through (4) (Sidak and Spulber, 1998). In other words, the essential facilities doctrine is a necessary condition for bottleneck monopoly facility-based competition impairment, but it is not a sufficient condition. The idea expressed in condition (5) is advocated in the US's 1992 Merger Guidelines, and in combination with conditions (1) through (4) does represent necessary

sufficient conditions for competition impairment. The Merger Guidelines define condition (5) as occurring when a hypothetical monopolist's profits are increased by a small but significant and nontransitory increase in price (SSNIP). Faced with an SSNIP, many consumers would move away from the service in question to another service, thus causing the hypothetical monopolist's profits to fall, so the SSNIP cannot be sustained. So at least in this case, the hypothetical monopolist is unable to leverage market dominance even though the firm may wish to do so.

Now let us consider the situation described in Case 4. Assuming that NTT East and West having market dominance over fixed networks and NTT DoCoMo having market dominance over mobile networks, provide FMC services, how does one determine whether regulations should be imposed? Here, wholesale service is represented by mobile phone network functions including database and location information, and retail service is represented by FMC service. Firm A can here be identified as the NTT Group, providing both wholesale and retail services. Firm B is a competing operator—say, a CATV company—that does not have its own mobile phone network. If NTT DoCoMo's mobile phone network satisfies conditions (1)–(4), then as far as the CATV company that wants to venture into FMC services is concerned, NTT DoCoMo's mobile network is an essential facility, and the necessary conditions for imposing regulations are satisfied. In this situation, the interpretation of conditions (1)–(4) becomes somewhat ambiguous. For KDDI and SoftBank—both of whom have their own nationwide mobile phone networks—NTT DoCoMo's mobile phone network is not an essential facility, but for the competing operator that does not have its own mobile telephone network, NTT DoCoMo's mobile phone network is an essential facility in order to provide FMC services. So it is apparent that identifying facilities as essential, which is a necessary condition for regulation, must be determined for each individual operator.

In order to determine if sufficient conditions are met to impose unbundling regulations of bottleneck facilities, it is necessary to determine the potential of the vertically integrated NTT Group leveraging its market dominance. This can be done by ascertaining whether the NTT Group's total profits from NTT DoCoMo and NTT East and West have increased as a result of raising its access charges, thus causing demand for FMC services to shift away from competing operators to NTT. In other words, under circumstances that the NTT Group is able to usurp a competing operator's demand using its leverage over wholesale services to increase NTT's own total profits, it can be said that the NTT Group has horizontal market dominance. Under these circumstances, NTT DoCoMo should be obligated to open its mobile phone network to competing operators under the same conditions as it extends to NTT East and West, and it would be appropriate to impose regulations ensuring that access charges do not deviate from competitive price levels. We summarize the main points as follows:

Market dominance and leverage

Fundamental challenges now facing Japan's telecommunications industry can be understood as vertically integrated bottleneck monopoly issues. Especially the issue of horizontal market dominance exemplified by FMC has drawn considerable attention. Two criteria for defining horizontal market dominance extending across adjacent markets are necessity of essential facilities and impairment of competition as evidenced by increased total profits achieved by raising wholesale prices.

(*) Critical market share test and expansion

Hausman-Sidak's test for competition impairment is based on measuring to determine if a hypothetical monopolist's critical market share is such that the monopolist's profits could be increased by an SSNIP. Noneconomists may omit this analysis (*). Hausman, Leonard, and Velturo (1996) have derived the critical market share where Firm A's wholesale service profits (not including retail service profits) becomes equal before and after prices are increased as follows:

$$\theta \geq \frac{1 + [(1 + \alpha) - M^U]\eta_B}{[(1 + \alpha) - M^U](\eta_B - \eta_A)}$$

where α is the price increase rate, M^U is the marginal cost/price ratio of Firm A's wholesale service, η_A is the price elasticity of demand for Firm A's retail service, and η_B is the price elasticity of demand for Firm B's retail service. For example, if $M^U = 0.5$, $\alpha = 0.05$, $\eta_A = -0.5$, and $\eta_B = -5$, then $\theta \geq 0.707$.

If the critical market share θ^* of vertically integrated Firm A with bottleneck monopoly facilities evolves as shown above, then by considering not only Firm A's wholesale service profits but also the firm's retail service profits, we obtain the following (see the Appendix):⁶

$$\theta^* \geq \frac{1 + [(1 + \alpha) - M^U]\eta_B}{[(1 + \alpha) - M^U](\eta_B - \eta_A) - \left(\frac{1}{M^D} - 1\right)[1 + (1 + \alpha)\eta_A]}$$

where M^D is the marginal cost/price ratio of Firm A's retail service. If Firm A's current retail service market share increases above θ^* , then Firm A can increase total profits by raising prices. In this case it is determined that Firm A is able to leverage its market dominance.⁷ For example, when $M^U = M^D = 0.5$, $\alpha = 0.05$, $\eta_A = -0.5$, $\eta_B = -5$, then $\theta^* \geq 0.593$. If Firm A's

market share of the retail market is more than 59.3%, then the firm's profits can be increased by raising prices by 5%, and the firm is leveraging its market power. In this case, the prices of Firm A's bottleneck monopoly facilities should be regulated to maintain the current level of competition.

However, if Firm A's share of the retail market is less than 59.3%, the firm's profits cannot be increased by raising prices by 5%, so the firm cannot leverage its market power. In this case, there is no concern that social welfare will be harmed, even if Firm A's mandatory obligation to provide access to its bottleneck monopoly is rescinded. This is the essence of the critical market share test for determining market dominance of vertically integrated firms having bottleneck monopoly facilities.

NGN and network neutrality

In light of the ongoing transition to broadband and changes in the competitive environment reflected in the horizontal market integration and vertical market integration, the MIC's New Competition Promotion Program 2010 is now reassessing bottleneck regulations and dominance regulations in terms of three neutralities: competition neutrality, technology neutrality, and network neutrality. Priority concerns include dealing with optical fiber local IP network designated facilities, arguments for and against tie-ups with NTT East and West and NTT DoCoMo, practical NTT Group operations, and the nature of special affiliated operators. The program is expected to establish competition safeguards and implement competition assessment and dispute resolution procedures.

Close attention should also be focused on the growing power of the NTT Group accompanying the transition to FTTH (see Chapter 8). Note in particular that half the FTTH subscribers used ADSL before upgrading to FTTH, and more than half of those moving from ADSL to FTTH currently get their service from NTT East or NTT West. There is also concern over the ability to exert leverage between adjacent markets, such as between fixed and mobile services (see Chapter 9). Specifically, FTTH usage among NTT DoCoMo 3G subscribers is significantly higher than among other 3G operators, and FTTH usage by NTT East and West subscribers is especially high. At the same time, 3G usage among NTT East and West FTTH subscribers is higher than the FTTH usage of other operators, and 3G usage by NTT DoCoMo subscribers is especially high.

Of particular concern here is NTT East and West's current commitment to build the next-generation network. Regarding deployment of NTT East and West's NGN, there is a need to establish a forum to review how NGN access rules should be defined, focusing on the following points:

- Assurance of equal access to the NGN for networks, servers, and end-users,
- Specification of the relations between the physical network, the tele-

communications network, and legacy designated telecommunications facilities,

- Handling of platform functions such as bandwidth control, authentication, charge assessment, and security.

With the legacy public Internet based on the principle of autonomous routing, it has been impossible for network operators to keep track of the amount of packets sent over different routes, so technically it has not been feasible to assess charges commensurate with the amount of bandwidth used in line with the benefit principle (those who benefit from services should be the ones who pay for them). Criticism has mounted over the fact that some providers and users have been enjoying a free ride by sharing content-rich files over a growing number of P2P file-sharing applications, while avoiding paying their fair share of costs to upgrade the network to accommodate the rapidly escalating volumes of IP traffic. By contrast, the NGN enables management of ID information, media classification, codec classification, bandwidth information, directionality, and more, so it becomes a simple matter to introduce bandwidth-based charging and guaranteed QoS. This raises the question as to whether introducing a bandwidth-based fee structure is really the fairest approach to support network cost-sharing.

Here I will consider two kinds of operators: Internet backbone providers (IBPs) and Internet service providers (ISPs). IBPs can provide services to end-users as ISPs, but ISPs must access an IBP to provide services. This network configuration is essentially the same as illustrated earlier in Figure 1.2.

This kind of network configuration raises two sets of issues for wholesale and retail, respectively. Regarding network neutrality at the wholesale level, this raises issues of what charges a vertically integrated IBP should charge itself as a competitor and also charge customer ISPs in terms of social efficiency and fairness. Assuming the LRIC rule as the lower limit and the stand-alone cost rule as the upper limit, a number of rules have been proposed for determining access charges: (1) the Ramsey pricing rule, (2) long-run incremental cost plus (LRIC+) rule, and (3) efficient component pricing rule (ECPR) (see Chapter 3). Rules (1) and (3) would generally be preferable from a welfare economics point of view, but in fact, rule (2) is most often adopted as a way of promoting competition.

Regarding network neutrality at the retail level, this raises issues of what retail charges a vertically integrated IBP and a non-vertically integrated ISP should charge large users and small users in terms of social efficiency and fairness. Regarding this issue, it is known that differentiation of charges between large users and small users based on (the reciprocal of) demand elasticity in accordance with Ramsey pricing is efficient from the standpoint of society (Ida, 2001, ch. 8). However, there are three problems with Ramsey pricing. First, Ramsey pricing tends to be income distribution regressive, so it cannot be easily applied to public service charges that take distributional considerations into account. Second, in order to apply differential pricing,

the operator must possess information about the type of user, but there is asymmetry of information between the two sides. This means that it is usually necessary to present the user with a self-selection-type rate structure that is a combination of a basic rate and a variable rate. Third, when competition for customers is fierce, there is a strong motive to retain large users, so Ramsey pricing that does not consider the strategic interdependence between the operator and user is simply not very practical.

So far we have been considering shorter term issues of how already deployed networks might be used most efficiently, but we have not addressed the problem of cost-sharing for the purpose of upgrading network facilities. It is a fact that network congestion occurs if excessive use of the network by some large users is not restrained or if the number of users increases beyond the carrying capacity of the network. When congestion does occur, the network processing speed slows to a crawl, which not only affects the perpetrator, but penalizes all the users of the network. The social cost of the congestion must be weighed against the benefits, and the network usage of the users causing the congestion must either be restricted, or some kind of congestion tax must be imposed. In cases where the disparity between network capacity and volume of usage is already substantial, control through imposition of a congestion tax would have limited effect, and upgrading network facilities to increase capacity may be the only option. Here again, the social costs of upgrading the network must be weighed against the benefits, and the cost burden on users should be commensurate with amount of use. Note, however, that because there is a disparity between private costs and social costs, it is often a very challenging problem to adjust the cost burden for upgrading network facilities.⁸

In addition to these charge-related issues affecting network neutrality, there are a number of social problems raised by the NGN, which can be summarized in the following four points:

- Impact of the NGN on disparities within the telecom industry,
- Impact of NGN on universal access,
- Impact of NGN on international competitiveness of Japanese industry,
- NGN as a telecommunications policy dilemma.

Let us first consider the impact of NGN on disparities within the telecommunications industry. One problem with NGN is that there are significant disparities in size and competitiveness of different kinds of firms within the telecommunications industry, including operating firms, CATV companies, ISPs, and content providers. While it may not be such a bad thing for firms that are unable to make the adjustment to NGN to simply go by the wayside, based on survival-of-the-fittest market principles, telecom policy aspects nevertheless find their way into discussions as to how all firms, including smaller hard-pressed firms with limited resources, might be included in the upgrade to NGN in a convoy approach. No doubt this is inevitable to some extent.

Second is the impact of NGN on universal access. This highlights the widening gap between the information-poor, who are stuck with a PSTN cheap-but-mediocre service (sometimes not so cheap but still mediocre) and the information-rich, who are able to move up to optical access networks costly-but-good service (sometimes cheap and good). The former are left behind with poor security networks, while the latter enjoy robust security networks and high-quality services. It will take a long time for the information-poor to make the transition to FTTH if merely left up to market forces, so social policy aspects must be considered.⁹

The third point involves standardization of NGN and information appliances, and is directly related to international competitiveness of the Japanese consumer electronics industry centering around flat-screen digital TVs (ie Sony, Sharp, and Matsusita). Fierce competition is now in progress to determine the layer where NGN intelligence should be endowed among powerful industry players: the telecoms with the most advanced infrastructure, the information appliance manufacturers with their superior technology development capabilities, Microsoft with its monopoly on basic software, and portal site firms such as Google, which has risen so spectacularly in recent years.

The fourth point is the dilemma that NGN poses for telecommunications policy. While the MIC heralded a paradigm shift from *ex ante* regulations to *ex post* regulations in telecommunications policy, it is exceedingly difficult to intervene and harmonize different interests after the fact once industries have been locked in, so persistent monitoring and prompt resolution of disputes are essential. We summarize the main points as follows.

The NGN and network neutrality

Considering the NGN, which will support bandwidth control and guaranteed quality of service (QoS), the most pressing concerns regarding competition policy are assurance of equal access, the relationship with legacy designated telecommunications facilities, and dealing with platform layer considerations. Another key issue is the development of a viable rate structure that will effectively prevent network congestion over the short and long terms. Other important concerns involve the impact that the NGN will have on disparities within the telecom industry, on universal access, on the international competitiveness of Japanese industry, and the dilemma that NGN poses for telecommunications policy.

Digital divide and investment incentives

Finally, let us consider the dark side of broadband—the problem of the digital divide. There are two common theories as to why the digital divide should be tolerated:

- The deployment of optical access networks is costly and therefore cannot be extended to rural areas.
- Rural areas are predominantly populated by the elderly, so there is relatively little demand for high-speed Internet and no need for FTTH.

I believe that both of these theories are mistaken. Regarding the first popular theory, there is no question that the nationwide deployment of optical access networks is costly. Deployment of new FTTH lines is estimated to cost somewhere between ¥150,000 and ¥300,000 per household, even more in rural areas of low demand density. Yet the costs to maintain the legacy copper-based network is also enormous, and just barely covered by the system of local subsidization of rural areas by the cities. Now, as urban areas migrate from the PSTN to the optical access network, the rural PSTN will no longer be able to stand on its own. Comparing switching equipment to routers, the maintenance costs of the routers supporting fiber are much less expensive than supporting PSTN switches. The challenge is the initial deployment costs of optical access networks, but considering that much legacy PSTN infrastructure such as existing conduit and telephone poles can still be used, the investment costs are really relatively minor compared to 100 years ago when the PSTN was first constructed, starting from zero.

The problem with the second popular theory is that FTTH is equated with high-speed Internet. It is probably true that ADSL is perfectly adequate for surfing the net using a PC, and the rate of computer use among the elderly is fairly low. However, the real value of FTTH is not for surfing the net, but to support the remote provisioning of broadcast, health, welfare, education, government and a host of other services, based on high-definition digital images. The chief beneficiaries of these high-quality remote public services are precisely the elderly populations, who reside in remote areas that are poorly served by transportation systems.

In terms of telecommunications policy, the digital divide presents two problems. First is how to decommission the legacy copper PSTN, and second is how to deploy the optical access network. The entities confronting these two issues are NTT East and West. Announcing their Mid-Term Management Strategy in November 2004, the NTT Group is aiming to migrate half of their telephone subscribers—roughly 30 million—to FTTH by the year 2010. Once half the population is served by FTTH, digital divide issues will become very apparent, and debate will intensify over NTT's course of action, which will shake the foundations of the entire telecommunications industry. Yet, in a sense, the problem is very simple: the decommissioning

of old infrastructure, the deployment of new infrastructure, and the cost will ultimately be borne by the final consumers.

That having been said, when you consider the investment burden NTT faces in migrating from old infrastructure to new infrastructure, the risks and amounts of cash that must be procured are enormous. This has led some to suggest that NTT East and West should be exempted from the obligation to provide free access to fiber networks, but I am personally skeptical of the view that changing the obligation on NTT to provide access to fiber has anything to do with investment incentives.¹⁰ After all, NTT is currently locked in a fierce competitive struggle in the cities over facilities with the power system telecom operators, so clearly an investment incentive exists. However, turning to the regional cities where the power companies have not established a presence, it would indeed be difficult to create an investment incentive if NTT was obligated to lease its optical fiber lines to competing operators that do not have their own fiber infrastructure. So long as demand is not absolutely insufficient, the investment will be found to gradually extend optical fiber to the regional cities. More problematic are the isolated areas and remote islands. Such areas may not be profitable, so whether there is an obligation to provide access or not may be irrelevant, and there may be no investment incentive for any operator to deploy fiber to such places.¹¹ So the obligation to provide access and eliminating the digital divide are not necessarily connected. It is important to provide NTT with an investment incentive to reach remote areas and isolated islands, and to make full use of the infrastructure to make those communities less isolated.

Considered in this light, the factor most directly linked with eliminating the digital divide is a broad-based societal vision regarding the purposes that the optical network will serve. Certainly, if FTTH is merely used to surf the Web, it could hardly be justified. Indeed, it is only when FTTH is used as a new public infrastructure that the true value of fiber for society is realized. For example, the MIC is publicly committed to the decommissioning of analog terrestrial broadcasting and switching over to digital terrestrial broadcasting by the year 2011, but this national project would be very difficult to achieve if we were just talking about radio waves. In fact, considering the line-of-sight nature of radio waves, there would be a real risk of the poor reception areas actually increasing. In these poor reception areas, a fiber-based wire-line network is preferable for delivering images. Especially considering the rapid increase in elderly single households, once remote medical support systems are up and running. Linked by fiber to hospitals and other medical facilities, this will open the way to a host of valuable services, including health support services for the elderly using videophones, and collaborative services with medical facilities in larger cities supporting remote diagnosis of medical images by specialists and tele-consultations between local doctors and doctors in the city.

We must not forget that the market mechanism does not yield correctly valued prices of public goods (or merit goods).¹² Although optical access

networks are clearly linked to the creation of public benefits and public cost savings, it is hard to incorporate all this social value into the price structure of optical access networks. So when deploying new nationwide public infrastructure, it is important to first develop a vision involving the participation of public, private, and academic interests, which clearly defines when and by what procedure the infrastructure is going to be deployed. Continuing to operate rural networks at a deficit knowing that eventually they are going to be decommissioned and continuing to collect basic charges for landline universal services simply to prolong the life of these rural networks is clearly inefficient in terms of the public interest. Indeed, this would only serve to add yet another major drain on the national coffers, alongside the national railroad, rice farmers, and national healthcare. If funds were available to pursue this approach, they would be better invested in the deployment of optical fiber networks to rural areas. Local government also has an important role to play in this. The digital divide between different rural areas also highlights the difference between local governments, with some governments headed by enlightened leaders and others, not. The best policy for overcoming the digital divide is to focus on developing a viable access method that concentrates sparse demand and can be applied to these kinds of geographical environments.

The rural areas that have been most successful in quickly overcoming the digital divide share a number of common attributes (see Chapter 10):

- They felt a sense of urgency (in the course of municipal mergers and other occasions) in dealing with the digital divide.
- They exhibited cooperation between the national government, the local government, NTT, and the local population.
- They supported awareness activities that elevated the IT literacy of the local population.

Effective use of broadband is essential for overcoming many of the problems afflicting rural communities: delivering digital terrestrial broadcasting to areas with poor reception, upgrading the education information environment as part of the effort to counter the falling birthrate, utilizing services for watching over elderly people who live alone, and many other potential applications. However, there is a limit to what local governments can do on their own. Uncertain finances after fiber is deployed, emergence of pockets of telecom disadvantaged—digital divides within digital divides, little or no progress in cooperation between local governments or improved efficiency within the government are just a few of the problems that have been pointed out. To address these issues, the MIC and central government must play a strong leadership role in the widespread dissemination of best practices and other initiatives. Japan's optical access network may be the envy of the world, but it should not end up as a pawn in the money game to be manipulated by managers riding the IT bubble. That boom will pass before the decade is out.

It is only by leveraging a new public infrastructure, based on broadband, that Japan can break out of its current predicament of declining birthrate and shrinking population with a major far-reaching plan that will serve the nation into the future. We summarize the main points as follows:

The digital divide and investment incentives

It is widely held that extending FTTH to rural areas would be extremely costly and serve very little demand. However, in reality, supporting the deployment of both copper and optical fiber is exceedingly wasteful, and there are tremendous expectations regarding the kinds of public services that can be delivered over FTTH. A unified approach involving industry, government, and academia is required to conceive investment incentives for deploying optical fiber to rural areas. Local governments must be centrally involved in the planning of a vision that matches the actual circumstances of local communities.

Conclusions

The principle conclusions of this chapter can be summarized below. The NTT Group is pursuing a Mid-Term Management Strategy that aims to extend optical fiber access to 30 million homes (FTTH) by the year 2010. Deployment of NGN and FMC, in particular, may demonstrate NTT's collective strength like never before. On the other hand, the MIC launched a New Competition Promotion Program that identifies the year 2010 as a critical milestone. As part of this initiative, MIC is considering whether leveraging horizontal market dominance should be restrained through regulation to ensure network neutrality.

A fundamental concern of the telecommunications industry (that very much also applies to NGN and FMC) is vertically integrated bottleneck monopoly structures. In the presence of such structures, competing operators must have access to some layers of the layered competition model, and if vertically integrated firms impair competition, then unbundling obligations are justified. Furthermore, the commonly held belief that the digital divide should be tolerated is flawed. It is essential to develop a clear vision of how FTTH will be used in order to provide an investment incentive for extending optical access networks to rural areas. Local governments will play an important role in developing the visionary plan.

We can anticipate considerable controversy in 2010, a critical milestone in the migration to broadband, over the shape and future of Japan's telecommunications industry. Of particular concern is how NTT responds to apprehensions about the increasing market dominance of the NTT Group

with the deployment of FTTH and FMC services. As usual, hard-liners will call for the breakup of the NTT Group. However, with industries characterized by increasing returns to scale, it is dubious from an academic standpoint that structural measures or enforced artificial division of the increasing returns would have any beneficial results for consumers. This is because the telecommunications industry is a kind of complex system, characterized by unpredictability (see Chapter 3).

Rather, a moderate but sure regulatory reform has been adopted involving a strict open access policy and dominance regulations ensuring that the NTT Group's economies of scale and scope and network externalities were not internalized to the firm, but externalized to society as a whole, and in fact a consistent flow has been adopted since the deregulation of telecommunications until the success of Japan's broadband. Reform just for the sake of reform is undesirable, but there are conditions attached. As I observed at the beginning, one criterion of whether fundamental reform is necessary is whether users are provided with a range of at least three genuine service options plus extra functions. The primary purpose of competition policy after all is to guarantee equal opportunity for all operators while ensuring that consumers have a diverse range of options to choose from.

Appendix to Chapter 1

Critical market share of vertically integrated firms

Firm A is a vertically integrated firm providing both wholesale and retail services. Firm B is a non-vertically integrated firm that purchases wholesale services from Firm A and provides retail service.

First, regarding wholesale service we define P as the price of Firm A's wholesale service, P_0 as the current price (either the competitive price or the regulated price), Q as demand for Firm A's wholesale service, C as the critical price of Firm A's wholesale service, and $M^U = C/P_0$ as the critical price/price ratio of Firm A's wholesale service. Next, regarding retail service we define P_A as the price of Firm A's retail service, Q_A as demand for Firm A's retail service, η_A as the price elasticity of demand for Firm A's retail service,¹ P_B as Firm B's retail service price, Q_B as Firm B's retail service demand, η_B as the price elasticity of Firm B's retail service demand, $Q = Q_A + Q_B$ as the wholesale service demand, $\theta = Q_A(P_0)/Q(P_0)$ as vertically integrated Firm A's retail service market share, and $M^D = P_0/P_A$ as Firm A's retail service critical price/price ratio.

At current prices, Firm A's wholesale and retail market profits are given by: $\Pi_0^U = (P_0 - C)[Q_A(P_0) + Q_B(P_0)]$ is Firm A's wholesale market profit at current prices, $\Pi_0^D = (P_A - P_0)Q_A(P_0)$ is Firm A's retail market profit at current prices, and $\Pi_0 = \Pi_0^U + \Pi_0^D$ is Firm A's total profits at current prices.

Where a is the rate of price increase (accompanying SSNIP), Firm A's wholesale market and retail market profits are given as follows after the price:² First, Firm A's wholesale market profits after the price increase are given as follows:³

$$\begin{aligned}\Pi_1^U &= (P_0 - C)[Q_A(P_0) + Q_B(P_0)] + aP_0[Q_A(P_0) + Q_B(P_0)] \\ &\quad + (P_0 - C)[\eta_A a Q_A(P_0) + \eta_B a Q_B(P_0)] + aP_0[\eta_A a Q_A(P_0) + \eta_B a Q_B(P_0)]\end{aligned}$$

Next, Firm A's retail market profits after the price increase are given as follows:

$$\begin{aligned}\Pi_1^D &= (P_A - P_0)Q_A(P_0) + a(P_A - P_0)Q_A(P_0) \\ &\quad + (P_A - P_0)\eta_A a Q_A(P_0) + a(P_A - P_0)\eta_A a Q_A(P_0)\end{aligned}$$

$\Pi_1 = \Pi_1^U + \Pi_1^D$ represents Company's A's total profits after the price increase. Assuming that Firm A only provides wholesale services, Hausman, Leonard, and Velturo (1996) calculate Firm A's critical market share where profits from the firm's wholesale services before and after the price increase as follows:

$$\Pi_1^U \geq \Pi_0^U \Leftrightarrow \theta \geq \frac{1 + [(1 + a) - M^U]\eta_B}{[(1 + a) - M^U](\eta_B - \eta_A)}.$$

Next, taking the case of Firm A that provides both wholesale and retail services, the critical market share reflects retail service profits, and is modified as follows:⁴

$$\Pi_1 \geq \Pi_0 \Leftrightarrow \theta^* \geq \frac{1 + [(1 + a) - M^U]\eta_B}{[(1 + a) - M^U](\eta_B - \eta_A) - \left(\frac{1}{M^D} - 1\right)[1 + (1 + a)\eta_A]}.$$

Part I

Broadband economics basics and analytical tools

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2 Broadband in Japan: Current situation and issues

This chapter will provide an overview of the current state of broadband and competition policy in Japan, and highlight the primary factors contributing to Japan's ongoing success in implementing broadband. While referring here to Japan's broadband success, I would also caution that this has not brought prosperity to all sectors of the telecommunications industry. Indeed, the center of gravity of the industry is shifting away from fixed to mobile telephony while the underlying technology is moving away from the public switched telephone network (PSTN) to an Internet protocol-based network, and the telecommunications industry as a whole is actually contracting. This is an unavoidable phenomenon when migrating from an old network infrastructure to a new network infrastructure. While Japan is clearly in the lead now in migrating to fiber to the home (FTTH) services and third-generation (3G) mobile services, we must remain cautious in observing future trends to see if this progress can be turned into longer term sustained success. Yet for Japan's telecommunications industry to cease moving ahead at this point is most unlikely. Giving one pause is that at this stage Japan has both old and new networks, resulting in an industry structure that is inefficient and costly. This is a structural change that once embarked upon, must be followed through to the end. Paralleling the structural change of the industry, the government declared a paradigm shift in which competition policy is moving away from the competition creation and promotion stage to the competition maintenance and monitoring stage. In other words, an irreversible historical change has been set in motion. In this chapter, I address the question of why this historic transformation occurred in Japan, especially considering that Japan was assumed to lag behind the West in regulatory reforms. Here I will analyze Japan's success in implementing broadband in terms of four factors: unintended consequences of competition policies, the intended consequences of Japan's competition policies, the emergence of new common carriers with capability and drive, and NTT's grudging but unavoidable efforts to reduce its operating costs.

Current state of broadband in Japan

Let us begin in this section by examining the current penetration of broadband Internet access services in Japan. We will take a detailed look at each service later in the chapter, but first I would like to confirm where Japan's broadband fits into the larger international scheme of things.

I will start with some basic figures. Table 2.1 shows the market scale of Japan's telecommunications industry from 1998 until 2005. The surprising thing to note about these figures is that the scale of Japan's telecom industry reached a high point in 2001, then began to decline. Meanwhile, as I detail below, it was in 2002 that broadband really began to take off in Japan. So what happened during this brief interval where the telecom industry is stagnating on the one hand and broadband is showing such dramatic progress on the other hand? Briefly, the classic telecom industry was based on the plain old fixed telephone service over the PSTN. Users paid an installation fee when they signed up for phone service, then paid a monthly subscriber line charge plus a usage charge for each call they made.

But it is apparent from Table 2.2 that the fixed-line telephone market has been contracting now for some years. The number of fixed telephony subscribers (including Integrated Services Digital Network (ISDN)) has been declining since a peak of 63 million subscribers was reached in 1997. The number of calls made from fixed-line phones (including those made to mobile phones), besides, has fallen off precipitously since the peak of 97 billion calls recorded in 2000. Growth of the mobile phone market more than made up for the slumping fixed phone market, but now the mobile market has also leveled off. Meanwhile, the broadband market is growing explosively, yet so far has not done anything to make up for the slumping fixed telephone market. A key player in the recent broadband growth has been Softbank BB, but this firm has been so aggressive in slashing the price of its ADSL (asynchronous digital subscriber line) service that revenues have not increased even though they continue to sign up many new subscribers. Once we see a full-scale rollout of true broadband services over fiber lines extended all the way to residential subscribers' homes (FTTH), we can anticipate that IP telephone service with ensured quality equivalent to fixed-line service and featuring

Table 2.1 Telecommunications industry market revenues

	1998	1999	2000	2001	2002	2003	2004	2005
Type 1	138,482	153,929	162,187	176,086	143,876	145,856	—	—
Type 2	9,678	9,188	13,751	14,468	18,319	15,758	—	—
Total	148,169	163,117	175,938	190,554	162,195	161,614	145,767	149,573

Note: Figures in ¥100 million (end of fiscal year). Distinction between Type 1 and Type 2 business was discontinued in 2004.

Source: "Telecommunications Industry Survey," "Current State of the Telecommunications Industry," and other documents produced by the MIC.

Table 2.2 Change in the fixed telephony market

(a) Number of subscribers										
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Fixed telephony	60.3	61.6	62.6	62.9	62.6	62.2	62.0	61.3	60.8	60.2
Mobile telephony	4.3	11.7	26.9	38.3	47.3	56.9	66.8	74.8	81.1	86.7

Note: Figures in million (end of fiscal year). ISDN included in fixed telephony.

Source: Compiled by the author from MIC public documents.

(b) Numbers from types of calls

	1998	1999	2000	2001	2002	2003	2004	2005
Fixed to fixed	86.7	85.8	86.1	80.4	73.0	67.9	64.1	57.0
Fixed to mobile	10.5	10.5	11.2	10.2	9.7	9.5	9.0	6.0
Mobile to fixed	12.9	13.6	14.9	15.5	15.7	16.0	15.8	15.0
Mobile to mobile	17.0	24.5	32.5	32.4	34.0	36.5	37.6	37.9

Note: Figures in billion (end of fiscal year).

Source: MIC report "Japan's Communications in Terms of Traffic."

0ABJ number portability will begin to replace fixed-line telephone service. We summarize the main points as follows:

Current state of broadband in Japan

Although the growth of broadband has so far not resulted in any expansion of the telecommunications industry as a whole, it is apparent that broadband will eventually supercede fixed-line telephony. The *growth* of broadband will thus likely result in the *decline* of the telecommunications industry as a whole.

Growth of fixed-line broadband

In this subsection we will consider the growth of fixed-line broadband services in Japan. Table 2.3 shows the number of Japanese households using the Internet from 1999 to 2004. The figures reveal that narrowband services such as dial-up Internet and the ISDN had the largest share of the market by far through the year 2001. But starting in 2002, broadband Internet service began to grow very rapidly with broadband catching up and surpassing narrowband in 2004. The percentage of households in Japan connected to the Internet stands at around 75%, with users about equally divided between narrowband and broadband. It is highly likely that the remaining narrowband subscribers will switch over to broadband in the near future.

Now let us take a closer look at the different broadband services. Table 2.4(a) summarizes broadband subscription trends in Japan from 2001 to 2006. One can see from the figures that the growth of Japan's broadband over this period was largely supported by the expansion of ADSL. Initially more people signed up for cable Internet, but subsequent growth has been very modest. Note the contrast here with Europe and the US, where the role of CATV Internet has been much more significant in extending broadband. Most striking is the fact that FTTH took off in Japan for the first time anywhere. By the latter half of 2004, ADSL and FTTH were attracting practically the same number of net new subscribers—880,000 for ADSL versus

Table 2.3 Households using the Internet

	<i>Dec. 1999</i>	<i>Dec. 2000</i>	<i>Dec. 2001</i>	<i>Dec. 2002</i>	<i>Dec. 2003</i>	<i>Dec. 2004</i>
Narrowband	10.6	15.8	19.8	21.2	19.1	18.6
Broadband	0.1	0.6	1.3	7.8	13.6	18.6
Internet total	10.7	16.4	21.1	29.0	32.7	37.2

Note: Figures are million contracts.

Source: Compiled by the author from data published by the MIC.

820,000 for FTTH—and by the first half of 2005 the relationship between the two services had reversed with 1.01 million people signing up for FTTH and only 630,000 subscribing to ADSL. Table 2.4(b) shows the change in share of broadband subscriptions for the different services from 2001 to 2007. Two facts stand out during this timeframe. First, we observe that while CATV Internet had over 90% share of the market at the beginning of the period, its share had fallen to less than 15% after five years. Second, we see that ADSL, the service superseding CATV Internet, continued to grow until it peaked at 74% in September 2003, then began to fall off. Clearly the most likely winner by the end of the period is FTTH. The continuing growth of broadband from this point on will be manifested as growth of FTTH.¹ We summarize the main points as follows:

Growth of fixed-line broadband

After 2002, it was apparent that users were moving away from narrowband to broadband. And within broadband, there is a discernable trend of users moving first from CATV Internet to ADSL, then from ADSL to FTTH.

Comparison of broadband in Japan and other countries

We have observed how broadband evolved in Japan. Let us now in this subsection compare broadband in Japan with broadband in other industrial countries. Table 2.5 summarizes the number of broadband lines and household penetration rates for a number of advanced countries. One can see that Korea is far in the lead with a household penetration rate of 75.8%, followed by Japan with a penetration rate of 33.6%. One certainly does not get the impression from these figures that Japan is the decisive leader in broadband, and yet many industry experts do bestow this distinction on Japan. The reason is that only Japan is now moving ahead with actual deployment of FTTH. Fully exploiting the potential of FTTH could revolutionize the nature of public services such as telemedicine and electronic government, and open the way to new lifestyle choices through distance learning and telecommuting. Considering this potential, ADSL and CATV Internet can be regarded as no more than introductory level broadband services, while FTTH represents *true broadband*.

Table 2.6 shows a comparison of broadband rates per 100 Kbps for countries around the world compiled by the International Telecommunication Union (ITU). At the time these figures were compiled in December of 2005, Japan had the lowest rates at \$0.07 per 100 Kbps. Note however that these figures should be approached with caution for two reasons. First, the figures do not include FTTH. While this does not present a problem for countries

Table 2.4 Numbers of subscribers broken out by type of broadband service

	March 2001	Sept. 2001	March 2002	Sept. 2002	March 2003	Sept. 2003	March 2004	Sept. 2004	March 2005	Sept. 2005	March 2006	Sept. 2006	March 2007
(a) Subscribers for different broadband services													
CATV	0.8	1.2	1.5	1.8	2.1	2.3	2.6	2.8	3.0	3.1	3.3	3.5	3.6
ADSL	0.1	0.7	2.4	4.2	7.0	9.2	11.2	12.8	13.7	14.3	14.5	14.4	14.0
FTTH	0.0	0.0	0.1	0.2	0.4	0.9	1.5	2.0	2.9	4.0	5.4	7.2	8.8
Total	0.9	1.8	3.9	6.2	9.5	12.4	15.2	17.6	19.5	21.4	23.3	25.1	26.4
(b) Percentage share of subscribers for different broadband services													
CATV	90.6%	63.0%	37.3%	29.0%	21.8%	18.8%	16.9%	15.8%	15.2%	14.6%	14.2%	13.9%	13.6%
ADSL	8.2%	35.7%	60.9%	68.0%	73.8%	74.3%	73.5%	72.6%	70.2%	66.8%	62.3%	57.3%	53.0%
FTTH	1.2%	1.3%	1.8%	3.1%	4.4%	6.9%	9.5%	11.5%	14.6%	18.6%	23.4%	28.7%	33.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Figures are million lines.

Source: Compiled by the author from public MIC documents.

Table 2.5 Number of broadband lines and household penetration rates for the most advanced countries

	US	UK	France	Germany	Sweden	Korea	Japan
DSL	8.9	1.7	4.7	5.5	0.6	7.4	12.1
Cable	16.4	1.3	0.4	0.1	0.2	3.8	2.7
FTTH	—	—	—	—	—	—	1.8
Broadband	25.4	3.0	5.1	5.6	0.8	11.2	16.6
Broadband household penetration rate	23.4%	12.3%	20.9%	14.4%	17.6%	75.8%	33.6%
Date	Dec. 2003	Dec. 2003	June 2004	June 2004	June 2004	Jan. 2004	June 2004

Note: Figures are million lines.

Source: Compiled by InfoCom Research Inc. from public documents produced by the FCC (June 2004), OFTEL (Dec. 2003), Telecom Markets (Aug. 10, Sept. 7, and Oct. 5, 2004), and the MIC (June 2004).

Table 2.6 Comparison of world broadband rates per 100 Kbps

Japan	Korea	Holland	Iceland	Sweden	Singapore	Taiwan	Finland	France	US	Canada	Belgium	UK
\$0.07	\$0.08	\$0.14	\$0.20	\$0.23	\$0.24	\$0.34	\$0.36	\$0.36	\$0.49	\$1.01	\$1.21	\$1.35

Source: ITU Internet Reports 2006.

other than Japan, the figure for Japan cannot be reliable if FTTH is excluded. Second, it should be noted that ADSL is a best-effort service, and there can be an enormous difference between nominal throughput and actual throughput speed.² If true broadband FTTH were included in the figures, then Japan's lead would be even more striking. We summarize the main points as follows:

Comparison of broadband in Japan and other countries

In terms of broadband penetration, Japan is well behind Korea. But where Japan stands out from the crowd, and indeed is the only contender, is in its deployment of FTTH. If FTTH is taken into account, Japan's broadband is far faster and far cheaper than in any other country.

Growth of third-generation mobile telephony

In the previous subsection I described how Japan leads the world in fixed-line broadband, but if Japan's success was confined to just this one sector, one might assume it was just a matter of luck. But if it can be shown that Japan is ahead in mobile communications as well, then the country's broadband success would have to be based on something more substantial than mere luck. So in this subsection I will examine the current state of Japan's mobile communications services.

Table 2.7 shows the number of subscribers to Japan's mobile phone and Personal Handyphone System (PHS) services from 1989 to 2005. Mobile telephony really took off in Japan in the latter half of the 1990s, until a penetration rate of 70% was reached. However, these figures alone are not all that impressive compared with some other countries. For example, Table 2.8 shows the percentage ownership of mobile phones for a number of countries, and Japan ownership rate is not especially remarkable and trails behind several countries including Sweden and the UK. Table 2.9 shows the ranking of Japan's mobile phone rates among the 30 member nations of the Organization for Economic Cooperation and Development (OECD). While it is notoriously difficult to compare phone rates because they are affected by so many special conditions—ratio of prepaid to postpaid, flat-rate versus metered rate schemes, and so on—it will be apparent from just looking at the exchange rate levels, that Japan's mobile phone rates are in the higher priced category.

So from a quantitative standpoint, the performance of Japan's mobile telephony sector is not especially noteworthy. But viewed in terms of qualitative criteria, a different picture emerges. Looking back at Table 2.7, for example, it is apparent that Japan's mobile phones have evolved beyond plain old telephony features to a remarkable degree.

Table 2.7 Number of mobile telephony, PHS subscribers

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Mobile telephony	0.5	0.9	1.4	1.7	2.1	4.3	10.2	20.9	31.5	41.5	51.1	61.1	69.4	75.9	81.9	87.0	91.8	96.7
Segment—mobile Internet										0.1	20.0	34.6	51.9	62.5	69.8	75.1	79.8	84.4
Segment—mobile phones with built-in cameras													4.4	22.2	47.9	66.4	—	—
Segment—3G													0.1	7.2	16.7	30.4	48.3	69.9
PHS							1.5	6.0	6.7	5.8	5.7	5.8	5.7	5.5	5.1	4.5	4.7	5.0
Total	0.5	0.9	1.4	1.7	2.1	4.3	11.7	26.9	38.3	47.3	56.9	66.8	74.8	81.1	86.7	91.5	96.5	101.7

Note: Figures are million handsets (end of fiscal year).

Source: Compiled by the author from public MIC documents.

Table 2.8 Number of mobile phone subscribers and percent penetration of the population for key countries

	US	UK	France	Germany	Sweden	Korea	China	Japan
Number subscribers	213	68	49	78	10	39	411	93
Percent population	73.4%	111.7%	79.8%	94.8%	113.9%	81.5%	31.3%	72.9%

Note: Figures are million handsets.

Source: ITU Internet report 2006.

Table 2.9 Japan's mobile phone rate level among 30 member nations of the OECD

	<i>Low-use user</i>	<i>Average-use user</i>	<i>High-use user</i>
Exchange rate	1st place	5th place	9th place
Purchasing power parity	7th place	24th place	26th place

Source: OECD Whitepaper (2003).

- In 1999 NTT DoCoMo launched its i-mode service, and by 2005 some 86% of subscribers were using the browser phone service.
- In 2000 the J-phone with built-in camera was made available, and by 2005 some 76% of subscribers were using handsets with built-in cameras.
- In 2001 NTT DoCoMo launched its 3G mobile phone service supporting W-CDMA, and in 2002 au Corporation began offering CDMA 2000 service. By 2005 some 35% of mobile phone subscribers had signed up for the 3G service.

Figure 2.1 shows the number of subscribers to data services and subscriber rates for the main telecoms in a number of different countries. While Japan has an 80% browser phone subscription rate, no other country except for Korea has made any significant headway with this service. In regards to 3G mobile services as well, Japan, along with Korea, has a decisive lead. We summarize the main points as follows:

Growth of 3G mobile telephony

Japan's mobile phone performance is not especially noteworthy by international standards in terms of penetration or usage charges. But Japan leads the world in the usage of browser phone, 3G, and other advanced mobile phone services.

Competition policy paradigm shift

In this section I will consider the progress of the policy paradigm shift that has been implemented along with structural changes taking place in Japan's telecommunications industry. Telecommunications policy and the structure of the telecommunications industry are inextricably linked such that changes in policy cause the structure of the industry to change, and changes in the structure of the telecommunications industry likewise cause the telecommunications policy to change. Here I will examine competition policy from two perspectives.³

First, competition policies can be classified as policies designed to create and promote competition or as policies whose purpose is to maintain and

Figure 2.1 Percentage browser phone subscribers of main operators of select countries.

Note: Vertical axis on the left (bar graph) is the number of browser phone subscribers (1,000 subscribers). Vertical axis on the right (line graph) shows the percentage of mobile phone subscribers also subscribing to browser phone service. Figures are from the first quarter, 2004.

Source: Materials for the “2004 Telecommunications Industry Conference” held at Kyoto University Department of Economics, prepared by Keiko Yada, InfoCom Research, Inc.

monitor competition. Policies to create and promote competition are adopted to inject competition into areas newly liberalized or privatized, which formerly allowed monopolistic services by public corporations or enterprises. It is easy for incumbent companies to exploit their market dominance right after liberalization and privatization, so it is necessary to adopt *ex ante* regulations that restrain competition-limiting behavior by incumbents. Measures that are favorable to new entrants are also adopted until the new companies can get established and capture a reasonable share of the market. In other words, regulations that are *asymmetric* in terms of their treatment of incumbents and new entrants are imposed. Once liberalization and privatization have had time to take hold, then a different regulatory phase is entered with the adoption of policies to maintain and monitor competition. These policies ensure that competition continues to work effectively and restrain incumbents from leveraging market dominance. This stage is marked by a transition from *ex ante* regulations that are relaxed or rescinded to *ex post* regulations that clearly define competent authorities for settling disputes when problems arise and for drafting and revising competition rules.

Second, competition policies can be classified as structural measures or as behavioral measures. Structural measures are first adopted at the competition

creation and promotion stage. Liberalization and privatization involve great changes in the way that a firm operates, and in some cases, the firm is broken up by taking away some of the former monopoly's facilities or partitioning the former monopoly's services. The breakup of the US telecommunications company (telco) AT&T is a well-known case in point, but in Japan there was a prolonged national debate lasting 15 years over what form of firm NTT should be. And while the right to enter the telecom market was now recognized, the number of new entrants was restricted to avoid destructive competition, and restrictions were imposed on withdrawal from the market. Similarly, at the competition creation and promotion stage, restraints are imposed on incumbents in a number of ways: their freedom to set rates is regulated, they are forced to provide access to their facilities, and their ability to establish side businesses is restricted. Indeed, their operations are so closely regulated in so many ways that the competitive situation between operators is sometimes referred to as *managed competition*. Then in due course, as effective competition emerges and the incumbents' ability to exercise market dominance is restrained, emphasis shifts to establishing *autonomous competition* involving judicial decisions based on the Antitrust Law, setting up Dispute Settlement Commission, and conducting periodic competition reviews.

Table 2.10 shows a schematic summary of the points covered in this section. In historical sequence, first structural measures to create and promote competition are implemented (Domain I in the figure), followed by behavior measures (Domain II). At the stage where it is determined that these initial objectives have been achieved, a competition policy paradigm shift is declared and a transition is made to behavioral measures supporting policies to maintain and monitor competition (Domain IV).⁴ Note however that a complete shift is rare.⁵ First, in cases where effective competition in the final goods market is a consequence of a policy of open access to facilities in the intermediate goods market, regulation of the intermediate goods market must be retained, even if regulations in the final goods market are rescinded. Second, there is a huge disparity between promoting effective competition in urban areas and in rural areas, and special measures are always required to promote local development in rural areas. Third, when technical innovation is evolving very quickly, old and new technologies will typically coexist, so it is often the case that some *ex ante* regulations must be retained, even as new competition rules are developed to deal with new services.

So far I have been discussing competition policy, but in addition to competition policy that seeks to promote economic efficiency based on market principles, there is also industrial policy (including social policy) intended to promote security, fairness, and other social values besides efficiency. For example, some goals of industrial policy that relate to telecommunications policy include assuring universal service, alleviating the digital divide, technical standardization, promoting research and development, and ensuring data security. Between competition policy and industrial policy it is not possible to simply shift from one to the other. For competition policy, industrial

Table 2.10 Four stages of competition policy

	Structural measures	Behavioral measures
	I	II
Competition creation, promotion regs.		
• <i>Ex ante</i> regulations	• Deregulation, privatization	• Charges regs.
• Asymmetric regulations	• Breakup measures • Entrance, exit regs.	• Procedural regs. • Service regs.
	III	IV
Competition maintenance, monitoring regs.		
• <i>Ex post</i> regulations		• Anti-monopoly regs.
• Relax, rescind regulations		• Dispute resolution • Competition assessment

policy is an institutional given, but a total reevaluation of industrial policy may be critical to the success or failure of competition policy. In this sense, competition policy and industrial policy must mutually complement one another, but there is also a real danger that the two policy objectives may conflict with each other. We summarize the main points as follows:

Competition policy paradigm shift

As competition changes and evolves, competition policy undergoes two paradigm shifts that reflect those changes: first from policies to create and promote competition to policies to maintain and monitor competition, and second from structural measures to behavioral measures. Yet there are also issues that cannot be resolved through these simple shifts, such as the regulation of the intermediate goods market and compatibility between competition and industrial policies.

Competition policy in Japan's telecommunications industry sector

In this subsection I will review the current situation of competition policy in Japan's telecommunications sector. The pending question of whether NTT was to be broken up was finally resolved after 15 long years in July 1997 when it was decided that the firm would be restructured as a holding firm. At the same time, competition policy in Japan's telecommunications industry underwent a fundamental shift from *ex ante* regulation to *ex post* regulation and from regulations to create and promote competition to regulations designed to

maintain and monitor competition. The year 1997 also saw deregulation of the separation between domestic and international telecom markets, and elimination of rules regulating entering and exiting the industry to adjust supply and demand. Controls on foreign investment were also deregulated the next year in 1998. In 2001, Japan introduced the *My Line* system allowing users to preselect their preferred carrier, and by 2004 the paradigm shift in competition policy had been completed. Japan's Telecommunication Business Law also underwent a major revision. The regulatory distinction between network-owning and leasing carriers (Type 1 and Type 2 operators) was eliminated, telecom rates (excluding the dominant carriers) were deregulated, and periodic reviews to ensure continued effective competition were instituted. Closely coordinated with these developments, policy initiatives with public, private, and academic involvement were launched to promote smooth migration to broadband. In 2001, the Japanese government launched the e-Japan Strategy with the goal of putting in place an infrastructure that would make Japan the most advanced ICT (information and communications technology) nation in the world, and encouraged market competition based on a nongovernment initiative. Once the objectives of the e-Japan Strategy had been achieved, the government followed with e-Japan Strategy II in 2003 and u-Japan Strategy in 2005 promoting a ubiquitous networking society based on ICT.

Competition reviews of the telecommunications sector

The primary purpose of competition policy in the telecommunications sector is to create a level playing field and a competitive environment where market forces can operate fairly and effectively. To this end, the government in 2003 conducted the first of a series of competition reviews to objectively analyze and ascertain the current state of competition, so draft policies could be quickly and accurately prepared that reflected actual competitive conditions. Several econometric analyses in this book were done in cooperation with these competition reviews. In this subsection, I will comment on the competition reviews of Japan's telecommunications sector that began in 2003 against the backdrop of the policy paradigm shift that I described earlier (MIC 2003, 2004, 2005a, 2006a).

The primary objectives of the competition reviews are summarized as follows:

- Correctly apprehend the more complex state of competition with the transition to IP and broadband networks,
- Create shared perceptions regarding the state of competition,
- Promote consistency with international developments.

To briefly elaborate, the first objective of the competition reviews is to obtain a clear understanding of the current state of the more complex telecommunications sector in Japan. The sector has become more diversified and

competition more intense as new common carriers have entered the market and new services and business models have been introduced. The second objective is to reach agreement about the data and analytical methods used in the competition reviews, and improve transparency and predictability of government action. Lastly, the third objective is to keep abreast of competition review procedures that have already taken place in the UK and the EU to ensure that Japan's telecommunications policies are consistent with the international community.

The steps in actually implementing the competition reviews are summarized as follows:

- Determine the objects of analysis,
- Demarcate markets,
- Analyze and assess the state of competition.

The first step of a competition review is to identify the objects of analysis including fixed telephone services, mobile telephone services, leased lines, Internet access services, data communications, and so on. The second step is to specify the smallest unit service, then using that as a starting point, demarcate relevant markets while making comparisons with adjacent services. Finally, the third step is to quantitatively analyze market growth, the number of new common carriers, the degree of market concentration, market shares held by different operators, revenues and factors indicative of relations between dominant incumbents and nondominant carriers. In addition, a qualitative assessment is done of other factors affecting the relation between dominant incumbents and nondominant carriers.⁶

The competition reviews are thus able to determine first whether market dominance exists in a demarcated market, and second whether there is cause for concern about that market power being exercised. *Market dominance* in this context refers to the ability of a carrier to freely change the prices and/or quality of a good or service. In other words, if a nondominant carrier is able to compete against a dominant incumbent in a particular market, then *market dominance does not exist*. If it is found that market dominance does exist, this raises concern as to whether that market dominance is being exercised. If it is the case that *market dominance does exist* and there is concern that market dominance is being leveraged, then *market competition is insufficient*.

Effective competition thus refers to a state in which a carrier possessed of the means and capability to exercise market dominance nevertheless does not leverage that capability. Basically, what deters a carrier from exercising market dominance is the presence of determined competitors possessed with both the capability and drive. The competition reviews focus on the following three points in assessing the state of competition in a particular demarcated market:

- Does the ability to deter market dominance from being leveraged exist *in* the market (actual competitor analysis)?

- Does the ability to deter market dominance from being leveraged exist *outside* the market such as in adjacent markets (potential competitor analysis)?
- Are the policy measures in effect sufficient to deter market dominance from being leveraged (policy measure analysis)?

These periodic competition reviews are used to verify the effectiveness of policies to maintain and monitor competition, and if it is found necessary, a second or third round of policies will be enacted to create and promote greater competition. We summarize the main points as follows:

Competition reviews of the telecommunications sector

Competition reviews are periodically conducted to correctly apprehend the more complex state of competition with the transition to IP and broadband networks, and to ensure that the same perceptions are held by all the stakeholders. The competition reviews identify objects of analysis, demarcate markets, assess the state of competition, and determine whether market dominance exists and is being leveraged.

Correlation between competition reviews and competition/industrial policies

Here I will address a number of points regarding how the competition reviews are reflected in actual policies. In terms of the way these competition reviews are used, there are two approaches: *direct use* where analytical results are immediately reflected in competition policy, and *indirect use* where the analytical results and competition policy are not directly connected. The approach used by the UK's Office of Telecommunications (OFTEL) approaches the former, while that of the Japan's Ministry of Internal Affairs and Communications (MIC) is closer to the latter. The former approach enables competition policy to be administered more consistently and coherently. The problem with the second approach is that there is a time lag between the review and the measure that is implemented, and this leaves room for all sorts of social and political factors to intervene in the policy. It would therefore be preferable, if the current system and level of technology are regarded as more or less fixed, to adopt a more tightly integrated approach between the competition reviews and policy measures. In addition, the competition reviews should not only analyze leveraging of current market dominance but also past competition policies, because they can have many indirect effects. The points made in this section are summarized in Table 2.11.

There is a correlation between the competition reviews on the one hand and competition and industrial policies on the other. The objectives of the

Table 2.11 Correlation between effective competition and policy measures

Policies to create and promote competition	Without measures	Leveraging market dominance	
		Effective restraint	
		No effective restraint	
	With measures	I Competition functions effectively	II Competition insufficient
		III Competition functions effectively Policy effects sufficient	IV Competition insufficient Policy effects insufficient

Source: Compiled by the author from MIC 2004 report, Figure 3-1-3, p. 121.

competition reviews are not only to illuminate the current state of competition but also to review the effects of past competition policies. At the same time, the pace of technological innovation is so rapid in the telecommunications sector that competition policies must be drafted while looking ahead and anticipating the future structure of the industry. Therefore, in addition to reviewing past policies, it is also necessary to forecast future industry structure and preview the structure that is likely to emerge in the years ahead.⁷ In this sense, the competition reviews provide a forum for discussing what future competition policies should be, and play a role in projecting future competition policy related issues on the present. Furthermore, the consequence of past and future competition policies are intertwined in complex ways with other social values—universal service, safety and security, and so on—to sum up, the competition reviews are also related to industrial policy. The points made in this section are summarized in Table 2.12. The competition reviews, competition policies, and industrial policies are thus mutually complementary and should be pursued as three aspects of telecommunications policy. We summarize the main points as follows:

Correlation between competition reviews and competition/ industrial policies

The competition reviews can be either directly connected or not directly connected to competition policies. The UK adopts the former approach, while Japan is closer to the latter. The competition reviews are also correlated with industrial policy. Indeed, all three aspects—competition reviews, competition policy, and industrial policy—should be organically interconnected.

Table 2.12 Competition review and competition and technology policies

(Example) <ul style="list-style-type: none">• Universal service• Protects users• Network security	Concerns of industrial policy
(Example) <ul style="list-style-type: none">• Correlation coefficient with adjacent markets Prospects for competition in market (preview)	Concerns of competition policy = object of analysis
(Example) State of competition in demarcated market (review)	State of market competition = object of review

Source: Compiled by the author from MIC 2004 report, Figure 3-1-5, p. 131.

Why Japan's broadband deployment succeeded

In the 1990s it was generally held that Japan's telecommunications industry lagged at least ten years behind the West. Yet suddenly it seemed, beginning about 2002, that we saw a remarkable development of broadband in Japan that attracted worldwide attention. To many foreign observers, this apparent reversal was a *puzzle* (Fransman, 2006). In this section I will unravel this conundrum by analyzing Japan's successful implementation of broadband in terms of four factors (Ida 2006a, b):

- Unintended consequences of competition policies,
- Intended consequences of competition policies,
- Emergence of new common carriers with capability and drive,
- NTT's grudging but serious efforts to reduce operating costs.

Unintended consequences of competition policies

One unintended consequence of Japan's competition policies that nevertheless contributed to the successful deployment of broadband in Japan was the fact that, unlike AT&T in the US, NTT was never broken up. The eventual decision to not partition NTT turned out to be beneficial for the subsequent nationwide deployment of optical fiber. Key dates in the NTT breakup controversy are summarized as follows:

- 1982: Second Provisional Council on Administrative Reform (Rincho) proposes that Nippon Telegraph and Telephone Public Corporation be broken up.
- 1985: Nippon Telegraph and Telephone Public Corporation is privatized, and question of whether to break up NTT to be reconsidered five years later.
- 1990: MPT Telecommunications Council again calls for NTT to be broken up.
- 1991: Government puts off the breakup decision for another five years.
- 1996: MPT Telecommunications Council issues final report on the NTT breakup issue.⁸

After this 15-year-long tug-of-war between the former Ministry of Posts and Telecommunications (MPT) and NTT, finally in December 1996 the two parties reached an agreement based on the following terms:⁹

- NTT would be reorganized into a holding firm, two regional service providers covering eastern Japan and western Japan, and a long-distance provider.
- NTT would be allowed to enter into the international telecommunications market through a subsidiary.

Certainly one factor behind this compromise solution was the intent of then Prime Minister, Ryutaro Hashimoto, for Japan to have a powerful flagship carrier. Critically important in this context was the positive effect that the breakup controversy had on NTT's commitment to invest the hundreds of billions of yen a year needed to support a nationwide deployment of optical fiber. Essentially launched as a counterproposal to the MPT's breakup plan, NTT announced its VI&P vision for communications that are more Visual, Intelligent, and Personal in 1990, and committed the firm to upgrade the entire national telecom infrastructure to optical fiber by the year 2015. Some have speculated that the US Vice President Al Gore's *Information Superhighway* initiative was patterned after NTT's VI&P Vision. In response to the American initiative, the Japanese government did an abrupt about-face. The government established the Advanced Information and Telecommunications Society Promotion Headquarters in 1995 and announced that its goal too was to upgrade the nationwide infrastructure to optical fiber by the year 2010. The fact that the plan for nationwide deployment of fiber originated from the private carrier NTT and not from the government MPT, right in the middle of the breakup debate, is significant.

Beginning in the 1990s, NTT East and West have continued to invest more than ¥200 billion annually in the deployment of optical fiber infrastructure, an investment flow that continued after NTT was reorganized. Table 2.13 shows the percentage of optical fiber coverage within the respective territories of NTT East and West from 1999 to 2004. One can see that more than 90% of the access networks in cities and more than 80% of access networks in their territories as a whole have now been converted to fiber for both NTT East and West. NTT thus now stands on the brink of achieving its objective of extending fiber as far as the remote terminal (RT) nationwide. Japan's current near nationwide deployment of fiber infrastructure, which is unprecedented worldwide, was essentially a by-product of the long controversy over whether NTT should be broken up. Ironically, in the end the firm was not broken up, but it was the fear of being partitioned that pushed NTT to take on the enormous risk and enormous investment in optical fiber deployment. We summarize the main points as follows:

Unintended consequences of competition policies

The first factor in Japan's successful deployment of broadband came as an unintended by-product of competition policies and the 15-year-long controversy over whether NTT should be broken up. This led NTT to commit itself early on to a large-scale ongoing investment to achieve nationwide deployment of optical fiber.

Table 2.13 Percent fiber deployment in NTT East and West access networks

	1999	2000	2001	2002	2003	2004
(a) NTT East						
Urban areas	60%	65%	84%	82%	95%	98%
Regional cities	36%	43%	62%	78%	86%	88%
Other	19%	29%	41%	49%	55%	57%
Total	41%	48%	66%	76%	81%	83%
(b) NTT West						
Urban areas	50%	56%	68%	84%	92%	93%
Regional cities	25%	37%	43%	66%	86%	89%
Other	19%	17%	36%	50%	63%	64%
Total	29%	37%	50%	67%	80%	81%

Note: Figures are percentage of fiber deployment to the remote terminal (RT).

Source: Figures compiled by the author from public data disclosed by NTT.

Intended consequences of competition policies

One factor in Japan's successful implementation of broadband that was intended by Japan's competition policies resulted from the government's insistence on extensive open access to NTT's local exchange networks. Many new common carriers were encouraged to enter the market by asymmetric regulations that, while one-sided in their impact on NTT, greatly benefited society as a whole by opening up access to NTT's networks. Key dates in Japan's open access policy are summarized as follows:

- 1987: No interconnection charge system exists; rather, long-distance new common carriers pay local call charges to NTT according to an additional charge scheme
- 1994: Interoperator interconnection charge system is introduced, and public network interconnection charges are calculated based on historical costs
- 1999: Introduction of copper and line-sharing
- 2000: Public network interconnection charges based on long-run incremental costs. Introduction of dark fiber
- 2001: Unbundling of local IP networks

Opening access to line-sharing in 1999 and to dark fiber in 2000 were especially important in fostering the startup and growth of broadband in Japan. This policy of extensive open access made it possible for the new common carriers to offer ADSL and FTTH services without having to own the infrastructure in advance. Japan's broadband thus derived from service-based competition.

While the former MPT was unable to achieve the breakup of NTT, the ministry did impose extensive local loop unbundling (LLU) on NTT with the result that Japan has more open access to its local exchange networks than any other country in the world. Especially noteworthy are the low charges for line-sharing and dark fiber. Initially, NTT calculated its line-sharing costs at ¥400, but eventually provided access at a cost of ¥187. For dark fiber, NTT originally insisted that it needed ¥20,000 for subscriber dark fiber access, but eventually came down to ¥5,231. While this local loop unbundling policy forces NTT to provide open access to its facilities at well below cost, it has enabled new entrants to offer a diverse range of services over the most advanced infrastructure in the world. What enables NTT to sustain these onerous open-access policies is the NTT Group's enormous capital resources. Had NTT been broken up, it is most unlikely that the industry would now be in a position to support such a degree of open access to its local exchange networks:

Intended consequences of competition policies

The second factor in the successful deployment of broadband in Japan were policies of extensive open access to local exchange networks made possible by the NTT Group's enormous capital resources. These policies opened the way to service-based competition from new entrants to the telecom market.

Emergence of new common carriers with capability and drive

A key to understanding the rapid growth of broadband in Japan is the emergence of new common carriers with both the capability and the drive to succeed in the market. Here I will focus on two carriers in particular that have emerged as price leaders in their respective markets: Softbank BB Corporation with its ADSL services and Kansai Electric Power's K-Opticom Corporation in the FTTH market. Even NTT East and West have been hard-pressed to keep pace with these two new dynamos.

ADSL service has been available in Japan since 1999, but initially saw little popular acceptance because it was relatively expensive and the service area was not very extensive. The rapid spread of ADSL in Japan came after 2001 when Softbank BB entered the market with a service priced at ¥2,280 a month (including the ISP charges), about half the price of NTT's comparable service. Softbank started as a computer software firm established in 1981 by Masayoshi Son. Milestones in the firm's history are summarized as follows:

1981: Masayoshi Son establishes Nihon Softbank Corp

1996: Invests in Yahoo and becomes largest shareholder

- 1998: Listed in first section of the Tokyo Stock Exchange. Adopts holding Firm organization
- 2001: Launches Yahoo! BB 8M ADSL service
- 2002: Launches Yahoo! BB 12M service, surpasses one million subscribers
- 2003: Launches Yahoo!BB 26M, surpasses three million subscribers. Begins IP telephone service
- 2004: Launches Yahoo! BB 45M service, surpasses four million subscribers. Begins 3G mobile phone trials
- 2006: Acquires Vodaphone

Softbank launched a number of different ventures in communication and broadcasting in cooperation with Microsoft, Sony, Tokyo Electric Power Firm, and others, but success was elusive. After a grueling string of failures and near misses, it finally hit upon ADSL. Even though Softbank had finally found the niche that would make the business successful, it took a long time before Softbank could turn ADSL into a profitable business. Softbank initially hoped that they could turn a corner and be operating in the black by the time they had signed up one million subscribers, but the firm was still showing a loss of over ¥80 billion in 2003 with more than three million subscribers. Profitability improved for the firm's broadband operations after 2005, but it is highly likely that eventually the ADSL market upon which Softbank relies will be superseded by the FTTH market.

After venturing into the ADSL market, it took a long time before Softbank saw a profit, but if it were not for Softbank's sudden and unexpected entry, it is exceedingly unlikely that Japan's broadband market would have taken off as quickly as it did. NTT East and West had little choice but to follow Softbank's aggressive price-slashing, and as a result Japan became the broadband power that it is today with the fastest, least costly broadband in the world. And note that the beneficiaries of Japan's ADSL market are not the carriers but the consumers.

If Softbank can be credited with launching Japan's ADSL market, then K-Opticom can similarly be recognized for launching the FTTH market. K-Opticom is well positioned to challenge the NTT Group, considering that its parent firm is Kansai Electric Power Firm, as big a name as NTT West in that part of the country, and not in any way dependent on NTT's optical fiber network.¹⁰ Milestones in the firm's history are summarized as follows:

- 1988: Firm established under the name Kansai Communications Equipment Services
- 2000: Changed name to K-Opticom, and authorized to operate as Type 1 telecommunications business
- 2002: Launches a mega-fiber FTTH service
- 2004: Slashes rates for its FTTH service, and launches optical IP phone service

K-Opticom took over Kansai Electric Power Firm's telecom network and also initially made good use of the parent firm's conduit and utility poles, which are instrumental in deploying optical fiber. K-Opticom was thus able to offer FTTH with 70% coverage of households in its territory at the remarkably low price of ¥6,000 (IPS charges included) a month. Note that in practical terms, it is only the power companies that are able to compete with NTT, based on their own fiber network facilities. Furthermore, the power companies are under no obligation to provide the same kind of open access to their optical fiber networks that NTT East and West are obliged to do, and this certainly gives the power companies greater flexibility. In 2004, K-Opticom slashed their prices by 20%, and introduced a *triple-play* package of services including high-speed Internet, IP telephone with 0ABJ number portability, and broadcasting. Anticipating the full-scale rollout of FTTH that is just ahead, there can be no doubt that K-Opticom will emerge as NTT's most formidable rival when that day comes:

Emergence of new common carriers with capability and drive

The third factor in Japan's successful deployment of broadband was the emergence of new common carriers with both the capability and the drive to succeed in the marketplace. There is no question that the successful launch of ADSL and FTTH services in Japan can be attributed to the reasonably priced, attractive services made available by Softbank in the case of ADSL and by K-Opticom in the case of FTTH.

NTT's grudging but serious efforts to reduce operating costs

After NTT Public Corporation was privatized, NTT became embroiled in the breakup controversy with the former MPT, and faced one of the most challenging periods in the firm's history. If we compare NTT when it was privatized in 1985 and when the firm was reorganized in 1999, we can see that it went through a remarkable transformation. NTT's workforce was slashed by more than half (175,400) from 313,600 to 138,200 employees.¹¹ The number of branch offices and retail outlets was also dramatically scaled back with the number of branch offices cut from 70 to 11, and the number of retail stores reduced from 1,700 to 47. During this same period, the number of NTT subscribers increased from 45.30 million to 58.47 million,¹² and rates for a three-minute call between Tokyo and Osaka during daytime hours was pared from ¥400 to ¥90. NTT's intent behind these assiduous cost-cutting initiatives was to get the MPT to back off and modify its position that NTT should be broken up and to respond to complaints from the new common carriers about NTT monopoly power. Regardless of the firm's motives, however,

NTT should be commended for its thoroughgoing streamlining and efforts to reduce operating costs after privatization.

Following the reorganization in 1999, NTT East and West's financial situation abruptly worsened due to structural changes in the industry with the transition from voice and fixed telephony to IP and mobile telephony and the introduction of the long-run incremental costs based model. It was clear that, without even more radical cost-cutting, NTT East and West simply would not be able to survive the competition. This led NTT East and West to implement the following structural reforms in 2002:

- NTT reassigned 100,000 employees (including 60,000 from NTT East and West) to outsourcing companies, thus cutting 15–30% of these employees salaries. The firm also accepted early voluntary retirement from a total of 16,400 employees. As a result of these measures, personnel costs were reduced by a total of ¥100 billion.
- Investment in plant and equipment and other miscellaneous expenditures were further reduced. This resulted in cost reductions totaling ¥150 billion.

While corporate streamlining before NTT's reorganization was motivated primarily by outside pressure, structural reforms after the reorganization were driven more by internal pressures just in order for the firm to survive. Table 2.14 summarizes financial data for NTT East and West in the years after reorganization.

One can see that NTT East and West's sales have steadily fallen after reorganization. This can be attributed in large part to the decline in revenues from voice telephone service. Business performance for NTT East and West barely managed to recover after the structural reforms in 2002, but whether this recovery can be sustained is uncertain. As IP telephone service over

Table 2.14 Financial performance of NTT East and West

	2001	2002	2003	2004	2005	2006
(a) NTT East						
Revenues	2,573.6	2,352.2	2,267.1	2,180.9	2,125.3	2,057.0
Operating profits	4.5	48.3	86.4	87.7	65.9	65.0
Recurring profits	7.5	63.3	97.8	97.6	84.2	80.0
(b) NTT West						
Revenues	2,406.7	2,215.0	2,166.8	2,098.0	2,029.6	1,974.0
Operating profits	-166.7	42.6	86.6	70.1	32.0	22.0
Recurring profits	-170.4	44.9	9.0	80.0	56.5	30.0

Note: Figures are ¥ billion.

Source: Figures compiled by the author from public data disclosed by NTT.

fiber lines with 0ABJ number portability becomes more generally available, many subscribers will drop their fixed telephone service altogether, and NTT East and West will lose what has always been their primary source of revenue—basic monthly telephone charges. It was amid these gloomy prospects that the NTT holding firm unveiled its Mid-Term Management Strategy in November 2004, declaring its intent to move aggressively away from PSTN-provided services to broadband. The plan calls for:

- Stepping up deployment of high-speed broadband services and migrating 30 million users to FTTH service by the year 2010,
- Working out a detailed plan by 2010 for migrating the nationwide PSTN to an optical IP network.

NTT's biggest corporate challenge in the past was its excessive workforce. The challenge facing the firm now and for some years to come is NTT's capital infrastructure: decommissioning the PSTN and upgrading the nationwide network to optical IP. As the incumbents, NTT East and West are also obligated to provide universal service and extensive open access to its optical fiber network. NTT's corporate responsibilities are heavy indeed. Yet it is also safe to say that, regardless of the diversity of new common carriers that come on the scene, at this point in time only NTT has the wherewithal to provide FTTH services on a nationwide scale. At present, as in the past and through good times and bad, NTT will continue to play the leading role in Japan's telecommunications industry.

NTT's grudging but serious efforts to reduce operating costs

The fourth and most significant factor in the successful deployment of broadband in Japan was NTT's grudging but serious efforts to reduce the running costs of the firm. While NTT made remarkable progress in reducing its operating costs after the firm was privatized, NTT must undergo even further restructuring as the industry continues to evolve from a PSTN to an IP-based network.

Conclusions

The principal conclusions of this chapter can be summarized as follows. Japan's fixed telephony market has been contracting since 2001, while the country's broadband market has been expanding since 2002. The fundamental question is whether the expansion of broadband will be sufficient to cover the contraction of fixed-line telephony. In Japan's broadband, CATV Internet played a key role at first, but penetration of ADSL assumed the leading role in the rapid growth of broadband, which followed. But by 2005,

FTTH exceeded ADSL in net number of new lines deployed, and future growth of broadband will be sustained by FTTH.

Japan's success in implementing broadband can be attributed to four factors. First were the unintended consequences of Japan's competition policies, most notably NTT's commitment to deploy a nationwide optical fiber network in response to the MPT's plan to break NTT up. The second factor in Japan's successful migration to broadband was the intended consequences of competition policy. Though unsuccessful in achieving the breakup of NTT, the former MPT implemented a policy of extensive open access to NTT's local exchange networks and optical fiber networks, and this policy has proven very effective. The third factor was the timely emergence of new common carriers with capability and drive that are able to challenge NTT's dominance. Most notably, Softbank BB in ADSL and K-Opticom in FTTH have seized leadership positions in their respective areas, both in terms of price and service. The fourth factor in Japan's successful deployment of broadband was NTT's grudging, but serious efforts to reduce running costs that contributed to the emergence of a broadband market in Japan that is both efficient and fair.

In this chapter I have given a summary overview of the current state of broadband in Japan. In the remainder of the book, I will examine the past, present, and future of broadband using data analysis and econometric analysis.

3 Network economics: Theory and policy

This chapter will provide a critical evaluation of the extensive literature on the economic features of networks (Ida, 2004). As a result of rapid innovation, network industries such as telecommunications, electric power, city gas, and railway, have played an important role in determining a country's economic growth. The US and the UK have rapidly furthered regulatory reforms in these industries, whereas the pace of Japan's reform, which used to be quite slow, has finally overtaken other countries. We can summarize the regulatory reforms of Japan's network industries as follows:

- The telecommunications industry: The Nippon Telegraph and Telephone Public Corporation was privatized as the Nippon Telegraph and Telephone Corporation (NTT) in 1985, and New Common Carrier (NCC) has also commenced business since 1987. NCC has steadily improved its share of the long-distance toll market, and this figure has reached more than 50%. NTT was reorganized as one long-distance telephone company and two regional telephone companies under a holding company system in 1999, and fair competition in this industry has significantly progressed.
- The electric power industry: This industry had been regionally monopolized, and the first regulatory reform was introduced in 1995, when a yardstick assessment of the operating costs was imposed on nine incumbent power companies, and regulation of entry to the market of power generation was abolished. Furthermore, a second round of regulatory reform was implemented in 2000, when about 30% of the retail market was liberalized. Further expansion of this liberalization policy is now being discussed.
- The passenger transport industry: The Japan National Railway was privatized in 1987, when six passenger and one freight Japan Railway (JR) companies were established. The running of the business has stayed on track since privatization. Turning to the air transport industry, regulation of entry (a double-tracking/ triple-tracking system) was abolished in 1992, and price regulation was also relaxed significantly.

Interestingly, several attempts have been made to grasp the economic effects of the regulatory reforms in Japan's network industries. The annual increases in total factor productivity (TFP) caused by the regulatory reforms amount to 3.4% in the telecommunications and 1.1% in the air transport business. In addition, the annual increases in labor productivity are 1.2% in the electric power industry and 2.4% in the city gas industry (the Cabinet Office, 2001a). Turning to the consumer benefits brought about by the regulatory reforms, official figures until 2000 show that the benefits reached 4.1% of GDP (15.7 trillion yen), and even the figure that was calculated only in 2000 was 0.19% of the GDP (1.4 trillion yen) (Cabinet Office, 2001b).

Why are special considerations necessary for regulatory reforms in network industries? This question is to be studied from two points of view.

The first point is what is called a *bottleneck monopoly*. Network infrastructures, such as local telecommunications loops, power transmission lines, gas pipelines, and railroads, are essential for supplying services to customers in these industries. Therefore, in the past a firm could not enter into a market without holding enormous network facilities. However, it is currently becoming possible to enter into some areas of network industries, such as the long-distance toll market, power generation, and refining of natural gas. Accordingly, the regulatory reforms to open up bottlenecked facilities to all competitive providers have certainly become important matters of policy.

The second point addresses *network externalities*. Network externalities, which means that users of a service benefit when more people use it, frequently exist in network industries. To take an example from telecommunications, since the aim of a user is not to join a network but to communicate with more people in the network, it is advantageous for him/her to choose a larger-scale network. Thus, it is desirable that networks are interconnected and a network of networks is formed so that network externalities work effectively and efficiently. It is a matter of policy, therefore, to investigate the conditions under which the network autonomously expands.

Bottleneck monopolies represent economies of scale on the supply side, whereas network externalities do so on the demand side. It is important to note that some positive feedback may occur under a system with economies of scale; in this way, an inferior technology might spread, or remain for a long period, causing a social inefficiency. Moreover, since the system is nonlinear, it is very difficult to predict precisely what results an industrial policy will bring about. To sum up, network industries are very complex. This paper will also examine these characteristics of network industries.

From regulation to competition

This section provides an outline of the regulation and competition in network industries.

Public utilities regulation

There are two types of *direct regulation*, which means that the government legally restricts the structure of a market and the behaviors of private enterprises: *economic regulation*, which aims to avoid allocative inefficiencies, and *social regulation*, which aims to secure the safety, health, and environment of citizens. A *natural monopoly*, as well as *asymmetric information*, provides a ground for economic regulation. Naturally, monopolistic industries are represented in public utilities such as telecommunications, electric power, city gas, and railroad industries, which require enormous amounts of fixed capital and are necessities in our lives.¹ *Public utilities law* gives the government the legal authority to restrict the entry and exit of a firm in order to avoid destructive competition and determines the price and investment needed for improving allocative efficiencies.

Theoretically, the government can solve the market failures of a natural monopoly by implementing public utilities regulations, attaining the socially desirable level of economic welfare. However, several types of government failure have been pointed out in various studies. The first type is *X inefficiency* (Leibenstein, 1950), which is the difference between the efficient behavior of a firm assumed by economic theory and the observed behavior in practice when the cost is promised to be reimbursed by the government. The second is *Averch-Johnson effect* (Averch and Johnson, 1962), which insists that since the allowed profit is predicated on the rate base, the firm has an incentive to augment its capital stock. The third is *rent seeking* (Posner, 1975), which represents the expenditure of resources in order to bring about an uncompensated transfer of services from another person to one's self as the result of a favorable decision on some public policy. We summarize the main points as follows.

Public utilities regulation

Public utilities regulation is necessary because of market failures including natural monopoly. However, we cannot ignore government failures and need to take into consideration both failures.

Contestable market theory

The contestable market theory was developed by Baumol and his colleagues in the 1970s to investigate sustainable industrial structure, the characteristics of the multi-goods cost function, and the definition of cross-subsidization, among others. Baumol, Panzar and Willig (1982) compiled all related works into one book. Along with criticism of the government failures in those days, this theory is said to have provided the theoretical grounds for deregulation. One major point of the contestable market theory can be summarized as follows:

- Contestability theorem: If a market is contestable, socially desirable welfare can be automatically attained as a result of the potential pressure of a new entrant, even in a traditionally regulated industry; consequently, no public utilities regulation is necessary.²

The contestable market theory was considered as a benchmark model for deregulating public utilities. A representative opinion can be seen in the following quotation:

The Contestability benchmark proves highly useful as a framework for evaluating policies and outcomes. Under the contestability framework, entry and price regulation is deemed inappropriate in industries which do not have system-wide natural monopoly characteristics. On this criterion, brokerage, airline, trucking, long-distance telephone and terminal equipment should not be regulated (Bailey, 1986, p. 1).

Nevertheless, the influence of the contestable market theory in the academic world did not last long, because it countered various criticisms from conceptual, theoretical, and empirical points of view. Typical criticisms are as follows:

- Conceptual criticisms: A contestable market does not always have a sustainable equilibrium (Vickers and Yarrow, 1988); the concept of contestability does not accurately reflect the presumed *ultra free-entry conditions* (Shepherd, 1984, 1995); it also contradicts the economies of scale (Weitzman, 1983).
- Theoretical criticisms: The contestability theorem is not robust in an imperfect contestable market where the assumptions of the reaction lag of an incumbent firm and zero sunk cost are partially satisfied (Schwartz and Reynolds, 1983; Schwartz, 1986). Baumol et al. at last accepted these criticisms (Baumol, Panzar and Willig, 1983).
- Empirical criticisms: Passenger fares are positively correlated with market share (Keeler and Abrahams, 1981; Graham, Kaplan and Sibley, 1983; Bailey, Graham and Kaplan, 1985; Call and Keeler, 1985; Town and Milliman, 1989); passenger fares also depend upon whether a competitor actually exists (Moore, 1986; Morrison and Winston, 1987; Baker and Pratte, 1989). The above observations show that the assumptions necessary for the contestability theorem are not satisfied.

We summarize the main points as follows:

Contestable market theory

Even in a naturally monopolistic industry, public utilities regulation is unnecessary if the market is contestable. However, the perfect

contestable market seldom exist, therefore the theory does not widely hold.

Incentive regulation

A simple deregulation theory based on the contestability theorem had lost the support since the 1980s. Instead, a regulatory reform movement that synthesizes the market failures and the government failures became popular in the 1990s. One representative example of regulatory reforms is *incentive regulation*, which means that the government should delegate a firm the authority to determine public charges to some extent so that a desirable economic performance is to be achieved (Sappington and Weisman, 1996). There are several types of incentive regulation, outlined as follows:

- Profit sharing regulation: A firm is permitted to obtain a part of the excess profit when it earns more than a fair rate of return; thus, this firm will have the incentive to improve its management efficiency.³ Given that Π is the gained profit, Π_0 is a benchmark profit, Π_a is the realized profit, and a is a distribution weight, we obtain $\Pi = \Pi_0 + a(\Pi_a - \Pi_0) = (1-a)\Pi_0 + a\Pi_a$.⁴
- Price cap regulation: The government sets a ceiling on the average price that can be charged by a firm, but the firm can rebalance freely the prices within this constraint.⁵ Given that P_t represents the average price at period t , RPI is the rate of the price index, X is the rate of rise of productive efficiency, and Z is the adjustment rate of other factors, we obtain $P_t = P_{t-1}(1 + RPI - X + Z)$.⁶
- Yardstick regulation: Economic performances of regional monopolies are compared with each other, so that an indirect competition works.⁷ Japan's private railway and city bus industries have adopted standard cost comparisons, which are examples of yardstick regulation.
- Franchise bidding: A business license is put up for auction.⁸ A famous example in the world is the third-generation (3G) mobile phone airwave auction.
- Bayesian mechanism design: The government offers a self-selecting contract to a firm to solve the asymmetric information problem.⁹

Incentive regulation has played an important role in present regulatory reforms. There have been some attempts to measure the economic effects of incentive regulation,¹⁰ although it is still difficult to determine whether incentive regulation certainly guarantees the success of the restructuring of network industries. The first reason for this is that incentive regulations described above have their own respective faults, such as the difficulty in determining the X-term in price cap regulation or the ambiguity of subjective

probability under the Bayesian mechanism. The second reason is, more importantly, that the previous research on incentive regulation has not fully investigated the inherent characteristics of the network industries on both the supply and demand sides: bottleneck monopolies and network externalities. We summarize the main points as follows.

Incentive regulation

Incentive regulation is a method in which the government should delegate a firm the authority to some extent so that a desirable economic performance is to be achieved. Such methods as price cap regulation have been advocated, but each has advantages and disadvantages.

Bottleneck monopoly

This section previews the characteristics of the supply side of network industries, namely the bottleneck monopoly, and proposes a model to address this problem.

Preview of bottleneck monopoly

One major problem of liberalization or deregulation in network industries, such as telecommunications, electricity, city gas and railroad, is that competition does not work effectively because the network facilities have the characteristics of a bottleneck or *essential facilities*. The essential facilities doctrine originated in commentary on U.S. antitrust law (cf the Supreme Court 1912 *Terminal Railroads* decision) and has featured prominently in a number of decisions made by competition authorities around the world (Sidak and Spulber, 1998). There are two types of open-access policies for essential facilities:

- Behavioral regulation: The government determines or intervenes in the various decisions of a bottleneck monopoly, including entry, exit, price, investment, side-business, and even technical standards. An example is *asymmetric regulation*: only the dominant firm whose market share is sufficiently high is asymmetrically regulated.
- Structural regulation: The government stipulates specific terms for a firm to enter and exit a market, and designs the market structure itself. Examples are the divestiture of the US telecommunications industry or the unbundling of the U.K. electric power industry.

It is difficult to determine which is more desirable in general—behavioral regulation or structural regulation. To put it another way, if we can set an

access charge adequately, which is the wholesale price to be paid to a bottleneck monopoly for an interconnection, behavioral regulation is satisfactory enough and structural regulation is not necessary; and vice versa.

At this point, we suppose a bottleneck monopoly, X , which has the long-distance telecommunications network and the local loop, and an entrant, N , which has only the long-distance telecommunications network. Since X has both networks, it can supply an end-to-end service to consumers by itself. On the other hand, N cannot provide an end-to-end service without accessing the local network owned by X . The key question is how much N should pay X for accessing the network. There are two basic rules that address the access charge problem:

- Incremental cost rule: The access charge should be set based on the average cost that arises as a result of the interconnection of N to the network of X .
- Stand-alone cost rule: The access charge should be set based on the average cost that arises when N produces solely the set of services.

It is said that the incremental cost is the lower limit of the access charge because the new entrant does not pay the common cost between the long-distance network and the local loop at all. On the other hand, the stand-alone cost is the upper limit of the access charge because the new entrant has to pay the total common cost.

As a matter of fact, the above two rules seem to be the extremes; the following intermediate rules are in fact the ones used (Baumol and Sidak, 1994).

- Efficient component-pricing rule: The access charge should be equal to the average loss in profit of X that is incurred when it provides access to N .
- Incremental cost-plus rule: If the incremental cost rule is adopted, X cannot redeem the past investment; therefore the access charge should be set based on the sum of the average incremental cost and the suitable markup for the redemption.

The efficient component-pricing rule is desirable for the bottleneck monopoly in that it obtains the profit irrespective of whether the entry occurs. We cannot insist, however, that this rule is always socially efficient because its profit generally includes monopolistic rents and technical inefficiencies. Accordingly, it is the incremental cost-plus rule that is widely supported in many countries.¹¹

Yet, we have not fully analyzed which is socially desirable, behavioral regulation or structural regulation, or whether we can actually control bottleneck monopolies by employing access charges. We will proceed to the model analysis to answer these questions. We summarize the main points as follows.

Bottleneck monopoly

Bottleneck monopoly is defined as the industrial structure where an entrant must buy an intermediate good from the incumbent to provide a final good. There are two methods to regulate the bottleneck monopolistic industry: behavioral regulation and structural regulation. In both cases, the rule of access charge becomes important.

(*) Model analysis of bottleneck monopoly

At this point, we will consider the bottleneck monopoly problem with a model analysis. Novices can skip sections with * hereafter. We define a market in which bottleneck facilities exist as a *service-based competition* and a market in which they do not exist as a *facility-based competition*. See Figure 3.1 for a graphical representation.

- Service-based competition: One firm needs access to another, but the reverse does not hold.¹²
- Facility-based competition: Customers communicating with each other belong to two different local networks, and each carrier must buy termination access from the other network.¹³

We will compare service-based and facility-based competitions with a *components model*.¹⁴ The components model analyzes how complementary components are combined to produce a valuable system.

We assume that there are two levels of *components*: A and B . It is also assumed that each component has two types: namely A_1/A_2 and B_1/B_2 . One interpretation is that component A denotes a long-distance one, and component B a local loop one in the telecommunications service. We call the combination of components a *system*. In this model, systems are represented by A_1B_1 , A_1B_2 , A_2B_1 , and A_2B_2 . Defining the prices of components A_i and B_j are P_i and Q_j respectively, the price of system A_iB_j , S_{ij} , can be represented as the sum of the prices of components:

Figure 3.1 Service-based competition (left) and facility-based competition (right).

$$S_{ij}=P_i+Q_j, i,j=1,2. \quad (3.1)$$

Let us assume linear demand functions of systems A_iB_j , D_{ij} , following the previous research into components model. The own-effect of price to demand is assumed as one, the cross-effects are represented by coefficient c . Accordingly, the demand functions of systems are given as follows:

$$\begin{aligned} D_{11} &= a - S_{11} + c(S_{12} + S_{21} + S_{22}), \\ D_{12} &= a - S_{12} + c(S_{11} + S_{22} + S_{21}), \\ D_{21} &= a - S_{21} + c(S_{22} + S_{11} + S_{12}), \\ D_{22} &= a - S_{22} + c(S_{21} + S_{12} + S_{11}). \end{aligned} \quad (3.2)$$

The demand functions of components are given as follows: for example, the demand of component A_1 , D_{A1} , is represented as the sum of the demands of systems A_1B_1 and A_1B_2 , D_{11} and D_{12} :

$$\begin{aligned} D_{A1} &= D_{11} + D_{12}, \\ D_{A2} &= D_{21} + D_{22}, \\ D_{B1} &= D_{11} + D_{21}, \\ D_{B2} &= D_{12} + D_{22}. \end{aligned} \quad (3.3)$$

In addition, we need further assumptions to simplify the analysis: the non-negative equilibrium prices and quantities, namely $1 > 3c > 0$; the zero marginal costs of production.

(*) *Service-based competition*

The service-based competition model (abbreviated as Iw) demonstrates the case where two types of firms exist: one is a dominant firm that monopolizes one level of a component, while the other is a partial entrant. The dominant firm X provides $A_1/B_1/B_2$, whereas the partial entrant N provides only A_2 . Furthermore, X sets the prices of components $A_1/B_1/B_2$, and N sets the price of component A_2 . The firms' profit functions Π_X and Π_N are given as follows:

$$\begin{aligned} \Pi_X &= P_1 D_{A1} + Q_1 D_{B1} + Q_2 D_{B2}, \\ \Pi_N &= P_2 D_{A2}. \end{aligned} \quad (3.4)$$

The first-order conditions of the profit maximization problem can be obtained by differentiating profits functions Π_X and Π_N from prices $P_1/Q_1/Q_2$ and P_2 . The equilibrium prices and quantities are shown in Table 3.1(a).

(*) *Facility-based competition*

The facility-based competition model (abbreviated as 2w) demonstrates that there is no dominant firm and that X provides A_1/B_1 while N provides A_2/B_2 . Each component has two types, A_1/A_2 and B_1/B_2 . Component B is compatible with two providers, and B_1 can be combined with A_2 as well as A_1 to produce the systems A_1B_1 and A_2B_1 , respectively. The same can be said of B_2 ; X sets the prices of A_1/B_1 and N sets the prices of A_2/B_2 . The firms' profit functions Π_X and Π_N are given as follows:

$$\begin{aligned}\Pi_X &= P_1 D_{A1} + Q_1 D_{B1}, \\ \Pi_N &= P_2 D_{A2} + Q_2 D_{B2}.\end{aligned}\tag{3.5}$$

The first-order conditions of the profit maximization problem can be obtained by differentiating profit functions Π_X and Π_N from prices P_1/Q_1 and Q_2/P_2 . The equilibrium prices and quantities are shown in Table 3.1(b).

The main conclusions obtained from two models can be summarized as the following theorem:

The first theorem of bottleneck monopoly: $\Sigma \Sigma D^{1w} < \Sigma \Sigma D^{2w}$.

This theorem compares the total outputs between the models of service-based and facility-based competitions.¹⁵ Facility-based competition is more socially desirable than service-based competition in that the total output of the facility-based competition model is larger than that of the service-based competition model. Why is facility-based competition more socially desirable than service-based competition? There are two reasons for this. One is the internalization of vertical externalities. Vertical integrators can set prices based upon the demands of systems instead of components. The other is the action of the horizontal substitution effect; since there is no firm that monopolizes components, the price competition in terms of systems works effectively and system demands are increased.

(*) *Behavioral regulation*

Next we will examine how to regulate a bottleneck monopoly and improve its performance. There are two possible methods of regulation: access-charge regulation (behavioral regulation) and unbundling (structural regulation). The access-charge model of service-based competition (abbreviated as 1w-ac) demonstrates what happens when the government regulates the upper limits of prices Q_1/Q_2 of components B_1, B_2 up to f , whereas a dominant firm provides $A_1/B_1/B_2$ and an entrant provides A_2 . X sets the price P_1 and N sets the price P_2 . Profit functions, Π_X and Π_N , are given as follows:

$$\begin{aligned}\Pi_X &= P_1 D_{A1} + f D_{B1} + f D_{B2}, \\ \Pi_N &= P_2 D_{A2}.\end{aligned}\tag{3.6}$$

The equilibrium prices and quantities are shown in Table 3.1(c).

(*) *Structural regulation*

The unbundling model of service-based competition (abbreviated as *lw-ub*) demonstrates what occurs when the government disintegrates components B_1 and B_2 from a dominant firm X and regulate the prices at level f , while X still provides A_1 and N provides A_2 . X sets the price P_1 and N sets the price P_2 . Profit functions Π_X and Π_N are given as follows:

$$\begin{aligned}\Pi_X &= P_1 D_{A1}, \\ \Pi_N &= P_2 D_{A2}.\end{aligned}\tag{3.7}$$

The equilibrium prices and quantities are shown in Table 3.1(d).

The main conclusions obtained from two models can be summarized as the following theorem:

The second theorem of bottleneck monopoly: $\Sigma \Sigma D^{lw-pc} \geq \Sigma \Sigma D^{lw-ub}$.

This theorem compares the total outputs between the access charge model and the unbundling model. The former is more socially desirable than the latter in that the total output of the access-charge model is greater than that of the unbundling model. This is because under the access-charge regulation, the dominant firm can determine the price of component A_1 to maximize the total profit of the systems, even though it is not permitted to determine the prices of components B_1 and B_2 . It is interesting to note, in passing, that when the government sets the prices of components B_1 and B_2 to be the marginal costs, namely $f=0$, the equilibrium prices and equilibrium quantities in the case of access-charge regulation are exactly equivalent to those in the case of unbundling.

Social welfare of bottleneck monopoly

When we compare the bottleneck monopoly (service-based competition model), in which one vertically integrated firm monopolizes components at one level, and the network competition (facility-based competition model), in which two vertically integrated firms compete, the latter is socially superior to the former.¹⁶ Therefore, we can conclude that a facility-based entry into a bottleneck market is socially desirable, though in reality it will take both

Table 3.1 Model analysis of bottleneck monopoly

(a) Service-based competition (1w)				
D_{11}^{1w}	D_{12}^{1w}	D_{21}^{1w}	D_{22}^{1w}	$\Sigma\Sigma D^{1w}$
$\frac{a(3-c)}{6(1-c)}$	$\frac{a(3-c)}{6(1-c)}$	$\frac{a}{3}$	$\frac{a}{3}$	$\frac{a(5-3c)}{3(1-c)}$
(b) Facility-based competition (2w)				
D_{11}^{2w}	D_{12}^{2w}	D_{21}^{2w}	D_{22}^{2w}	$\Sigma\Sigma D^{2w}$
$\frac{a(3-5c)}{7-17c}$	$\frac{a(3-5c)}{7-17c}$	$\frac{a(3-5c)}{7-17c}$	$\frac{a(3-5c)}{7-17c}$	$\frac{4a(3-5c)}{7-17c}$
(c) Access charge regulation (1w-pc)				
D_{11}^{1w-pc}	D_{12}^{1w-pc}	D_{21}^{1w-pc}	D_{22}^{1w-pc}	$\Sigma\Sigma D^{1w-pc}$
$\frac{a(1-c) + c(-1+2c+3c^2)f}{2-4c}$	$\frac{a(1-c) + c(-1+2c+3c^2)f}{2-4c}$	$\frac{(1-c)(a+(-1+2c+3c^2)f)}{2-4c}$	$\frac{(1-c)(a+(-1+2c+3c^2)f)}{2-4c}$	$\frac{2a(1-c)+(-1+2c+3c^2)f}{1-2c}$
(d) Unbundling regulation (1w-ub)				
D_{11}^{1w-ub}	D_{12}^{1w-ub}	D_{21}^{1w-ub}	D_{22}^{1w-ub}	$\Sigma\Sigma D^{1w-ub}$
$\frac{(1-c)(a+(-1+3c)f)}{2-4c}$	$\frac{(1-c)(a+(-1+3c)f)}{2-4c}$	$\frac{(1-c)(a+(-1+3c)f)}{2-4c}$	$\frac{(1-c)(a+(-1+3c)f)}{2-4c}$	$\frac{2(1-c)(a+(-1+3c)f)}{1-2c}$

money and time for the entrant to construct a substitute network in full. In this sense, we need to regulate the bottleneck monopoly to restrict its significant market power. Next, when we compare behavioral regulation (access charge regulation) and structural regulation (unbundling), we conclude that the former is socially superior to the latter. It is interesting to note that the divestiture of a vertically integrated firm is not necessarily socially desirable.

There are two reasons why facility-based competition is more socially desirable than service-based competition. One is the internalization of vertical externalities. Vertical integrators can set prices based upon the demands of systems instead of components. The other is the action of the horizontal substitution effect; since there is no firm that monopolizes components, the price competition in terms of systems works effectively and system demands are increased. We summarize the main points as follows:

Social welfare of bottleneck monopoly

Service-based competition is socially inferior to facility-based competition. In regulating service-based competition, structural regulation to unbundle bottleneck monopoly is more socially inefficient than access charge regulation.

Network externalities

This section, first, previews the characteristics of the demand side of network industries, namely network externalities and, second, proposes a model to analyze these problems.

The preview of network externalities

Network externalities, which represent the economies of scale on the demand side, frequently exist in network industries. For example, a consumer wants to subscribe to a larger network when s/he chooses a mobile phone company, because s/he can talk to more people for the same price. Katz and Shapiro (1994) classified network externalities into two types:

- Direct network externalities: A consumer's utility depends not only on a price but also on a network scale in the communications service. Since the private benefit is lower than the social benefit under network externalities, the scale of the privately owned network tends to be smaller than the socially optimum level.
- Indirect network externalities: Even if the scale of a network does not influence a consumer's subscription choice, the variety of contents will

do. An example is *lock-in*, in which hardware that has more usable software is favored by consumers.

Two noteworthy pioneers who have studied network externalities are Leibenstein (1950) and Rohlfs (1974).

- Bandwagon effect: It is said the external effects of demand exist when one's utility is directly influenced by others' consumption behaviors, either positively or negatively. Leibenstein (1950) in particular called the positive one the *Bandwagon effect*.
- The interdependency of telecommunications demand: The more people can communicate with, the more they are satisfied. The reverse also holds. Rohlfs (1974) analyzed in the telecommunications service that even a potentially viable network might not develop under network externalities because it could not obtain the *critical mass* in the early stage of diffusion.

Many attempts have been made to study network externalities since game theory was widely accepted in the field of industrial organization theory. Most important are studies by Katz and Shapiro (1985) and Farrell and Saloner (1985). First, Katz and Shapiro (1985, 1986a, 1986b) made it clear that the following problems would occur under network externalities:

- Installed base: Network externalities represent the economies of scale on the demand side. If many consumers predict that some network (or technical standard) will spread in the future, they are willing to pay more for it, and it will actually take precedence over others in the manner of a self-fulfilling prophecy.
- Small social incentive of compatibility: It will be problematic under network externalities whether a firm has the proper incentive to interconnect (or make compatibility) with another. The private incentive is expected to be often smaller than the social incentive.

Turning to the next point, Farrell and Saloner (1985, 1986) pointed out that the market mechanism did not necessarily bring about socially desirable welfare.

- Excess inertia: Once an inefficient old technology has already obtained the installed base, another efficient new technology cannot spread.
- Excess momentum: When an inefficient new technology is expected to diffuse in the future, an efficient old technology is driven away from the market.

Typical examples of these market failures are, first, the QWERTY keyboard layout and, second, the standard competition of VCR formats (David,

1985).¹⁷ The original keyboards used in the nineteenth century often became tangled, so the QWERTY keyboard layout was designed to decrease the speed of typing. Ironically, typewriter performance improved later, and, in addition, the speed of typing needed to be increased. Although the new DVORAK keyboard was invented for this reason, it could not spread because the QWERTY keyboard had already become the *de facto* standard. Moving on to VCRs, Sony was the first to release the Betamax format in 1975.¹⁸ One year later, Victor released the rival VHS format. It was said at that time that Betamax was superior to VHS with respect to picture quality. However, Matsushita and Victor succeeded in establishing strong support for the VHS format by using licensing strategies, and the VHS format finally prevailed.

It is often said that network externalities have played an important role in both of the above cases. For all that, there are some researchers who are cautious in overestimating the importance of network externalities. Representative of this school of thought are Liebowitz and Margolis (2002). They insist that direct network externalities can only apply to very restricted cases such as telephone or fax services, while many examples of network externalities are in fact indirect, to which the *software–hardware paradigm* applies. Therefore, network externalities do not cause any serious market failures because they are merely pecuniary.

It may be true, as Liebowitz and Margolis have stated, that previous research on network externalities has overemphasized the importance of network externalities. We cannot say for certain at present that government intervention into private activities is always necessary: as long as consumers' or producers' surpluses reflect network externalities even partially, the social welfare will increase regardless. In this respect, network externalities are different from public nuisances, which are negative externalities. We summarize the main points as follows.

Network externalities

Network externalities represent the economies of scale on the demand side. There are two types of network externalities: direct and indirect network externalities. In the case of direct one, such market failures as excess inertia and excess momentum may happen.

(*) *The model analysis of network externalities*

Here, we determine whether the network externalities really matter from the perspective of social welfare. An important problem of network externalities is *interlinking*. See Katz and Shapiro (1994), Shapiro and Varian (1998), and Rohlfs (2001) for details. Interlinking is the ability of products to generate

network externalities.¹⁹ There are two scenarios for this effect. First, the optimistic scenario is that agreeing to interlink is likely to be profitable for all firms if no firm has a strong technological edge, because interlinking yields substantial benefits to consumers and, at the same time, firms can make a profit from the resulting increase in demand. Second, the pessimistic scenario is that the proprietor of a superior technology may be reluctant to interlink, since it stands to win outright when competing with others without interlinking; furthermore, consumers will be reluctant to purchase the product of any competing supplier, as they fear being stuck with a product that may become a losing technology.

It appears that the pessimistic scenario, which may feature problems such as a lack of incentives to interlink, or excess inertia/momentum, has been overemphasized. At this point, upon establishing a simple model of network externalities, we will attempt to determine which scenario is most reasonable; in other words, whether the network externalities truly have the characteristics of market failures.

We consider the Cournot-type duopolistic competition. This competition can be classified into the cases of *no interlinking* and of *interlinking*. Furthermore, interlinking falls into two categories: the first is *one-way interlinking*, where one firm interlinks to the other firm but the reverse does not hold. The second is *two-way interlinking*, where both firms interlink.

The basic analytical framework is given below, owing much to Katz and Shapiro (1985). In this framework, a consumer purchases one or no unit of a good (in other words, demands access). The surplus that a consumer derives from buying a unit of the good depends on the number of other consumers who join the network interlinked with that good. The term x_i represents the output of the good of firm i , $i=1,2$, and the term y_i^e represents the expected scale of the network that is interlinked with the good of firm i . The term $R + ky_i^e$ corresponds to the willingness of consumers to pay for the good of firm i , where R means that type of consumers that is assumed to be distributed uniformly at a density of one on $(0, A]$; k ($0 < k < 1$) means the parameter that represents the degree of network externalities. The term P_i means the price of the good of firm i , and the expression $R + ky_i^e - P_i$ describes the net utility function of a consumer who is of type R .

Assuming that the goods are homogeneous except for the expected scale of a network, the equation $P_1 - ky_1^e = P_2 - ky_2^e$ holds. Since R is distributed uniformly on $(0, A]$, the term $A - (P_i - ky_i^e)$ describes the total demand for the goods. The term N denotes the total supply of the goods; then we obtain $N = x_1 + x_2$. Therefore, the equation $A - (P_i - ky_i^e) = N$ represents the equilibrium quantity and the equation $P_i = A + ky_i^e - N$ represents the equilibrium price. Finally, let C_i be the marginal cost of firm i , and we assume here that $C_1 = 0$, $C_2 = c$ ($0 < c < A$). That is to say, firm 1 is superior to firm 2 in terms of costs.

Having assumed Cournot competition (abbreviated as (C)), the profit functions (Π_1^C , Π_2^C), consumer surplus (S^C), and social welfare (W^C) are given as follows:

$$\begin{aligned}\Pi_1^C &= x_1 (A + ky_1^e - N^C), \\ \Pi_2^C &= x_2 (A + ky_2^e - N^C),\end{aligned}\tag{3.8}$$

$$S^C = \int_{A-N^C}^A (R + N^C - A) dR,$$

$$W^C = \Pi_1^C + \Pi_2^C + S^C.$$

The profit maximization problems of firms 1 and 2 are given as $\text{Max } \Pi_1$ and $\text{Max } \Pi_2$, the first-order conditions and equilibrium outputs are given as follows:

$$\begin{aligned}x_1^C &= \frac{A + 2ky_1^e - ky_2^e + c}{3}, \\ x_2^C &= \frac{A - ky_1^e + 2ky_2^e - 2c}{3}.\end{aligned}\tag{3.9}$$

(*) *Four structures of interlinking*

Here, Cournot competition is classified into four types, based on the degree of interlinking: (1) no interlinking (CN); (2) one-way interlinking by a superior firm (CO1); (3) one-way interlinking by an inferior firm (CO2); and (4) two-way interlinking (CT). Furthermore, we will adopt the fulfilled expectations equilibrium (FEE) as an equilibrium concept, following Katz and Shapiro (1985), and consider each maximization problem and equilibrium.

- FEE without interlinking (CN): Since there is no interlinking, the expected scale of the network of each firm is equal to its output; thus the equations $y_1^e = x_1$, $y_2^e = x_2$ hold. The FEE (CN) outputs, profits, surplus, and welfare are given in Table 3.2(a).
- FEE with one-way interlinking by the superior firm (CO1): Firm 1 is a superior firm in terms of costs. Since there is only one-way interlinking, the expected scale of the network of firm 1 is equal to the total industry output, which is the sum of the outputs of firms 1 and 2; accordingly the equations $y_1^e = x_1 + x_2$, $y_2^e = x_2$ hold. The FEE (CO1) outputs, profits, surplus, and welfare are given in Table 3.2(b).
- FEE with one-way interlinking by the inferior firm (CO2): Firm 2 is an inferior firm in terms of costs. Since there is only one-way interlinking, the expected scale of the network of firm 2 is equal to the total industry output, which is the sum of the outputs of firms 1 and 2; accordingly the equations $y_1^e = x_1$, $y_2^e = x_1 + x_2$ hold. The FEE (CO2) outputs, profits, surplus, and welfare are given in Table 3.2(c).
- FEE with two-way interlinking (CT): Since there is two-way interlinking, the expected scale of the network of each firm is equal to the total

industry output, and accordingly the equations $y_1^e = x_1 + x_2$, $y_2^e = x_1 + x_2$ hold. The FEE (CT) outputs, profits, surplus, and welfare are given in Table 3.2(d).

Here we compare the social welfare values of the four cases described above. First, because $W^{CT} > W^{CN}$ holds, two-way interlinking (T) is more socially desirable than no interlinking (N). Second, because $W^{CT} > W^{CO1}$ holds, two-way interlinking (T) is more socially desirable than one-way interlinking by the superior firm ($O1$). Third, because $W^{CO1} > W^{CO2}$ holds, one-way interlinking by the superior firm ($O1$) is more socially desirable than that by the inferior firm ($O2$). Fourth, because $W^{CO2} > W^{CN}$ holds, one-way interlinking by the inferior firm ($O2$) is more socially desirable than no interlinking (N). The above conclusions can be summarized in the following theorem:

Network externalities and social welfare: When network externalities are present, (i) interlinking is better than no interlinking, (ii) two-way interlinking is better than one-way interlinking, and (iii) one-way interlinking by a superior firm is better than that by an inferior firm.

(*) *Incentive to promote interconnection*

Next, we determine whether firms want to interlink voluntarily based on non-cooperative game theory. Let us suppose here that players are firms 1 and 2, and strategies are interlinking and no interlinking, then we can obtain the payoff matrix of the game as in Table 3.3. With the aim of deriving the Nash equilibrium of the game, we solve four inequalities as follows:

$$\begin{aligned}
 \Pi_1^{CT} \geq \Pi_1^{CO2} &\Leftrightarrow 0 \leq \frac{A}{2-k}, \\
 \Pi_1^{CO1} \geq \Pi_1^{CN} &\Leftrightarrow 0 \leq \frac{(1-k)A}{2-k}, \\
 \Pi_2^{CT} \geq \Pi_2^{CO1} &\Leftrightarrow 0 \leq \frac{A}{1-k}, \\
 \Pi_2^{CO2} \geq \Pi_2^{CN} &\Leftrightarrow 0 \leq (1-k)A.
 \end{aligned} \tag{3.10}$$

All inequalities above hold because of $0 < k < 1$. That is to say, a strategy in which firms 1 and 2 interlink becomes the dominant one. Consequently, the Nash equilibrium is two-way interlinking in which both firms want to interlink. In conclusion, we obtain the next theorem (see p. 75):

Table 3.2 Model analysis of network externalities

(a) No interlinking (CN)					
x_1^{CN}	x_2^{CN}	Π_1^{CN}	Π_2^{CN}	S^{CN}	W^{CN}
$\frac{(1-k)A+c}{(1-k)(3-k)}$	$\frac{(1-k)A-(2-k)c}{(1-k)(3-k)}$	$(x_1^{CN})^2$	$(x_2^{CN})^2$	$\frac{(x_1^{CN}+x_2^{CN})^2}{2}$	$\frac{3(x_1^{CN}+x_2^{CN})^2-4x_1^{CN}x_2^{CN}}{2}$
(b) One-way interlinking of firm 1 (COI)					
x_1^{COI}	x_2^{COI}	Π_1^{COI}	Π_2^{COI}	S^{COI}	W^{COI}
$\frac{A+(1-k)c}{k^2-3k+3}$	$\frac{(1-k)A-(2-k)c}{k^2-3k+3}$	$(x_1^{COI})^2$	$(x_2^{COI})^2$	$\frac{(x_1^{COI}+x_2^{COI})^2}{2}$	$\frac{3(x_1^{COI}+x_2^{COI})^2-4x_1^{COI}x_2^{COI}}{2}$
(c) One-way interlinking of firm 2 (CO2)					
x_1^{CO2}	x_2^{CO2}	Π_1^{CO2}	Π_2^{CO2}	S^{CO2}	W^{CO2}
$\frac{(1-k)A+c}{k^2-3k+3}$	$\frac{A-(2-k)c}{k^2-3k+3}$	$(x_1^{CO2})^2$	$(x_2^{CO2})^2$	$\frac{(x_1^{CO2}+x_2^{CO2})^2}{2}$	$\frac{3(x_1^{CO2}+x_2^{CO2})^2-4x_1^{CO2}x_2^{CO2}}{2}$
(d) Two-way interlinking (CT)					
x_1^{CT}	x_2^{CT}	Π_1^{CT}	Π_2^{CT}	S^{CT}	W^{CT}
$\frac{A+(1-k)c}{3-2k}$	$\frac{A-(2-k)c}{3-2k}$	$(x_1^{CT})^2$	$(x_2^{CT})^2$	$\frac{(x_1^{CT}+x_2^{CT})^2}{2}$	$\frac{3(x_1^{CT}+x_2^{CT})^2-4x_1^{CT}x_2^{CT}}{2}$

Table 3.3 The incentive of interlinking

		Firm 2	
		Interlinking	No interlinking
Firm 1	Interlinking	Π_1^{CT}, Π_2^{CT}	Π_1^{CO1}, Π_2^{CO1}
	No interlinking	Π_1^{CO2}, Π_2^{CO2}	Π_1^{CN}, Π_2^{CN}

Network externalities and interconnection incentive: Both firms have incentives to interlink, and therefore two-way interlinking is realized under network externalities.

The social welfare of network externalities

Network externalities are some of the most important topics in modern industrial economics. As a rule, the negative aspects of network externalities have been overemphasized, though a lot of networking services have voluntarily taken off without special intervention by the government. For that, this paper has demonstrated that network externalities do not always have the characteristics of market failures in interlinking, and a desirable industry structure is likely to be realized as a result of a voluntary interlinking arrangement, based on the simple model of network externalities.

However, this conclusion seems to be too optimistic in comparison to other research. So far, we have not taken into account the existence of the cost of interlinking (or making compatibility), unlike Katz and Shapiro (1985). If we had included the cost of interlinking in our model, the private incentives to interlink would have been different from the social incentives. We do not mean here that the excess momentum or inertia does not matter; on the contrary, we demonstrate under what conditions such market failures actually happen. We summarize the main points as follows.

The social welfare of network externalities

Network externalities do not always cause market failures. The incentive to promote interconnection under network externalities depends on the cost to promote interconnection compared to the benefit from interconnection.

Industrial convergence and the complexity of network economy

In this section, we briefly discuss industrial convergence and the complexity of a network economy.

Industrial convergence

An interesting topic of network economics is the convergence of industries as a result of innovation and deregulation. Industrial convergence is defined as follows:

- **Industrial convergence:** Industries that had been classified into separate ones have been substituted mutually owing to technical innovations, or firms that were engaged in different businesses have been competing with each other after the deregulation of line-of-business restrictions.

One good example is the convergence of telecommunications and broadcasting. We no longer make a clear distinction between data communication and media broadcasting due to the development of information technology (IT) such as opticalization, digitization, interactivation and broadbanding. A similar thing can be said of the energy industries; both electricity producers and city gas providers have developed cogeneration systems.

Industries that were traditionally considered as being naturally monopolistic are now becoming competitive after the convergence of industries. However, since economic institutions cannot change as rapidly as technologies, economic regulations that have assumed old industrial structures remain in shackles. In this sense, it is the vested interests of regulated firms and bureaucratic sectionalism that deter the convergence of industries.

Having already demonstrated it in the previous sections, facility-based network competition is more socially desirable than service-based bottleneck monopolies, and a convergence of multi-networks is socially preferable. Therefore, the industrial policy of the future is not only to control market power and open essential facilities inside an industry, but also to promote mutual entries into highly centralized markets and establish rules for equal footing. We summarize the main points as follows:

Industrial convergence

Both innovation and deregulation continuously advance industrial convergences. On the other hand, institutions do not change continuously. Industrial convergences should be promoted to increase social welfare with service-based competition and network externalities.

The complexity of a network economy

As has been emphasized above, the two main points of network economics are bottleneck monopolies, which are economies of scale on the supply side, and network externalities, which are the economies of scale on the demand side. At this point, we collectively refer to them as *the economies of network*.

- The economies of network: Bottleneck monopolies originate in the economies of scale, which cause an irreversible entry-and-exit due to enormous sunk costs, bringing an incumbent firm huge vested interests. On the other hand, network externalities also make the choice of a consumer irreversible owing to switching costs.

It is important here to understand that the network economics is not founded in “simplicity,” but in “complexity” (Arthur, 1989).

- The complexity of a network economy: It is impossible to predict which firm will be able to appropriate the economies of network because a *path dependency* can occur, depending on the initial condition. Also, since positive feedback is caused by the economies of network, *lock-in* occurs and excess inertia or momentum matters. Consequently, the complex network economy is very different from the simple world that standard economics, like the general equilibrium theory, has presumed.

The purposes of network economics are to understand complex phenomena such as the growth and atrophy of firms, the emergence of innovation, the life cycle of commodities, the transition of consumers’ preferences, and the development of industry (Antonelli, 1997). Thus, network economics is also a form of evolutionary economics. We summarize the main points as follows.

The complexity of a network economy

There are economies of scale both on the supply side and on the demand side in network industries. Therefore, the network economics should be founded in complexity.

Conclusions

This chapter has discussed several aspects of network industries that are important in the modern economy.²⁰ There are two main points in network industries: bottleneck monopolies and network externalities. Both represent the economies of scale on the supply and demand sides, and therefore the market mechanism may not work well. Furthermore, network industries have

been merging, and the complexity surrounding the network economy has been increasing. Consequently, it is impossible to accurately predict the result of industrial policy, although it will be possible to design a higher grade of industrial policy under the assumption that we are not able to predict the future.

4 Discrete choice analysis: Methodology and case studies

This chapter introduces the basic knowledge of discrete choice model analysis used in this book. Specifically, the following aspects of discrete choice model analysis are explained:

- Random utility theory,
- Conditional logit model,
- Nested logit model,
- Mixed logit model,
- Revealed preference method,
- Stated preference method,
- Conjoint analysis.

The research on these topics, which dates from the 1920s, greatly expanded in the 1970s, leading to D. McFadden and J. Heckman winning the Nobel Prize in 2000. Due to the development of computer technologies and simulation methods, innovations are still advancing in this field. Accordingly, introducing such state-of-the-art economic science to beginners is difficult, but fortunately the following excellent textbooks clearly explain discrete choice model analysis from the basics to applications:

- J.J. Louviere, D.A. Hensher, and J. Swait (2000) *Stated Choice Methods*, Cambridge University Press,
- K. Train (2003) *Discrete Choice Methods with Simulation*, Cambridge University Press,
- D.A. Hensher, J.M. Rose, and W.H. Greene (2005) *Applied Choice Analysis*, Cambridge University Press.

However, since these three books are all voluminous, novices might experience difficulties completely reading them. Therefore, this chapter summarizes the minimum knowledge necessary to understand discrete choice model analysis. Advanced mathematics may not be necessary to interpret the estimation results, and explanations are added to equations. Beginners may skip sections with (*).

Random utility theory

This subsection explains random utility theory, which provides the basis of discrete choice model analysis (Louviere et al., 2000, ch. 3; Train, 2003, ch. 2; Hensher et al., 2005, ch. 3). We begin by explaining discrete choice. Discrete choice is the selection of one alternative among a choice set, and choice set is the set of alternatives from which a decision-maker chooses. Therefore, discrete choice model represents analysis of which alternative to choose from the choice set based on specified levels of attributes that then become the characteristics of an alternative. The choice set is characterized as follows:

- Alternatives must be mutually exclusive.
- The choice set must be exhaustive.
- The number of alternatives must be definite.

Let us consider an example from broadband (high-speed Internet access) service. As seen in Chapter 2, representative alternatives in broadband service include ADSL, CATV Internet, and FTTH. Assuming that the choice set is composed of those three alternatives, a decision-maker chooses an alternative from the broadband choice set.

The level of satisfaction received by a decision-maker from choosing an alternative is called *utility*. Particularly, random utility theory (RUT) assumes that utility is divided into two components:¹

- Representative utility, which an analyst can observe,
- Random components, which an analyst cannot observe.

RUT also assumes that the probability that decision-maker n chooses alternative i is determined such that the difference between the random components of alternatives j and i is less than the difference between the representative utilities of alternatives i and j for all alternatives in the choice set. Decision-maker n chooses one among J alternatives. The utility that decision-maker n obtains from choosing alternative j is denoted as U_{nj} , $j = 1 \dots J$. Decision-maker n chooses alternative i if and only if $U_{ni} > U_{nj}$, $i \neq j$. The analyst does not observe the utility of decision-maker n but observes the attributes of alternatives x_{nj} and the characteristics of decision-maker s_n . The utility function of decision-maker n is denoted as $V_{nj} = V(x_{nj}, s_n)$ and is called *representative utility*. Utility is formally expressed as $U_{nj} = V_{nj} + \varepsilon_{nj}$, where ε_{nj} represents the random factors. The joint density of random factors vector $\varepsilon_n = \langle \varepsilon_{n1} \dots \varepsilon_{nJ} \rangle$ is denoted as $f(\varepsilon_n)$. Then the probability that decision-maker n chooses alternative i is

$$\begin{aligned} P_{ni} &= \Pr(U_{ni} > U_{nj}) \\ &= \Pr(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}) \end{aligned}$$

$$\begin{aligned}
&= \Pr(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj}), \\
&= \int I(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj}) f(\varepsilon_n) d\varepsilon_n, j \neq i
\end{aligned} \tag{4.1}$$

where $I(\square)$ is the indicator function, which is 1 when the expression in the parentheses is true, and 0 otherwise (Train, 2003, pp. 18–19).

The above is the essence of RUT. Furthermore, the observed utility is frequently assumed to be linear in the parameters as follows:

$$V_{nj} = \alpha_j + \sum_{k=1}^K \beta_{kj} x_{knj}, \tag{4.2}$$

where x_{knj} , $k = 1 \dots K$ is a variable that relates to alternative j as faced by decision-maker n and α_j , β_{kj} , $k = 1 \dots K$ are coefficients of the parameters. Parameters are called *alternative-specific* in the case of α_j , β_{kj} . Otherwise, they are *generic* across alternatives in the case of α , β (Train, 2003, p. 24). We summarize the main points as follows:

Random utility theory (RUT)

Discrete choice model assumes the selection of one alternative from the choice set, based on random utility theory. Utility is divided into observable and unobservable parts, and choice probability is calculated given that the actual chosen alternative has the highest utility.

RUT example

We provide an example that illustrates RUT. Assume that *PRICE* and *SPEED* are the attributes for ADSL and FTTH services, respectively, and α , β are coefficients to be estimated. Then we can write the linear representative utility as

$$\begin{aligned}
V_{ADSL} &= \alpha_{ADSL} + \beta_{1ADSL} PRICE_{ADSL} + \beta_{2ADSL} SPEED_{ADSL}. \\
V_{FTTH} &= \alpha_{FTTH} + \beta_{1FTTH} PRICE_{FTTH} + \beta_{2FTTH} SPEED_{FTTH}.
\end{aligned} \tag{4.3}$$

Due to $V_{FTTH} + \varepsilon_{FTTH} > V_{ADSL} + \varepsilon_{ADSL}$, the probability of choosing FTTH is written as

$$P_{FTTH} = \Pr(V_{FTTH} + \varepsilon_{FTTH} > V_{ADSL} + \varepsilon_{ADSL}). \tag{4.4}$$

The same thing is said of P_{ADSL} .

Conditional logit model

This subsection explains the most basic conditional logit (CL) model (Louviere et al., 2000, ch. 3; Train, 2003, ch. 3; Hensher et al., 2005, chs. 10, 11).² The condition of the CL model is that random components are independently and identically distributed (IID). In other words, the random components of the utility of all alternatives are uncorrelated with the unobserved components of utility for all other alternatives, and each of these unobserved components has identical distribution. Due to this IID condition, the independence of irrelevant alternative (IIA) property is derived.³

In the CL model, random term ε_{nj} has independently and identically distributed extreme value (IID-EV) (Train, 2003, pp. 38–40). The density and cumulative distribution for ε_{nj} are formally written as

$$f(\varepsilon_{nj}) = e^{-\varepsilon_{nj}} e^{-e^{-\varepsilon_{nj}}}, F(\varepsilon_{nj}) = e^{-e^{-\varepsilon_{nj}}}. \quad (4.5)$$

The difference between two EV variables, $\varepsilon = \varepsilon_{nj} - \varepsilon_{ni}$, follows logistic distribution:

$$F(\varepsilon) = e^{\varepsilon} / (1 + e^{\varepsilon}). \quad (4.6)$$

The CL choice probability is now given as

$$P_{ni} = \int I(\varepsilon_{nj} - \varepsilon_{ni} < V_{ni} - V_{nj}) f(\varepsilon) d\varepsilon = \frac{e^{V_{ni}}}{\sum_j e^{V_{nj}}}, j \neq i. \quad (4.7)$$

When the representative utility is linear in the parameters, CL probability is written as

$$P_{ni} = \frac{e^{a_j + \sum_{k=1}^K \beta_k j^{x_{kj}}}}{\sum_j e^{a_j + \sum_{k=1}^K \beta_k j^{x_{kj}}}}, j \neq i. \quad (4.8)$$

We can summarize the main points as follows:

Conditional logit (CL) model

The most basic discrete choice model is the conditional logit (CL) model, which assumes that random terms follow the IID property. CL choice probability is written in logit form, but the IIA property derived from the IID assumption is quite restrictive for practical analysis.

(*) *IIA property*

This subsection explains the IIA property and its statistical test (see Hausman and McFadden, 1984 for details). The IIA property states that the ratio of choice probabilities is independent of the presence or absence of any other alternatives in the choice set. In other words, the IIA property demonstrates

$$\frac{P_{ni}}{P_{nk}} = \frac{e^{V_{ni}} / \sum_j e^{V_{nj}}}{e^{V_{nk}} / \sum_j e^{V_{nj}}} = \frac{e^{V_{ni}}}{e^{V_{nk}}} = e^{V_{ni} - V_{nk}}, \quad (4.9)$$

where the ratio of the CL choice probabilities does not depend on any other alternatives except i and k .

The Hausman test determines the existence of the IIA property. If the IIA property holds, then the parameter estimates obtained on the subset of alternatives will not be significantly different from those obtained on the full set of alternatives (Louviere et al., 2000, p. 161). The Hausman test proceeds as follows:

- Estimate coefficients β_u and variance-covariance matrix V_u for the CL model with all alternatives,
- Estimate coefficients β_r and variance matrix V_r for the restricted model with reduced alternatives,
- Compare both estimates based on Hausman statistic $[\beta_u - \beta_r]'[V_r - V_u]^{-1}[\beta_u - \beta_r]$, which follows χ^2 distribution.

(*) *CL elasticity*

This subsection explains CL elasticity. Elasticity is the percentage change in one variable (ie choice probability) with respect to a percentage change in another (ie price) (Train, 2003, pp. 63–64).

There are two kinds of elasticity. First, own-elasticity is the percentage change in the probability that decision-maker n chooses alternative i with respect to a given percentage change in k -th attribute x_{kni} of the same alternative:

$$\begin{aligned} E_{x_{kni}}^{P_{ni}} &= \frac{\partial P_{ni} / P_{ni}}{\partial x_{kni} / x_{kni}} = \frac{\partial V_{ni}}{\partial x_{kni}} x_{kni} (1 - P_{ni}) \\ &= \beta_{ki} x_{kni} (1 - P_{ni}) \text{ in the case of linear form } (V_{ni} = \sum_{k=1}^K \beta_{ki} x_{kni}). \end{aligned} \quad (4.10)$$

Next, cross-elasticity is the percentage change in the probability that

decision-maker n chooses alternative i with respect to a given percentage change in the k -th attribute of another alternative j :

$$E_{x_{knj}}^{P_{ni}} = \frac{\partial P_{ni} / P_{ni}}{\partial x_{knj} / x_{knj}} = - \frac{\partial V_{nj}}{\partial x_{knj}} x_{knj} P_{nj} \quad (4.11)$$

$$= - \beta_{kj} x_{knj} P_{nj} \text{ in the case of linear form } (V_{nj} = \sum_{k=1}^K \beta_{kj} x_{knj}).$$

Cross-elasticity, which depends on variables associated with alternative j , is independent of alternative i . Therefore, CL cross-elasticity with respect to a variable associated with alternative j is constant across other alternatives $i \neq j$. This constant cross-elasticity property is a consequence of the IID assumption of the CL model.

(*) *Maximum likelihood estimation*

This subsection explains maximum likelihood estimation (MLE), which is a method where parameters that best explain the data are estimated (Louviere et al., 2000, p. 43). MLE estimates are obtained by maximizing a probabilistic function with respect to utility parameters in the following two steps:

- We assume that decision-maker n selects alternative i if and only if the level of utility of alternatives i , U_{ni} , is greater than the level of utility of all other alternatives, U_{nj} , $j \neq i$.
- We calculate the probability that decision-maker n would rank alternative i higher than any other alternatives j in the choice set, conditional on knowing U_{nj} , $j \neq i$.

Then we indicate the likelihood function in the MLE method (Train, 2003, pp. 64–65). The probability that decision-maker n chooses alternative i can be expressed as $\Pi_j (P_{nj})^{I_{ni}}$, where $I_{ni} = 1$ if person n chooses i and 0 otherwise. Then the probability that decision-maker n chooses alternative j , called the *likelihood function*, is given as

$$L(\beta) = \prod_n \prod_j (P_{nj})^{I_{nj}}, n = 1 \dots N, j = 1 \dots J, \quad (4.12)$$

where β is a vector of parameters. Taking a log of the likelihood function, we obtain the *log-likelihood function*:

$$LL(\beta) = \sum_n \sum_j I_{nj} \ln P_{nj}, n = 1 \dots N, j = 1 \dots J. \quad (4.13)$$

The estimator is the value of β that maximizes the log-likelihood function such that the derivative of $LL(\beta)$ with respect to β is zero:

$$dLL(\beta) / d\beta = 0. \quad (4.14)$$

(*) *Goodness of fit*

This subsection explains the goodness of fit in the MLE model. McFadden's ρ (or pseudo- R^2) is a famous measure of model fitness for MLE models, defined as the proportion of variation in the data that is explained by the model (Louviere et al., 2000, p. 54):

$$\rho = 1 - \frac{LL(\beta)}{LL(0)}, \quad (4.15)$$

where $LL(\beta)$ is the value of the log-likelihood function at the estimated parameters and $LL(0)$ is the value when all parameters are zero. This likelihood ratio ranges from 0 to 1; models with higher ρ fit the data better.⁴

Example of CL model

We provide an example illustrating the CL model. Note that all figures are imaginary. We assume three alternatives (ADSL, CATV Internet, and FTTH) and two explanatory variables (price and speed). The basic statistics are shown in Table 4.1(a), which indicates the number and ratio of alternatives chosen and the average price and speed figures. First, we confirm that the IIA property holds in the CL model. At this point, the ratio of alternatives chosen is 3:1:1 among ADSL, CATV Internet, and FTTH. Then, given that CATV Internet is unavailable, the ratio is still preserved as 3:1 between ADSL and FTTH.

Next, the estimation result is shown in Table 4.1(b), in which the number of observations, $LL(\beta)$, $LL(0)$, ρ are indicated. McFadden's $\rho=0.33$ approximately corresponds to OLS's $R^2=0.6$, which is rather high for discrete choice models. Besides, variable names, estimates, standard errors, and t-values are indicated. Variables are alternative specific constants for ADSL and FTTH, and alternative common parameters for price and speed. Looking at the sign conditions, price estimate is expectedly negative, while speed estimate is expectedly positive. MLE estimates asymptotically follow t-distribution (Louviere et al., 2000, pp. 51–52). Thus, the ratio of the mean parameter to its standard error is the t-value, in which a value of 1.96 or higher means 95% or greater confidence. Looking at t-values, ADSL constant, price, and speed are statistically significant, but only FTTH constant is not significant.

Elasticities of demand with respect to price are shown in Figure 4.1(c), in which rows represent the alternative whose price is supposed to change while columns represent the alternative whose probability is supposed to change; diagonal figures are own-elasticities, which we leave negative for easy comparison to cross-elasticities. ADSL own-elasticity is -0.96 , while CATV Internet elasticity is -2.56 , and FTTH elasticity is -3.2 . Goods or services whose elasticity is larger than 1 are called elastic, while if elasticity is less than

Table 4.1 Estimation result of CL model: Example

(a) Basic statistics

	<i>Choice No.</i>	<i>Choice ratio</i>	<i>Average price</i>	<i>Average speed</i>
ADSL	600	0.60	¥3,000	10Mbps
CATV	200	0.20	¥4,000	20Mbps
FTTH	200	0.20	¥5,000	100Mbps
Total	1000	1.00	¥3,600	30Mbps

(b) Estimation result

Observation No.	1000		
$LL(\beta)$	-1000.0		
$LL(0)$	-1500.0		
ρ	0.3333		
<i>Variables</i>	<i>Estimates</i>	<i>Standard errors</i>	<i>t values</i>
ADSL constant	1.5000	0.5000	3.0000
FTTH constant	0.2000	0.4000	0.5000
Price	-0.0008	0.0003	-2.6667
Speed	0.0200	0.0100	2.0000

(c) Price elasticities

		<i>ADSL</i>	<i>Choice probability</i> <i>CATV</i>	<i>FTTH</i>
Price	ADSL	-0.9600	1.4400	1.4400
	CATV	0.6400	-2.5600	0.6400
	FTTH	0.8000	0.8000	-3.2000

(d) WTP for a speed up

¥25 /1Mbps

1 are called inelastic. In this respect, CATV Internet and FTTH are elastic while ADSL is inelastic. Focusing on the first row, cross-elasticities with respect to ADSL price are 1.44 for CATV Internet and FTTH choice probabilities. This is the constant cross-elasticity property derived from the IID condition. The same holds for the second and third rows.

Last, the amount of money that a decision-maker is willing to pay is called willingness to pay (WTP). If one of the attributes is measured in monetary units, the ratio of two parameters is an indicator of WTP in a linear model (Louviere et al., 2000, p. 61). WTP is shown in Table 4.1(d). The figure for WTP per 1 Mbps is ¥25 due to 0.02/0.0008.

Limitations of CL model

The IID condition of the CL model suggests the IIA property. This leads to quite strict restrictions for practical analysis. Train (2003, p. 46) points out the following three limitations of the CL model:

- It cannot represent taste variation among heterogeneous decision-makers.
- It cannot capture flexible substitution patterns that are not proportionate across alternatives.
- It cannot handle a dynamic situation if random factors are correlated over time.

To overcome these limitations, other more flexible models are needed.

Nested logit (NL) model

This section explains nested logit (NL) models that partially alleviate the IID assumption (Louviere et al., 2000, ch. 6; Train, 2003, ch. 4; Hensher et al., 2005, chs.13, 14).⁵ The term “nest” represents a hierarchy that belongs to a mutually exclusive subset of outcomes. The NL model partitions the choice set to allow alternatives to share common unobserved components among one another compared with non-nested alternatives (Louviere et al., 2000, p. 138). In other words, the NL model includes additional parameters for each choice set partition that equal the inverse of the scale parameters attached to an index variable and that are normally referred to as inclusive value (IV) (Louviere et al., 2000, p. 144). In this way, the set of alternatives that a decision-maker faces can be partitioned into nests:

- The IIA property holds within the same nest.
- The IIA property does not hold in different nests.

We call this feature of the NL model the independence of irrelevant nests (IIN) (Train, 2003, p. 81).

Let us take an example from Internet access service that is composed of dial-up, ISDN, ADSL, CATV Internet, and FTTH. It is unreasonable to suppose that the fastest FTTH and the slowest dial-up Internet have identical substitution patterns (namely, the constant cross-elasticity) for ADSL. More reasonably, dial-up and ISDN are grouped into the narrowband category, while ADSL, CATV Internet, and FTTH are classified as the broadband category.

The NL model assumes, therefore, that the decision-maker faces a choice between narrowband and broadband categories and then chooses one alternative in either the narrowband or broadband category.⁶ Let us now partition the choice set into K nests denoted as $B_1, \dots, B_K$.⁷ The vector of the random

terms of the NL model, $\langle \varepsilon_{n1}, \dots, \varepsilon_{nJ} \rangle$, has the following cumulative distribution:

$$F(\varepsilon_{nj}) = e^{-\sum_{j \in B_k} e^{-\varepsilon_{nj}/\lambda_k}}, k = 1 \dots K. \quad (4.16)$$

The ε_{nj} s are correlated within nests but not across nests. Parameter λ_k measures the correlation between ε_{nj} and ε_{nm} , given $\varepsilon_{nj}, \varepsilon_{nm} \in B_k$. The higher λ_k is, the less correlated are ε_{nj} and ε_{nm} , and vice versa.

Normalization is required for the NL model such that one or more scale parameters equal 1, and the other scale parameters are to be estimated. We differentiate random utility model (RUM) into two types (Louviere et al., 2000, pp. 165–167):

- Random utility model 1 (RUM1) if normalizing the lower level scale parameter,
- Random utility model 2 (RUM2) if normalizing the upper level scale parameter.

Although determining which scale parameter should be normalized is arbitrary, RUM2 may be preferred because RUM2 estimates are identical to the more complicated model with an extra level of nodes and links (Hunt, 1998).

Finally, we obtain the NL choice probability as follows (Train, 2003, pp. 83–84):

$$P_{ni} = \frac{e^{V_{ni}/\lambda_k} (\sum_{j \in B_k} e^{V_{nj}/\lambda_k})^{\lambda_k - 1}}{\sum_{l=1}^K (\sum_{j \in B_l} e^{V_{nj}/\lambda_k})^{\lambda_l}}. \quad (4.17)$$

Estimation of the NL model can be either sequential or simultaneous. If the tree has two to four levels, simultaneous estimation is commonly adopted that is called the full information maximum likelihood (FIML) method because it leads to more efficient estimation (Louviere et al., 2000, pp. 149–150). We can summarize the main points as follows:

Nested logit (NL) model

The NL model partially alleviates the CL model's IID assumption, since it categorizes the choice set into subsets, although the IIN property still holds.

(*) *Simple description of NL choice probability*

This subsection provides a simple description of NL choice probability. To understand it, utility can be conveniently decomposed into the following two parts (Train, 2003, pp. 85–87):

- part (W) that is constant for all alternatives within a nest,
- part (Y) that varies over alternatives within a nest.

The utility is given as

$$U_{nj} = W_{nk} + Y_{nj} + \varepsilon_{nj}, j \in B_k, \quad (4.18)$$

where W_{nk} are nest-specific variables and Y_{nj} are alternative-specific variables. The NL choice probability that decision-maker n chooses alternative i in nest B_k is given as

$$P_{ni} = P_{ni|B_k} P_{nB_k}, \quad (4.19)$$

where

$$P_{ni|B_k} = \frac{e^{Y_{ni}/\lambda_k}}{\sum_{j \in B_k} e^{Y_{nj}/\lambda_k}}, P_{nB_k} = \frac{e^{W_{nk} + \lambda_k IV_{nk}}}{\sum_{l=1}^K e^{W_{nl} + \lambda_l IV_{nl}}}, IV_{nk} = \ln \sum_{j \in B_k} e^{Y_{nj}/\lambda_k}.$$

In other words, P_{ni} is the product of two probabilities: the first component $P_{ni|B_k}$ denotes the conditional probability that decision-maker n chooses alternative i given that the alternative is in nest B_k , and the second component P_{nB_k} represents the marginal probability that decision-maker n chooses an alternative in nest B_k .⁸

(*) *NL elasticity*

This subsection explains NL elasticities that can take different elasticities when alternatives are categorized with different branches of a nested partition. NL own-elasticities are written as follows (Louviere et al., 2000, pp. 148–149):

$$E_{x_{kni}}^{P_{ni}} = [(1 - P_{nB_k}) + (\frac{1}{\lambda_k} - 1)(1 - P_{ni|B_k})]\beta_k x_{kni}, i \in B_k, \quad (4.20)$$

where P_{nB_k} is the marginal probability that decision-maker n chooses alternative i and $P_{ni|B_k}$ is the probability conditional on choice set G . NL cross-elasticities are then written as

$$E_{x_{nj}}^{P_{ni}} = -[P_{n_j} + (\frac{1}{\lambda_k} - 1)P_{n_j|B_k}] \beta x_{nj}, \quad i, j \in B_k. \quad (4.21)$$

Note that NL elasticity corresponds to CL elasticity when $\lambda_k = 1$ holds.

Example of NL model

This subsection provides an example of the NL model. Note that all figures are imaginary. We assume here that the alternatives are ADSL, CATV Internet, and FTTH and that the explanatory variables are price and speed.

Before turning to the NL model, we have to check whether the IIA property holds using the Hausman test. First, suppose that the choice ratio is 3:1:1 for ADSL, CATV Internet, and FTTH. If we delete CATV Internet from the choice set, the IIA property requires that a 3:1 choice ratio is preserved for ADSL and FTTH. However, this IIA property is occasionally violated. For example, if CATV Internet is a complete substitute for ADSL, the choice ratio becomes 4:1 for ADSL and FTTH. In this case, it is possible to consider that ADSL and CATV Internet belong to the same nest, while FTTH lies outside the nest. When the Hausman statistic is higher than χ^2 ($d.f. = 2$, $p = 0.05$) = 5.99, dropping CATV Internet, we conclude that here adopting the CL model is inappropriate.⁹

Once the IIA property is rejected, we should adopt the NL model. Comparing the NL estimation result indicated in Table 4.2(b) and the CL estimation result indicated in Table 4.1(b), we see that McFadden's ρ improves from 0.33 to 0.40; each t-value also improves. Additionally, the estimate for the IV parameter is inserted in the NL model, which reasonably lies in [0,1] and is statistically significant based on its t-value. For NL elasticity indicated in Table 4.2(c), the constant cross-elasticity property derived from IIA does not hold; cross-elasticity between ADSL and CATV Internet is higher than that for FTTH.¹⁰

() HEV model*

This subsection introduces the heteroscedastic extreme value (HEV) model. It has type 1 EV distribution associated with the random error term with unrestricted variance and therefore allows cross-elasticities to vary among all alternatives (Louviere et al., 2000, pp. 189–193).¹¹ The HEV choice probability is written as follows (Train, 2003, p. 96):

$$P_{ni} = \int [\prod_{j \neq i} e^{-e^{-(v_{ni} - v_{nj} + \epsilon_{nj})/\theta_j}}] e^{-e^{-v_{ni}/\theta_i}} e^{-\epsilon_{ni}/\theta_i} d(\epsilon_{ni}/\theta_i). \quad (4.22)$$

The HEV log-likelihood function does not take the closed form expression, which must be estimated by the simulation method.

Table 4.2 Estimation result of NL model: Example

(a) Basic statistics

	<i>Choice No.</i>	<i>Choice ratio</i>	<i>Average price</i>	<i>Average speed</i>
ADSL	600	0.60	¥3,000	10Mbps
CATV	200	0.20	¥4,000	20Mbps
FTTH	200	0.20	¥5,000	100Mbps
Total	1000	1.00	¥3,600	30Mbps

(b) Estimation result

Observation No.	1000
$LL(\beta)$	-900
$LL(0)$	-1500
ρ	0.4000

<i>Variables</i>	<i>Estimates</i>	<i>Standard errors</i>	<i>t values</i>
ADSL constant	1.0000	0.3000	3.3333
FTTH constant	0.4000	0.4000	1.0000
Price	-0.0009	0.0003	-3.0000
Speed	0.0250	0.0100	2.5000
IV parameter	0.7500	0.2500	3.0000

(c) Price elasticities

		<i>ADSL</i>	<i>Choice probability</i> <i>CATV</i>	<i>FTTH</i>
Price	ADSL	-0.9113	2.2950	1.6200
	CATV	1.0200	-2.2050	0.7200
	FTTH	0.9000	0.9000	-3.6000

(d) WTP for a speed up

¥28 /1Mbps

Mixed logit (ML) model

This section explains the mixed logit (ML) model, which allows for random taste variation, unrestricted substitution patterns, and correlation random terms over time (Louviere et al., 2000, ch. 6; Train, 2003, chs. 5, 6; Hensher et al., 2005, chs. 15, 16). The ML model, which can accommodate differences in covariance of random components, is also called the random parameter or random coefficients model.¹²

The ML model assumes that parameter β is distributed with density function $f(\beta)$, which is in many cases assumed to be normal.¹³ Given parameter β , the logit probability that decision-maker n chooses alternative i is expressed as

$$L_{ni}(\beta) = \frac{e^{v_{ni}(\beta)}}{\sum_{j=1}^J e^{v_{nj}(\beta)}}, \quad (4.23)$$

which is the normal logit form. Since parameters in the ML model are distributed, choice probability is a weighted average of logit probability $L_{ni}(\beta)$ evaluated at parameter β with density function $f(\beta)$ (Train, 2003, p.138). Thus the ML choice probability is given as

$$P_{ni} = \int L_{ni}(\beta) f(\beta) d\beta, \quad (4.24)$$

which is the integrals of logit probabilities over a density of parameters $f(\beta)$.

Next, we explain that the ML model can show a flexible substitution pattern. It can represent an analog to the NL model by specifying a dummy variable for each nest that equals 1 for each alternative in the nest and 0 for alternatives outside the nest. To express the K non-overlapping NL model, error components are set to $\sum_{k=1}^K \mu_{nk} d_{jk}$. Note that $d_{jk} = 1$ if the alternative is in nest k and 0 otherwise, where μ_{nk} is independently normally distributed as $N(0, \sigma_k)$. Allowing different variance σ_k for random variables in different nests is equivalent to allowing inclusive parameters to differ across nests in the NL model. We can even represent the overlapping NL model with dummy d_{jk} that identifies overlapping sets of alternatives (Ben-Akiva, Bolduc, and Walker, 2001).

The demand elasticity of the ML model is the percentage change in the ML choice probability for one alternative given a change in the k -th attribute of another alternative (Train, 2003, pp. 143–145). ML elasticity can be expressed as

$$E_{x_{kij}}^{ni} = - \left[\beta_k L_{nj}(\beta) \left[\frac{L_{ni}(\beta)}{P_{ni}} \right] f(\beta) d\beta \right], \quad (4.25)$$

where β_k is the k -th coefficient. This elasticity varies for each alternative, and the constant elasticity property is not imposed here.

Last, we can calculate the estimator of the conditional mean of the random parameters, conditioned on individually specific choice profile y_n (Revelt and Train, 2000), given as

$$h(\beta | y_n) = \frac{P(y_n | \beta) f(\beta)}{\int P(y_n | \beta) f(\beta) d\beta}. \quad (4.26)$$

We can summarize the main points as follows:

Mixed logit (ML) model

The ML model completely generalizes the CL model in the following three points: random taste variation, unrestricted substitution patterns, and correlation random terms over time. To obtain ML choice probability, however, we need to use a simulation method.

(*) *Simulation*

This subsection deals with the estimation method for the ML model. Since ML choice probability is not expressed in the closed-form, a simulation must be performed for the ML model estimation. Let θ be a deep parameter of parameter β : in other words, the mean and covariance of parameter density function $f(\beta|\theta)$. Concretely, the simulation is conducted as follows (Train, 2003, p. 148):

- Draw a value of β from $f(\beta|\theta)$ for any given value of θ R times (labeled β^r , $r = 1 \dots R$).
- Calculate logit formula probability $L_{ni}(\beta)$ with each draw.
- Average $L_{ni}(\beta)$ and calculate the simulated choice probability $\hat{P}_{ni} = \frac{1}{R} \sum_{r=1}^R L_{ni}(\beta^r)$.

This simulated choice probability $\hat{P}_{ni}$ is an unbiased estimator of P_{ni} whose variance decreases as R increases. The simulated log-likelihood (SLL) function is given as $\sum_{n=1}^N \sum_{j=1}^J d_{nj} \ln \hat{P}_{ni}$, where $d_{nj} = 1$ if decision-maker n chooses alternative j and 0 otherwise. The maximum simulated likelihood (MSL) estimator is the value of θ that maximizes this SLL function.

There are two main types of drawing methods (Train, 2003, pp. 208–239):

- Random draws: A value is drawn from a standard normal density or a uniform density. This is the most prominent method in simulation because the statistical properties of the resulting simulator are easy to derive. However, two issues are pointed out in random draw methods: first, insufficient coverage with no draws from large areas of the domain remains, and second, zero covariance over draws is heavily dependent on the number of draws. Louviere et al. (2000) suggested that 100 replications are normally sufficient for a typical problem involving 5 alternatives, 1,000 observations, and up to 10 attributes.
- Halton draws: This is defined in terms of *prime* numbers, inducing a negative correlation over observations (Halton, 1960). For example, a Halton sequence for three is created by dividing the unit interval into

three parts with breakpoints $1/3$ and $2/3$. Then each of the three segments is divided into thirds with breakpoints derived in a specific way ($1/9, 4/9, 7/9, 2/9, 5/9, 8/9$, and so on). Halton draws are reported to be more efficient than random draws; Bhat (2001) found that 100 Halton draws are more precise than 1,000 random draws for simulating an ML model.¹⁴

Example of ML model

This subsection explains the estimation results of the ML model. Note that all figures here are imaginary. We assume that the alternatives are ADSL, CATV Internet, and FTTH and that the explanatory variables are price and speed.

Since some variables are randomly distributed in the ML model, determining which variables are distributed is important. This question depends on the purpose of analysis. In what follows, we consider that two variables are distributed by the MSL method as follows:

- ADSL and CATV Internet alternatives share a common constant term that follows normal distribution. Consequently, a correlation exists between ADSL and CATV Internet, allowing for a flexible substitution pattern between them and different cross-elasticities in the choice set.
- The speed parameter is distributed normally. Consequently, diversity in preference regarding transmission speed can be demonstrated at the individual level.

The estimation result is indicated in Table 4.3(b). The explanatory variables are divided into random and non-random parameters, and mean estimates and standard deviation estimates are reported for the random parameters. The mean estimate is 1, and the standard deviation estimate is 0.7 for the ADSL/CATV Internet constant term, so that 8% of the samples have negative coefficients while 92% have positive coefficients. Similarly, the mean estimate is 0.02, and the standard deviation estimate is 0.015 for the speed parameter, so that 5% of the samples have negative coefficients while 95% have positive coefficients.

Next, ML elasticities are indicated in Table 4.3(c). Since ADSL and CATV Internet share the random common constant term, they are considered to belong to the same nest, resulting in cross-elasticities that vary across alternatives.

(*) Multinomial probit model

This subsection explains the multinomial probit (MNP) model that completely alleviates the IID assumption as the ML model.¹⁵ The MNP model, which accommodates differences in the covariance of random components, is formally equivalent to the ML model under the following conditions:

- Alternative-specific constants are random,
- No invariant characteristics produce individual heterogeneity,
- The full lower triangular (Cholesky) matrix of covariance is not restricted.

Table 4.3 Estimation result of ML model: Example

(a) Basic statistics

	<i>Choice No.</i>	<i>Choice ratio</i>	<i>Average price</i>	<i>Average speed</i>
ADSL	600	0.60	¥3,000	10Mbps
CATV	200	0.20	¥4,000	20Mbps
FTTH	200	0.20	¥5,000	100Mbps
Total	1000	1.00	¥3,600	30Mbps

(b) Estimation result

Observation No.	1000		
$LL(\beta)$	-850		
$LL(0)$	-1500		
ρ	0.4333		
<i>Variables</i>	<i>Estimates</i>	<i>Standard errors</i>	<i>t values</i>
Random parameter (mean)			
Constant	1.0000	0.3000	3.3333
Speed	0.0200	0.0100	2.0000
Random parameter (s.d.)			
Constant	0.7000	0.2500	2.8000
Speed	0.0150	0.0050	3.0000
Non-random parameter			
Price	-0.0008	0.0003	-2.6667

(c) Price elasticities

		<i>ADSL</i>	<i>Choice probability</i> <i>CATV</i>	<i>FTTH</i>
Price	ADSL	-0.9600	1.6400	1.2400
	CATV	0.8400	-2.5600	0.4400
	FTTH	1.0000	0.6000	-3.2000

(d) WTP for a speed up

¥25 /1Mbps

In this sense, the MNP model provides an alternative to the ML model (Louviere et al., 2000, pp. 199–204).

Here, let the utility function as $U_{nj} = V_{nj} + \varepsilon_{nj}$, where $\varepsilon_n = < \varepsilon_{n1}, \dots, \varepsilon_{nj} >$ are normally distributed with a mean vector of zero and covariance matrix Ω . Then the density function is given as

$$\phi(\varepsilon_n) = \frac{1}{(2\pi)^{J/2} |\Omega|^{1/2}} e^{-\frac{1}{2} \varepsilon_n' \Omega^{-1} \varepsilon_n}. \quad (4.27)$$

The MNP choice probability is given as

$$P_{ni} = \int I(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}) \phi(\varepsilon_n) d\varepsilon_n \quad (4.28)$$

where $I(\cdot)$ is an indicator function (Train, 2003, pp. 101–102). The $(J-1)$ integrals do not take a closed form, and therefore the MNP model must be estimated by a simulation method such as ML model.

RP and SP data

Since we have not so far discussed the data used in discrete choice model analysis, we introduce two kinds of data (Louviere et al., 2000, chs. 8, 9; Train, 2003, ch. 7; Hensher et al., 2005, chs. 4, 6).

The first kind is called revealed preference (RP) data, which is collected from behaviors observed in an actual market (Louviere et al., 2000, pp. 228–230). RP data, which are generally related to preferences within an existing market and technology structure, contain information about current market equilibrium for the behavior of interest and can be used to forecast short-term departures from current equilibrium. On the other hand, RP data are inflexible and inappropriate for forecasting a market other than a historical one. Now we summarize the characteristics of RP data as follows (Louviere et al., 2000, pp. 23–24):

- RP data depict the current market equilibrium.
- RP data process fixed technological constraints.
- RP data have existing alternatives as observables.
- RP data embody market and personal constraints of the decision-maker.
- RP data have high reliability and face validity.
- RP data yield one observation per decision-maker at each observation point.

The second kind is called stated preference (SP) data, which are more useful for forecasting changes in consumer behaviors, but may be affected by the degree of *contextual realism* for respondents (Louviere et al., 2000, pp. 230–231). SP data, which can capture a wider and broader array of preference-driven

behaviors than RP data, are rich in attribute tradeoff information because wider attribute ranges can be built into experiments. On the other hand, SP data are hypothetical and experience difficulty taking into account certain types of real market constraints; hence, SP-derived models may not predict existing-specific constants well. SP-derived models may be more appropriate to predict structural changes that occur over longer time periods. We summarize the characteristics of SP data as follows (Louviere et al., 2000, pp. 23–24):

- SP data describe hypothetical or virtual decision contexts.
- SP data permit mapping of utility functions with technologies different from existing ones.
- SP data can include both labeled and unlabeled alternatives.
- SP data may effectively fail to capture changes in market and personal constraints.
- SP data are reliable when decision-makers understand the tasks to which they are committed.
- SP data yield multiple observations per respondent at each observation point.

Note that at this point we are not discussing the superiority of either RP or SP data. They both have advantages and disadvantages. In this respect, they can be used complementarily. We can summarize the main points as follows:

RP and SP data

Two kinds of data are usually used in discrete choice model analysis. RP data are based on revealed preferences observed from actual choices in markets. SP data are derived from hypothetical experiments. The former is suited for explaining the current status or forecasting short-term transition, while the latter can deal with long-term changes of technology or utilities.

(*) Combining RP and SP data

This subsection explains a method that combines RP and SP data. RP data have strength because they reflect the actual preferences of decision-makers, but they are weak as explanatory variables because RP data have little variability and are often highly collinear. The motivation for combining RP and SP data lies in the fact that SP data help identify parameters that RP data cannot, so more efficient and stable estimates can be obtained.¹⁶ The process of Swait and Louviere (1993) combined two data if they have identical model

parameters for common attributes. This tests the hypothesis that parameters are equal between RP and SP data models, controlling scale differences between the data sets as follows (Louviere et al., 2000, pp. 244):

- Separately estimate the models for the RP and SP data. Let the corresponding log-likelihood functions be $LL(RP)$ for the RP data and $LL(SP)$ for the SP data.
- Estimate the model for the pooled data. Let the corresponding log-likelihood functions be $LL(RP+SP)$.
- Calculate the χ^2 chi-squared statistic for the hypothesis that common utility parameters β are equal based on $-2[(LL(RP) + LL(SP)) - LL(RP + SP)]$. This value is asymptotically χ^2 chi-squared distributed with $|\beta| - 1$ degrees of freedom, where $|\beta|$ is the number of parameters.

For example, Table 4.1 reports $LL(RP) = -1000$ for RP data. Suppose here $LL(SP) = -900$ for SP data and $LL(RP+SP) = -1896$ for the pooled data. Then the test statistic for parameter equality is eight. Due to $\chi^2(d.f. = 4, p = 0.05) = 9.49$, the hypothesis that parameter estimates are equal between the RP and SP data models is not rejected. Thus, we may combine the RP and SP data into the pooled data.

Conjoint analysis

In this section, we discuss conjoint analysis, a powerful method to obtain SP data (Louviere et al., 2000, chs. 4, 5, and 7; Hensher et al., 2005, chs. 4, 5, and 6). Conjoint analysis uses an experiment in which decision-makers rank or rate each profile, and in the experimental design setting, manipulated variables are called *attributes* (factors), manipulated values are called *attribute levels* (factor levels), and each combination of attribute levels is a *profile* (Louviere et al., 2000, pp. 83–84).

The experimental design process can be depicted as follows (Hensher et al., 2005, pp. 100–102):

- 1 Problem refinements,
- 2 Stimuli refinements,
 - Alternative identification,
 - Attribute identification,
 - Attribute level identification.
- 3 Experimental design consideration,
 - Types of design,
 - Model specifications,
 - Reduction of experimental size.
- 4 Generate experimental design,

- 5 Allocate attributes to design columns,
 - Main effect vs. Interactive.
- 6 Generate choice sets,
- 7 Randomize choice sets,
- 8 Construct survey instrument.

Among those steps, Step 3 is the most important. Full factorial design is a method enumerating all possible profiles. Assume that broadband services have two attributes, *price* and *speed*, and that each attribute has three levels, *low*(*L*), *medium*(*M*), and *high*(*H*). Full factorial design leads to the following nine combinations of price and speed levels:

[L,L] [L,M] [L,H] [M,L] [M,M] [M,H] [H,L] [H,M] [H,H].

Coding format assigns a unique number to each attribute level. There are two kinds of coding formats. First, design coding assigns values 0, 1, or 2 for three levels. Second, orthogonal coding assigns values -1, 0, or 1 for three levels such that all values for a given attribute equal 0. Table 4.4 summarizes attribute levels, design coding, and orthogonal coding in the full functional design.

Next, we can let the experiment be either unlabeled or labeled. First, in the unlabeled experiment, the title, such as alternatives 1 or 2, does not convey any information to the decision-makers, while in the labeled experiment, such titles as ADSL or FTTH offer clear meaning for the decision-makers. In general, when interested in prediction and forecasting, a labeled experiment is preferred. On the other hand, when focusing on WTP for a specific attribute, an unlabeled experiment is desirable. Table 4.5 indicates an example of labeled and unlabeled experiments.

Finally, two formulas are available for selecting a model (Louviere et al., 2000, p. 94; Hensher et al., 2005, p. 116). First, the main effect model only

Table 4.4 Full factorial design and coding

Profile	Attribute level		Design coding		Orthogonal coding	
	Price	Speed	Price	Speed	Price	Speed
1	L	L	0	0	-1	-1
2	L	M	0	1	-1	0
3	L	H	0	2	-1	1
4	M	L	1	0	0	-1
5	M	M	1	1	0	0
6	M	H	1	2	0	1
7	H	L	2	0	1	-1
8	H	M	2	1	1	0
9	H	H	2	2	1	1

Table 4.5 Unlabeled experiment vs. labeled experiment

	<i>Alternative 1</i>		<i>Alternative 2</i>	
	<i>Price</i>	<i>Speed</i>	<i>Price</i>	<i>Speed</i>
Unlabeled experiment				
Profile	¥3,000	12Mbps	¥5,000	100Mbps
Labeled experiment				
Profile	¥3,000	12Mbps	¥5,000	100Mbps

considers the direct and independent effect of each attribute (ie price, speed) on the response variable (ie ADSL, FTTH). Second, on the other hand, the interaction effect model takes into account indirect effects obtained by combining two or more attributes (ie price*speed) as well as the main effects. On this point, Dawes and Corrigan (1974) show that alienating interaction effects with main effects may be justified because main effects typically account for 70% to 90% of explained variance; two-way interaction effects and high-order interaction effects account for the remaining explained variance. We can summarize the main points as follows:

Conjoint analysis

Conjoint analysis is frequently used among SP data models. Since conjoint analysis allows for flexible experimental design, it is free from the actual restrictions based on hypothetical setting.

(*) Orthogonal factorial design

This subsection explains how to decrease the redundancy of profiles. Carson et al. (1994) reports that many experiments have successfully employed more than 32 profiles; however, task complexity increases for respondents by number of attributes and attribute levels; therefore, if there are more than 10 attributes, we must reduce the number of profiles.

The full enumeration of possible choice sets equals L^{MA} for a labeled experiment and L^A for an unlabeled experiment, where L is the number of levels, M is the number of alternatives, and A is the number of attributes (Hensher et al., 2005, pp. 112–116). Taking an example from broadband service choice with two alternatives, three levels, and two attributes, the number is $3^{2*2}=81$ for the labeled experiment and $3^2=9$ for the unlabeled experiment. To reduce the size of the full factorial designs, especially for labeled experiments, we should only use

a fraction of the total number of profiles. Orthogonal factorial designs are useful because the statistically desirable feature of zero correlations holds between explanatory variables. Orthogonality is a mathematical constraint that makes all attributes statistically independent of one another, where parameters are likely to be correctly estimated and of correct signs.

(*) Degree of freedom

Last, we briefly refer to the degree of freedom. The degree of freedom required for an experiment can be calculated as the number of observations in a sample minus the number of parameters to be estimated (namely, independent constraints placed in a model) (Hensher et al., 2005, p. 122). Taking an example from the broadband service choice with two alternatives and two attributes, there are four alternative-specific parameters (namely, price and speed parameters for ADSL and FTTH). Hence, an additional degree of freedom is required, and at least five degrees of freedom are required. To sum up, minimum profile requirements for the main effect model are $MA + 1$ for labeled orthogonal factorial designs and $A + 1$ for unlabeled orthogonal factorial designs, where M is the number of alternatives and A is the number of attributes.

Conclusion

The recent development of micro-econometrics is remarkable, especially discrete choice model analysis. The CL model is the most basic. However, since the IID assumption is too restrictive to allow flexible substitution patterns among alternatives, generalizations of the IID assumption have been proposed. The most successful is the NL model, which partitions the choice set into subsets called nests. Furthermore, the ML model is very promising because it completely allows for flexible substitution patterns or variety in preferences at individual levels. The data used in discrete choice model analysis are either revealed or stated. Conjoint analysis is very useful to collect SP data. Using RP and SP data for different purposes is important as is occasionally combining them.

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Part II

The current status of Japan's broadband

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5 Fixed-line broadband: From ADSL to FTTH

This chapter will consider the structure of the fixed-line broadband market during the initial period of deployment, including observations based on econometric analysis. Fixed-line broadband began its explosive growth in Japan in 2001 when Softbank BB entered the market. Today, there are clear indications of a full-scale rollout of fiber to the home (FTTH) services, so it is widely believed that ADSL will be superseded by FTTH in the not-too-distant future. In this chapter I will consider fixed-line broadband from the following four points. First, citing data, I will examine the supply-side structure of fixed-line broadband. Taking up ADSL, FTTH, and CATV Internet in turn, I will examine trends in the number of subscribers, market shares, and price levels of each type of service. Second, I will consider the broadband user demand structure, based on a consumer questionnaire. I will examine peoples' objectives in using the Internet, their reasons for selecting a particular service provider, and how and why they migrated from narrowband to broadband and from ADSL to FTTH Internet services. Third, I conduct a discrete choice model analysis based on the consumer questionnaire data. First, I will measure demand substitutability using actual revealed preferences (RP) data, focusing on the degree of price elasticity for the various services. Next, I consider the amount people claim they would be willing to pay for faster throughput using hypothetical choice situations and stated preferences (SP) data. Here, I focus on how the actual availability of FTTH affects consumers' preferences. Fourth, I will address policy-related issues now under discussion including the definition of broadband markets, the state of effective competition in the ADSL market, and the degree of market dominance over the FTTH market.

Analysis of fixed-line broadband supply

Table 2.4 in Chapter 2 displayed the number of subscribers to different broadband services. This section analyzes broadband supply-side trends for each service. Today, the majority of broadband subscribers receive service over ADSL connections, followed by FTTH, then CATV Internet. When broadband first started to take hold in Japan around the year 2000, CATV

Internet predominated. But then with the widespread popularity and rapid penetration of ADSL in 2002, people quickly came to associate ADSL with broadband. More recently, FTTH has begun to cut into ADSL's market share, and especially in the cities where there is already little difference in price, we can anticipate that FTTH will supersede ADSL over the next few years. Given these extreme changes in the broadband sphere, it is not surprising that supply trend fluctuations have also been striking. Now I take a closer look at ADSL, FTTH, and CATV Internet in turn and examine recent developments involving these services.

ADSL supply analysis

Table 5.1(a) shows the change in the number of ADSL subscribers from 2001 to 2007. ADSL saw a full-scale rollout in 2002 and experienced steady continuous growth until the number of lines exceeded 10 million in 2004. But examining the figures a little closer in half-year increments we see that the greatest growth was achieved in the latter half of 2002 when 2.8 million connections were added, but that the growth rate had slowed to only 880 thousand new lines added by second half of 2004. By then, the ADSL market had matured and was largely saturated. And now that FTTH services are becoming available, we might expect the demand for ADSL to change from a net increase to a net decrease if there is a major shift from ADSL to FTTH. These trends well convey the intensity of ongoing change and dynamism of the broadband market.

Table 5.1(b) shows the changes in market share among Japanese providers of ADSL services from 2002 to 2007. The providers lease lines from NTT East and West in a line-sharing arrangement, and market the ADSL services to end-users. In other words, the services are close to 100% dependent on NTT's infrastructure, but NTT East and West have less than 50% share of the ADSL market between them. NTT did not share in the initial period of rapid ADSL penetration from 2002 to 2003—in fact, the company's share of the market slipped from 40% to 30%—so it is apparent that the explosive growth during this period was driven not by NTT but by the nondominant competing carriers. Eventually, after 2004, NTT's share of the market stabilized around the mid 30% range. Essentially, the ADSL market reached maturity through fierce competition between NTT and the competing providers until the urban areas were largely saturated, and now the battle for market share has shifted from the cities to the countryside. The competing carriers have shown much less interest in the rural areas where the demand density is so low, so by exploiting its ability to provision services nationwide, NTT's market share rebounded somewhat of its own accord.

Now let us consider the competitive situation among providers a little more closely. Table 5.2 shows the number of ADSL subscribers broken down by provider in March 2007. NTT East and West have the largest share of 38%, but Softbank is a close second with 37% share of the ADSL market. The two

Table 5.1 ADSL market trends

	2001.3	2001.9	2002.3	2002.9	2003.3	2003.9	2004.3	2004.9	2005.3	2005.9	2006.3	2006.9	2007.3
(a) Change in ADSL subscribers													
NTT East	n.a.	n.a.	0.5	0.9	1.4	1.9	2.3	2.6	2.8	2.6	3.0	2.9	2.8
NTT West	n.a.	n.a.	0.5	0.8	1.1	1.5	1.8	2.1	2.4	3.0	2.7	2.6	2.5
Others	n.a.	n.a.	1.4	2.5	4.5	5.8	7.1	8.1	8.5	8.7	8.9	8.9	8.7
Total	0.1	0.7	2.4	4.2	7.0	9.2	11.2	12.8	13.7	14.3	14.5	14.4	14.0
(b) Changes in market share among ADSL providers													
NTT East			24.1%	22.2%	20.4%	20.8%	20.4%	20.5%	20.7%	20.8%	20.4%	20.2%	19.9%
NTT West			21.4%	18.7%	16.1%	16.6%	16.1%	16.6%	17.4%	18.2%	18.4%	18.3%	18.1%
Others			54.5%	59.1%	63.5%	62.6%	63.5%	62.9%	61.9%	61.0%	61.2%	61.5%	62.0%
Total			100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Figures are millions.

Source: MIC (2007).

leaders are followed by eAccess and ACCA Networks, so Japan's ADSL market is essentially an oligopolistic structure dominated by these four companies. A kind of polarized structure has emerged with Softbank and other competing carriers maintaining a competitive advantage in the cities through aggressive price competition, and NTT East and West having a competitive edge in rural areas because the competing carriers have shown only passive interest in these areas. While the market is an oligopoly, there is nevertheless fierce competition for customers among the big four. Competition is clearly working very effectively in this market as the service providers woo consumers with free service promotional campaigns, faster throughput speeds, and other service improvements.

Next, let us take a closer look at the actual substance of the ADSL services. A low-speed version of ADSL was first made available about the year 2000, which supported a download rate of about 1.5 Mbps. This was followed by intermediate-speed services with throughputs of 8 Mbps and 12 Mbps, and it was these offerings that sparked the rapid growth of ADSL in 2002. ADSL speeds have continued to accelerate, most recently from 40 Mbps to 50 Mbps. Note however that the Internet supports best-effort services, so actual speed diminishes the further the user is from the telephone exchange. Table 5.3 shows the number of ADSL subscriber lines broken down by download speed. First, one will observe the relatively small number of users who subscribe to the low-speed ADSL services. These are mostly people who do not use the Internet very much or people who live in rural areas where high-speed ADSL is not available. Second, one can see that the intermediate-speed services are the most popular, constituting 58% of the ADSL market. Many of these users signed up for nominally higher speed services, but because of freezes and congestion and other problems, the actual performance was slower, which moved them into the intermediate-speed category. Third, despite the difficulty of reaching nominal speeds, the number of high-speed ADSL lines has steadily increased. This means that some users will always opt for the highest speed service that is available, migrating from low-speed ADSL to intermediate-, then high-speed ADSL, and finally to FTTH.

Table 5.4 shows a comparison of ADSL rates charged by NTT East and by Softbank. Note that NTT East's line connection and ISP services are not vertically integrated so ISP charges are not included in these figures, while Softbank's line connection and ISP services are vertically integrated so the ISP charges are included in Softbank's figures. In other words, ISP charges of ¥500 to ¥2,000 must be added to NTT East's rates in order to make the figures comparable. When NTT's figures are adjusted, it is apparent that Softbank's charges are substantially less than NTT's. Before Softbank, ADSL service cost about ¥5,000 a month, but then Softbank entered the market offering ADSL services for less than half that amount. Softbank also radically increased consumer awareness of ADSL with a marketing strategy of selling services from local stores, which contrasted sharply with NTT's approach. It is no exaggeration to say that Softbank single-handedly brought

Table 5.2 Number of ADSL subscribers by provider

	<i>Softbank</i>	<i>NTT East</i>	<i>NTT West</i>	<i>a Access</i>	<i>ACCA</i>	<i>Others</i>	<i>Total</i>
No. of contracts	5.3	2.9	2.6	2.0	1.1	0.5	14.4
Market shares	36.8%	19.9%	18.1%	13.7%	7.8%	3.7%	100%

Note: Figures are millions, as of March 2007.

Source: MIC (2007).

Table 5.3 Number of ADSL subscriber lines by download speed

	2004.3	2004.9	2004.12
Low-speed (Around 1.5Mbps)	1.7	1.9	2.0
Medium-speed (Around 8–12Mbps)	7.7	7.8	7.8
High-speed (24Mbps and over)	1.8	3.1	3.6

Note: Figures are millions.

Source: MIC (2007).

about the explosive growth of ADSL in Japan. Nor must we overlook the fact that it was the Ministry of Internal Affairs and Communications' (MIC) competition policy of permitting new entrants to access NTT lines at relatively low cost that enabled this to happen. Given the substantial difference in price, it is surprising that NTT has been able to hold onto roughly the same share of market as Softbank. Demand analysis distinguishes two very different groups of users: the group gravitating to Softbank is primarily concerned with price, while the group that stayed with NTT is more concerned with brand recognition and stability. We summarize the main points as follows:

ADSL supply analysis

ADSL, which accounts for more than half of Japan's broadband lines, spread very rapidly beginning around 2002 as a result of Softbank's aggressive price-slashing strategy. The current ADSL market is an oligopoly dominated by four companies, with NTT and Softbank almost tied for largest market shares. However, there are clear indications that the ADSL market has reached maturity, and it is likely that ADSL will be superseded by FTTH in the not-too-distant future.

FTTH supply analysis

Table 5.5(a) shows the change in number of FTTH subscriber lines from 2002 to 2007. While the uptake of FTTH could not be described as explosive, the number of lines has steadily increased over the period. By 2004, the number of lines had exceeded 2 million, approximately on a par with CATV Internet. Even at this scale, Japan is the only country with such a robust and growing FTTH market. Having all the genuine attributes of true broadband—enormous capacity, ultrahigh speed, symmetrical upload and download throughputs—FTTH is the ultimate fixed-line broadband topology, and will certainly converge with mobile services in the near future.

Table 5.5(b) shows the change in market share among providers of FTTH services from 2002 to 2007. In 2002, when FTTH services first became available in Japan, NTT East and West had a very modest share of the market

Table 5.4 Comparison of ADSL rates

		2001 1st	2001 2nd	2002 1st	2002 2nd	2003 1st	2003 2nd	2004 1st	2004 2nd
NTT East	Speed	1.5Mbps	8Mbps		12Mbps		24Mbps	40Mbps	47Mbps
	Price	¥4,050	¥3,100		¥3,200		¥2,750	¥2,750	¥2,800
Note: Figures do not include payment for Internet service providers.									
Softbank BB	Speed		8Mbps		12Mbps		26Mbps	45Mbps	50Mbps
	Price		¥2,280		¥2,480		¥2,680	¥2,780	¥2,780

Note: Figures include ISP charges.

Source: MIC (2007).

while the competing carriers had the predominant share. In other words, initially, NTT East and West were not dominant incumbent providers in the FTTH sector. However, subsequently, NTT greatly extended its share, so that by September 2004, NTT East and West had captured 60% of the FTTH market. NTT is thus the central driving force in the recent rapid penetration of FTTH. The competing carriers can be divided into two camps: the power company operators who deliver FTTH services over their own optical fiber facilities, and the other operators who provide FTTH services over fiber lines leased from NTT. The former are referred to as *facilities-based competing operators*, and the latter are called *service-based competing operators*. When the power company operators take customers away from NTT East and West, this creates a class of users that does not use NTT's facilities at all, so NTT loses all income from these customers, including wholesale and retail revenues. It is clear that the power companies, with financial resources and brand recognition on a par with NTT, will emerge as NTT's most formidable rivals in the years ahead. Currently, the power companies have less than 10% share of the market, but this reflects the stalwart efforts of just a handful of utilities including Kansai Electric Power and Kyushu Electric Power. As other utilities enter and capture shares of the market, the power companies will assume a far greater presence in the FTTH market in the future.¹

Table 5.6 shows a comparison of FTTH rates charged by the main FTTH service providers. Note that the figures for NTT East and West do not include ISP charges, while the figures for K-Opticom and USEN do include the ISP charges. This means that ISP charges of ¥500 to ¥2,000 must be added to NTT's rates to make the figures comparable. One can see that, as a result of competition, FTTH service charges have steadily declined. It is important to note that this price competition does not only involve FTTH, but also directly competes with the price of ADSL services. For example, in cities, subscribers pay a total of ¥4,500 a month for NTT's ADSL service when including a plain basic telephone minimum charge of ¥1,500 to ¥1,700. Meanwhile, single-family residential subscribers pay about that same amount (¥4,500) and condominium residents pay even less for NTT's FTTH service, since they can cancel the fixed-line charges by signing up for Voice over Internet Protocol (VoIP) telephone with 0ABJ number portability. At least in the cities, price is no longer an obstacle to upgrading from ADSL to FTTH service.

So far, we have not distinguished between FTTH services for single-family residences (detached house-type) and businesses on the one hand and FTTH services for multi-dwelling units (Mdialup, or apartment-type) on the other. Table 5.7 shows the change in the number of single-family and business FTTH subscribers, and Table 5.8 shows the change in the number of multi-dwelling unit FTTH subscribers. Comparing Tables 5.7(a) and 5.8(a), one can see that more fiber lines are being deployed to single-family homes and businesses than to multi-dwelling units. The lag in line deployments to Mdialups is attributed to the difficulty of working out arrangements among the different people living in Mdialup complexes (say if some residents want FTTH

Table 5.5 FTTH market trends

	2002.3	2002.9	2003.3	2003.9	2004.3	2004.9	2005.3	2005.9	2006.3	2006.9	2007.3
(a) Change in number of FTTH subscribers											
NTT East	n.a.	0.05	0.11	0.25	0.43	0.63	0.89	1.30	1.89	2.60	3.40
NTT West	n.a.	0.02	0.09	0.25	0.41	0.58	0.78	1.05	1.53	2.12	2.68
Power Company	n.a.	0.03	0.06	0.10	0.18	0.27	0.48	0.66	0.86	1.07	0.92
USEN	n.a.	0.02	0.06	0.10	0.14	0.19	0.28	0.38	0.47	0.52	0.55
Others	n.a.	0.07	0.11	0.16	0.29	0.35	0.47	0.59	0.70	0.84	1.27
Total	0.07	0.19	0.42	0.86	1.45	2.03	2.90	3.98	5.46	7.16	8.80
(b) Change in market share among FTTH providers											
NTT East		27.1%	26.4%	28.9%	29.4%	31.1%	30.6%	32.7%	34.6%	36.4%	38.6%
NTT West		10.1%	20.9%	28.8%	28.5%	28.7%	26.9%	26.5%	28.0%	29.6%	30.4%
Power Company		15.2%	13.7%	12.2%	12.1%	13.4%	16.5%	16.5%	15.8%	15.0%	10.4%
USEN		11.7%	13.1%	11.3%	9.9%	9.5%	9.7%	9.5%	8.7%	7.3%	6.2%
Others		35.9%	25.9%	18.9%	20.1%	17.3%	16.4%	14.8%	12.9%	11.7%	14.4%
Total		100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Figures are millions.

Source: MIC (2007).

Table 5.6 Comparison of FTTH rates

	2nd of 2001	1st of 2002	2nd of 2002	1st of 2003	2nd of 2003	1st of 2004	2nd of 2004	1st of 2005
NTT East	Detached house-type	¥5,000						¥4,100
	Apartment-type	¥3,800	¥3,500	¥4,500			¥2,900	

Note: Figure do not include ISP charges.

Source: MIC (2007).

while others do not), additional problems installing fiber in Mdialups, and other factors. What is most interesting here is the market shares of these sectors held by the different service providers. Table 5.7(b) shows the market shares of the different operators for FTTH services to single-family homes and businesses. As of March 2007, NTT East and West had a 79% share of this market, and the power company providers were trailing far behind with only 13% share of the market. NTT is thus overwhelmingly dominant in the market to provide FTTH services to single-family homes and businesses. Now turning to Table 5.8(b), this shows the market shares of different operators to provide FTTH services to Mdialups. In this market, NTT had less than 60% share as of March 2007, though the figure is rapidly increasing. It will be apparent that, in discussing market dominance in provisioning FTTH services, it is necessary to differentiate the single-family home and business market from the Mdialup market. We summarize the main points as follows:

FTTH supply analysis

NTT East and West control a commanding share of the FTTH market. A few of the power company providers have made a good effort to get into the FTTH market, but so far they have not evolved into a truly countervailing force. Interestingly, NTT's share of the market to supply FTTH services to Mdialups is far less than its share of the market to provide FTTH services to single-family homes and businesses. The cost of FTTH services is not markedly higher than other alternative services, so a rapid migration from ADSL to FTTH services is anticipated.

CATV Internet supply analysis

Table 5.9 shows the change in the number of CATV Internet connections from 2002 to 2007. A lot of people signed up for CATV Internet when broadband first became available, but growth has been very modest since ADSL and FTTH services were rolled out. The fact that CATV Internet has played such a modest role in Japan compared with other countries distinguishes Japan's broadband deployment. In Japan there are more than 300 CATV Internet service providers, most of which are local companies. Most of these service providers offer throughputs of around 30 Mbps on a best-effort basis for a basic charge of about ¥5,000 a month, which is relatively expensive compared to the cost of ADSL service. A key issue is how these CATV Internet operators will be able to maintain their unique identity in the face of explosive ADSL growth and full-scale rollout of FTTH services. One radically different approach that deserves close attention is that of Jupiter Telecommunications (J-COM), which is growing very rapidly by taking equity stakes in other cable companies and by providing value-added capabilities to

Table 5.7 Detached house-type FTTH market trends

	2003.9	2004.3	2004.9	2005.3	2005.9	2006.3	2006.9	2007.3
(a) Change in number of detached house-type FTTH subscribers								
NTT East	0.19	0.32	0.46	0.61	0.85	1.19	1.57	2.03
NTT West	0.22	0.35	0.48	0.62	0.80	1.14	1.54	1.88
Power Company	0.08	0.12	0.20	0.37	0.52	0.69	0.86	0.67
Others	0.01	0.02	0.02	0.02	0.06	0.11	0.13	0.43
Total	0.50	0.83	1.18	1.64	2.26	3.13	4.09	5.01
(b) Change in market share among detached house-type FTTH providers								
NTT East	39%	39%	39%	37%	38%	38%	38%	41%
NTT West	43%	43%	41%	38%	35%	36%	38%	38%
Power Company	16%	15%	17%	22%	23%	22%	21%	13%
Others	3%	4%	3%	3%	4%	4%	3%	9%
Total	100%	100%	100%	100%	100%	100%	100%	100%

Note: Figures are millions.

Source: MIC (2007).

Table 5.8 Apartment-type FTTH market trends

	2003.9	2004.3	2004.9	2005.3	2005.9	2006.3	2006.9	2007.3
(a) Change in number of apartment-type FTTH subscribers								
NTT East	0.05	0.10	0.17	0.28	0.44	0.70	1.03	1.37
NTT West	0.03	0.06	0.10	0.16	0.26	0.39	0.58	0.79
USEN	0.09	0.13	0.17	0.26	0.35	0.44	0.49	0.51
Power Company	0.03	0.06	0.08	0.10	0.13	0.17	0.21	0.20
KDDI	0.01	0.04	0.07	0.09	0.13	0.16	0.15	0.28
Others	0.15	0.24	0.29	0.37	0.4	0.46	0.59	0.64
Total	0.36	0.62	0.88	1.26	1.72	2.33	3.06	3.79
(b) Change in market share among apartment-type FTTH providers								
NTT East	15.1%	16.4%	19.7%	22.2%	25.6%	30.1%	33.8%	36.1%
NTT West	8.7%	9.8%	11.4%	12.9%	15.0%	16.7%	18.8%	20.8%
USEN	23.8%	20.3%	19.4%	20.3%	20.1%	19.1%	16.0%	13.5%
Power Company	7.6%	8.8%	8.5%	8.1%	7.8%	7.3%	7.0%	5.4%
KDDI	3.4%	5.8%	7.9%	7.2%	7.8%	7.0%	5.0%	7.3%
Others	30.0%	34.4%	33.0%	30.1%	26.1%	19.8%	19.4%	16.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note: Figures are millions.

Source: MIC (2007).

existing fixed-line telephony and Internet connection services. We summarize the main points as follows:

CATV Internet supply analysis

The relative proportion of CATV Internet compared with other kinds of connections is declining. There are many providers of this kind of service, and most are small-scale. The CATV Internet providers are also mostly local operators, and there is a question as to how they will maintain their unique identity in competition with other services.

Demand analysis of fixed-line broadband

This section analyzes the demand for access to Internet by using a discrete choice model. The survey was carried out as a Web questionnaire and a representative sample was randomly chosen from households with all five Internet access alternatives. The total number of respondents is 1,013 and the draw of samples reflects national population densities.

Basic statistics of survey

In the following we explain the basic descriptive statistics and the data collected by a series of surveys of Internet access demand for private use conducted according to *The Effective Competition Review of Japan's Telecommunications*, published in June 2004 by the MIC.

Table 5.10 gives the reasons for using the Internet (note: multiple answers are permitted here): (1) Web browsing (44.7%); (2) email (34.9%); (3) online shopping (5.5%); (4) online chat and bulletin boards (4.2%). We observe that the main reasons for using the Internet are still confined to such basic uses as Web and email, and users fail to handle advanced functions. Table 5.11 next shows the reasons for choosing their present Internet access line service provider: (1) low price (44.4%); (2) brand power (23.0%); (3) transmission speed (22.7%); and such miscellaneous reasons as service reliability and using IP telephone, watching cable TV. Therefore, the three important factors for determining providers are price, brand power, and service quality.

Table 5.12(a) shows the selection ratio of the currently using Internet access services. Selection ratios follow: dialup (2%), ISDN (5%), ADSL (67%), FTTH (8%), and CATV Internet (18%). The figure for narrowband Internet access services including dialup and ISDN is low (7.3%), while it is overwhelmingly high (92.7%) for broadband Internet access services composed of ADSL, CATV Internet, and FTTH. As seen in Table 5.12(b), the national ratio of narrowband users is 65%, while it is 35% for broadband users as of September 2003, therefore the overwhelming share of broadband

Table 5.9 CATV Internet market trends

	2002.3	2002.9	2003.3	2003.9	2004.3	2004.9	2005.3	2006.3	2006.9	2007.3
CATV Internet subscribers	1.5	1.8	2.1	2.3	2.6	2.8	3.0	3.3	3.5	3.6
No. of CATV Internet providers	252	274	282	304	307	347	372	377	382	n.a.

Note: Figures are millions.

Source: MIC (2007).

Table 5.10 Reasons for using the Internet

<i>Web browsing</i>	<i>Email</i>	<i>Online shopping</i>	<i>Online chat</i>	<i>Online banking</i>	<i>Game</i>
44.7%	34.9%	5.5%	4.2%	3.6%	3.0%

Note: Multiple answers are permitted.

Source: MIC (2004).

Table 5.11 Reasons for choosing Internet access provider

<i>Low price</i>	<i>Brand power</i>	<i>Transmission speed</i>	<i>Service reliability</i>	<i>IP telephone</i>
44.4%	23.0%	22.7%	17.9%	14.0%

Note: Multiple answers are permitted.

Source: MIC (2004).

Table 5.12 Selection ratio of Internet access services

	<i>Dialup</i>	<i>ISDN</i>	<i>ADSL</i>	<i>FTTH</i>	<i>CATV</i>	<i>Total</i>
(a) Ratio of this survey						
No. of samples	18	40	534	66	141	799
Selection ratio	2.3%	5.0%	66.8%	8.3%	17.6%	100%

(b) Ratio of national average (as of 2003.9)

Selection ratio	61%	4%	27%	2%	6%	100%
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Source: MIC (2004).

is no doubt due to the bias coming from the Web survey. However, as far as broadband users is concerned, the breakdown of 72%(ADSL) : 9%(CATV) : 19%(FTTH) in our survey corresponds to 77%(ADSL) : 6%(CATV) : 17%(FTTH) very well. Thus, this survey can apply for the broadband demand investigation.

Table 5.13 indicates basic statistics. Average monthly expenditures, defined as the sum of connection fees and ISP charges are shown as follows: dialup: ¥3946 (\$35.9), ISDN: ¥5207 (\$47.3), ADSL: ¥4344 (\$39.5), FTTH: ¥5929 (\$54.1), and CATV: ¥5200 (\$47.3). Narrowband services are not always cheaper than broadband services because their charges are usage sensitive while broadband are flat. Among broadband services, FTTH is the most expensive while ADSL is the cheapest, as obviously expected. Average nominal access speeds are shown as follows: dialup: 52 Kbps, ISDN: 65 Kbps, ADSL: 10 Mbps, FTTH: 82 Mbps, and CATV: 11 Mbps. A huge gap exists between narrowband and broadband services as well as differences among broadband services (ADSL, CATV, and FTTH) concerning nominal access speed. We summarize the main points as follows:

Table 5.13 Basic statistics

<i>Dialup</i>	<i>ISDN</i>	<i>ADSL</i>	<i>FTTH</i>	<i>CATV</i>
(a) Average monthly price (Internet access line charge + ISP charge)				
¥3,946	¥5,208	¥4,344	¥5,929	¥5,199
(b) Average nominal speed				
52Kbps	65Kbps	10Mbps	82Mbps	11Mbps
(c) Average effective speed				
37Kbps	58Kbps	2Mbps	9Mbps	3Mbps

Source: MIC(2004)

Broadband users survey

Most broadband users are still confined to using basic services including Web browsing and email. Price is the most important factor when choosing an Internet access service, reflecting the fact that the majority of the current broadband users are subscribing to ADSL.

Demand substitutability of broadband services

This subsection explores the demand substitutability of broadband services based on the demand survey. Table 5.14 shows the reasons for choosing their present Internet access service: (1) always-on connectivity (55.9%); (2) a flat rate system (41.0%); (3) low prices (31.7%); (4) transmission speed (25.7%); and such miscellaneous reasons as easy introduction, no-charge campaigns, IP telephony, and CATV service. Looking closely at each service, always-on connectivity and flat rate system rank higher for ADSL and CATV, which is a general feature of broadband service compared to narrowband services. For FTTH, transmission speed ranks top, followed by always-on connectivity and flat rate system. Accordingly, we can consider that ADSL and CATV Internet are entry services for broadband and FTTH is an exit to which ADSL and CATV Internet users migrate.

Table 5.15 shows access line services to which they subscribed before moving to the currently using services. It is observed that most users migrated from dialup, ISDN, CATV Internet to ADSL. And ADSL users are gradually moving to FTTH. In this respect, ADSL is an entry to broadband service and FTTH is the exit.

Last, Table 5.16 indicates access line services that they want to use one year later. Users of dialup, ISDN, and ADSL services reply that they will use

Table 5.14 Reasons for choosing Internet access service

	<i>Always-on</i>	<i>Flat rate</i>	<i>Low prices</i>	<i>Transmission speed</i>	<i>No-charge campaigns</i>
(a) Total	55.9%	41.0%	31.7%	25.7%	9.3%
(b) ADSL	64.8%	40.2%	29.3%	7.0%	30.5%
(c) FTTH	72.4%	35.2%	20.0%	20.0%	11.4%
(d) CATV	64.7%	36.6%	26.8%	17.0%	16.3%

Note: Multiple answers permitted.

Source: MIC (2004).

Table 5.15 Previously subscribed access line services

Before	After		
(a) Dialup (547 cases)	ADSL	CATV	ISDN
	63%	14%	13%
(b) ISDN (163 cases)	ADSL	FTTH	CATV
	77%	15%	6%
(c) ADSL (43 cases)	FTTH	CATV	
	79%	14%	
(d) CATV (30 cases)	ADSL	FTTH	
	63%	37%	
(e) FTTH (3cases)	ADSL	Dialup	
	67%	33%	

Source: MIC (2004).

ADSL, but it is important that FTTH ranks second in ISDN and ADSL and top in CATV Internet. To sum up, most narrowband users will gradually migrate to entry broadband services such as ADSL and CATV Internet and finally to FTTH. We summarize the main points as follows:

Table 5.16 Access line services to use one year

<i>Before</i>	<i>After</i>		
	ADSL	Dialup	FTTH
(a) Dialup	29%	25%	13%
	ADSL	FTTH	ISDN
(b) ISDN	30%	23%	20%
	ADSL	FTTH	CATV
(c) ADSL	37%	34%	11%
	FTTH	ADSL	
(d) CATV	35%	29%	
	FTTH		
(e) FTTH	61%		

Source: MIC (2004).

Broadband demand substitutability

ADSL and CATV Internet are entry services for broadband Internet, and their always-on connectivity and flat rate system are evaluated higher. On the other hand, FTTH is the final broadband service, and its ultra-transmission speed is considered important. Therefore, broadband migration will be from narrowband to ADSL and CATV Internet, and then to FTTH.

Discrete choice model analysis of broadband (revealed preference method)

Much econometrics research has analyzed the demand structure of local telecommunications markets. Taylor's informative survey analyzed customer demand of telecommunications services (2002). One innovation of the demand analysis in the literature of the 1980s and 1990s is the widespread use of discrete choice models, particularly for analyzing access demand under the assumption that consumer choice is qualitative with or without access. Perl (1978, 1983) was one of the first to apply a discrete choice model to the analysis of telecommunications access demand, followed by such discrete choice models as logit and probit (for example, Ben-Akiva and Gershensfeld, 1989; Kridel, 1988; Taylor and Kridel, 1990; Kridel and Taylor, 1993; Bodnar,

Dilworth, and Iacono, 1988; Solvason, 1997). The emergence of a nested logit model, which partially alleviated the independence of irrelevant alternative (IIA) property of a conditional logit model, was also important (see Train et al., 1987, 1989; Train, 2003).

This section analyzes the demand for access to Internet by using a discrete choice model based on Ida and Kuroda (2006), which is the first comprehensive analysis of the demand for broadband services including FTTH. Although analyses of broadband demands are limited, Madden, Savage, and Coble-Neal (1999), Madden and Simpson (1997), Eisner and Waldon (2001), Kridel, Rappoport, and Taylor (2001), and Duffy-Deno (2003) are noteworthy pioneers in the field.

RP data

In the following we explain the basic descriptive statistics and the data collected by a series of surveys of Internet access demand for private use conducted according to *The Competition Review of Japan's Telecommunications for FY 2003*, published in June 2004 by MIC.

The survey was carried out as a Web questionnaire and a representative sample was randomly chosen from households with all five Internet access alternatives: (i) dialup, (ii) always-on ISDN, (iii) ADSL, (iv) FTTH, and (v) CATV Internet. The total number of observations was 1,013; excluding omissions and abnormalities, we obtained 799 observations for nominal speed data and 789 observations for actual speed data.

Table 5.17 summarizes the basic descriptive statistics. Selection ratios follow: (i) dialup: 2%, (ii) ISDN: 5%, (iii) ADSL: 67%, (iv) FTTH: 8%, and (v) CATV: 18%. Since the number of dialup and ISDN users was very limited, it was difficult to consider them as independent alternatives; therefore, we combined dialup and ISDN into one narrowband alternative at this point.²

Table 5.18 then examines the differences between NTT users and non-NTT users. As for average monthly expenditures, NTT users pay about ¥1000–1500 more than non-NTT users. Results of the Welch test allow us to reject the null hypothesis that both users pay the same rates at a 1% level of statistical significance (t -value = 7.16 for ADSL and 3.86 for FTTH).³ NTT dominates the market despite the fact that NTT's Internet access line fees are higher. NTT users still account for 32% of the ADSL market and 65% of the FTTH market. The results of a poll on the choice criteria of current Internet access line providers (allowing for multiple answers) are summarized as follows: (1) low price (44.4%), (2) brand power (23.0%), (3) access speed and functionality (22.7%), (4) stability and reliability (17.9%). The Internet service users can be divided into two groups: non-NTT users who mainly focus on price aspects, and NTT users who emphasize brand power or reliability. We summarize the main points as follows:

Table 5.17 RP data basic statistics

		<i>Dialup</i>	<i>ISDN</i>	<i>ADSL</i>	<i>FTTH</i>	<i>CATV</i>
(a) Nominal speed						
No. of samples		18	40	534	66	141
Price (¥)	mean	3,946	5,207	4,344	5,929	5,200
	s.d.	3,007	2,121	1,395	1,780	1,921
	minimum	1,030	3,500	1,580	2,625	2,100
	maximum	13,000	12,175	12,000	13,600	12,000
Nominal speed (Kbps)	mean	52	65	10,044	81,909	10,589
	s.d.	9	10	5,919	33,594	8,602
	minimum	32	56	1,000	10,000	1,000
	maximum	56	128	26,000	100,000	30,000
(b) Effective speed						
No. of samples		18	38	511	61	149
Price (¥)	mean	3,889	5,026	4,285	5,872	5,162
	s.d.	3,071	2,178	1,512	1,819	1,989
	minimum	1,030	3,800	1,580	2,625	2,100
	maximum	9,650	10,547	18,000	9,600	10,600
Effective speed (Kbps)	mean	37	57	2,073	9,351	2,803
	s.d.	12	16	2,096	9,752	2,666
	minimum	13	54	13	1,000	83
	maximum	41	121	24,754	48,346	17,187

Source: Ida and Kuroda (2006).

Table 5.18 Average expenditures of NTT and non-NTT users

		<i>ADSL</i>		<i>FTTH</i>	
		<i>NTT users</i>	<i>Non-NTT users</i>	<i>NTT users</i>	<i>Non-NTT users</i>
No. of samples	173	361	43	23	
Average expenditures (¥)	5,000	4,028	6,439	4,974	
Variance	1,590	1,169	1,826	1,236	
Welch – t value	7.16			3.86	

Source: Ida and Kuroda (2006).

RP data

Looking at the RP data derived from the broadband demand survey, although NTT users pay about ¥1000–1500 more than non-NTT users, the market shares of NTT East and West are still higher. The reason for this may be that broadband users are divided into the price-oriented and the quality-oriented.

Four alternative models and the criteria of model selection

Here we analyze Internet access demand using a representative discrete choice model. Dependent variables are the four Internet access services: (i) narrowband (dialup/ISDN), (ii) ADSL, (iii) CATV Internet, and (iv) FTTH. The independent variables are: (i) the fixed term of each alternative, (ii) average monthly expenditure (price), (iii) nominal or effective access speed, and (iv) the NTT users dummy variable.

Here is a problem. What proxies should be used for the prices and speeds of non-chosen alternatives? We do not know them for the non-chosen alternatives. However, we do have detailed information on individual characteristics including Internet access line provider, Internet service provider, and income class for each customer. Therefore, we classify all customers according to the above individual characteristics (such as IAP, ISP, and income class) and calculate the price and speed averages for respective groups. Then, we use them as proxies for all alternatives, including the chosen one.⁴

Note, furthermore, that we first investigate nominal access speed and later discuss effective access speed; since such individual characteristics as age, gender, and income are not statistically significant, we did not directly address them in this analysis.

We consider the following kinds of logit models: one conditional logit (CL) model and four two-level nested logit (NL) models:

- CL: [narrowband, ADSL, CATV, FTTH],
- 2-NL (i): [narrowband] v. [ADSL, CATV, FTTH],
- 2-NL (ii): [narrowband] v. [ADSL] v. [CATV, FTTH],
- 2-NL (iii): [narrowband] v. [FTTH] v. [ADSL, CATV],
- 2-NL (iv): [narrowband] v. [CATV] v. [ADSL, FTTH],

Note: [] denotes a choice set, and v. means a partition of choice sets.

Since a CL model requires that the IIA property must hold, we conduct the Hausman test based on this assumption. If we adopt the NL model, determining the nested choice structure becomes problematic (Greene, 2003). So we establish the following model selection criteria.⁵ First, we examine whether the coefficient signs of such important variables as price and speed meet our expectations: the sign of price parameter is expected to be negative, and the

speed parameter is expected to be positive. Second, we investigate whether, at the 1% or 5% level, the t-values of such important parameters as price and speed are statistically significant. Third, we compare the goodness of fit of the models and determine the best model with the highest value. We consider a McFadden R^2 to be the goodness of fit measure.

Estimation results of four alternative models

Table 5.19 compares the estimation results of the four alternative models. Beginning with the CL model, the sign conditions of price/nominal-speed parameters and the statistical significance at a 1% level of price parameter are satisfied, but, on the other hand, the statistical significance of the nominal speed parameter is satisfied only at a 10% level. When we execute the Hausman test and exclude ADSL and CATV alternatives from the choice set, we obtain $\chi^2(2)=17.7677$, which means that the IIA assumption of the CL model can be rejected at a 1% level of statistical significance. Consequently, the CL model is not appropriate.

Second, turning to the four kinds of two-level NL models, the sign conditions and the statistical significance at the 1% level of price/nominal-speed are all satisfied. Comparing their figures of McFadden R^2 , we see that the 2-NL (i) model has the highest McFadden R^2 ; therefore, it is appropriate to divide the four alternatives into two categories: a narrowband category that

Table 5.19 Comparison of four alternative models

<i>Sign conditions</i>		<i>Statistical significances</i>		<i>McFadden R²</i>
(a) The CL model [NB, ADSL, CATV, FTTH]				
price (-)	nominal speed (+)	price 1% significant	nominal speed 10% significant	0.38399
(b) NL models				
(i) [NB] v. [ADSL, CATV, FTTH]				
price (-)	nominal speed (+)	price 1% significant	nominal speed 1% significant	0.50130
(ii) [NB] v. [ADSL] v. [CATV, FTTH]				
price (-)	nominal speed (+)	price 1% significant	nominal speed 1% significant	0.33823
(iii) [NB] v. [ADSL, CATV] v. [FTTH]				
price (-)	nominal speed (+)	price 1% significant	nominal speed 1% significant	0.49365
(iv) [NB] v. [ADSL, FTTH] v. [CATV]				
price (-)	nominal speed (+)	price 1% significant	nominal speed 1% significant	0.47265

Note: Hausman test $X^2(2)=17.7677$ p-value=0.00014.

Source: Ida and Kuroda (2006).

includes dialup and ISDN, and a broadband category that includes ADSL, CATV Internet, and FTTH.⁶

We conclude from the above that we should adopt the 2-NL (i) model with estimation results shown in Table 5.20. Since a value of 0.3 of McFadden R^2 generally corresponds to around 0.6 of OLS R^2 , we conclude that 0.5 of McFadden R^2 represents a high goodness of fit. Constant terms, price, nominal speed, and IV parameters are statistically significant. Furthermore, although we include the NTT dummy variable in the model because NTT users pay significantly more than non-NTT users, this statistical significance is very low.

Let us next consider the own-price elasticities of access demand.⁷ This figure of ADSL is about 0.8, and thus the ADSL service is inelastic. An increase in ADSL price does not significantly decrease the demand for ADSL. The ADSL market itself is so gigantic that ADSL users are switching from low-speed (1.5 Mbps) to medium-speed (8–12 Mbps) and finally to high-speed band (more than 24 Mbps) within the ADSL market. We later scrutinize the ADSL market and divide it into three submarkets.

On the other hand, own-price elasticities of access demand are about 3.2

Table 5.20 Estimation results of the 2-NL (i) model

No. of samples	799		
LL(1234)	−682.175		
LL(0)	−1367.896		
ρ	0.50130		
<i>Parameters</i>	<i>Coefficients</i>	<i>Standard errors</i>	<i>t-values</i>
price	−0.00074	0.00010	−7.37000
nominal speed	0.000022	0.000006	3.69100
constant term (NB)	−1.03264	0.25091	−4.11600
constant term (FTTH)	−2.43898	0.58094	−4.19800
constant term (CATV)	−0.49144	0.21204	−2.31800
NTT dummy	34.08949	271145.0	0.00000
IV parameter	0.77620	0.14203	5.46500
Price own-elasticities of demand			
NB	−3.325		
ADSL	−0.846		
FTTH	−3.150		
CATV	−2.500		
Nominal speed own-elasticities of demand			
NB	0.001		
ADSL	0.058		
FTTH	1.261		
CATV	0.147		

Note: The model structure is [NB] v. [ADSL, CATV, FTTH].

Source: Ida and Kuroda (2006).

for FTTH and 2.5 for CATV, which are elastic. This means that a 1% increase in price decreases the demand for FTTH or CATV significantly. Consequently, ADSL service is less elastic to price than FTTH and CATV.⁸ We summarize the main points as follows:

Estimation results of four alternatives model

The best model for explaining the demand for broadband services is the nested logit model in which a decision-maker first chooses narrowband or broadband nest and then chooses ADSL, CATV Internet, or FTTH after choosing the broadband nest. Investigating the own-elasticity of demand with respect to price, ADSL is inelastic, while CATV Internet and FTTH are elastic.

() Nominal speed or effective speed?*

There are two kinds of Internet transmission speed: nominal and effective. We cannot intuitively determine to which speed consumers attach more importance when choosing services or providers. Having dealt with nominal speed, we also estimate models with effective speed being assumed to be an explanatory variable. We consequently see that neither sign condition nor statistical significance was satisfied; using effective speed is less advantageous than nominal speed as an explanatory variable for two reasons. First, the variance of effective speed is so large that it is not suited for econometric analysis; second, since the Internet is a so-called “best-effort” type of service, we cannot know the true quality of service (eg effective speed) before actual use.⁹ However, consumer preferences may eventually rely on effective speed rather than nominal speed as broadband services become more popular.

Analysis of ADSL submarkets

We have shown that the own-price elasticity of ADSL demand is much lower than FTTH and CATV Internet. However, since the ADSL market itself is so huge, occupying around 70% of the whole broadband market, it is informative to examine the submarkets of ADSL. At this point, we divide the ADSL market into three submarkets: low-speed (around 1.5 Mbps), medium-speed (around 8–12 Mbps), and high-speed (more than 24 Mbps). Table 5.21 shows the basic descriptive statistics of the ADSL market. Note that medium-speed ADSL users account for 74% of the ADSL market.

Here we scrutinize the ADSL submarkets. Table 5.22 indicates the results of model selection. Beginning with the CL model, the sign conditions and the

Table 5.21 Basic statistics of the ADSL market

	<i>No. of samples</i>	<i>NTT users</i>	<i>Price</i>		<i>Nominal speed average s.d.</i>	
			<i>average (¥)</i>	<i>s.d.</i>	<i>(Kbps)</i>	<i>s.d.</i>
L-ADSL	87	32	4,248	1,712	1,397	204
M-ADSL	396	118	4,329	1,294	10,090	1,995
H-ADSL	51	23	4,615	1,543	24,431	831

Source: Ida and Kuroda (2006).

statistical significance at a 1% level of price/nominal-speed are satisfied. However, when we carried out the Hausman test, excluding the L-ADSL alternative from the choice set, we obtained $\chi^2(2)=289.3$, allowing us to reject the IIA assumption at a 1% level. Then, we compared the three two-level NL models:

- 2-NL(i): [L-ADSL] v. [M-ADSL, H-ADSL],
- 2-NL(ii): [M-ADSL] v. [L-ADSL, H-ADSL],
- 2-NL(iii): [H-ADSL] v. [L-ADSL, M-ADSL].

Note: [] denotes a choice set, and v. means a partition of choice sets.

Obviously, the 2-NL (ii) model is best because the sign conditions and statistical (1% level) significance of the price and speed parameters are all satisfied; furthermore, its McFadden R^2 is the highest. Table 5.23 indicates the

Table 5.22 Comparison of ADSL submarkets

<i>Sign conditions</i>		<i>Statistical significances</i>		<i>McFadden R²</i>
(a) The CL model [L-ADSL, M-ADSL, H-ADSL]				
price	nominal speed	price	nominal speed	0.48124
(-)	(+)	1% significant	1% significant	
(b) NL model				
(i) [L-ADSL] v. [M-ADSL, H-ADSL]				
price	nominal speed	price	nominal speed	0.50955
(-)	(+)	insignificant	5% significant	
(ii) [M-ADSL] v. [L-ADSL, H-ADSL]				
price	nominal speed	price	nominal speed	0.51341
(-)	(+)	1% significant	1% significant	
(iii) [H-ADSL] v. [L-ADSL, M-ADSL]				
price	nominal speed	price	nominal speed	0.49374
(-)	(+)	1% significant	5% significant	

Note: Hausman test $X^2(2)=289.3$ P-value=0.00000.

Source: Ida and Kuroda (2006).

Table 5.23 Estimation result of ADSL submarkets

No. of samples	534		
LL(1234)	-200.498		
LL(0)	-704.9307		
ρ	0.71558		
<i>Parameters</i>	<i>Coefficients</i>	<i>Standard errors</i>	<i>t-values</i>
price	-0.00120	0.00027	-4.34700
nominal speed	0.00019	0.00007	2.62800
constant term (L-ADSL)	2.28583	1.18310	1.93200
constant term (H-ADSL)	-2.08902	0.98504	-2.12100
NTT dummy	36.27031	665519.0	0.00000
IV parameter (L-ADSL)	0.51638	0.21706	2.37900
IV parameter (M-ADSL)	0.27175	0.07070	3.84400
Price own-elasticities of demand			
L-ADSL	-10.595		
M-ADSL	-2.585		
H-ADSL	-9.067		
Nominal speed own-elasticities of demand			
L-ADSL	0.543		
M-ADSL	0.934		
H-ADSL	7.453		

Note: The model structure is [M-ADSL] v. [L-ADSL, H-ADSL].

Source: Ida and Kuroda (2006).

estimation results of the 2-NL (ii) model. Looking at the own-*price* elasticities of access demand, the medium-speed ADSL figure is 2.6. On the other hand, since the figures are 10.6 for low-speed ADSL and 9.1 for high-speed ADSL, they are very elastic. In conclusion, ADSL users can be divided into two groups: those who are normally sensitive to price changes, the medium-speed ADSL users, and those who are extremely sensitive to price changes, the low-speed and high-speed ADSL users. We summarize the main points as follows:

Estimation results of four alternatives model

Looking closely at the ADSL demand structure, users can be divided into two categories: first, the low-speed and high-speed ADSL users and, second, the medium-speed ADSL users. The estimation results conclude that the former are very elastic, while the latter are inelastic.

Discrete choice model analysis of broadband (stated preference method)

This section investigates the stated preference (SP) of broadband markets based on Ida and Sato (2007). We first explain the SP data used in the analysis. We next discuss the estimation results. Consequently, we found that the actual availability of FTTH has an effect on the stated preferences of consumers and also that stated preference and revealed preference may vary for certain populations.

SP data

The key approach adopted here is *conjoint analysis*, or the stated preference method (SPM). It aims to measure consumers' preferences based not on the actual data observed in the market but instead on answers to a virtual questionnaire, which highlights a remarkable difference from revealed preference methods (RPM). Compared with RPM, one advantage of SPM is that it is virtual by nature and scrutinizes consumers' preferences that are generally ignored or overlooked. For instance, even when we cannot collect actual product data prior to its market launch, we can quantitatively evaluate such products with SPM.

Particular analysis purposes shape the contours and amount of the attributes that should be introduced into a profile. If we include too many attributes, the respondents will have difficulty answering the questions.¹⁰ On the other hand, if we adopt too few attributes, the description of alternative will become inadequate. In our research, the pretests were prudently carried out three times, and then we determined the attributes and levels. The attributes of profiles used in this research are presented as follows:

- Alternatives: ADSL, CATV Internet, FTTH,
- Prices of each service:
 - ADSL price: ¥2,500, ¥3,000, ¥3,500, or ¥4,000,
 - CATV Internet price: ¥4,500, ¥5,000, ¥5,500, or ¥6,000,
 - FTTH Price: ¥6,000, ¥6,500, ¥7,000, or ¥7,500.
- Access speeds of each service:
 - ADSL speed: 1Mbps, 10Mbps, or 20Mbps,
 - CATV Internet speed: 20Mbps or 30Mbps,
 - FTTH speed: 30Mbps or 100Mbps.
- IP telephony: available or unavailable for all services,
- TV programs: always unavailable for ADSL; always available for CATV Internet; available, partially available, or unavailable for FTTH,
- Provider's type: NTT or non-NTT for ADSL and FTTH; always non-NTT for CATV Internet,
- Transmission speed symmetry: always asymmetric for ADSL and CATV Internet; always symmetric for FTTH.

Since the number of profiles becomes too large if we consider all possible combinations of the attributes, we adopt an orthogonal planning method to avoid this problem. At this point, there are five alternatives in this multiple-choice question: alternatives 1 and 2 are ADSL, alternative 3 is CATV Internet, and alternatives 4 and 5 are FTTH. There may be strong similarities between alternatives 1 and 2 and between alternatives 4 and 5. Figure 5.1 indicates a representative questionnaire.

Next we explain the data and the basic descriptive statistics collected by the same survey based on *The Effective Competition Review* as explained above. We surveyed a random sample of two groups to investigate how actual FTTH availability influences SP, or how the SP and RP of identical populations are different. Group A, derived from a population having access to FTTH, is 105. Group N, derived from the population without access to FTTH, is 104. We conduct a conjoint analysis for these respondents, asking them the seven questions. Thus, the numbers of observations are $105 \times 7 = 735$ for group A and $104 \times 7 = 728$ for group N. The results of the questionnaire are summarized in Table 5.24.

Comparing groups A and N, the ratio of choosing ADSL is higher in group N (60.1%) than in group A (52.5%); on the other hand, choosing FTTH is lower in group N (27.6%) than in group A (32.5%). Accordingly, we suppose that the actual availability of FTTH would influence preferences and cause different choice behaviors in this conjoint analysis. We summarize the main points as follows:

SP data

SPM is effective for analyzing broadband services whose innovation is rapid and demand is quickly changing. By conjoint analysis, we scrutinize the influence of the availability of FTTH on consumers' preferences.

Estimation results of SP models

Conjoint analysis studies consumer preferences based on their hypothetical choices. It is then interesting to consider whether respondents' choices are influenced by the actual availability of alternatives. As stated, the respondents were divided into two sub-samples: group A with access to FTTH and group N without, a division merely based on the difference of living environments of respondents; otherwise the questionnaire was identical for the two groups. If this difference in the actual availability of FTTH systematically influences the consumers' SP, the estimated coefficients will be different between the two groups.

To test the null hypothesis that the estimated coefficients are the same between the two groups A and N, we used a likelihood ratio (LR) test

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Service	ADSL	ADSL	CATV	FTTH	FTTH
Price	¥2,500	¥4,000	¥5,500	¥7,000	¥6,000
Access speed	10Mbps	20Mbps	30Mbps	100Mbps	30Mbps
Symmetry	Asymmetric	Asymmetric	Asymmetric	Symmetric	Symmetric
IP telephony	Available	Unavailable	Available	Available	Unavailable
TV programs	Unavailable	Unavailable	Available	Partially available	Unavailable
Provider	Non-NTT	NTT	Non-NTT	Non-NTT	NTT

Figure 5.1 Representative questionnaire.

Source: Ida and Sato (2007).

Table 5.24 Answers to conjoint analysis

	ADSL		CATV		FTTH
(a) Answers from group A (FTTH available)					
Alternatives	1	2	3	4	5
No. of choice	276	110	110	146	93
Subtotal	386		110	239	
			Prices (¥)		
Mean	2916.7	3513.6	5100.0	6213.6	6639.8
S.D.	465.5	588.3	528.1	603.7	586.8
			Speeds (Mbps)		
Mean	12.3	11.5	24.7	80.3	87.2
S.D.	5.8	6.0	7.3	31.6	27.2
<i>Note:</i> No. of choice=7 questions × 105 samples=735.					
(b) Answers from group N (FTTH unavailable)					
No. of choice	294	150	83	107	94
Subtotal	444		83	201	
			Prices (¥)		
Mean	2960.9	3550.3	5066.3	6120.4	6585.1
S.D.	479.3	547.6	516.6	599.3	561.5
			Speeds (Mbps)		
Mean	12.6	12.3	27.1	79.3	84.4
S.D.	5.8	5.7	5.1	32.1	29.3

Note: No. of choice=7 questions × 104 samples=728.

Source: Ida and Sato (2007).

(Ben-Akiva and Lerman 1985). Concretely, we calculated the quantity of $LR = -2[LL(A+N) - \{LL(A) + LL(N)\}]$ that is asymptotically χ^2 distributed, where $LL(x)$ represents the log-likelihood of group $x \in \{A, N\}$. At this point, we obtain $LR = 21.919$. Consequently, we reject the null hypothesis at the 1% level of statistical significance. The actual availability of FTTH significantly changes the consumers' SP.

Table 5.25 indicates the estimation results of groups A and N, and Table 5.26 summarizes the values of willingness to pay (WTP). The WTP for 1 Mbps is about ¥32 (\$0.29) for group A individuals who can avail of FTTH, while it is about ¥45 (\$0.41) for group N who cannot. People without access to FTTH have a higher preference for an increase in access speed than those to whom FTTH is available.

This slightly surprising result can be explained as follows. FTTH is mostly available in urban areas such as Tokyo, Osaka, and Nagoya, while areas without access to FTTH are mainly rural or sparsely populated. In urban areas, the competition between firms who provide ADSL and FTTH is very fierce; therefore, people living in the urban areas can easily switch services or

Table 5.25 SP data estimation results

	(a) Group A (FTTH available)				(b) Group N (FTTH unavailable)			
	No. of samples	735	S.E.	t-value	728			
LL(b)		-1093.8830	S.E.	t-value	-1067.324			
LL(0)		-1182.9369	S.E.	t-value	-1171.6708			
ρ		0.0753	S.E.	t-value	0.0891			
Parameters		Coefficients	S.E.	t-value	Coefficients	S.E.	t-value	
Price		-0.00059	0.00011	-5.45518	-0.00038	0.00009	-4.19554	
Speed		0.01887	0.00254	7.43680	0.01708	0.00256	6.66874	
IP telephony		0.52844	0.10561	5.00364	0.29988	0.08646	3.46847	
Partial TV program		-0.10494	0.17823	-0.58880	0.15618	0.18659	0.83701	
Full TV program		0.81555	0.50075	1.62864	-0.47293	0.31972	-1.47921	
NTT dummy		-0.38844	0.15894	-2.44401	-0.16697	0.16209	-1.03015	
Symmetry dummy		-0.28544	1.20197	-0.23748	-0.98611	0.67430	-1.46242	
IV parameter ((ADSL)		0.21930	0.25615	0.85614	0.73095	0.55741	1.31134	
IV parameter (CATV)		1.00000	-	-	1.00000	-	-	
IV parameter (FTTH)		0.36153	0.19013	1.90150	0.77015	0.37258	2.06705	

Source: Ida and Sato (2007).

Table 5.26 WTP measurements

<i>Attributes</i>	<i>(a) Group A (FTH available)</i>			<i>(b) Group N (FTH unavailable)</i>		
	<i>Coefficients</i>	<i>WTP</i>	<i>Significance</i>	<i>Coefficients</i>	<i>WTP</i>	<i>Significance</i>
Price	-0.0006	—	***	-0.0004	—	***
Speed	0.0189	¥32	***	0.0171	¥45	***
IP telephony	0.5284	¥899	***	0.2999	¥783	***
Partial TV program	-0.1049	¥-178		0.1562	¥408	
Full TV program	0.8156	¥1,387		-0.4729	¥-1,235	
NTT dummy	-0.3884	¥-661	**	-0.1670	¥-436	
Symmetry dummy	-0.2854	¥-486		-0.9861	¥-2,576	

Note: *** 1% level significance, ** 5% level significance, * 10% level significance.

Source: Ida and Sato (2007).

providers. On the other hand, there is little or no competition in rural areas where a single, or at worst, no firm is providing broadband services. Therefore, since it is important for group A to seek better, cheaper broadband services, they are more aware of price; group N is less concerned because they are primarily concerned with securing access to broadband services, rather than price levels. This result is also interesting from a psychological point of view. Schwarz and Vaughn (2002) have stated that individuals are likely to rely on ease of recall when the judgement task is of low personal relevance, but draw on recalled content when the task is of high personal relevance. Therefore, it makes sense that the availability of an alternative leads consumers to severer evaluations.

This conclusion provides interesting implications for the digital divide problem for further diffusion of broadband services. Since people with limited access to broadband services have a higher WTP for high-speed Internet access, they represent potentially high preferences for them, especially in rural areas where the demand has not yet been actualized.¹¹ We summarize the main points as follows:

Analysis results of SPM

Availability of FTTH influences consumers' preference. Interestingly, people without access to FTTH have higher preferences for an increase in access speed than those to whom FTTH is available. This conclusion implies that potential demands exist even in rural areas.

Policy issues for fixed-line broadband

In this section I will discuss the primary policy issues relating to fixed-line broadband based on the analysis presented.

Defining Internet access markets

In this section I will discuss market definition of the Internet access market. Fixed-line Internet services can be divided into narrowband services and broadband services. Broadband services can then be further divided into ADSL, CATV Internet, and FTTH services. The question is whether these services constitute a single market or whether they can be regarded as separate markets.

Market definition is a critically important issue for antimonopoly policy and competition reviews, and the *SSNIP test* (or *hypothetical monopolist test*) has been widely accepted as an important tool for this purpose. However, to apply the SSNIP test requires own-price elasticity of demand and the price-cost mark-up. The demand elasticity can be estimated using discrete choice model analysis, but the price-cost markup for a single service is generally

unobtainable, which makes it difficult to apply the SSNIP test with rigor. Here, I will present an outline of market definition, while referring to the estimated results shown earlier in Table 5.3. First, we consider narrowband and broadband services, but it is apparent from the NL model comparative results that the two categories are different. Narrowband and broadband can therefore justifiably be defined as different markets.

Second, focusing attention on the own-price elasticity of demand for broadband services, we find that ADSL is inelastic while CATV Internet and FTTH are elastic. From an antimonopoly policy standpoint, a problematic critical price elasticity normally is in the range of approximately 1 to 2, so it is thought that ADSL does comprise an independently demarcated market (Werden, 1998, p. 390). ADSL comprises a large market and could be divided into several submarkets, but because slow-, intermediate-, and high-speed ADSL are all elastic, ADSL can be regarded as a single market.¹²

Third, both CATV Internet and FTTH require their own new infrastructure facilities to be deployed before services can be provided, so there are no operators that provide both CATV Internet and FTTH services. In other words, it would be quite difficult for a cable provider to enter the FTTH market or for an FTTH provider to enter the cable market, so it is assumed that supply substitutability does not exist between the two (MIC, 2004, p. 90). Based on these considerations, we first define narrowband and broadband as separate markets, then define ADSL, CATV Internet, and FTTH as distinct markets. We summarize the main points as follows:

Defining Internet access markets

Applying the SSNIP test to the definition of Internet access markets, it is apparent that, first, narrowband and broadband can be differentiated. Second, within broadband, ADSL constitutes an independent market based on demand substitutability considerations. And third, there are market boundaries differentiating the FTTH and CATV Internet markets based on supply substitutability.

SSNIP test

A market is essentially a relevant area of competition between firms and that provides some criteria for determining whether anticompetitive effects have arisen. Here, market definition will be examined from the two perspectives of *demand substitutability* and *supply substitutability*. Demand substitutability determines whether there are other products that could be substituted for the relevant product from the perspective of the buyer, and supply substitutability determines whether there are goods or services that could be easily substituted or interchanged with the relevant goods or services from the

perspective of suppliers. Debates regarding market definition criteria have generally developed around demand substitutability.¹³

The U.S. Department of Justice issued Merger Guidelines in 1968, which provide a formula for defining markets. The Guidelines were thoroughly overhauled in 1982, and the market definition procedure was also substantially revised. Basically, the procedure in the 1982 Guidelines tries to gauge how buyers would respond if, at prevailing prices, a hypothetical monopolist seeking to maximize profits imposed a “small but significant and nontransitory increase in price” (SSNIP) for the relevant product or service. If a price increase of 5% would cause enough buyers to switch to another product over a one-year period that the price increase would be unprofitable, then the next best substitute for the product is added to the product group. The SSNIP test is repeated and the product group enlarged until the hypothetical monopolist could impose the price increase on the group of products. The relevant product market is the smallest group of products that satisfies this test. Supply substitutability defines any firm capable of producing and selling the relevant product within six months in response to an SSNIP as a participant in the market.

In using the SSNIP test to define an actual market, it is necessary to calculate the critical elasticity of demand. If the critical elasticity of demand exceeds the demand elasticity measured at prevailing prices, then the maximum price increase that is profitable will exceed the SSNIP. Because this hypothetical monopolist is able to increase profits with an SSNIP, this kind of product is defined as a market. Conversely, if the critical elasticity of demand is less than the demand elasticity measured at prevailing prices, then the type of product or service is not defined as a market.

(*) *Critical elasticity*

Here I will elaborate on critical elasticity in the case of linear demand. Let $p = a - bq$ represent a linear demand curve, where p is price, q is demand, and a, b are parameters. The prevailing price is p^0 . So calculating the elasticity of demand at the prevailing price, we obtain $\varepsilon_{ii}(p^0) = (p^0) / (a - p^0)$. Next, calculating the hypothetical monopolist's profit maximizing price where the profit maximizing price is p^m and the critical cost is c , we obtain $p^m = (a + c) / 2$. If a hypothetical monopolist who obtains price-cost margin of m imposes a price increase (SSNIP) of t , calculating the critical elasticity that maximizes profits, we obtain $\bar{\varepsilon}_{ii}(p^0) = (p^0) / (2p^m - c - p^0) = 1 / (m + 2t)$ from $a = 2p^m - c$. Here the prevailing price-cost margin is $m = (p^0 - c) / p^0$, and the SSNIP is $t = (p^m - p^0) / p^0$.

Effective competition in the ADSL market

Key attributes of the ADSL market, accounting for more than half the current broadband connections, can be summarized as follow. The ADSL market has now evolved from a period of rapid growth to one of maturity. The

number of net new subscribers is now being overtaken by FTTH, so it likely that before too long ADSL will enter into a period of decline.

Globally, ADSL is the least expensive broadband service option that is available. Japan's ADSL market is an oligopoly dominated by four providers—NTT, Softbank, eAccess, and ACCA Networks—but none of the four has a conspicuously dominant position, so competition is working effectively in this market.

Featuring always-on connectivity and flat-rate pricing, ADSL has played a major role in moving people from narrowband to broadband service, a role that ADSL continues to play up to the present day.

The service areas where ADSL is available are now extended out from cities into rural areas, and NTT East and West have been particularly active in pursuing this rural development.

The nondominant competing carriers have greatly extended the availability of ADSL services through access to NTT's dark fiber and by line-sharing. This intense competition that has evolved in the ADSL market can be largely attributed to the MIC's successful access regulations. Currently, competition is working very effectively in the ADSL market, and has been a major factor in the rapid spread of broadband in Japan. Softbank's contribution based on one innovative marketing strategy after another—unprecedented low rates, selling services from local stores, offering 050 IP telephony services, and so on—has been especially noteworthy in furthering the penetration of ADSL.

But now a shadow has appeared that will likely diminish the prospects of further ADSL growth, as heavy users of the Internet living in cities have already begun to shift to FTTH. Note that this migration from ADSL to FTTH primarily involves users who have generated the most profits for the ADSL providers, and particularly when you factor in the loss of sales for higher functions, content, and the like, this loss of users is a major blow to the profitability of the ADSL providers.

NTT East and West support both ADSL and FTTH, but the competing operators are wholly invested in ADSL and have very little presence in the FTTH market. This means that subscribers to NTT's ADSL service can transit smoothly from ADSL to FTTH without having to change email addresses or other annoyances, while subscribers to the other service providers are burdened with a range of monetary and nonmonetary switching costs when they move to FTTH. These asymmetrical switching costs will have a serious adverse impact on the profitability of competing ADSL providers that will become increasingly apparent as ADSL evolves from its mature phase to one of decline (discussed in Chapter 8). A key policy issue is how to assist those ADSL users who find it difficult to make the transition to FTTH, due to the switching costs and whose continued use of ADSL is threatened by scaled-back services as the service providers cope with worsening profitability. We summarize the main points as follows:

Effective competition in the ADSL market

Although Japan's ADSL market is an oligopoly dominated by four companies, the market is highly competitive. However, there are now indications that the ADSL market is evolving from a mature phase to one of decline, and competition between ADSL and FTTH in the cities will likely intensify in the years ahead. As this develops, close attention must be paid to the competitive asymmetry between operators providing both ADSL and FTTH, and operators that only provide ADSL services.

Effective competition in the FTTH market

Key attributes of the FTTH market, much anticipated as the final broadband access solution, can be summarized as follows.

The FTTH market was launched and became firmly established after 2004. We can anticipate very rapid penetration of FTTH considering the aggressive efforts of service providers: NTT's stated goal of extending fiber to 30 million households in line with its Mid-Term Management Strategy, the aggressive rate reductions by K-Opticom Corporation, and the agreement between Tokyo Electric Power Company and KDDI Corporation to integrate their FTTH operations.

Demand is emerging for Triple Play service, provisioning of three services over a single optical broadband connection: high-speed Internet, IP telephony with 0ABJ number portability that is equivalent in quality and features with fixed-line telephony, and multi-channel television equivalent to satellite broadcasting. Triple Play is coming to be perceived not as a luxury but as an ordinary service offering. Note however that, from a supply-side perspective, Triple Play services must be made available as an integrated moderately priced package and not marketed as separate services as in the past, so this development will not do anything to improve the profitability of the operators.

Areas where FTTH service is available have rapidly expanded, but there are many rural areas where fiber has not yet been extended to the remote terminal (RT). Thus, the problem of the digital divide separating districts with broadband access from those without remains a serious social issue.

In provisioning FTTH services, there is facilities-based competition among NTT and power company providers who deliver services over their own fiber-optic infrastructure, and there is service-based competition among competing operators who deliver services over fiber lines leased from NTT. Facilities-based competition has focused mainly on providing services to single-family homes, and NTT East and West have a predominant share of this market. However, the service-based competition has focused more on the

multi-dwelling unit market, and NTT's share of this market is far more modest. Thus, a critical factor in the emergence of effective competition in the future FTTH market is whether the competing operators will make significant investments in optical facilities. The real issue is that, aside from NTT, no one is in a position to shoulder the heavy investment required to deploy optical fiber except the power companies, so trends among the power companies become highly important in the FTTH market. Meanwhile, the NTT Group also feels threatened that, in competition with power companies who are just as familiar to people as NTT, they may not emerge as the winner.

Currently, only NTT East and West are obligated to provide open access to their optical lines, a burden that is not imposed on the power company operators. There have thus been strong appeals that this obligation on NTT should be lifted, and some have contended that this obligation to provide open access to its fiber lines acts as a deterrent or a disincentive for NTT to invest in fiber deployment to rural areas. But the current competition between NTT and the power company operators is only being played out in the cities, and there is no guarantee that NTT would invest in fiber deployment to sparsely populated rural areas if the open access obligation was lifted. NTT might instead choose to focus on winning the competition for the more lucrative urban areas. Thus, the two issues of NTT's open access obligation and investment incentives for rural fiber deployment should be clearly distinguished, the former as a competition policy issue and the latter as an industrial policy issue. Aside from the fact that a number of new competing operators are already providing services over lines leased from NTT, if the open access regulations were removed, we would have to scrap the current competition policy guidelines that have worked so well up to now, and start over at the beginning. The important thing is to set charges for leasing NTT's dark fiber at a reasonable level, and take care to ensure that arrangements are not biased in such a way that only NTT East and West incur losses. Here as elsewhere, balance is critically important. We summarize the main points as follows:

Effective competition in the FTTH market

The FTTH market has gotten off to a good start. Yet there is an enormous gulf between availability of FTTH in the cities and in rural areas. In the cities, facilities-based competition is making rapid progress, but in rural areas there are many places where no services are available at all. We are thus now confronted with a difficult policy dilemma of competition policy and industrial policy working at cross-purposes.

Conclusions

In this chapter, we have discussed the fixed-line broadband services in Japan. Particularly, we carried out two empirical investigations based on RP data and SP data. First, we have analyzed the demand substitutability of four alternatives in Japan's broadband services with NL models. The nested choice structure with two categories of narrowband and broadband has the highest goodness of fit. In addition, ADSL is less sensitive to price changes than FTTH and CATV. We analyze ADSL submarkets and conclude that medium-speed ADSL is different from low-speed and high-speed ADSL: low-speed and high-speed ADSL are very elastic, based on the own-price elasticities of access demand. Thus, we conclude that in Japan's broadband services, ADSL is independent of other services but is actively competing with narrowband (dialup, ISDN) and broadband (FTTH, CATV) services on both ends of the spectrum. Second, using conjoint analysis this chapter has analyzed consumers' preferences with respect to Japan's broadband services. On analyzing whether the actual availability of FTTH influences SP, we found that SP differs depending on the actual availability of FTTH: the WTP for 1 Mbps is ¥32 (\$0.29) in areas with access to FTTH and ¥45 (\$0.41) in areas without access to FTTH.

6 IP telephony: Inception to widespread deployment

In this chapter we will consider the market structure of Internet protocol (IP) telephony, while referring to supporting data and econometric analysis. In Japan the number of IP telephony customers exceeded 10 million in December 2005, and there are clear signs that widespread penetration of IP telephony is imminent. Most of this uptake is 050-type IP telephony, a best-effort service and does not guarantee the quality and functionality of wire-line phones, but as fiber to the home (FTTH) becomes widely available, 0ABJ-type IP telephony that can fully replace public switched telephone network (PSTN), telephony is poised for takeoff. In this chapter we will consider IP telephony from the following four perspectives. First, we will examine the supply structure of IP telephony. We will begin by defining IP telephony, then explain the differences between 050-type and 0ABJ-type IP telephony. Second, we will outline the current state of IP telephony usage in Japan, based on the results of a consumer questionnaire. We will elaborate on why people use IP telephony services, how satisfied they are with the services, and other information gleaned from the survey responses. Third, we will examine the demand substitutability of IP telephony for fixed telephony, based on conjoint analysis. This will give a good quantitative picture of the basic conditions it would take to induce a fixed telephony user to switch to IP telephony, what conditions must be satisfied for IP telephony to be substituted for fixed telephony, and so on. Fourth and finally, we will address IP telephony interconnection, the impact IP telephony is having on fixed telephony, and some of the relevant policy issues that are in contention.

IP telephony supply analysis

In this section we will examine the supply side of IP telephony. IP telephony is the routing of voice conversations over the Internet or other IP-based network using the voice over Internet protocol (VoIP). Currently, IP telephony is provided as an additional service capability over broadband access services, mainly ADSL services. For example, this type of service enables subscribers to make and receive calls just as they would over the PSTN, among other subscribers to the same service provider at no extra cost.

There are a number of types of IP telephony, so we will begin by sorting out these different types. Highlighting the basic features of IP telephony, the Ministry of Internal Affairs and Communications (MIC) made the following distinctions in their “Effective Competition Review of Japan’s Telecommunications” for 2004:

- IP telephony not provided as voice service by telcos: PC-based IP telephony in which the call is made from a computer (PC) using the subscriber local loop and the public Internet for the transit trunk network. This service became available with the penetration of the Internet in the 1990s, but phone numbers were not allocated for the service, and there were significant quality issues due to latency and dropped packets. Quality of service has been markedly improved in recent years with the emergence peer-to-peer (P2P) software such as available from Skype and other providers. This area of IP telephony is treated as *Internet telephony*, and as a telecom service is not included in the category of IP telephony.
- IP telephony provided as voice service by telcos: IP telephony using an ordinary handset for making and receiving calls over a dedicated IP network using the PSTN, and a regular phone number is allocated. This type of IP telephony is further subdivided into service using a dedicated IP network over a transit trunk network, and service using an IP telephony network extending to the access line network. The former is called *trunked IP telephony* and the latter is referred to as *full IP telephony*. Trunked IP telephony is a disintermediation type of low-cost fixed telephony service, and will here not be considered under our narrower definition of IP telephony.¹ Full IP telephony is divided into two types of services, one that requires the caller to input a special IP extension number and the other that allows the caller to continue using a regularly assigned telephone number. These are referred to as 050-type IP telephony and 0ABJ-type IP telephony, respectively, based on their different numbering systems.

0ABJ-type and 050-type IP telephony

In this section we present an analysis of *full IP telephony*. Full IP telephony is supported by two number systems: “050” numbering and “0ABJ” numbering.

- 0ABJ-type IP telephony: Telephone numbering system specified by regular PSTN. The location of a handset can be identified from the phone number. IP telephony using an 0ABJ number is referred to as *0ABJ-type IP telephony*. A basic condition for provisioning 0ABJ-type IP telephony is that it must be defined by a technical standard or protocol. This means that an FTTH line supporting an ultra-high-speed large-capacity

Internet connection is generally required to supply 0ABJ-type IP telephony service. Since 0ABJ-type IP telephony supports emergency calls, ability to keep existing NTT phone numbers, and good voice quality equivalent to fixed telephony, it is generally assumed that 0ABJ-type IP telephony will supplant fixed telephony with the widespread penetration of FTTH.

- 050-type IP telephony: IP telephony specific numbering system. One drawback of this scheme is that users cannot keep their existing 0ABJ phone number because the handset's location cannot be determined from the number, but an advantage is that users can continue to use the same 050 phone number, regardless of where they are connected to the network. This service is now widely offered, mainly in conjunction with asymmetric digital subscriber line (ADSL) or cable TV (CATV) Internet services. Because *050-type IP telephony* provides relatively poor quality compared with fixed phones and does not support emergency calls, 050 services are unlikely to emerge as a viable substitute for PSTN services, but are rather expected to serve as supplemental location-free service.

Table 6.1 compares the relative functions of 0ABJ and 050 IP telephony services. Except for the power supply to the handset, the 0ABJ-type IP telephony service provides basically the same features and quality as wireline phones. The only cautionary note is that the 0ABJ-type IP telephony service is only currently used by some FTTH customers, so the key to further take-up of 0ABJ-type IP telephony is widespread penetration of FTTH services. Note too that, since users can cancel their wireline phone if they sign up for 0ABJ-type IP telephony in conjunction with FTTH, the cost of FTTH plus 0ABJ telephony is likely to be less than the total cost of basic service charges plus ADSL charges that ADSL users must pay. By contrast, 050-type IP telephony does not guarantee the same performance or functionality of fixed phones, so the great majority of users employ 050 telephony in addition to their regular wireline service, mainly as a cheap alternative by people who make a lot of long-distance calls.

Table 6.2 shows the change in number of IP telephony users. The total

Table 6.1 Relative functions of 0ABJ and 050 IP telephony services

	<i>0ABJ-type</i>	<i>050-type</i>
QoS guarantee	Good	Bad
Privacy security	Good	Bad
Voice quality	Good	Bad
Number portability	Moderate	Bad
Preselection service	Moderate	Bad
Emergency calls	Good	Bad
FAX sending or receiving	Good	Bad
Power supply to the handset	Bad	Bad

Table 6.2 Change in number of IP telephony users

	2004.3	2004.9	2005.3	2005.9	2006.3	2006.9
0ABJ	—	—	0.2	0.5	1.4	2.7
050	5.3	7.0	8.1	9.3	10.0	10.3
Total	5.3	7.0	8.3	9.8	11.5	13.0

Note: Figures are millions.

Source: MIC (2005a).

number of IP telephony subscribers was 13 million as of September 2006. Of these subscribers, 79% use the 050-type IP telephony service, and most of these subscribe to Softbank ADSL or NTT Communications' services. We summarize the main points as follows:

0ABJ-type and 050-type IP telephony

There are two varieties of IP telephony service in Japan: 0ABJ-type IP telephony guarantees voice quality equivalent to wireline phones, and 050-type IP telephony that does not make voice quality guarantees. The 0ABJ-type service assumes availability of FTTH, so its growth phase still lies in the future, while the 050-type service is bundled with ADSL, and already has reached 13 million users.

IP telephony business models

At present, IP telephony business models can be classified into three types. First is the *vertically integrated model* where the business undertakes the entire range of IP telephony, Internet connection, and Internet access line services. Softbank is a representative example of this model. The second type is the *non-vertically integrated model* represented mainly by ISPs that provide IP telephony services in which IP telephony, Internet connectivity, and Internet access line services are vertically separated. This model is represented by ISPs such as Nifty-Serve, which provides IP telephony and Internet connection services using NTT East/West's FLETS ADSL service. The third type is the *wholesale model* in which ISPs that provide IP telephony and Internet connectivity services also sell Internet access line services at the wholesale level. For example, there are some ISPs that provide both ADSL and FTTH lines according to this wholesale service model. Among these three business models, the vertically integrated model permitting unified sales, pricing, and business strategies prevails, and NTT East/West are now stepping up efforts to shift from the non-vertically integrated approach to the vertically integrated model. We summarize the main points as follows:

IP telephony business models

There are three basic IP telephony business models—vertically integrated, non-vertically integrated, and wholesale—but the vertically integrated model is currently the most prevalent.

IP telephony demand analysis

In this section, we will analyze demand trends for IP telephony. In November of 2004, the MIC conducted a questionnaire survey regarding IP telephony. The survey was conducted over the Web and involved a total of 1,500 subjects—300 people who use IP telephony and 1,200 people who do not. The age breakdown of the subjects was as follows: 3.3% of the respondents were in their teens, 24.3% were in their 20s, 36.6% were in their 30s, 24.2% were in their 40s, and 11.5% were in their 50s. The gender breakdown was 47.9% men and 52.1% women. In terms of occupation, 44.7% of the subjects were office workers, 6.2% self-employed, 11.6% part-time employees, 27.4% unemployed, 7.7% students, and 2.4% other. Now let us take a look at what the survey revealed.

Reasons for using and not using IP telephony

Let us begin by considering the reasons people gave for either using or not using IP telephony. Table 6.3 summarizes the reasons people gave for using IP telephony. The number one reason people gave for using IP telephony, accounting for 55% of the respondents who use the service, was that it came bundled with the service provided by their ISP. This included 48.4% who said the IP telephony service came as part of the ISP service and 7.0% who said it came as a discounted service with their ISP and access line service. One might consider these users as fairly noncommittal, who regard IP telephony as merely an added capability that came bundled with their Internet connection service. The second most common reason given by 30.3% of the respondents was that charges for the IP service are low. These respondents can be regarded as more committed users who are aware of the benefits of IP telephony. Table 6.4 summarizes the reasons the subjects gave for not using IP telephony. In order of lack of interest or need, 25.0% of the respondents said they did not know much about IP telephony, 22.0% do not use the telephone much, and 17.7% felt that wireline service was perfectly adequate. These results are probably not unrelated to the shift from fixed phone to mobile calling associated with the rapid penetration of mobile telephony that is going on in the background. In addition, a considerable number of respondents expressed interest, but had misgivings about the quality of IP telephony, including 8.3% who were loath to change phone numbers, 4.7% who were unsure about the

functional aspects of IP telephony, 4.3% who dislike the incoming call destination restrictions, and 3.0% who felt the subscription procedures were more trouble than the service was worth. We summarize the main points as follows:

Reasons for using and not using IP telephony

Some users of IP telephony are passive and noncommittal, while others are committed to the service. Among the reasons for not using IP telephony, some respondents indicated that they had little knowledge or awareness of the service, and others expressed misgivings about the quality of IP telephony.

Actual usage of IP telephony

Next we will consider the actual use of IP telephony in Japan. Table 6.5 shows the market shares of the main operators currently providing IP telephony services. The largest share of the IP telephony market by far is held by Softbank, with some 64.9% of the market. Softbank is primarily an ADSL provider, and offers a bundled set of services including Internet connectivity, Internet access line, and IP telephony services. Softbank's market share is consistent with the number one reason that 55% of the respondents gave for using IP telephony—that is, that it came bundled with other services. This suggests that the key to further penetration of IP telephony is to bundle the service with Internet connectivity or Internet access line services. Table 6.6 shows the relative shares of different types of connections used by IP telephony customers. One can see that most of the respondents use IP telephony over an ADSL connection with 88.7% share. Although the uptake of IP telephony thus far has been almost wholly 050-type IP telephony, we can anticipate a gradual increase in 0ABJ-type IP telephony as FTTH become more widely available. In any event, the impact that the differences between 050-type and 0ABJ-type IP telephony have on the future penetration rate of IP telephony is a critically important issue. We will return to this question in the next section, and see what light can be shed on the issue using conjoint analysis.

Table 6.7 shows the degree of satisfaction respondents experienced when actually using IP telephony services. Overall satisfaction with the service was fairly high at 72.6%, and results of 65.8% satisfaction with call charges and 55.5% satisfaction with quality were in line with information on these attributes. From these figures we can conclude that, on the whole, users of IP telephony are currently fairly well satisfied with the content of the service. Yet we should also note that 33% of the subjects stated that the quality of the service is still as poor as ever. Certainly on this score, there is plenty of room

Table 6.3 Reasons for using IP telephony

<i>Bundled service</i>	<i>Discounted services</i>	<i>Cheap rates</i>	<i>Friends subscription</i>	<i>Friends recommendation</i>	<i>Future diffusion of IP telephony</i>	<i>QoS upgrade</i>	<i>Others</i>
48.4%	7.0%	30.3%	6.8%	2.1%	2.5%	1.2%	1.7%

Note: Single answers.

Source: MIC (2005a).

Table 6.4 Reasons for not using IP telephony

<i>Little knowledge</i>	<i>Not using frequently</i>	<i>Satisfied with wireline phone</i>	<i>Phone number changes</i>	<i>Poor quality of service</i>	<i>Restricted call destinations</i>	<i>Unavailable areas</i>	<i>Procedures troublesome</i>	<i>Others</i>
25.0%	22.0%	17.7%	8.3%	4.7%	4.3%	3.7%	3.0%	11.3%

Note: Single answers.

Source: MIC (2005a).

Table 6.5 Market shares of IP telephony operators

<i>Softbank BB</i>	<i>NTT Com</i>	<i>KDDI</i>	<i>Plala Net</i>	<i>Nifty</i>	<i>Japan Telecom</i>	<i>Others</i>
64.9%	8.3%	5.6%	3.3%	3.1%	2.3%	12.5%

Note: Single answers.

Source: MIC (2005a).

Table 6.6 Shares of Internet connections by IP telephony customers

<i>ADSL</i>	<i>FTTH</i>	<i>CATV</i>	<i>Others</i>
88.7%	6.9%	2.5%	1.9%

Note: Single answers.

Source: MIC (2005a).

Table 6.7 Overall satisfaction with IP telephony

	<i>Satisfied</i>	<i>Not satisfied</i>	
<i>Service</i>	72.6%	27.4%	
<i>Call charges</i>	Cheap 31.6%	Moderate 65.8%	Expensive 2.7%
<i>Quality of service</i>	Good 11.4%	Moderate 55.5%	Bad 33.0%

Note: Single answers.

Source: MIC (2005a).

for improvement. Table 6.8 summarizes the advantages of IP telephony. The top two perceived advantages of IP telephony were the inexpensive rates mentioned by 49.6% of respondents and uniform flat rates noted by 37.9% of the subjects. The shortcomings of IP telephony are summarized in Table 6.9. The figures are fairly evenly divided because the subjects were instructed to only give one answer, but the two top complaints were as follows: 28.5% objected to the inability to make emergency calls, and 27.7% complained about the poor speech quality of IP telephony. The ability to make emergency calls and reasonable voice quality can be regarded as basic attributes of telephone service, and users consider these attributes just as important as ever. The next highest scoring shortcoming identified by the respondents were 16.4% pointed out the need to change phone numbers, and 10.8% objected to the inability of IP telephony to guarantee the quality of faxes. One significant

Table 6.8 Advantages of IP telephony

<i>Cheap rates</i>	<i>Flat rates</i>	<i>Convenience</i>	<i>Nothing</i>	<i>Others</i>
49.6%	37.9%	6.8%	4.7%	1.0%

Note: Single answers.

Source: MIC (2005a).

Table 6.9 Shortcomings of IP telephony

<i>Inability of emergency call</i>	<i>Poor voice quality</i>	<i>Phone number changes</i>	<i>Inability of FAX sending</i>	<i>Nothing</i>	<i>Others</i>
28.5%	27.7%	16.4%	10.8%	12.8%	3.8%

Note: Single answers.

Source: MIC (2005a).

point to note here is that all these perceived shortcomings only affect 050-type IP telephony, and will be eliminated once 0ABJ-type IP telephony becomes more widely available. This suggests that once 050-type service is superseded by 0ABJ-type service as the predominant mode of IP telephony, we could see extensive take-up of IP telephony. We will attempt to confirm this projection in the next section through econometric analysis. The main points of this section are briefly summarized as follows:

Actual usage of IP telephony

Currently Softbank, offering vertically integrated services over ADSL connections, has the largest share of the IP telephony market in Japan. Overall satisfaction with IP telephony services is quite high, but subjects expressed dissatisfaction that 050-type IP telephony does not guarantee the same level of quality as fixed telephony.

Conjoint analysis of demand for IP telephony

This section will apply conjoint analysis to demand for IP telephony.² There are two kinds of IP telephony. The first is best-effort IP telephony called “050-type” with a 050 prefix assigned for direct-dial calls from fixed telephones to IP telephony terminals. The second is quality of service (QoS) guaranteed IP telephony called “0ABJ-type” with the same numbering format used as 0AB-J for fixed telephones (eg 03 for Tokyo and 06 for Osaka).

According to the Japanese MIC, as of the end of 2005, the number of IP telephony subscribers reached 10 million, accounting for 40% of the current Japanese broadband Internet access lines. However, 90% of IP telephony subscribers are using 050-type IP telephony, in which QoS is not sufficiently guaranteed,³ including voice quality, number portability, fax usage, and emergency access. This lack of QoS may obstruct further penetration and utilization of IP telephony. As such, we analyze the potential demand for IP telephony by using a conjoint analysis, corroborating our findings with studies done by MIC.⁴

We quickly review related literature although the number of empirical studies on IP telephony demand is limited.⁵ Raina, Fildes, and Day (1998) argue that long-distance and international services currently available on telephones will be replaced by IP telephony. Zubey, Wagner, and Otto (2002) analyze demand substitutability between VoIP and POTS (plain old telephone service) by using conjoint analysis, concluding that it is important to improve the quality of connections between end-users and PSTN facilities; given such advantages of VoIP as low price and voice/data integration, there is huge potential for its growth.

Conjoint analysis

Since Japanese IP telephony service is now rapidly growing, it is quite difficult to collect sufficient, actual market data for a revealed preference method (RPM). As such, here we use conjoint analysis, or more generally, a stated preference method (SPM) that seems more suited for projecting such an emerging market as IP telephony.⁶

Conjoint analysis assumes that a service is a profile composed of attributes. In an IP telephony service context, for example, basic monthly charges, call charges, voice quality, number portability, emergency access, and fax usage 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.⁷ On the other hand, if we include too few attributes, the description of alternatives will become inadequate. After carrying out three pretests, we determined attributes and their levels. Since the number of profiles becomes unwieldy if we consider all possible combinations of attributes, we adopt an orthogonal planning method to avoid this problem.

To examine demand substitutability between IP and fixed telephones, we assume the following three alternatives:

- Only fixed phone: subscriptions to fixed telephone without a subscription to IP telephony,
- Parallel usage: subscriptions to both fixed telephone and IP telephony,
- Only IP phone: subscription to IP telephony without fixed telephone subscription.

Next, their attributes and levels are defined as follows:

- Basic monthly charge: Monthly charges are approximately ¥1500 (US\$14) for fixed telephone service and ¥500 (US\$4) for IP telephony service; therefore, levels are assumed to range from ¥1000 (US\$9) to ¥1800 (US\$16) for fixed telephone service, and from ¥0 (US\$0) to ¥800 (US\$7) for IP telephony service.
- Voice quality: The voice quality of IP telephony may be inferior to fixed telephone services; therefore, IP telephony voice quality is either good (1) or poor (0).
- Number portability: There are two types of IP telephony prefixes: one is 050 restricted for IP telephony (phone number must be changed), and the other is 0AB-J, which is the same as current fixed telephone numbers (03 in Tokyo and 06 in Osaka), allowing consumers to keep their numbers; therefore, number portability of IP telephony service is either possible (1) or impossible (0).
- Emergency access: Direct dial calls from IP telephony to 110 (police) or 119 (fire station) may not be available; therefore, emergency access from IP telephony is either possible (1) or impossible (0). We assume that emergency access is always possible (1) in the case of parallel usage because one can dial from fixed telephones.
- Fax usage: IP telephony may not guarantee the sending and receiving of faxes depending on traffic conditions or equipment; therefore, fax usage from IP telephony is either possible (1) or impossible (0). We assume that fax usage is always possible (1) in the case of parallel usage because one can send and receive faxes using fixed telephones.
- Call charges: Long-distance charges (per three minutes) are approximately ¥10 (US\$0.1) to ¥80 (US\$0.7), depending on distance and time as well as user contract on carrier preselection for fixed telephone services and ¥0 (US\$0) to ¥10 (US\$0.1) regardless of distance and time for IP telephony services;⁸ therefore, levels are assumed to range from ¥10 (US\$0.1) to ¥25 (US\$0.2) for preselection contracts and a maximum of ¥80 (US\$0.7) in the cases without preselection contracts for fixed telephone services, while from ¥0 (US\$0) to ¥10 (US\$0.1) for IP telephony service.

Fig. 6.1 depicts the scope of the representative questionnaire covering profiles and attributes. We asked 10 questions per respondent. The respondents of this online sample survey are monitors registered with a Web investigative company designated by MIC.⁹ Consumer preferences may differ depending on the type of Internet access services. For this reason, we collected 100 samples according to the following Internet connection:

- FTTH Internet users at home,
- CATV Internet users at home,

Service		Alternative 1		Alternative 2		Alternative 3	
Basic monthly charge (Breakdown)	Basic monthly charge (Fixed phone) (IP phone)	Only fixed phone		Both fixed phone and IP phone		Only IP phone	
		¥1,400 ¥1,400 --		¥1,600 ¥1,200 ¥400		¥400 -- ¥400	
Other attributes	Voice quality	(by using fixed phone) Good		(by using fixed phone) Good by using IP phone Good		(by using IP phone) Good	
	Number portability (03, 06 and so on)	(by using fixed phone) Possible		(by using fixed phone) Possible by using IP phone Impossible		(by using IP phone) Possible	
	Emergency calling (police, fire station)	(by using fixed phone) Possible		(by using fixed phone) Possible		(by using IP phone) Impossible	
	FAX usage	(by using fixed phone) Possible		(by using fixed phone) Possible		(by using IP phone) Impossible	
	Call charge (daytime, long- distance)	(by using fixed phone) ¥80 at maximum (by using pre-selection) Flat ¥20		(by using fixed phone) ¥80 at maximum (by using IP phone) Flat ¥4		(by using IP phone) Flat ¥0	

Figure 6.1 Questionnaire sample.

Source: Ida, Kinoshita, and Sato (2007).

- ADSL Internet users at home,
- Dial-up or ISDN Internet users at home.

We used a stratified random sampling method (see Louviere, Hensher, and Swait, 2000 for details) on a pooled data set constructed from a total of 4000 (400×10) samples. We summarize the main points as follows:

Conjoint analysis

We carried out conjoint analysis to examine stated preferences for IP telephony. Assumed alternatives are only fixed phone, parallel usage, and only IP phone. Also, assumed attributes are basic monthly charge, voice quality, number portability, emergency access, fax usage, and call charges. We collected 100 samples according to the Internet connection.

Basic statistics and estimations results

Table 6.10 indicates the basic statistics of the experimental choices. Examining the pooled data, the choice ratio is 44% for Alternative 1 (only fixed phone), 36% for Alternative 2 (parallel usage), and 21% for Alternative 3 (only IP phone).¹⁰ The total choice ratio of using fixed telephone (the sum of the choice ratios of Alternatives 1 and 2) amounts to 80%. We observe, therefore, that at this stage, few users are considering shifting from fixed telephones to IP telephony. On the other hand, the total choice ratio of using IP telephony (the sum of the choice ratios of Alternatives 2 and 3) amounts to 57%, demonstrating that more than half of the users are highly interested in using IP telephony. This seemingly contradictory tendency may suggest the current changeover from POTS to IP telephony.

Note here that since non-compensatory decision-making was observed, substitutability between attributes was not considered by decision-makers, and only one attribute determines the decision (see Payne, Bettman, and Johnson, 1993, pp. 240–243) similar to the case of lexicographic preferences. In our experiment, 108 of 400 respondents chose the same alternative among three, regardless of the different levels of attributes in the profiles. The breakdown of this adherence to only one alternative is 56 people for Alternative 1, 28 people for Alternative 2, and 24 people for Alternative 3. It follows that only fixed phone users exhibit such a strong tendency. In this respect, we observe the status quo bias that current choices (namely, using fixed phones) determine the stated preferences of users.¹¹

We used a conditional logit (CL) model for estimating the data.¹² Table 6.11 indicates the estimation results. Estimations were carried out for (a) the pooled data (=e+f), (b) the FTTH user group, (c) the CATV Internet user group, (d) the ADSL user group, (e) the broadband (BB) user group

Table 6.10 Basic statistics

Alternative	Choice no.	Choice ratio	Monthly charge	Voice quality	Number portability	Emergency calls	FAX usage	Call charges
1 (Only fixed phone)	1751	0.44	¥1,389.38	1.00	1.00	.100	1.00	¥17.07
2 (Parallel usage)	1422	0.36	¥1,622.36	0.48	0.53	1.00	1.00	¥3.78
3 (Only IP phone)	827	0.21	¥318.86	0.54	0.57	0.54	0.43	¥3.43

Note: Figures are sample means of chosen alternatives.

Source: Ida, Kinoshita, and Sato (2007).

Table 6.11 Estimation results

Parameter	Pooled data	FTH	CATV	ADSL	BB	NB
Monthly charge	-0.00100 0.00011	-0.00105 0.00022	-0.00105 0.00022	-0.00080 0.00021	-0.00096 0.00012	-0.00122 0.00025
Voice quality	0.59873 0.05853	0.57475 0.11672	0.73401 0.11818	0.56260 0.11399	0.62015 0.06696	0.54197 0.12202
Number portability	0.37706 0.05474	0.38882 0.10912	0.22493 0.10880	0.49633 0.10581	0.37206 0.06213	0.41418 0.11803
Emergency calls	0.82917 0.08626	0.96145 0.16937	0.84335 0.16625	0.77991 0.16297	0.85629 0.09574	0.75931 0.20690
FAX usage	0.33052 0.08410	0.23825 0.16552	0.40102 0.16221	0.34462 0.15936	0.32752 0.09357	0.37048 0.19989
Call charges	-0.01382 0.00513	-0.01153 0.01025	-0.01565 0.01027	-0.01361 0.01024	-0.01362 0.00590	-0.01628 0.01054
Alt1 Constant	0.92057 0.17805	0.85091 0.35077	0.89773 0.34794	0.32221 0.34232	0.68310 0.19991	1.84472 0.40431
Alt2 Constant	1.28470 0.17112	1.26507 0.33788	1.07441 0.33280	0.87835 0.32267	1.06227 0.19073	2.18296 0.39905
No. of observations	4000	1000	1000	1000	3000	1000
Log Likelihood	-4100.352	-1032.072	-1021.674	-1049.380	-3114.960	-956.486

Note: Upper row denotes estimates. Lower row denotes standard errors.

Source: Ida, Kinoshita, and Sato (2007).

(=b+c+d), and (f) the narrowband (NB) user group. The signs of the parameters were correct in all cases: negative for basic monthly and call charges, positive for voice quality, number portability, emergency access, and fax usage. Turning to t-values, the results showed conclusive evidence as estimates in all cases were found to be statistically significant at the 1% level. We summarize the main points as follows:

Basic statistics and estimations results

Our results suggest the current changeover from POTS to IP telephony. The signs of the parameters were correct in all cases. Turning to t-values, furthermore, the results showed conclusive evidence.

(*) *Test for parameters equality*

We investigate whether consumer preferences, expressed as parameters, are equal across Internet access environments by using a likelihood ratio (LR) test. More concretely, we used the following procedure. Consider groups A and B; let $L(A)$ and $L(B)$ be the estimated log likelihood function values for groups A and B; furthermore, let $L(A+B)$ be the value of the estimated log likelihood function for the pooled group; then we obtain the test statistic of $-2[L(A+B)-(L(A)+L(B))]$, that is, chi-squared (χ^2) distributed.

Table 6.12 indicates test results for parameter equality. There are six patterns as follows: FTTH vs. CATV, FTTH vs. ADSL, FTTH vs. NB, CATV vs. ADSL, CATV vs. NB, and ADSL vs. NB. Preferences are not different between the FTTH and CATV groups and between the FTTH and ADSL groups, whereas the preferences are different for other patterns. In short, FTTH, CATV Internet, and ADSL users share similar preferences regarding IP telephony adoptions, and only narrowband users are distinctly different from the other users.

Table 6.12 Parameters-equality test

	<i>FTTH</i>	<i>CATV</i>	<i>ADSL</i>
CATV	6.938 Not rejected	—	—
ADSL	8.092 Not rejected	20.558 Rejected	—
NB	33.4282 Rejected	41.4582 Rejected	56.7282 Rejected

Notes 1: $\chi^2_{0.05}(8)=15.51$.

2: $\chi^2=57.81$ in the case of BB vs. NB.

Source: Ida, Kinoshita, and Sato (2007).

By performing an additional test for the BB vs. NB scenario, we confirmed that broadband users have different preferences from narrowband users. The reason may be that IP telephony is still considered only an optional supplement of broadband services, so that preference differences are not observed among FTTH, CATV Internet, and ADSL users; on the other hand, since narrowband users are not prepared to use IP telephony, they are generally not interested in using IP telephony.¹³ We summarize the main points as follows:

Test for parameters equality

FTTH, CATV Internet, and ADSL users share similar preferences regarding IP telephony adoptions, and only narrowband users are distinctly different from the other users.

Willingness to pay

We calculated the monthly willingness to pay (WTP) values of various IP telephony attributes, as indicated in Table 6.13. Focusing on the results of broadband users, the highest WTP is for emergency access, which is ¥894 (US\$8.1). They attach the most importance to emergency access. WTP for securing voice quality ranks second, which is ¥647 (US\$5.9). They demand the same voice quality from IP telephony as ordinary fixed telephones. Emergency access and voice quality are the most fundamental functions of POTS. Accordingly, we find that consumers are still unwilling to dispense with such fundamental functions when using IP telephony. On the other hand, WTPs are ¥388 (US\$3.5) for number portability and ¥342 (US\$3.1) for fax usage. The valuation is low for number portability, probably because many users have previously changed telephone numbers at least once or twice, and so they are unconcerned about it. The result also seems quite plausible for fax usage, considering the current penetration of email and the

Table 6.13 WTP

<i>WTP</i>	<i>Voice quality</i>	<i>Number portability</i>	<i>Emergency call</i>	<i>FAX usage</i>	<i>Call charge</i>
Pooled data	¥598.52	¥376.93	¥828.88	¥330.41	¥13.82
FTTH	¥545.55	¥369.06	¥912.60	¥226.14	¥10.94
CATV	¥697.67	¥213.79	¥801.60	¥381.16	¥14.88
ADSL	¥704.57	¥621.57	¥976.70	¥431.57	¥17.05
BB	¥647.42	¥388.42	¥893.94	¥341.92	¥14.22
NB	¥442.76	¥338.36	¥620.31	¥302.66	¥13.30

Source: Ida, Kinoshita, and Sato (2007).

smooth delivery of digital files via email. We summarize the main points as follows:

Willingness to pay

People are no longer satisfied with cheap and inferior IP telephony; on the other hand, they demand IP telephony with the same QoS as fixed telephone services.¹⁴ IP telephony must guarantee QoS for further diffusion.

Comparisons between 050- and 0ABJ-type IP telephony

As explained above, there are two kinds of IP telephony. First, the 050-type IP telephony, which has prefixes dedicated to IP telephony, does not guarantee an equivalent QoS of POTS including voice quality, number portability, emergency access, and fax usage. On the other hand, 0ABJ-type IP telephony does guarantee QoS. We calculated the choice probabilities of Alternatives 3 for both 050- and 0ABJ-types by using the estimation results given in Table 6.14.¹⁵

Focusing on broadband users, the calculated choice probability of Alternative 3 is 0.25 at the sample means. In the case of 050-type IP telephony, where all attribute levels of voice quality, number portability, emergency access, and fax usage are set to zero, the choice probability of Alternative 3 is only 0.09. On the other hand, in the case of 0ABJ-type IP telephony where all attribute levels are set to one, the choice probability of Alternative 3 increases to 0.48. As such, the future diffusion of IP telephony is largely based on whether the QoS of IP telephony is guaranteed. 0ABJ-type IP telephony could

Table 6.14 Comparison between 050- and 0ABJ-types of IP telephony

<i>Choice probability</i>	<i>Alternative 3 (Only IP phone)</i>		
	<i>Average</i>	<i>050</i>	<i>0ABJ</i>
Pool data	0.22	0.08	0.43
FTTH	0.23	0.09	0.46
CATV	0.24	0.09	0.47
ADSL	0.27	0.10	0.50
BB	0.25	0.09	0.48
NB	0.13	0.05	0.29

Source: Ida, Kinoshita, and Sato (2007).

conceivably replace existing fixed telephones. We summarize the main points as follows:

050- and 0ABJ-type IP telephony

The difference of choice probability between 050- and 0ABJ-type IP telephony is quite large. Thus, the future diffusion of IP telephony is largely based on whether the QoS of IP telephony is guaranteed.

Projection for IP telephony household penetration rates

Since conjoint analysis is suited for forecasting long-term consumer preferences, we forecast the spread of IP telephony by using estimation results. Parker (1994) advocates a model that includes the dynamic market potential of the form $cM(t)$, where c measures the percentage of non-adopters in the potential market (ie non-Internet users and narrowband users) while $M(t)$ is the number of potential units that could adopt (ie number of households).¹⁶

For our projections, we derive the estimated number of broadband subscribers as of 2009 from the Nomura Research Institute (NRI). According to NRI, the number of subscribers will be 9.0 million for FTTH (18.1%), 3.5 million for CATV Internet (7.0%), 16.1 million for ADSL (32.1%), for a total of 28.6 million broadband subscribers (57.4%). The figures in parentheses represent household penetration rates of 50 million, which is the approximate number of households in Japan in 2010, according to the National Institute of Population and Social Security Research.

We suppose two scenarios for Japan's household IP telephony penetration rate by 2009:

- Scenario 1: The values of all attributes are set to the sample means summarized in Table 1.
- Scenario 2: The attribute levels of voice quality, number portability, emergency access, and fax usage are set to one (ie 0ABJ-type IP telephony) while basic monthly and calling charges are set to the sample means.

Table 6.15 shows the projection results for the IP telephony household penetration rate in 2009. In Scenario 1 (sample means), the number of IP telephony subscribers is 17.6 million (35.1%) for Alternatives 2 and 3 (including parallel usage of fixed and IP phones) and 7.2 million (14.4%) for Alternative 3 (using only IP phones). In Scenario 2 (0ABJ-type IP telephony), the number of IP telephony subscribers is 22.0 million (44.1%) for Alternatives 2 and 3 (including parallel usage of fixed and IP phones) and 12.0 million (23.9%) for

Table 6.15 Household IP telephony penetration rates projections for 2009

<i>Including parallel usage (Alternatives 2 and 3)</i>			<i>Only IP telephony (Alternative 3)</i>		
	<i>Scenario 1 (Average)</i>	<i>Scenario 2 (0ABJ-type)</i>		<i>Scenario 1 (Average)</i>	<i>Scenario 2 (0ABJ-type)</i>
FTTH	10.6%	13.5%	FTTH	4.2%	7.2%
CATV	4.0%	5.1%	CATV	1.7%	2.9%
ADSL	20.6%	25.5%	ADSL	8.5%	13.8%
Total	35.1%	44.1%	Total	14.4%	23.9%

Scenario 1: The values of all attributes are set to the sample means.

Scenario 2: The values of voice quality, number portability, emergency calling, FAX usage are set to one (ie 0ABJ-type IP telephony) while basic monthly and calling charges are set to the sample means.

Source: Ida, Kinoshita, and Sato (2007).

Alternative 3 (exclusively IP telephony usage). We summarize the main points as follows:

Projection for IP telephony

The household penetration rate will probably reach 30% to 40%; moreover, half will eventually shift from fixed telephones to IP telephony.¹⁷

IP telephony policy issues

In this section we will take up and discuss the main competition policy issues in contention relating to IP telephony based on the analysis presented thus far (MIC, 2005a).

IP telephony interconnectivity

This section will address IP telephony interconnectivity. IP telephony is a call service, so of course network externalities arise from the network connections. We argued in Chapter 2 that when network externalities are involved, interconnectivity increases social welfare, but when the interests of service providers collide over interconnection cost burden, it is possible that only a minor interconnection incentive will result that is too small to contribute to social welfare. Currently, there are three basic interconnection scenarios for exchanging VoIP traffic between IP telephony service providers:

- 1 VoIP traffic exchanged over an IP (Internet protocol)-IP connection,
- 2 VoIP traffic not exchanged over an IP-to-IP connection, but over an IP-PSTN (public switched telephone network)-IP connection,
- 3 VoIP traffic is not interconnected at all, and traffic can only be exchanged over a PSTN connection.

In the first scenario, IP telephony services are directly connected, so this scenario is mainly represented by IP telephony providers offering free telephony service. In the second scenario, the PSTN is interposed between IP telephony services, so this scenario is mainly represented by IP telephony providers offering VoIP services at a flat rate of ¥8 for three minutes. In the third scenario, IP telephony cannot be used, so fixed telephony is used.

The main appeal of IP telephony is the low cost for the service. But in cases where part of the interconnection is over the PSTN, the primary appeal of low rates is attenuated and the relative advantage over fixed telephony is reduced. In terms of network externalities, IP telephony has considerable appeal if people you frequently call are IP telephony subscribers, but if the people you call are not subscribers or if the rates are little different from wireline telephony, then the motivation for subscribing to IP telephony is markedly reduced.

Let us next consider the model. Here we assume two service providers: Operator A with 4,000 subscribers and Operator B with 1,000 subscribers, and Operator B requests interconnection with Operator A. This would cost ¥100 million to modify the system to set up the interconnection, plus ¥100 million a year in maintenance costs. Operator A contends that Operator B should pay all the costs, since it is Operator B who wants to set up the interconnection. But Operator A says he will consider the arrangement, if the costs are split evenly between the two operators. Meanwhile, Operator B wants Operator A to bear all the costs considering the different sizes of their respective operations, but says that at least the costs should be prorated based on the number of subscribers. These kinds of cases are very often decided by the authorities-based political dynamics.

How should we approach this kind of an issue? First we would note that while costs are fixed, calls are completed through P2P connections between subscribers. So by considering all the possible call combinations, we can assess the network externalities that are dependent on the number of subscribers. Before the networks are interconnected, the call combinations for Network A are ${}_{4000}C_2 = 7,998,000$, and the call combinations for Network B are ${}_{1000}C_2 = 499,500$. Moreover, the total number of call combinations for both Networks A and B after they are interconnected is ${}_{5000}C_2 = 12,497,500$. It will be apparent that the number of call combinations for Network A increased by 4,499,500, while the number of call combinations for Network B increased by 11,998,000. Operator A's share of the increase in consumer call combinations resulting from interconnecting the two networks is 27.3% while Operator B's share of the increase is 72.7%. This would be one criterion for prorating fixed costs based on the relative benefit/burden ratio for the two operators.

Now turning to variable costs, simply assuming equal probability of one subscriber calling another subscriber, then 80% of calls from Network A would be to subscribers in Network A and 20% would be to subscribers in Network B. The percentages would be reversed for Network B, with 20% of

calls from Network B going to other subscribers in Network B and 80% to Network A. Since Network A has 4 times the number of subscribers as Network B, the connection charges will be exactly offset, unless there is a significant difference in calling patterns between the two networks. In other words, $4,000 \text{ subscribers} \times 20\%$ is the same as $1,000 \text{ subscribers} \times 80\%$. Thus, simply splitting the variable costs would be one approach to sharing the costs.

Summarizing, we find that A's share of costs in this model for the first year after interconnection would be ¥77.3 million while B's share would be ¥122.7 million. But do not become alarmed. Although this burden sharing may be perfectly fair from a logical standpoint, no one would think it was fair from an intuitive realistic standpoint. Indeed, this allocation would all but exclude all smaller scale network operators from entering the market. Under these terms, for example, each Network A subscriber's share would be about ¥20,000, while the amount borne by Network B subscribers would be about ¥120,000. If consumers were to rationally factor these interconnection charges into their decision-making, then all would opt for Network A and none would choose Network B. It is thus apparent that from the standpoint of policies designed to promote competition, identifying an appropriate cost-share burden for Operator A based on ability to pay, providing an opportunity for Operator B to enter the market, and invigorating market competition are all highly significant objectives. At the same time, careful consideration should be given to ensure that overly favorable treatment for Operator B does not have the contrary effect of exacerbating inefficiency of the industry. We summarize the main points as follows:

IP Telephony interconnectivity

There are three basic call scenarios for interconnecting IP telephony services: IP-IP, IP-PSTN-IP, and PSTN. When migrating from interconnection over the PSTN to IP, the cost burden becomes an issue. Based on the benefit/burden principle, new entrants must bear some share of the costs to enter the market, but their share should reflect ability to pay to promote competition.

Impact of IP telephony on fixed telephony

In this section, we discuss the impact that IP telephony is likely to have on fixed telephony. This raises two important concerns: the impact that IP telephony penetration will have on the stability of maintaining fixed telephony infrastructure, and the impact that IP telephony penetration will have on fixed telephony universal service. Of course these two concerns are essentially the opposite sides of the same issue, since the spread of IP telephony will reduce the profits of the fixed telephone service providers, thus making it

increasingly difficult for these operators to maintain legacy PSTN and POTS networks.

We have already seen that there are two types of IP telephony service: 050-type IP telephony and 0ABJ-type IP telephony. Let us consider the impact these two types of VoIP service will have on fixed telephony one at a time.

First, 050-type IP telephony is supported over ADSL or CATV Internet connections, and while offered at low rates—sometimes no additional cost at all—the service may have less than desirable voice quality. The 050 numbers do not support emergency calls and the calling range is limited, so 050-type IP telephony is not a viable substitute for PSTN services. Yet 050-type IP telephony has clearly captured a good share of long-distance and international call traffic, so the long-distance and international service providers in particular have been dealt a serious blow. It is clear that the fixed telephony portion that the long-distance and international call market supported is contracting, so we can anticipate that the profitability of the fixed telephony service providers will rapidly deteriorate in the years ahead. Then, as 0ABJ-type IP telephony services become available with the penetration of FTTH, users will no longer need to maintain their wireline phones since 0ABJ service guarantees voice quality and supports number portability, so we can anticipate that many will choose to cancel their fixed wireline service altogether. The fixed telephony service providers will then see their most basic source of revenue begin to dry up. Local exchange carriers like NTT East and West will be stuck in a position of having to maintain both the legacy PSTN and new FTTH network, and will see their revenues from voice services fall across the board even while their costs to support those services will remain the same or increase. There is a good probability that fixed wireline will emerge from all this as a heavily deficit ridden service.

Formerly, fixed universal telephone services were supported by subsidizing lower revenue sources with higher revenue sources—rural areas supported by urban areas, residential users supported by business users, and local calls supported by long-distance calls—and charges were set so that revenues and expenditures were balanced by overall multiple costing. But now it is precisely the urban dwellers, the business users, and the long-distance callers who bore the brunt of higher charges in the past that are in the first wave of users abandoning wireline services for IP telephony services, and while there have been vain efforts to restore funding and the cross-subsidies of the past, it is apparent that the universal fixed telephony service of the past is on the verge of collapsing. Even though one wanted to offset the losses from rural, residential, and local wireline subscribers, the urban, business, and long-distance callers are starting to abandon the PSTN for the optical IP network, and any attempt to levy punitive charges on these early adopters of new services would only be a backward policy propping up a declining industry.

Essentially there is only one viable option, particularly since there is no stopping the flood of users who will soon be migrating from fixed telephony

to 0ABJ-type IP telephony as the penetration of FTTH continues. First, we would note that the technology supporting IP telephony is far simpler than that supporting the PSTN, so IP-based networks can be deployed at relatively low cost. Since basic charges from users who migrate to FTTH will be the primary source of revenues in the years ahead, the only realistic option is to seek to avoid the wasteful costs of sustaining redundant networks by stepping up efforts to move rural, residential, and local call users to 0ABJ-type IP telephony as quickly as possible. In other words, to avoid the collapse of the telephone industry, there is no alternative but to move quickly and systematically to decommission the old network and roll out a new FTTH access network premised on 0ABJ-type IP telephony, which will provide a new standard of universal service and universal access. We will explore this issue in greater depth in Part III. We summarize the main points as follows:

Impact of IP telephony on fixed telephony

As the transition from fixed telephony to IP telephony continues, this raises a number of thorny issues as to how the telephone infrastructure can be maintained and how universal service currently supported by the PSTN can continue to be provided. There is already no stopping the transition from fixed telephony to 0ABJ-type IP telephony, so there is no alternative but to move quickly and systematically to decommission the old network and deploy new fiber-based infrastructure.

Conclusion

This chapter analyzes IP telephony demand by using conjoint analysis. Approximately 80% of the respondents maintain a fixed-line telephone, including parallel usage of a fixed telephone and IP telephony. Therefore, IP telephony is currently considered an add-on service option of broadband Internet access services in Japan, not as a close substitute for fixed telephones. The second finding, however, may be more interesting. If such IP telephony attributes as voice quality, number portability, emergency access, and fax usage are completely guaranteed, however, more than half of the respondents will choose IP telephony. Therefore, if 0ABJ-type IP telephony is provided at low prices, there will be rapid changeover from POTS to IP telephony. This conclusion is consistent with MIC's survey (2005a). However, since innovation is rapidly changing the landscape of telecommunication infrastructure and architecture, there are broad implications concerning the industrial structure of telecommunication services that need careful consideration in the future.

7 Mobile telephony: From voice to data services

In this chapter, we will consider the structure of the mobile telephony market, including some econometric analysis. Japan took an early lead in the mobile telephony sector when NTT DoCoMo launched i-mode in 1999, followed by the rollout of FOMA in 2001. Yet the initial take-up of FOMA was slower than the company anticipated; a three-way oligopoly emerged made up of NTT DoCoMo, KDDI, and Vodafone, and a number of other issues have arisen.¹ Here we will examine Japan's mobile phone sector by addressing the following four themes. First, the supply structure of Japan's mobile telephony is described, based on data. Primary emphasis will be on the changes accompanying the transition from second generation (2G) to third generation (3G) mobile telephony services. Second, we examine the current state of mobile phone usage in Japan and recent changes among service providers based on a consumer questionnaire. Of particular interest is the question of whether customers are locked in to service providers through mobile phone numbers, email addresses, and so on. Third, we present a discrete choice model analysis based on data from the consumer questionnaire. This is a pioneering application of this type of analysis to subscriber demand for 3G mobile telephony services, and a mixed logit (ML) model is employed to represent cross-nested structures. We analyzed whether provider company brand or technology (2G versus 3G) were more important factors in subscriber demand for mobile phone service, and whether there was a significant difference in usage between the different mobile phone technologies. Fourth, we will discuss mobile phone market definition, whether there is effective competition in the mobile telephony market, and other relevant policy issues.

Mobile telephony supply analysis

In this section, we will briefly consider the supply side of the mobile telephony market. The variety of mobile telephony services available in Japan today can be broadly divided into second-generation (2G) mobile telephony services, third-generation (3G) mobile telephony services, and PHS (Personal

Handyphone Systems) services; and the services themselves can be classified as voice services and data services (MIC, 2005a).² Second-generation (2G) digital services succeeded first-generation (1G) analog services. The 2G mobile phone standards implemented in Japan are Personal Digital Cellular (PDC) and cdmaONE. The former is used by NTT DoCoMo, Vodafone, and TuKa, and has 57.01 million subscribers (as of January 2005), while the latter is used by KDDI au and has a subscriber base of 1.81 million. Compliant with the ITU's IMT-2000 framework, NTT DoCoMo rolled out its first 3G offering in October 2002. The principal advantages of the 3G technology is that it supports high-speed data services and a greater range of advanced terminal capabilities, so users can do everything from sending and receiving video images to settling financial transactions using one and the same terminal or handset. The 3G standards in Japan are W-CDMA and cdma2000. The former is used by NTT DoCoMo and by Vodafone, with a subscriber base of 9.84 million (as of January 2005), and the latter is used by au and has 17.12 million customers. One objective of 3G was to increase the speed of data services, and 3.5G (HSDPA) supports throughputs up to 14 Mbps using W-CDMA and up to 2.4 Mbps using cdma2000. Now let us take a closer look at the supply structure of Japan's mobile phone market.

Transformation of Japan's mobile telephony market

Table 7.1 shows the change in number of subscribers for different mobile phone standards from March 2001 to March 2007. The total number of mobile telephony subscribers including PHS grew steadily all through the period, and by 2007 had exceeded 100 million. We should note however that the rate of growth is showing signs of saturation, and the mobile phone market is now reaching maturation. Noteworthy in these figures is the fact that many subscribers are switching from 2G to 3G services. Since 3G services were first made available in 2002, the number of subscribers has been steadily increasing, and currently as of March 2007, the ratio of 3G to 2G service subscribers is 72:28, and the number of 3G users has surpassed 2G customers.

Table 7.2 shows the change in number of subscribers for the different mobile phone service providers. In NTT DoCoMo's case, the company initially had some difficulty making the transition from 2G to 3G because:

- They began offering services before they were ready (too many dropped calls, short battery life, modest signal coverage, etc).
- They did not exploit the value-added potential of 3G technology (absence of enticing new features and services).
- They were late in developing handsets (problems with chip operating voltage, memory capacity, JAVA tuning, etc).

Table 7.1 Change in number of subscribers for 2G, 3G, and PHS services

	2001.3	2001.9	2002.3	2002.9	2003.3	2003.9	2004.3	2004.9	2005.3	2005.9	2006.3	2006.9	2007.3
Mobile	61.1	65.6	69.3	69.5	68.8	67.6	65.2	61.7	56.6	51.1	43.5	36.4	26.8
3G	0.0	0.0	0.1	2.8	7.2	11.3	16.7	22.6	30.4	38.1	48.3	57.4	69.9
Subtotal	61.1	65.6	69.4	72.3	75.9	78.9	81.9	84.3	87.0	89.1	91.8	93.8	96.7
PHS	5.8	5.7	5.7	5.6	5.5	5.3	5.1	4.8	4.5	4.5	4.7	4.9	5.0
Total	67.0	71.3	75.1	78.0	81.4	84.3	87.1	89.1	91.5	93.6	96.5	98.7	101.7

Note: Figures are millions. Source: MIC (2007).

Table 7.2 Change in number of subscribers for mobile phone service providers

	2001.3	2001.9	2002.3	2002.9	2003.3	2003.9	2004.3	2004.9	2005.3	2005.9	2006.3	2006.9	2007.3
NTT DoCoMo													
2G	36.2	38.7	40.9	42.3	43.8	44.4	43.3	40.9	37.3	33.1	27.7	23.0	17.1
3G	0.0	0.0	0.1	0.1	0.3	1.0	3.1	6.5	11.5	16.8	23.5	29.1	35.5
Subtotal	36.2	38.7	41.0	42.4	44.2	45.4	46.3	47.4	48.8	49.9	51.2	52.1	52.6
KDDI													
au2G	11.0	11.8	12.2	10.4	7.2	5.1	3.5	2.3	1.6	4.7	3.6	2.6	1.5
au3G	0.0	0.0	0.0	2.7	6.8	10.2	13.5	15.9	17.9	19.6	21.8	23.8	26.7
Subtotal	11.0	11.8	12.2	13.1	14.1	15.3	17.0	18.2	19.5	24.2	25.4	26.4	28.2
Vodafone													
TuKa	4.0	4.0	3.9	3.9	3.8	3.7	3.5	3.6	3.6	—	—	—	—
2G	10.0	11.1	12.2	13.0	14.0	14.6	14.9	14.9	14.1	13.2	12.2	10.7	8.3
3G	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.9	1.8	3.0	4.6	7.7
Subtotal	10.0	11.1	12.2	13.0	14.0	14.6	15.0	15.2	15.0	15.0	15.2	15.3	15.9

Note: Figure are millions. TuKa was merged into KDDI after 2005.9. Source: MIC (2007).

However, NTT DoCoMo made a comeback with the good reception of its 900 series handsets after 2004, and has been attracting a steady increase in its customer base. As of March 2007, NTT DoCoMo's ratio of 3G to 2G subscribers has narrowed to 67:33. Also, KDDI au's transition from 3G to 2G has been nothing short of astonishing. Their 3G users had already surpassed 2G subscribers in 2003, and their transition (including TuKa) is now virtually complete with a 3G-to-2G ratio of 95:5. KDDI au's great success can be attributed to the close affinity between cdmaONE and cdma2000 3G networks. This meant that no major new investment in 3G technology was required, so users could make the move to 3G by merely replacing their handsets. Another major factor was that au was quick to seize on the data delivery potential of 3G with Chaku-uta (music downloading service) and other engaging new services. In marked contrast to au is Vodafone. The company was late in implementing a 3G transition strategy, and as a result, is now struggling and has actually experienced a net decrease in their subscriber base. Vodafone (Softbank)'s 3G-to-2G ratio stands at 48:52 as of March 2007.

Table 7.3 shows the change in composition of mobile phone customers for the different mobile phone service providers. The first thing one notices is the commanding share of market controlled by NTT DoCoMo. DoCoMo has a solid 50% share of the mobile market, with the rest divided up among a three-way oligopoly of providers: two KDDI Group providers, au and TuKa, and Vodafone. Note however that the gap between the KDDI Group with the second largest share and Vodafone continues to widen. Meanwhile, the PHS system continues to lose market share.

Table 7.4 shows the change in the number of customers for different providers broken out by mobile phone standard. Looking first at the 2G market, one can see that NTT DoCoMo has the largest share of the market by far with over 60%, followed by Vodafone with a 30% share of the market. KDDI au's share of the 2G market (not including TuKa) is steadily shrinking, but this reflects au's early success in migrating from 2G to 3G while NTT DoCoMo and Vodafone were still struggling in their transition to 3G. Turning to the 3G market, while NTT DoCoMo was first to roll out a 3G offering, the numbers reveal that NTT DoCoMo has dealt a major defeat at the hands of au in the initial maneuvering for market share. But NTT DoCoMo learned its lesson and made a rapid comeback after 2004. NTT DoCoMo was outmaneuvered by au at the outset, but if DoCoMo's customers continue to migrate from 2G to 3G at the rates they are now, NTT DoCoMo could once again reclaim 3G market leadership. Looking at the overall mobile telephony market, NTT DoCoMo has seen its share slightly diminish, but still has the lion's share by a substantial margin. One sees a sharp contrast in the 3G market between the indomitable performance of au on the one hand and the lackluster performance of Vodafone on the other. Vodafone vows a comeback, and observers are keenly watching to see if they

Table 7.3 Change in shares of mobile phone service providers

	2001.3	2001.9	2002.3	2002.9	2003.3	2003.9	2004.3	2004.9	2005.3	2005.9	2006.3	2006.9	2007.3
PHS	8.7%	8.0%	7.6%	7.2%	6.7%	6.3%	5.9%	5.4%	4.9%	3.7%	4.1%	4.3%	5.9%
Vodafone	14.9%	15.6%	16.3%	16.7%	17.1%	17.3%	17.2%	17.0%	16.4%	16.0%	15.8%	15.5%	15.5%
KDDI	5.9%	5.6%	5.2%	5.0%	4.6%	4.4%	4.0%	4.0%	3.9%	—	—	—	—
TuKa	16.4%	16.6%	16.3%	16.7%	17.3%	18.1%	19.5%	20.4%	21.4%	25.9%	26.4%	26.8%	27.2%
au	54.1%	54.2%	54.6%	54.4%	54.2%	53.9%	53.2%	53.1%	53.4%	54.4%	53.8%	53.4%	51.4%
NTT DoCoMo													
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Note: TuKa was merged into au after 2005.9. Source: MIC (2007).

Table 7.4 Change in number of customers broken down by standard

	2001.3	2001.9	2002.3	2002.9	2003.3	2003.9	2004.3	2004.9	2005.3	2005.9	2006.3	2006.9	2007.3
2G													
NTT DoCoMo	59.2%	58.9%	59.1%	60.8%	63.7%	65.5%	66.5%	66.2%	65.9%	64.9%	63.7%	63.2%	63.8%
au	18.0%	18.0%	17.6%	15.0%	10.5%	7.5%	5.3%	3.8%	2.8%	9.2%	8.3%	7.2%	5.5%
TuKa	6.5%	6.1%	5.6%	5.6%	5.5%	5.5%	5.3%	5.8%	6.3%	—	—	—	—
Vodafone	16.3%	16.9%	17.7%	18.7%	20.3%	21.5%	22.8%	24.2%	24.9%	25.9%	28.0%	29.6%	30.7%
3G													
NTT DoCoMo	—	—	100.0%	4.7%	4.6%	8.9%	18.3%	28.7%	37.9%	44.1%	48.5%	50.7%	50.8%
au	—	—	—	95.3%	95.4%	91.1%	80.9%	70.1%	59.1%	51.3%	45.2%	41.4%	38.2%
Vodafone	—	—	0.0%	0.0%	0.0%	0.0%	0.8%	1.1%	3.0%	4.6%	6.3%	7.9%	11.0%
Total													
(2G+3G)													
NTT DoCoMo	59.2%	58.9%	59.1%	58.6%	58.1%	57.5%	56.7%	56.2%	56.1%	56.0%	55.7%	55.5%	54.4%
au	18.0%	18.0%	17.6%	18.0%	18.5%	19.3%	20.7%	21.6%	22.5%	27.2%	27.7%	28.1%	29.1%
TuKa	6.5%	6.1%	5.6%	5.3%	5.0%	4.7%	4.2%	4.3%	4.1%	—	—	—	—
Vodafone	16.3%	16.9%	17.6%	18.0%	18.4%	18.5%	18.4%	18.0%	17.3%	16.8%	16.6%	16.4%	16.5%

Note: TuKa was merged into au after 2005.9. Source: MIC (2007).

can regain some share of the 3G market. We summarize the main points as follows:

Transformation of Japan's mobile telephony market

Japan continues to evolve from 2G to 3G mobile telephony services, with KDDI au in the vanguard. NTT DoCoMo, which controls more than half of Japan's mobile telephony market had difficulty at first making the transition to 3G, but now it is fair to say that they are back on course. Vodafone got off to a very late start in transitioning to 3G, and is struggling to regain market share.

Other indicators

Table 7.5 shows the change in number of browser phone service subscribers. NTT DoCoMo rolled out its i-mode service in 1999, but utilization of browser phone service climbed to over 50% in just two years time, and has reached 87% as of March 2007. And the growth has not just been quantitative. The quality of browser phone services has also shown remarkable improvement as 3G networks have spread including faster data services, more diversified content and services, and the introduction of a flat-rate schedule for data. This suggests that mobile Internet is not just a minor niche broadband service, and could very well develop into a hugely popular mobile application. Table 7.6 illustrates the growth of the mobile phone industry from several different perspectives. Looking at call traffic, one can see that the volume of calls made from wireline phones and received on mobile phones has been declining since 1999, while the volume of calls from mobiles to wireline phones has shown a remarkable increase. This reflects the fact that we have entered a period in which the number of wireline subscribers is declining, and telephony leadership has clearly passed from fixed telephony to mobile telephony. Particularly noteworthy is the great increase in the volume of mobile-to-mobile calls. This surge in calls made and received on mobile phones is another way of saying that the fixed telephony market is contracting.

Mobile telephony demand analysis

In this section we will analyze demand trends for mobile telephony. To analyze the demand trends for mobile telephony, we conducted a questionnaire survey in collaboration with the Ministry of Internal Affairs and Communications (MIC) regarding mobile telephony and PHS services in September 2004. The questionnaire was sent by regular mail to 1,000 people who work as monitors for the Telecommunications Bureau of MIC. The response rate was 94%. The quantitative analysis presented in the next section is based on the data obtained through this questionnaire. The attributes of the

Table 7.5 Change in number of browser phone service subscribers

	2001.3	2001.9	2002.3	2002.9	2003.3	2003.9	2004.3	2004.9	2005.3	2005.9	2006.3	2006.9	2007.3
Mobile total	61.1	65.6	69.4	72.3	75.9	78.9	81.9	84.3	87.0	89.1	91.8	93.8	96.7
Browser phone total	34.6	44.9	51.9	57.1	62.5	66.3	69.7	72.3	75.1	77.2	79.8	81.6	84.4
Usage rate	56.5%	68.5%	74.9%	79.0%	82.2%	84.0%	85.1%	85.8%	86.4%	86.6%	86.9%	87.0%	87.2%

Note: Figures are millions.

Source: MIC (2007).

Table 7.6 Growth of mobile phone industry

	1999	2000	2001	2002	2003	2004	2005
From wireline to mobile	105	105	112	102	97	95	90
From mobile to wireline	129	136	149	155	157	160	158
From mobile to mobile	170	245	325	324	340	365	376

Note: Figures are the volume of calls (normarized as 100 in 1998).

Source: MIC (2005a).

respondents are summarized as follows. First, in terms of their ages, 16.8% of the respondents were in their 20s, 29.5% were in their 30s, 23.7% in their 40s, 15.8% in their 50s, and 14.2% were 60 years old and older. The gender of the respondents was 39.5% male and 60.5% female. In terms of occupation, 32.4% of the subjects were company or government employees, 9.2% were self-employed, 20.8% were part-time workers, 33.2% were unemployed, 3.0% were students, and 1.4% were other than the above categories. Out of all the subjects who returned the questionnaire, 81.4% used either a mobile phone or a PHS handset. The service providers of the respondents were 46.9% NTT DoCoMo, 24.2% au, 20.1% Vodafone, 3.6% TuKa, 2.5% NTT DoCoMo PHS, 2.3% DDI Pocket PHS, and 0.4% other providers. The underlying mobile telephony standards represented by the respondents were 56.4% 2G, 38.2% 3G, and 5.4% PHS. Now let us consider the main findings of the survey.

Consumer questionnaire results

Let me first present a broad overview of the survey findings. Table 7.7 summarizes the reasons people gave for using mobile phones. The overwhelming majority said they use their mobile phones when outdoors or away from home or the office, and frequently used their phones to send and receive email. When at home, the respondents do not generally use mobile phones to make phone calls, but again reported fairly high usage for email. The subjects do not use their mobile phones much for Web browsing either at home or away from home. Let us next consider the amount of time and the number of times that the subjects use mobile phones for talking, exchanging email, and for Web browsing.

Table 7.8 shows the monthly charges that people pay for mobile telephony services in Japan. Most respondents pay between ¥2,000 and ¥4,000 a month for a mobile phone service, but quite a few people pay higher charges ranging from ¥10,000 to ¥20,000 a month. When asked to assess the reasonableness of the charges, 8.1% of the respondents felt the charges were very high, 54.0% said the charges were moderately high, 34.4% felt they were about right, 3.2% thought the charges were moderately priced, and 0.4% felt the mobile service charges were very moderately priced. Overall, the users felt that the charges for mobile telephony service were relatively high. A comparison of perceptions regarding charges for the different underlying technologies—2G

Table 7.7 Reasons for using mobile phone

(a) Reasons and places

Outdoors			At home		
<i>Call</i>	<i>Email</i>	<i>Web</i>	<i>Call</i>	<i>Email</i>	<i>Web</i>
96.1%	69.7%	19.6%	32.4%	55.2%	14.6%

Note: Multiple answers permitted.

(b) Amount of calling time per week

<i>–10 min.</i>	<i>10–20 min.</i>	<i>20–30 min.</i>	<i>30 min.–1 H</i>	<i>1–2 H</i>	<i>2 H</i>
39.9%	23.4%	14.0%	11.5%	6.2%	5.0%

(c) Number of email exchanged per week

<i>None</i>	<i>–5</i>	<i>5–10</i>	<i>10–20</i>	<i>20–30</i>	<i>30–50</i>	<i>50–100</i>	<i>100</i>
12.3%	18.7%	19.1%	16.9%	15.4%	9.0%	5.0%	3.7%

(d) Amount of Web-browsing time per week

<i>None</i>	<i>–10 min</i>	<i>10–20 min.</i>	<i>20–30 min.</i>	<i>30 min.–1 H</i>	<i>1 H</i>
49.0%	30.1%	9.5%	3.8%	4.2%	3.3%

Source: MIC (2005a).

versus 3G—is particularly interesting in this context. Compared to the 2G users, the 3G users regarded ¥4,000 as a critical break point: when monthly expenditures were less than that amount, they were perceived as on the low side, and when they were more than ¥4,000, they were perceived as being on the high side. It is apparent that from the service providers' perspective, 3G users generate high average revenue per user (ARPU), but mobile phone expenditures include call charges plus data charges, and the latter charges can easily become quite high considering the high-speed data capabilities of 3G. However, 3G service providers have introduced rate policies to hold down user expenditures such as a flat-rate schedule for packet-switched data services. Certainly, the way ARPU figures evolve for 3G users will be an important point for discussion in the years ahead.

Excluding voice, Table 7.9 shows the other commonly used services and features of mobile phones. As one might expect, usage of mobile phones for sending and receiving email is extremely popular. Ranking high after email were features that have nothing to do with voice or data transmission such as clocks and built-in cameras, so it is evident that additional mobile handset features are valued. The next services ranked after that were web browsing and sending and receiving still images. Usage of 3G mobile phones for sending video images and videophone services exploiting the greater speed and data capacity, which is supposed to be one of the main attractions of 3G services, has not caught on and is still fairly low. The respondents were found to be fairly well satisfied with current mobile telephony services. Principle complaints in order of greatest dissatisfaction were the relatively high rates,

Table 7.8 Monthly charges for mobile telephony services

	¥2,000–4,000	¥4,000–6,000	¥6,000–8,000	¥8,000–10,000	¥10,000–20,000	¥20,000–
(a) Monthly charges for mobile telephony services (all users)						
4.6%	40.7%	25.5%	11.6%	4.8%	10.6%	2.2%
(b) Monthly charges for mobile telephony services (2G users)						
4.9%	44.1%	25.2%	9.8%	4.2%	10.3%	1.5%
(c) Monthly charges for mobile telephony services (3G users)						
0.7%	35.1%	27.5%	14.5%	6.2%	12.3%	3.6%

Source: MIC (2005a).

Table 7.9 Other commonly used services of mobile phones

(a) Other commonly used services of mobile phones									
<i>Email</i>	<i>Clock</i>	<i>Built-in Camera</i>	<i>Web browsing</i>	<i>Still picture</i>	<i>Applications (game etc)</i>	<i>Moving picture</i>	<i>Music</i>	<i>Videophone</i>	
84.8%	65.5%	52.2%	31.5%	12.5%	8.6%	6.6%	6.3%	1.3%	
(b) Satisfaction with current mobile telephony services									
<i>Very satisfactory</i>	<i>Satisfactory</i>	<i>Moderate</i>	<i>Dissatisfactory</i>	<i>Very dissatisfactory</i>					
4.6%	35.3%	46.2%	11.2%	2.6%					
(c) Dissatisfactory points									
<i>High rates</i>	<i>Limited voice coverage</i>	<i>Cumbersome operability</i>	<i>Poor functioning</i>	<i>Overall services</i>	<i>Customer services</i>	<i>Voice quality</i>	<i>Transmission speeds</i>	<i>Others</i>	
43.6%	19.1%	8.5%	7.4%	4.3%	3.2%	2.1%	2.1%	8.5%	

Note: For (b) and (c) multiple answers permitted.

Source: MIC (2005a).

followed by limited voice coverage and cumbersome operability. The main points of this section are summarized as follows:

Consumer questionnaire results

People use their mobile phones extensively to make calls when away from home as one would expect, but also frequently use their mobiles for email when they are home. Users of 3G services felt that the monthly rates were on the high side, and close attention will focus on how price competition evolves over the next few years. Email services are extensively used, but the new 3G services involving greater transfer speeds and capacity are relatively little used.

Choosing and changing service providers

In this section we will analyze the motivations users have for selecting and for changing service providers. Table 7.10 summarizes the factors that users considered most important in selecting a service provider and mobile telephony technology (2G versus 3G). The number one criterion in selecting both provider and mobile technology was voice coverage. Practically all service providers today have completed nationwide deployment of their networks, so it is hard to conceive that voice coverage would be an issue today under ordinary circumstance. However, this concern with voice coverage reflects the fact that voice coverage used to be limited and a major issue when subscribing to a mobile phone service, and also reflects the fact that there are still some pockets where signal reception is poor and this is a major source of dissatisfaction. Other significant factors in choosing a provider were usage by other family members or friends, discount offerings, brand, and so on, but whether the underlying technology was 2G or 3G was not a major consideration for most of the respondents.

Table 7.11 presents the motivations people had for changing service providers. We found that 60% of the subjects had never changed providers, while 40% had. One gets the impression that, once a user commits to a service provider, he has a strong tendency to continue using that provider's services. This is because, once one signs up with a provider, the cost of switching to another provider outweighs the potential benefits from switching, which suggests that customers are essentially locked in to service providers. When asked if they had any intention of changing providers, the great majority of respondents said that they did not. Some replied that there was no reason to change because they were not dissatisfied with the service, while many others mentioned the inconvenience of changing their phone number and email address and the procedural inconvenience and cost of changing as reasons they did not want to change. Introducing policies that would reduce switching

Table 7.10 Important factors in choosing providers and standards

Voice coverage	Family/friends usage	Discount offering	Brand power	Procedural convenience	Toll rates	Handset prices	Voice quality	Handset design	Data transfer rates	Various services	Transmission speed	Customer services
(a) Factors in choosing providers												
47.3%	39.2%	34.8%	34.7%	25.4%	24.7%	22.9%	16.0%	12.1%	11.9%	5.5%	4.5%	4.4%
(b) Factors in choosing standards (2G)												
46.0%	40.5%	35.3%	37.8%	26.1%	24.6%	24.4%	13.4%	12.4%	8.2%	5.0%	3.5%	5.2%
(c) Factors in choosing standards (3G)												
51.6%	39.7%	35.4%	31.4%	21.7%	22.7%	19.9%	18.4%	12.6%	17.7%	6.1%	5.1%	4.0%

Note: multiple answers permitted.

Source: MIC (2005a).

Table 7.11 Motivations for changing service providers

(a) Number of times of changing providers					
<i>None</i>	<i>Once</i>	<i>Twice</i>	<i>Three</i>	<i>Four</i>	<i>Five</i> <i>Six and over</i> <i>Others</i>
58.0%	26.3%	7.3%	4.6%	2.1%	1.0% 0.4% 0.4%
(b) Intentions of changing providers					
<i>Yes</i>	<i>Satisfied with current services</i>	<i>Not want to change phone number or email address</i>	<i>Family/friends use</i>	<i>No Family/friends use</i>	<i>Merits are ambiguous</i> <i>Procedures are troublesome</i> <i>Switching takes time</i> <i>Others</i>
23.2%	28.5%	18.7%	5.1%	4.5%	2.1% 2.0% 7.9% 8.0%
(c) Important factors in determining next providers					
<i>Toll rates</i>	<i>Discount offering</i>	<i>Voice coverage</i>	<i>Procedural convenience</i>	<i>Data transfer rates</i>	<i>Handset prices</i> <i>Family/friends use</i> <i>Voice quality</i> <i>Brand power</i> <i>Various services</i> <i>Handset design</i> <i>Transmission speed</i> <i>Customer services</i>
48.7%	37.6%	37.2%	31.6%	28.6%	20.1% 17.1% 16.2% 14.5% 13.7% 9.0% 7.3% 5.6%

Note: For (c) multiple answers permitted.

Source: MIC (2005a).

costs such as number portability would give users greater freedom to change service providers, and probably make the mobile telephony market more fluid. We can anticipate that user priorities in choosing a service provider will change. They will begin to see such past considerations as voice coverage, usage by friends and family members, and company brand as less important; and price considerations such as the basic rate and discounting as relatively more important in their decision-making. This also strongly suggests the possibility that the availability of number portability will trigger price competition among service providers in order to corral customers. The main points of this section are summarized as follows:

Choosing and changing service providers

A user's first consideration in choosing a mobile service provider is the provider's voice coverage, and s/he may also be influenced by the usage of friends and other family members. We find that once users sign up with a service provider, they tend to be locked in with that provider because of the switching costs involved. The effect of number portability on provider lock-in bears close scrutiny.

Econometric analysis of demand for mobile telephone

The purpose here is to investigate this rapidly evolving demand for mobile telephone services including 3G services by using a discrete choice model called a mixed logit (ML) model.³ A brief review of the related literature shows that few papers have studied demand for mobile telephone services, as previously pointed out by Taylor (2002, p. 130). Research on demand for 3G services is even less common. An exception is Kim (2005), who investigated consumer stated preferences for 3G services (called International Mobile Telecommunication 2000, or IMT2000) in Korea by using conjoint analysis. For our purposes, significant analysis of demand for mobile telephone services can be seen in the following cross-comparative and country studies.⁴ For cross-country research, Ahn and Lee (1999) compared the subscriber rates of mobile telephone services in developed countries and found that income is a more important attribute than charges. Wallsten (2001) explored the effects of privatization, competition, and regulation on mobile operator performance in 30 African and Latin American countries, and Madden, Coble-Neal, and Dalzell (2004) estimated elasticities of demand for mobile telephone service with respect to price and income, based on panel data from 56 countries. Liikanen, Stoneman, and Toivanen (2004) analyzed the role of generational effects in diffusion, interestingly finding positive within-generation network effects. Garbacz and Thompson (2005) estimated worldwide mobile telephone

service by using separate models for developed and developing countries for the period 1996–2001.

For country case studies, Tishler, Ventura, and Watters (2001) and Kim and Kwon (2003) analyzed mobile telephone demand: the former offered projections for the Israeli mobile telephone market up to 2008, while the latter discussed the advantages of network size in acquiring new subscribers in the Korean mobile telephone market. On the other hand, Ahn (2001) estimated the access demand for mobile telephone service in Korea and found that age, gender, and education are important determinants. Iimi (2005) analyzed the Japanese mobile telephone service industry, concluding that the market is highly product-differentiated and no longer displays conventional network externalities. Finally, Doganoglu and Grzybowski (2007) analyzed the demand for mobile telecommunication services in Germany in the period from January 1998 to June 2003.

This section analyzes the access demand for Japanese mobile telephone services by using a discrete choice model. It makes two contributions. We analyze consumers' revealed preferences regarding mobile telephone subscriptions with a special emphasis on the differences between 2G and 3G services, and thus far, is considered one of the first few studies that explicitly deal with 3G services. To analyze decision-making structures in Japan's mobile telephone market, we need to relax the independence from irrelevant alternatives (IIA) properties imposed on conditional logit (CL) models. We adopt here an ML model that can flexibly express an analog to an overlapping nested structure made possible only by recently developed econometric innovations.

Survey method and data

This section introduces the survey and data used here. We carried out sample surveys on individual usage of mobile telephones and PHS in September 2004 jointly with the MIC. The survey was conducted on 1,000 monitors (aged 20 years old and above) registered with 11 local offices of the MIC. The number of respondents was 939. Among them, 764 people (81.4%) subscribe to a mobile telephone or PHS (Personal Handy-phone System). Excluding omissions, we finally obtained 687 effective respondents whose breakdown is given in Table 7.12, according to technical standards (ie 2G, 3G, and PHS) and providers (ie NTT DoCoMo, KDDI (au and Tu-ka), and Vodafone).

The choice ratios are broken down into 3G (37.5%), 2G (57.4%), and PHS (5.2%), according to technical standards. Compared to actual market shares, the 3G choice ratios are higher in our survey, indicating that the monitors registered with the survey are more interested in telecommunications services than the average Japanese person.⁵ Also, by provider the choice ratios are NTT (50.2%), KDDI (29.1%), and Vodafone (19.8%). Compared to actual market shares, NTT's choice ratio is lower in our survey, which is in part based on the fact that the 3G choice ratio is higher in our sample survey and that NTT's share is not so high in the 3G market.

Table 7.12 Basic statistics

Standard	Provider	Observations	Monthly expenditure	Call time (minutes)	Mail no.	Web browsing	Picture	Movie	TV telephone
(a) Classified by alternatives									
3G	NTT DoCoMo	124	¥7,349.1	48.2	21.7	72	17	12	9
	Ratio (%)	18.1%				58.1%	13.7%	9.7%	7.3%
	KDDI (au)	133	¥5,643.8	36.4	19.2	75	24	16	0
	Ratio (%)	19.4%				56.4%	18.0%	12.0%	0.0%
2G	NTT DoCoMo	202	¥5,835.7	34.5	19.7	105	24	—	—
	Ratio (%)	29.4%				52.0%	11.9%	—	—
	KDDI (au+Tu-ka)	56	¥4,021.8	22.2	16.0	24	2	—	—
	Ratio (%)	8.2%				42.9%	3.6%	—	—
	Vodafone	136	¥5,208.0	25.4	23.1	63	18	—	—
	Ratio (%)	19.8%				46.3%	13.2%	—	—
PHS	Total	36	¥3,404.9	28.3	8.8	6	1	—	—
	Ratio (%)	5.2%				16.7%	2.8%	—	—
(b) Classified by standard									
3G		257	¥6,466.6	42.1	20.4	147	41	28	9
Ratio (%)		37.5%				57.2%	16.0%	10.9%	3.5%
2G		394	¥5,361.2	29.6	20.3	192	44	—	—
Ratio (%)		57.4%				48.7%	11.2%	—	—
PHS		36	¥3,404.9	28.3	8.8	6	1	—	—
Ratio (%)		5.2%				16.7%	2.8%	—	—

(c) Classified by Provider									
NTT DoCoMo		326	¥6,411.4	39.7	20.5	177	41	12	9
Ratio (%)		50.2%				54.3%	12.6%	3.7%	2.8%
KDDI		189	¥5,163.2	32.2	18.3	99	26	16	0
Ratio (%)		29.1%				52.4%	13.8%	8.5%	0.0%
Vodafone		136	¥5,208.0	25.4	23.1	63	18	—	—
Ratio (%)		19.8%				46.3%	13.2%	—	—

Note 1: Figures of *Ratio (%)* in the *Observations* column denote the choice ratio in each classification.

Note 2: Figures of *Ratio (%)* in the Web browsing, Picture, Movie, TV telephone columns denote the choice ratio of the number of subscribers using these functions to the number of subscribers in each alternative.

Source: Ida and Kuroda (2007).

Let us now examine the details. *Monthly Expenditure* includes basic monthly charges, additional function charges, call charges, and packet-switched data transmission charges.⁶ 3G services are more expensive than 2G and PHS services, and the monthly expenditures of NTT are also more expensive than KDDI and Vodafone. *Call Time* indicates minutes called per week. 3G services accumulate more minutes than 2G and PHS services; likewise, NTT's 3G accumulates more call time than KDDI and Vodafone. *Mail No.* indicates the number of sent/received emails per week. Note that 87.7% of mobile telephone subscribers who replied said that they use email services by mobile telephone. There is no big difference between 2G and 3G services while PHS mail number is much smaller, and Vodafone subscribers use email services more frequently than NTT and KDDI subscribers. *Web Browsing* represents the number of users who replied that they frequently use Web browsing services by mobile telephone. Forty-nine point three percent of mobile telephone subscribers frequently use Web browsing services. 3G service ranks first, followed by 2G service and then PHS service; NTT also leads KDDI and Vodafone in Web browsing. *Picture* represents the number of users who replied that they frequently use still-picture delivery services by mobile telephone. Twelve and a half percent of mobile telephone subscribers frequently use still picture delivery services. 3G service ranks first, followed by 2G service and PHS service, and KDDI also slightly leads Vodafone and NTT in picture delivery service. *Movie* represents the number of users who frequently use moving picture delivery services via mobile telephone. This service is basically provided by 3G services, and only 10.9% of 3G subscribers frequently use moving picture delivery services. Only 3.5% of 3G subscribers use TV telephone services. The last two facts demonstrate that 3G high-speed data transmission services have not yet been fully utilized. We can summarize the main points as follows:

Survey method and data

For the monthly expenditures, 3G services are more expensive than 2G and PHS services, but 3G high-speed data transmission services have not yet been fully utilized.

Model and variables

We here analyze mobile telephone service demand by using a discrete choice 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 partitions the choice set allowing alternatives to have common unobserved components compared

with non-nested alternatives by partially relaxing strong IID assumptions. However, even the NL model is not suited for our analysis because of its arbitrary nature in determining the nested structure. Though the factors of technical standard or provider brand are both important to mobile telephone subscribers, we have no information about which factor predominates in the decision-making of mobile telephone subscribers. In such a case, we need to construct an overlapping nested structure composed of both technical standard and provider brand. Consequently, the most prominent model is a mixed logit (ML) model that accommodates differences in covariance of the random components (or unobserved heterogeneity). ML models are flexible enough to overcome the limitations of the CL model by allowing for random taste variation, unrestricted substitution patterns including overlapping nested structure, and the correlation of random terms over time (see McFadden and Train, 2000; Ben-Akiva, Bolduc, and Walker, 2001 for details).

In what follows, we adopt the ML model for the estimation, specify dummy variables for 2G and 3G users and for NTT and KDDI users, respectively, in such a way that these dummy variables intersect with random parameters. Accordingly, we can express an analog to the overlapping nested structure of decision-making in mobile telephone services. We then use the maximum simulated likelihood (MSL) method for estimation by setting 100 time random draws.^{7,8}

Here we illustrate the explained and explanatory variables in our model. First, the explained variables are the following six alternatives:⁹

- NTT's 3G,
- KDDI's 3G,
- NTT's 2G,
- KDDI's 2G,
- Vodafone's 2G,
- PHS.

Next, we define the explanatory variables as follows:

- Constant: Dummy variables are specified for 2G, 3G, NTT, and KDDI users. As such, for example, the constant term for NTT's 3G is expressed as the sum of the 3G dummy coefficient and the NTT dummy coefficient,
- Flat rate: Monthly expenditures in Table 7.13 are composed of monthly flat charges and usage charges that increase with call time.¹⁰ Therefore, monthly expenditure is not a proper explanatory variable because it is endogenously determined by other explanatory variables such as call time: an increase in call time increases monthly expenditures. At this point, we adopt the following strategy to avoid this problem: we first regress Monthly expenditure on call time and other variables including mail no., Web browsing, picture, and movie, and, second, separate the monthly expenditure into flat rate and usage rate parts. Following Kim (2005), we

define flat rate independent of call time as a basic price variable. Table 7.13 depicts the separation of monthly expenditure into flat rate and usage charges,¹¹

- Call time: call minutes per week,
- Mail no.: number of sent/received emails per week,
- Web: dummy variable for an individual who often uses Web browsing services,¹²
- Picture: dummy variable for an individual who often uses still picture delivery services,
- Movie: dummy variable for an individual who often uses the moving picture delivery service.

For parameters, the utilities derived from various functions are likely to differ between the 2G and 3G services because the service quality varies. Therefore, we estimate different parameters for technical standards. Furthermore, such explanatory variables as call time, mail no., Web, picture, and movie are so-called *individual characteristics*. Since only the differences of utility parameters between two alternatives matter in the discrete choice model analysis, we actually measure the influences of individual characteristics on the choice probabilities of 2G and 3G alternatives on the basis of the PHS alternative (see Greene, 2003 for details). For example, parameter call time 3G represents an incremental utility of choosing the 3G alternative compared to the PHS alternative.¹³ We can summarize the main points as follows:

Model and variables

In the ML model, we assume that explained variables are the following six alternatives: NTT's 3G, KDDI's 3G, NTT's 2G, KDDI's 2G, Vodafone's 2G, and PHS. Explanatory variables are flat rate, call time, mail no., Web, picture, and movie.

Estimation results

This section discusses the estimation results of the ML model. Results are given in Table 7.14.¹⁴ First, we see that constants (means of 2G and 3G), flat rate (2G, 3G), mail (2G, 3G), Web (2G, 3G), and movie (2G, 3G) are statistically significant at the 5% level, according to the t-values. Assuming that parameters for 2G, 3G, NTT, and KDDI dummies are normally distributed, correlations between alternatives are allowed here. The values of standard deviations of random parameters are not statistically significant except that NTT is statistically significant at the 10% level. However, the IIA property is completely relaxed in the ML model so that flexible substitution patterns can be expressed. A strong point of the ML model can be seen in that cross-elasticities of demand are all different, which will be discussed below.

Table 7.13 Separation of monthly expenditure

	<i>Monthly expenditure</i>	<i>Flat rate</i>	<i>Call charge</i>
NTT 3G	¥7,349.0	¥6,081.7 468.635	¥1,267.3 235.361
KDDI 3G	¥5,643.8	¥4,675.1 314.800	¥968.7 124.743
NTT 2G	¥5,848.1	¥4,582.8 265.253	¥1,265.3 137.341
KDDI 2G	¥4,021.8	¥3,234.5 315.728	¥787.3 181.267
Vodafone 2G	¥5,208.0	¥4,648.7 294.447	¥559.3 147.904
PHS	¥3,405.0	¥2,760.6 370.575	¥644.4 227.809

Note 1: The figures in the upper row are calculated at sample means.

Note 2: The figures in the lower row indicate standard errors.

Source: Ida and Kuroda (2007).

Table 7.14 Estimation results

Observations	687		
log likelihood	-1137.5517		
<i>Variables</i>	<i>Estimates</i>	<i>Standard error</i>	<i>t-value</i>
Random parameter			
3G Mean	2.0315	0.8730	2.3270
Standard Deviation	0.2313	0.4207	0.5500
2G Mean	1.6736	0.8335	2.0080
Standard Deviation	0.2543	0.4796	0.5300
NTT Mean	0.5129	0.4144	1.2380
Standard Deviation	2.3814	1.4595	1.6320
KDDI Mean	-3.8664	2.9478	-1.3120
Standard Deviation	7.8455	5.5727	1.4080
Non random parameter			
Flat Rate 3G	-0.0002	0.0001	-2.7050
Flat Rate 2G	-0.0001	0.0000	-2.4700
Flat Rate PHS	0.0003	0.0003	0.8990
Call Time 3G	-0.0007	0.0041	-0.1770
Call Time 2G	-0.0031	0.0039	-0.7810
Mail No. 3G	0.0407	0.0169	2.4110
Mail No. 2G	0.0392	0.0159	2.4620
Web 3G	1.6514	0.5316	3.1070
Web 2G	1.4313	0.5130	2.7900
Picture Data 3G	1.5231	1.1201	1.3600
Picture Data 2G	1.0718	1.0884	0.9850
Movie Data 3G	1.7735	0.5466	3.2450

Source: Ida and Kuroda (2007).

Price elasticities

We investigate the elasticities of access demand (choice probability) with respect to monthly flat rate price (hereafter price elasticities). There are two kinds of price elasticities. The first is own (or direct) elasticity, which measures the percentage change in the choice probability with respect to a given percentage change in the price of the same alternative. The second is cross-elasticity, which measures the percentage change in the choice probability with respect to a given percentage change in the price of another alternative.

Calculation results are indicated in Table 7.15(a).

Looking at the first row, with respect to NTT's 3G price, the own elasticity of NTT's 3G is -0.783, and cross-elasticities are 0.067 for KDDI's 3G, 0.471 for NTT's 2G, 0.055 for KDDI's 2G, 0.213 for KDDI's 2G, and 0.203 for PHS. Note that cross-elasticities vary across alternatives because the IIA property is completely relaxed here.

Let us go into the details. A 1% decrease in NTT's 3G flat rate price increases the probability of choosing NTT's 3G by 0.8%. At the same time, this price change decreases the probability of choosing NTT's 2G by 0.5%, while decreasing the probability of KDDI's 3G by only 0.1%. The closest substitute for NTT's 3G is not KDDI's 3G, but NTT's 2G. Similarly, the 1% decrease in NTT's 2G flat rate price increases the probability of choosing NTT's 2G by 0.3%. At the same time, this price change decreases the probability of choosing NTT's 3G by 0.2%, while hardly affecting the probability of KDDI's 2G and decreasing the probability of choosing Vodafone's 2G by only 0.1%. The closest substitute for NTT's 2G is neither KDDI's 2G nor Vodafone's 2G, but NTT's 3G. The same thing applies to KDDI's 3G and 2G. Consequently, the demand substitutability of mobile telephone services works not within technical-standard categories but within the provider-brand categories. A possible reason is that subscribers tend to be locked in to their current providers through switching costs caused by telephone numbers, email addresses, family-member discount services, long-term discount services, and so on.¹⁵

Next, we compare the total price elasticities according to technical standards (namely, 2G and 3G). The total price elasticities of 3G services can be derived in the following way (see Motta, 2004, pp. 125–126).¹⁶ Suppose that the prices of NTT's 3G and KDDI's 3G services increase independently and simultaneously by 1%; the probability of choosing NTT's 3G decreases by 0.783% with a 1% increase in NTT's 3G price but increases by 0.032% with a 1% increase in KDDI's 3G price; in sum, the total price elasticity of NTT's 3G is 0.751. In the same way, the total price elasticity of KDDI's 3G is 0.497. Turning to the total price elasticities of 2G services, the values are 0.214 for NTT's 2G, 0.179 for KDDI's 2G, and 0.179 for Vodafone's 2G. It follows that 3G services are more price-sensitive than 2G services based on total price elasticities. In other words, the probability of choosing 3G services changes more sensitively than 2G services for percent changes in prices. We can summarize the main points as follows.

Table 7.15 Elasticities

(a) Price elasticities		Choice probability					
		NTT 3G	KDDI3G	NTT 2G	KDDI2G	Vodafone 2G	PHS
Price	NTT 3G	-0.783	0.067	0.471	0.055	0.213	0.203
	KDDI3G	0.032	-0.564	0.026	0.436	0.035	0.032
	NTT 2G	0.194	0.022	-0.303	0.025	0.091	0.085
	KDDI2G	0.011	0.156	0.010	-0.231	0.013	0.016
	Vodafone 2G	0.076	0.025	0.079	0.027	-0.283	0.200
(b) Email elasticities		Choice probability					
		NTT 3G	AU 3G	NTT 2G	AU 2G	Vodafone 2G	PHS
Email	NTT 3G	0.467	-0.043	-0.286	-0.035	-0.132	-0.070
	AU 3G	-0.026	0.423	-0.022	-0.322	-0.028	-0.011
	NTT 2G	-0.287	-0.036	0.447	-0.039	-0.149	-0.056
	AU 2G	-0.019	-0.289	-0.021	0.420	-0.026	-0.012
	Vodafone 2G	-0.105	-0.037	-0.118	-0.038	0.368	-0.146
(c) Web browsing elasticities		Choice probability					
		NTT 3G	AU 3G	NTT 2G	AU 2G	Vodafone 2G	PHS
Web browsing	NTT 3G	0.511	-0.047	-0.307	-0.037	-0.148	-0.089
	AU 3G	-0.029	0.450	-0.022	-0.343	-0.030	-0.013
	NTT 2G	-0.277	-0.032	0.413	-0.031	-0.127	-0.050
	AU 2G	-0.018	-0.277	-0.017	0.398	-0.022	-0.012
	Vodafone 2G	-0.106	-0.036	-0.101	-0.033	0.340	-0.133
(d) Moving picture elasticities		Choice probability					
		NTT 3G	AU 3G	NTT 2G	AU 2G	Vodafone 2G	PHS
Moving picture	NTT 3G	0.074	-0.015	-0.039	-0.003	-0.025	-0.010
	AU 3G	-0.009	0.057	-0.003	-0.031	-0.005	-0.002

Source: Ida and Kuroda (2007).

Price elasticities

The demand substitutability of mobile telephone services works not within technical-standard categories but within the provider-brand categories. The closest substitute for NTT's 2G is neither KDDI's 2G nor Vodafone's 2G, but NTT's 3G. The same thing applies to KDDI's 3G and 2G.

Other elasticities

We then refer to other elasticities with respect to various functions including email, Web browsing, and moving picture delivery, which are statistically significant variables.

Table 7.15(b) indicates the demand elasticities for the number of emails per week. There is only a small difference between NTT's 3G and NTT's 2G and between KDDI's 3G and KDDI's 2G for email own-elasticities. This is probably because 3G services have an advantage over 2G services for simple text message services.

Table 7.15(c) indicates demand elasticities with respect to the frequent use of Web browsing services. The figures are about 0.5 for 3G services and about 0.4 for 2G services; the Web-browsing elasticities are a little larger for 3G services than for 2G services, reflecting that Web browsing requires larger volume data transmission, and 3G service has an advantage over 2G service in this respect, although the difference of elasticities is still small.

Lastly, Table 7.15(d) indicates the demand elasticities of the frequent use of moving picture delivery services. The figures of the elasticities are less than 0.1 for 3G services. Although moving picture delivery service is statistically significant, its positive impact on the probability of choosing 3G services is quite small. Although a moving picture delivery service that requires high-speed, large-volume data transmission is thought to be a "killer application" for further diffusion of 3G services, it has not yet been fully utilized by 3G subscribers. We can summarize the main points as follows:

Other elasticities

After examining demand elasticities for various functions including email, Web browsing, and moving picture delivery, we failed to observe significant differences between 2G and 3G services. Perhaps a change-over is now occurring from 2G services to 3G, while even progressive 3G subscribers fail to make full use of new 3G services.

Mobile phone policy issues

In this section we will discuss the main policy issues relating to mobile telephony based on the analysis presented so far.

Mobile telephony market definition

Here we will discuss market demarcation of the mobile telephony market. There are two key questions that must be addressed in discussing market definition of the mobile telephony market (MIC, 2005a):

- Mobile telephony market horizontal substitutability relationship:
Is strong demand substitutability at work in forming just a single relevant market consisting of mobile phones, PHS, 2G, 3G, and other wireless services?
- Mobile telephony vertical complementarity relationship:
The mobile telephony market is a multilayered structure consisting of subscriber services, voice services, data services, platforms, and content. Three companies currently offer vertically integrated services. Do these vertical complementary services form a single relevant market?

Let us consider these questions, starting with the horizontal substitutability relationship. Substitutability is determined using the small but significant and nontransitory increase in price (SSNIP) test as described earlier in Chapter 5, but in reality it is not easy to assemble all of the data necessary to perform the SSNIP test. This being the case, here we will analyze the demand substitutability structure of the mobile telephony market (particularly 2G and 3G services) based on the demand elasticity estimated in the previous section.

In the previous section we found that technology-oriented market segmentation exhibits greater elasticity than provider brand-oriented market segmentation. In other words, the change in demand occurring when the price of a specified technology changes by 1% is greater than the change in demand occurring when the price of a specified provider brand changes by 1%. This means that in the realm of mobile telephony, it is easier to form an independent market based on a company brand than based on a system technology (2G, 3G, and so on). As the market definition starting point, therefore, it would be better to focus on the service provider brand than on the underlying technology. This is because once a subscriber commits to a particular provider brand, the user would incur switching costs to change providers later—the inconvenience of changing telephone number, email address, and so on—so it becomes easy to lock the subscriber in to a particular provider. And looking at usage of the different capabilities supported by mobile telephony such as email, Web browsing, and sending and receiving video, no clear difference in elasticity could be observed between 2G and 3G services. In light of these facts, we think it is still too early to draw a clear boundary between

2G and 3G markets. Currently, companies as diverse as au, which has all but completed its transition from 2G to 3G, NTT DoCoMo now in the midst of migrating to 3G, and Vodafone, which is only just beginning the move to 3G, all coexist within the same market structure, and the overall mobile telephony market cannot be demarcated into separate 2G and 3G markets. Yet we should also note that no one is strongly asserting that 2G and 3G constitute the same market.

Let us next consider the vertical complementarity relationship. Mobile telephony supports two means of communication—voice and email. There is overlap among the recipients of voice calls and emails; typically there are some people with whom you talk frequently on the phone and other people with whom you exchange email on a regular basis. Viewed in this way, voice service and data service have a complementarity relationship with one another such that if one increases then the other also increases. There is still no clear standard for determining whether these kinds of complementary services form a single market. The SSNIP test is no help here, because it is strictly a standard for defining markets based on the substitutability of goods or services. It may be that even in the case of services with different functionality and utility, they can nevertheless be treated as the same service if prices are set in a unified manner. However, this unified price setting approach has a flaw. Because services A and B having a complementary relationship are not unbundled, but rather are bundled and marketed as a corporate strategy, determination is not made based on extraneous data such as market demand substitutability or supply substitutability, but rather markets are defined endogenously by the service providers. This means that if providers bundle as many services as possible and make them available, the scope of the market can be freely expanded. But unfortunately, as we mentioned, we do not yet have a clear standard for defining markets where services exhibiting a complementarity relationship are involved. So without shedding any light on the complementarity relationship between voice services and data services, the only method of market definition currently available is to fall back on subscription demand. How to define markets where a vertical complementarity relationship exists is an issue including methodology that must be addressed in the future. The main points of this section are summarized as follows:

Mobile telephony market definition

In mobile telephony, it is easier to form an independent market based on a company brand than based on system technology. However, in the mobile telephony market, there is a complementarity relationship between voice services and data services, which makes market definition difficult.

Effective competition in the mobile telephony market

One observes an asymmetrical relationship in Japan's mobile telephony market with NTT DoCoMo controlling more than half the 2G market and au possessing more than half the 3G market. But as we discovered in the previous section, there is no clear proof that 2G and 3G are really different markets. Examining market shares of the mobile telephony market as a whole, we observe a three-way oligopoly, dominated by NTT DoCoMo, the dominant incumbent controlling more than half the market, followed by KDDI and Vodafone controlling most of the rest of the market. This raises the question of whether Japan's mobile telephony market can be described as an industry dominated by a single carrier or jointly dominated by three carriers.

Analysis focusing on the network structures of the fixed telephony market and mobile telephony market will help clarify this point. In the fixed telephony market, NTT East and West have virtual monopolies in their respective regional network spheres, and long-distance new common carriers (NCCs) are unable to offer services unless they interconnect to NTT's local exchange networks and pay interconnection charges. In Chapter 2, we referred to this network structure as *service-based competition*. Turning to the mobile telephony market, NTT DoCoMo, KDDI, and Vodafone all have their own mobile phone networks, thus forming an interconnected structure. This we referred to as *facilities-based competition*. Facilities-based competition has fundamentally different competition policy issues than service-based competition. In service-based competition, the main policy issue is how bottleneck monopoly providers can be restrained to prevent them from exercising market dominance over new entrants. Facilities-based competition is more concerned with the potential risk of a small number of carriers exercising collaborative dominance (tacit collusion) using interconnection charges as a lever. The basic logic is that, even though a carrier might attempt to adopt a low-price strategy to attract many new customers, if the price is set so low as to generate lots of calls per subscriber, this results in excessive interconnection charges that must be paid to the higher cost carrier. This means that in facilities-based competition, an excessive burden imposed through high interconnection charges essentially acts as a stop-guard that thwarts price competition between the two companies (Armstrong, 1998).

In facilities-based competition such as in mobile telephony, one must be concerned not only about market dominance through solitary leverage by a single company, but also about market dominance through joint leverage by a group of companies. The interconnection charges in particular should be closely scrutinized to see if they are being maintained at a high level, and if they are, regulatory measures should be imposed to reduce the charges. Fortunately, in Japan's case, mobile telephony interconnection charges have continued to fall year after year, and now, together with the UK's rates, are the lowest in the world. Thus, in Japan's mobile telephony market, there is no need for any immediate determination in order to avoid a price war between

carriers conducted through high interconnection charges. However, we observed earlier in this chapter that many mobile phone users believe that mobile telephony charges in Japan are high, so it will be necessary to keep a close eye on charge level changes in the years ahead.

Finally, in the previous section we described the real prospect in Japan's mobile telephony market of customers getting locked in to the services of a particular service provider. This is a consequence of scarce spectrum resources, a limited number of new entrants, and the fact that number portability for mobile telephony has not yet been achieved. To address these issues, the MIC has decided to allocate spectrum to new entrants and introduce number portability. These policies, designed to promote competition, should have the effect of spurring Japan's mobile telephony market to new levels of competitiveness. The main points of this section are summarized as follows:

Effective competition in the mobile telephony market

Japan's mobile telephony market is an oligopoly dominated by NTT DoCoMo, which controls more than half of the market, and followed by KDDI and Vodafone. The competition structure of the mobile telephony market is facilities-based competition, and regulators should remain watchful that market dominance is not imposed through the solitary leverage of a single company or the joint leverage of a group of companies.

Conclusion

This chapter investigated the demand for mobile telephone services including 3G. We particularly focused on the demand substitutability between mature 2G services and emerging 3G services. Two main conclusions are obtained. First, there is a clear distinction between 2G and 3G services for values of price elasticity. 3G services are more price-elastic than 2G services. This conclusion demonstrates that 3G service is still in the process of full-scale diffusion, and new 3G subscribers are currently more sensitive to price changes than 2G subscribers. Second, turning to the analysis of functions such as email, Web browsing, and moving picture delivery, we failed to discover distinct evidence to show that 3G subscribers make full use of new 3G services. However, due to the rapidly changing trends in mobile telephone services, market developments deserve careful consideration and study.

Part III

The future of Japan's broadband

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8 Fiber to the home: Migration and lock-in

Japan's high-speed Internet access services, or broadband services, have rapidly developed since 2000 and are reputedly the cheapest and fastest in the world. Particularly noteworthy is the explosive diffusion of the fiber to the home (FTTH) service: whereas asymmetric digital subscriber line (ADSL) service is an easy step to broadband services, FTTH is the final broadband service. Two problems must be faced when discussing *broadband migration*. The first is migration from narrowband services (including dial-up Internet) to broadband services (including ADSL, cable TV (CATV) Internet, and FTTH), which seems to have quickly dissolved. The second is migration inside broadband services. FTTH has consistently increased, while ADSL and CATV Internet market shares have decreased since 2003 when the FTTH market exploded in Japan. In time, the center of broadband services will undoubtedly shift from ADSL to FTTH. We reach two main conclusions in this chapter. First, individual characteristics significantly influence broadband migration from ADSL to FTTH; a high-income broadband user who frequently views moving-pictures and lives in an apartment is more likely to migrate to FTTH. Second, for NTT significant lock-in effects exist; NTT's previous ADSL users rate NTT's FTTH higher by ¥2,400 (US\$21.2, where ¥1=US\$110), while Softbank's previous ADSL users value NTT's FTTH lower by ¥1,600 (US\$14.5). We may consider this asymmetry in rates as switching costs in broadband migration.

Current status of broadband migration

This subsection explains the survey method and data and then analyzes which users tend to migrate successfully to FTTH. We jointly carried out sample surveys on the individual usage of Internet access services in November 2005 with the Ministry of Internal Affairs and Communications (MIC). Random surveys were conducted on monitors registered with a consumer monitor investigative company that has a total of about 220,000. Questions included: (i) basic fee per month (price), (ii) nominal and effective access speeds, (iii) types of Internet access line and Internet service providers, (iv) such Internet usages as Web browsing, IP phone, moving-picture viewing, and

(v) such individual characteristics as gender, age, annual household income, type of residence, living area, occupation, and so on. Excluding omissions, we finally obtained 2,361 effective respondents whose sociodemographics are given in Table 8.1. Although all respondents used broadband services, 20% replied that they could not choose FTTH in their living areas even if they wanted to subscribe. Accordingly, for estimation, we used 1,890 respondents who replied that they could choose FTTH if they wanted.

Breakdowns are given in Table 8.2 based on Internet usage. Selection ratios follow: ADSL (63%), FTTH (21%), and CATV Internet (17%). Looking at ADSL, market shares are 39% for Softbank and 34% for NTT. Current major Internet usages of ADSL subscribers include Web browsing (84%), IP phone (40%), and moving-picture viewing (35%). Next for FTTH, market shares are 52% for NTT and 11% for K-opticom. Current major Internet usages of FTTH subscribers include Web browsing (85%), IP phone (24%), and moving-picture viewing (40%). Last, for CATV Internet, market shares are 19% for Jupiter and 9% for Kansai Multimedia. Current major Internet usages of CATV Internet subscribers include Web browsing (83%), IP phone (6%), and moving-picture viewing (24%).

Econometric analysis of FTTH migration

As stated, we jointly surveyed Internet access services with the Japanese MIC. To analyze decision-making structures in broadband services, we adopt a mixed logit (ML) model, which relaxes the independence from irrelevant alternatives (IIA) properties imposed on conditional logit (CL) models. The basic descriptive statistics are shown in Table 8.3. Basic monthly fees are defined as the sum of Internet access line connection fees and various Internet service charges. Income classes are classified from bottom (class 1) to top (class 6). In addition, dummy variables with a value of one are included for IP phone usage, moving-picture viewing, and living in apartments.

Model and variables

This subsection describes our econometric model. CL models, which 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 CL models is too strict to allow flexible substitution patterns. The most prominent model is an ML model, which accommodates differences in variance of random components (Ben-Akiva, Bolduc, and Walker, 2001).¹ It is flexible enough to overcome the limitations of CL models by allowing random taste variation, unrestricted substitution patterns, and the correlation of random terms over time (McFadden and Train, 2000). The ML model assumes that parameter β is distributed with density function $f(\beta)$ (Train, 2003; Louviere, Hensher, and Swait 2000).

Table 8.1 Sociodemographics (broadband users)

(a) No. respondents		<i>Broadband</i>		<i>FTTH available</i>															
No.		2,361		1,890															
Ratio		100%		80%															
(b) Gender		<i>Male</i>		<i>Female</i>															
Ratio		50.1%		49.9%															
(c) Age		<i>20s</i>		<i>30s</i>		<i>40s</i>		<i>50s and over</i>											
Ratio		23.1%		37.3%		27.2%		12.4%											
(d) Occupation		<i>Office worker</i>		<i>Self-employed</i>		<i>Professional</i>		<i>Public official</i>		<i>Students</i>		<i>Housewife</i>		<i>Part-time</i>		<i>No occupation</i>		<i>Other</i>	
Ratio		39.8%		7.3%		3.9%		4.5%		5.0%		21.3%		11.1%		3.9%		3.1%	
(e) Annual income class		<i>¥3M<</i>		<i>¥3–5M</i>		<i>¥5–7M</i>		<i>¥7–10M</i>		<i>¥10–15M</i>		<i><¥15M</i>							
Ratio		16.7%		30.8%		23.7%		18.1%		8.9%		1.8%							

Source: Ida and Sakahira (2008).

Table 8.2 Internet usage (broadband users)

(a) Type of Internet access line		<i>FTTH</i>	<i>CATV</i>					
Ratio	<i>ADSL</i>	20.5%	16.6%					
(b) ADSL market share		<i>NTT</i>	<i>E access</i>	<i>Acca</i>	<i>Other</i>			
Ratio		34.1%	8.6%	8.0%	10.4%			
(c) ADSL Internet usage (multiple answers)		<i>Web browsing</i>	<i>050-IP phone</i>	<i>0ABJ-IP phone</i>	<i>Online shopping</i>	<i>Net banking</i>	<i>Free movie</i>	<i>TV phone</i>
Ratio	<i>Email</i>	97.0%	39.7%	0.0%	67.5%	57.5%	29.8%	1.7%
(d) FTTH market share		<i>NTT</i>	<i>USEN</i>	<i>KDDI</i>	<i>Other</i>			
Ratio		52.0%	9.5%	5.8%	22.3%			
(e) FTTH Internet usage (multiple answers)		<i>Web browsing</i>	<i>050-IP phone</i>	<i>0ABJ-IP phone</i>	<i>Online shopping</i>	<i>Net banking</i>	<i>Free movie</i>	<i>TV phone</i>
Ratio	<i>Email</i>	96.7%	17.7%	6.0%	65.6%	58.1%	32.8%	1.4%
(f) CATV Internet market share		<i>Jupiter</i>	<i>Its Com</i>	<i>Other</i>				
Ratio		19.4%	3.3%	68.6%				
(g) CATV Internet usage (multiple answers)		<i>Web browsing</i>	<i>050-IP phone</i>	<i>0ABJ-IP phone</i>	<i>Online shopping</i>	<i>Net banking</i>	<i>Free movie</i>	<i>TV phone</i>
Ratio	<i>Email</i>	98.0%	5.4%	0.5%	56.9%	47.7%	20.9%	1.0%

Source: Ida and Sakahira (2008).

Table 8.3 Basic descriptive statistics (broadband users)

		Choice no.	Price averages	Income averages	IP phone no.	Movie no.	Apartment no.
ADSL	No./Averages Ratio	1,099 58.1%	¥3,728.2 —	2.67 —	431 39.2%	334 30.4%	487 44.3%
FTTH	No./Averages Ratio	468 24.8%	¥4,991.2 —	3.09 —	103 22.0%	163 34.8%	264 56.4%
CATV	No./Averages Ratio	323 17.1%	¥4,863.8 —	2.92 —	19 5.9%	71 22.0%	96 29.7%

Source: Ida and Sakahira (2008).

In what follows, we assume that parameters, except for constant terms and monthly fixed basic fee parameters, follow normal distribution. Accordingly, we can demonstrate variety in individual-level parameters. We use the maximum simulated likelihood (MSL) method for estimation by setting both 100 Halton sequence and 250 random draws to confirm the robustness of the estimation results.²

Next, we elucidate the explained and explanatory variables in our model. The explained variables are the following three alternatives: (i) FTTH, (ii) ADSL, and (iii) CATV Internet. We define the explanatory variables as follows. Non-random parameter variables are (i) constant terms (CONSTANT) and (ii) monthly fixed basic fee (composed of Internet access line connection fees and various Internet service charges) (PRICE). Random parameter variables (normally distributed) are (iii) income class index (INCOME), (iv) IP phone usage dummy variable (IP PHONE), (v) moving-picture viewing dummy variable (MOVIE), and (vi) apartment dummy variable (APARTMENT).

For parameters, the incremental utilities of linear-in-parameter derived from various Internet usages are likely to differ among ADSL, FTTH, and CATV Internet, because service quality varies. Therefore, we estimate different parameters for alternatives. Furthermore, such explanatory variables as INCOME, IP PHONE, MOVIE, and APARTMENT are *individual characteristics*. Since the differences of utility parameters between two alternatives matter in random utility model analysis, we are actually measuring the influences of individual characteristics on the choice probabilities of ADSL and FTTH alternatives based on the CATV Internet alternative.

Estimation results

We turn to the estimation results given in Table 8.4. For sign conditions, all estimates are as expected except that INCOME (ADSL) is negative. According to *t*-values, PRICE, CONSTANT (FTTH), and CONSTANT (ADSL) are all statistically significant at 1% or 5% levels. Having assumed that random parameters are distributed normally, each parameter has mean (MEAN) and standard-deviation (SD) estimates. INCOME (MEAN) (FTTH), MOVIE (MEAN) (FTTH), and APARTMENT (MEAN) (FTTH) are statistically significant at the 1% level, whereas only IP PHONE (SD) (FTTH) is statistically significant at the 5% level; INCOME (MEAN) (ADSL), IP PHONE (MEAN) (ADSL), and APARTMENT (MEAN) (FTTH) are statistically significant at 1% or 5% levels, whereas IP PHONE (SD) (ADSL) and APARTMENT (SD) (FTTH) are only statistically significant at the 10% level.

We here investigate demand elasticities with respect to monthly fixed basic fees (hereafter, price elasticities). There are two kinds of price elasticities. The first is own elasticity, which measures the percentage change in choice probability with respect to a given percentage change in the price of

Table 8.4 Estimation results (broadband users)

<i>Variables</i>		<i>Coefficients</i>	<i>Standard errors</i>	<i>t-value</i>	<i>p-value</i>
Sample No.	1,890				
Max log likelihood	-1,647.6				
Initial log likelihood	-2,076.4				
Pseudo R ²	0.206				
<i>Non-random parameters</i>					
Constant (FTTH)		-0.84680	0.28029	-3.021	0.003
Constant (ADSL)		0.56832	0.28534	1.992	0.046
Price		-0.00049	0.00009	-5.224	0.000
<i>Random parameters</i>					
Income (FTTH)	MEAN	0.18787	0.06925	2.713	0.007
	SD	0.14440	0.15545	0.929	0.353
IP phone (FTTH)	MEAN	1.19968	0.78013	1.538	0.124
	SD	2.89417	1.44557	2.002	0.045
Movie (FTTH)	MEAN	0.74122	0.20937	3.540	0.000
	SD	0.42748	0.89528	0.477	0.633
Apartment (FTTH)	MEAN	0.61881	0.22328	2.771	0.006
	SD	0.38232	0.46837	0.816	0.414
Income (ADSL)	MEAN	-0.25925	0.11421	-2.270	0.023
	SD	0.50818	0.32641	1.557	0.120
IP Phone (ADSL)	MEAN	4.84433	1.76356	2.747	0.006
	SD	2.76682	1.66564	1.661	0.097
Movie (ADSL)	MEAN	0.50943	0.28667	1.777	0.076
	SD	2.04449	1.24767	1.639	0.101
Apartment (ADSL)	MEAN	0.58845	0.22239	2.646	0.008
	SD	1.82676	0.95651	1.910	0.056

Source: Ida and Sakahira (2008).

Table 8.5 Price elasticities (broadband users)

		<i>Choice probability</i>		
		<i>FTTH</i>	<i>ADSL</i>	<i>CATV</i>
Price	FTTH	−1.308	0.291	0.764
	ADSL	0.537	−0.439	0.642
	CATV	0.533	0.261	−1.675

Source: Ida and Sakahira (2008).

the same alternative. The second is cross-elasticity, which measures the percentage change in choice probability with respect to a given percentage change in the price of another alternative. Calculation results are indicated in Table 8.5.

Looking at the first row for FTTH price, the own elasticity of FTTH is −1.3, and cross-elasticities are 0.3 for ADSL and 0.8 for CATV. As for the second row with respect to ADSL price, the own elasticity of ADSL is −0.4, and cross-elasticities are 0.5 for FTTH and 0.6 for CATV. Last, as for the third row with respect to CATV price, the own elasticity of CATV is −1.7, and cross-elasticities are 0.5 for FTTH and 0.3 for ADSL. Note that cross-elasticities vary across alternatives because the IIA assumption is relaxed by the ML model. We can summarize the main points as follows.

FTTH migration estimation results

For FTTH migration, income, using services, and residential type are all significant variables. ADSL is still inelastic, while FTTH and CATV Internet are sufficiently elastic, which are findings consistent with previous results by Ida and Kuroda (2006).

Analysis of FTTH migration

We here examine the effects of individual characteristics on FTTH choice probability, focusing on such statistically significant variables as INCOME, MOVIE, and APARTMENT.³ The results of comparative static analysis are shown in Table 8.6. First, changing INCOME from the lowest (1) to the highest class (6), FTTH choice probability increases by 9%. Second, changing MOVIE from not use (0) to use (1), FTTH choice probability increases by 7%. Third, changing APARTMENT from not living (0) to living (1), FTTH choice probability increases by 5%.

Since individual characteristics significantly influence FTTH choice probability, different individual characteristics may lead to different attitudes

Table 8.6 Simulation results (broadband users)

Changed variables	Levels of variables		Increases in choice probability			
	Before	After	FTTH	ADSL	CATV	
Income (FTTH)	1.0	6.0	8.65%	-8.13%	-0.52%	
Movie (FTTH)	0.0	1.0	6.97%	-6.55%	-0.42%	
Apartment (FTTH)	0.0	1.0	5.14%	-4.83%	-0.31%	

Source: Ida and Sakahira (2008).

Figure 8.1 Conditional distributions of IP PHONE (broadband users).

Source: Ida and Sakahira (2008).

toward broadband migration: high income, frequently viewing moving-pictures, and apartment living all promote broadband migration to FTTH. These conclusions are interesting in planning information communication policies. In the early stages, high income, frequently viewing moving-pictures, and living in apartment users spontaneously migrate to FTTH. On the other hand, in the final periods, since stranded users fail to migrate to FTTH, public assistances may be needed to help them migrate to FTTH to address the digital divide problem.

In ML model, we can indicate varieties of individual preferences by standard deviations of random parameters. We can therefore estimate the conditional mean of random parameters based on the Bayes theorem. Figure 8.1 displays the conditional distribution of IP PHONE. We observe that IP PHONE (FTTH) is distributed in the left area (lower preferences), while IP PHONE (ADSL) is distributed in the right area (higher preferences). This reflects the fact that most IP phone users are still using 050-type (low quality) IP phones popular in ADSL, while 0ABJ-type (high quality) IP phones, most suited for FTTH, are not widely diffused (Ida, Kinoshita, and Sato, 2007).

Figure 8.2 also displays the conditional distributions of MOVIE. MOVIE (FTTH) is narrowly distributed (uniform preferences), while MOVIE (ADSL)

Figure 8.2 Conditional distributions of MOVIE (broadband users).

Source: Ida and Sakahira (2008).

is widely distributed (scattered preferences) because most FTTH users are more interested in viewing moving-pictures by Internet than ADSL users. We can summarize the main points as follows.

Analysis of FTTH migration

High income, frequently viewing moving-pictures, and apartment living all promote broadband migration to FTTH. FTTH users have higher preferences for IP phone than for moving pictures.

Econometric analysis of lock-in effects

This section analyzes the services to which current FTTH users subscribed before migrating to FTTH and then measures NTT's lock-in effects. Note that the market shares of the NTT group are high especially in the FTTH market: whereas the figure has slightly increased from 38% in 2002 to 39% in 2005 for ADSL, it has significantly increased from 45% in 2002 to 60% in 2005 for FTTH. It is only the NTT group that has high market shares in both ADSL and FTTH markets.

Lock-in effects have been discussed as the phenomenon that a specific firm or technology monopolizes under network externalities or increasing returns (Shapiro and Varian, 1999; Witt, 1999; Liebowitz and Margolis, 2002). At this point, we consider the lock-in effect as follows: NTT users can more

easily migrate from ADSL to FTTH than other users because NTT users do not need to pay switching costs in the broadband migration.

We jointly carried out supplemental surveys on FTTH services in November 2005 with MIC and obtained 996 respondents whose sociodemographics are given in Table 8.7. All respondents currently subscribe to FTTH. A breakdown is given in Table 8.8. Almost half (48%) previously subscribed to ADSL before migrating to FTTH. Furthermore, more than half (56%) subscribe to NTT's FTTH.⁴ Therefore, there is a tendency that broadband migration advances more smoothly in NTT, which supplies both ADSL and FTTH, than in competitors that supply either ADSL or FTTH.

One reason may be that switching costs are much lower in an integrated firm than in a disintegrated firm, due to easy introduction and email address portability. As a result, NTT's FTTH market share is much higher than ADSL's. On the other hand, Softbank, which has garnered a large share of the ADSL market, fails in the FTTH market because it is very passive in providing FTTH; Softbank's ADSL users cannot migrate to FTTH even if they want to. Besides, many narrowband Internet users (30%) have directly migrated to FTTH, more than half of whom (59%) currently subscribe to NTT's FTTH.⁵ In conclusion, migration to FTTH has reinforced NTT's lock-in.⁶ Accordingly, measuring the lock-in effects will be interesting.

(*) Model and variables

We use the ML model for estimation. Note that logit models can include past explained variables in explanatory variables.⁷ The inclusion of lagged explained variables does not induce inconsistency in estimation due to the IID assumption of logit models (Train, 2003, pp. 55–56; Maddala, 1983, pp. 105–113).⁸ Let n be an individual, j a chosen alternative, and t a period. Then the random utility function can be written as, $U_{njt} = V_{njt} + \varepsilon_{njt}$, where V_{njt} denotes a fixed term and ε_{njt} denotes a random term that follows the IID assumption. We write the fixed term in which alternative j is chosen in the current period as well as in the previous period as $V_{njt} = \alpha X_{njt} + \beta Y_{nj(t-1)}$, where $Y_{nj(t-1)} = 1$, if n chooses j in period $t-1$, and zero otherwise; X_{njt} denotes other explanatory variables, such as price; α and β are parameters to be estimated. At this point, $\beta > 0$ represents lock-in effects because the utility of choosing alternative j in the current period is higher if alternative j was chosen in the previous period. On the other hand, $\beta < 0$ represents lock-out effects because the utility of choosing alternative j in the current period is lower if alternative j was chosen in the previous period. The ratio of lock-in parameter to price parameter, $-\beta/\alpha$, represents the pecuniary value of the lock-in effect if $\beta > 0$ (or lock-out effect if $\beta < 0$).

Here, excluding omissions, we used 956 respondents who subscribe to FTTH for estimation. The basic descriptive statistics are shown in Table 8.9. All definitions follow the above. The explained variables are the following

Table 8.7 Sociodemographics (FTTH users)

(a) No. respondents		FTTH		996	
No.					
(b) Gender		Male		Female	
Ratio		52.1%		47.9%	
(c) Age		20s		30s	
Ratio		21.1%		35.1%	
				40s	
				30.5%	
				50s and over	
				13.3%	
(d) Occupation		Office worker		Self-employed	
Ratio		40.5%		6.8%	
				Professional	
				4.2%	
				Public official	
				4.8%	
				Students	
				4.4%	
				Housewife	
				24.3%	
				Part-time	
				9.3%	
				No occupation	
				3.4%	
				Other	
				2.2%	
(e) Annual income class		¥3 M<		¥3-5 M	
Ratio		12.0%		25.0%	
				¥5-7 M	
				25.6%	
				¥7-10 M	
				24.0%	
				¥10-15 M	
				9.9%	
				<¥15 M	
				3.4%	

Source: Ida and Sakahira (2008).

Table 8.8 Services before and after migration (FTTH users)

	Currently using FTTH services				Total
	NTT	Powers	Other		
Previously used services before migrating to FTTH					
NTT	14.7%	2.7%	4.2%	21.6%	
Softbank	4.6%	2.6%	3.4%	10.6%	
ADSL	2.5%	1.2%	1.3%	5.0%	
E-access	2.4%	1.0%	1.8%	5.2%	47.6%
Acca	2.3%	0.7%	2.1%	5.1%	
Other	4.2%	3.5%	2.8%		10.5%
CATV	11.1%	3.0%	3.0%		17.2%
ISDN	6.8%	2.7%	3.4%		13.0%
Dial-up	1.9%	0.7%	0.6%		3.2%
Mobile/wireless	3.5%	2.0%	2.9%		8.4%
Not using Internet					
Total	54.1%	20.2%	25.7%		100.0%

Source: Ida and Sakahira (2008).

Table 8.9 Basic descriptive statistics (FTTH users)

		Choice no.	Price averages	Income averages	IP phone no.	Movie no.	Apartment no.
NTT	No./Averages	505	¥5,291.6	3.04	110	188	259
	Ratio	52.8%	—	—	21.8%	37.2%	51.3%
Powers	No./Averages	200	¥5,128.9	3.12	49	66	64
	Ratio	20.9%	—	—	24.5%	33.0%	32.0%
Other	No./Averages	251	¥4,278.6	3.07	51	77	227
	Ratio	26.3%	—	—	20.3%	30.7%	90.4%

Source: Ida and Sakahira (2008).

three alternatives: (i) NTT's FTTH, (ii) electric power companies' FTTH, and (iii) other companies' FTTH. Next, we define the explanatory variables as follows. Non-random parameter variables are (i) constant terms (CONSTANT) and (ii) monthly fixed basic fee (composed of Internet access line connection fees and various Internet service charges) (PRICE), (iii) income class dummy variable (INCOME), (iv) IP phone usage dummy variable (IP PHONE), (v) moving-picture viewing dummy variable (MOVIE), and (vi) apartment dummy variable (APARTMENT). Random parameter variable (normally distributed) is (vii) previously chosen service before migrating to FTTH (PAST CHOICE).⁹ Hereafter, we suppose three cases for PAST CHOICE: NTT's ADSL (Model 1), NTT's ADSL or narrowband (Model 2), and Softbank's ADSL (Model 3).

Estimation results

Estimation results are given in Table 8.10. The signs of PAST CHOICE are positive in Models 1 and 2 (lock-in effects), but negative in Model 3 (lock-out effect). Furthermore, *t*-values of PAST CHOICE (MEAN) are statistically significant at the 1% level in Models 1 and 2, at the 5% level in Model 3, while PAST CHOICE (SD) is only statistically significant at the 10% level in Model 2.

Measuring lock-in effects

Here we measure the lock-in (or lock-out) effects. Beginning with Model 1, we observe that lock-in effect exists because previously choosing NTT's ADSL significantly increases the probability of choosing NTT's FTTH. The value of the lock-in effect is ¥2,355 (US\$21.4), which is derived from—PAST CHOICE (0.73372) / PRICE (−0.00031). Similarly, we observe that lock-in effect exists in Model 2 since previously choosing NTT's ADSL or narrowband services significantly increases the probability of choosing NTT's FTTH. The value of the lock-in effect is ¥2,433 (US\$22.1). We may interpret the lock-in effects as switching costs because NTT's ADSL users value NTT's FTTH higher and, therefore, resist persuasion by competitors. On the other hand, we observe that lock-out effect exists in Model 3 since previously choosing Softbank's ADSL significantly decreases the probability of choosing NTT's FTTH. The value of the lock-out effect is ¥1,616 (US\$14.7). In this respect, current Softbank's ADSL users are stranded and cannot migrate to FTTH, partly because Softbank is very more passive in supplying FTTH than NTT. As explained, we can indicate varieties of individual preferences by standard deviations of random parameters in ML models. The conditional distributions of PAST CHOICE, displayed in Figure 8.3, are distributed in the positive region for NTT's ADSL (Model 1) and NTT's ADSL or narrowband services (Model 2), while in the negative region for Softbank's ADSL (Model 3).¹⁰

Table 8.10 Estimation results (FTTH users)

Variables	Model 1 (NTT's ADSL)				Model 2 (NTT's ADSL + Narrowband)				Model 3 (Softbank's ADSL)			
	Coefficients	Standard errors	t-value	p-value	Coefficients	Standard errors	t-value	p-value	Coefficients	Standard errors	t-value	p-value
Sample No.			956				956				956	
Max log likelihood			-934.4				-925.4				-940.8	
Initial log likelihood			-1,050				-1,050				-1,050	
Pseudo R2			0.110				0.119				0.104	
<hr/>												
Non-random parameters												
Constant (NTT)	1.0881	0.2016	5.396	0.000	0.8229	0.2131	3.862	0.000	1.3368	0.1963	6.809	0.000
Constant (POWER)	-0.1976	0.0957	-2.066	0.039	-0.1939	0.0958	-2.025	0.043	-0.1987	0.0957	-2.079	0.038
Price	-0.0003	0.0001	-5.480	0.000	-0.0003	0.0001	-5.755	0.000	-0.0003	0.0001	-5.555	0.000
Income (NTT)	-0.0646	0.0435	-1.485	0.137	-0.0730	0.0438	-1.667	0.096	-0.0733	0.0432	-1.697	0.090
IP Phone (NTT)	-0.0606	0.1616	-0.375	0.708	0.0345	0.1645	0.210	0.834	-0.0153	0.1623	-0.094	0.925
Movie (NTT)	0.3001	0.1420	2.113	0.035	0.3286	0.1435	2.289	0.022	0.2907	0.1409	2.063	0.039
Apartment (NTT)	-0.5864	0.1383	-4.240	0.000	-0.5657	0.1396	-4.053	0.000	-0.6252	0.1372	-4.557	0.000
Random parameters												
Mean	0.7337	0.1708	4.296	0.000	0.7975	0.1369	5.825	0.000	-0.5100	0.2176	-2.343	0.019
Past Choice	0.1227	0.1385	0.886	0.376	0.1670	0.0941	1.776	0.076	0.1634	0.1876	0.871	0.384
<hr/>												
Lock-in (lock-out) effects	NTT's ADSL		¥2,355		NTT's ADSL + NB		¥2,433		Softbank's ADSL		¥-1,616	
<hr/>												

Source: Ida and Sakahira (2008).

Figure 8.3 Conditional distributions of PAST CHOICE.

Source: Ida and Sakahira (2008).

These conclusions are important for planning information communication policies. According to Ida (2006a, b), the factors behind the success of broadband in Japan are the appearance of newcomers with strong capabilities and desires (ie Softbank in ADSL and K-opticom in FTTH), and reluctant but concerted efforts by NTT's management. We have observed that since only NTT is providing both ADSL and FTTH, Japanese FTTH users tend to be absorbed into NTT. Therefore, NTT's dominance in the FTTH market will likely increase as broadband migration advances further. Therefore, we need to carefully monitor NTT's significant market power.¹¹ We can summarize the main points as follows.

Lock-in effects

Significant lock-in effects exist whose values are measured around ¥2,400 (US\$21.2). Since only NTT is providing both ADSL and FTTH, Japanese FTTH users tend to be absorbed into NTT

Conclusion

This chapter investigated broadband migration to FTTH, measured NTT's lock-in effects, and obtained two main conclusions. First, individual characteristics including income, service usages including moving-picture viewing, and type of residence significantly influence broadband migration to FTTH.

Second, lock-in effects are measured around ¥2,400 (US\$21.4). These conclusions are important when discussing future Japanese information communication policies. The first result implies that in the final stage of broadband migration, the information poor fail to migrate to FTTH, the final broadband service; some public assistance may be required. Second, since lock-in effects exist in the FTTH market, NTT's market power will increase, and thus we also need to carefully monitor the market so that NTT does not abuse its dominant position.

9 The future of fixed-mobile convergence

Japan's fixed-line Internet access (broadband) and third generation (3G) mobile phone services have rapidly developed, blazing a trail in the world (Taplin and Wakui, 2006; Fransman, 2006). As of December 2006, the number of contracts subscribing to fixed-line broadband services was 25 million (household penetration rate of about 50%), broken down as FTTH (31%), ADSL (53%), and CATV Internet (16%). ADSL users still form the majority, while the FTTH share continues to grow rapidly. Analyzing market share by providers, NTT East/West gained 39% and 68% in the ADSL and FTTH markets, respectively. On the other hand, turning to mobile phone services, the number of contracts reached 100 million by December 2006, and the mobile Internet penetration rate is almost 90%. The shares are broken down as second generation (2G) (32%) and 3G mobile phone services (63%). Note that 3G users now overwhelmingly exceed 2G users. Looking at market share by providers, NTT DoCoMo is dominant in both 2G (63%) and 3G (51%) services. Empirical analysis of the interdependencies between fixed-line broadband and mobile phone services will increase in importance, based on the expected emergence of *fixed mobile convergence (FMC)* services. We reach two conclusions in this chapter. First, there are statistically significant, though inelastic, lock-in effects from fixed-line broadband to mobile phone services. A 1% increase in the broadband market share of NTT East/West only increases the mobile phone market share of NTT DoCoMo by 0.06%. Furthermore, the impact of the lock-in effect is larger in 3G than in 2G services. Second, there are statistically significant lock-in effects from mobile phone to fixed-line broadband services. A 1% increase in the mobile phone market share of NTT DoCoMo increases the broadband market share of NTT East/West by 1.05%. Furthermore, the impact of the lock-in effect is larger in FTTH than in ADSL services.

Fixed-mobile convergence (FMC) service

At this moment, as the *next-generation network (NGN)* plan proposed by the NTT group advances, *fixed-mobile convergence (FMC)* services are expected to emerge in the near future (Curwen 2006).¹ FMC services can be classified into the following three categories:

- One charge system: Customers can benefit from one-stop billing services with discounts.
- One handset (or equipment): Customers can make telephone calls with one telephone and one number.
- One network: Providers can provide enhanced services with one database and one seamless network.

From the top to the bottom, added values increase for consumers, while development costs increase for providers. Note that most enhanced FMC services assume advanced customers who use both FTTH and 3G services; only the NTT, KDDI, and Softbank groups can provide both FTTH and 3G services. The NTT group has especially large shares in both FTTH and 3G markets. These facts raise serious concerns for maintaining effective competition. At this point, we pose two questions:

- Do lock-in effects exist from broadband to mobile phone services? In other words, are NTT East/West broadband users more likely to choose NTT DoCoMo mobile phone services? If so, how much more likely?
- Do lock-in effects exist from mobile phone to broadband services? In other words, are NTT DoCoMo mobile phone users more likely to choose NTT East/West broadband services? If so, how much?

We use the term *lock-in effect* to denote that a specific firm or technology monopolizes by network externalities or increasing returns (Shapiro and Varian, 1999; Witt, 1999; Liebowitz and Margolis, 2002). We consider the lock-in effect in the sense that NTT fixed-line broadband users are more likely to choose NTT mobile phone services than other mobile phone providers because NTT fixed-line broadband users do not need to pay pecuniary or non-pecuniary switching costs.

In December 2006, we jointly surveyed Internet access services with the Japanese Ministry of Internal Affairs and Communications (MIC). To analyze decision-making structures in broadband services, we adopt a mixed logit (ML) model, which relaxes the independence from irrelevant alternatives (IIA) properties imposed on conditional logit (CL) models. In related literatures, Ida and Kuroda (2006) analyzed Internet connection demand,² and Ida and Kuroda (2008) analyzed mobile phone demand.³ Furthermore, Ida and Sakahira (2008) analyzed broadband migration from ADSL to FTTH services. This current research, however, is the first to deal with FMC services using a discrete choice model analysis.

Survey method and data

We jointly conducted sample surveys with MIC on the individual usage of Internet access and mobile phone services in December 2006. Random surveys were conducted on monitors registered with a consumer monitor

investigative company. We obtained 1,874 samples currently using both fixed-line Internet and mobile phone services. Socio-demographics including gender, age, occupation, household income, and so on are given in Table 9.1.

Breakdowns are given in Table 9.2 based on broadband Internet usage. Selection ratios follow: ADSL (52%), FTTH (33%), and CATV Internet (15%). The market shares of NTT East/West are 36% for ADSL and 63% for FTTH. Current major Internet usages are indicated in Table 9.3. The 050-type IP phone (whose quality of service (QoS) are not guaranteed) are popular in ADSL (45%) and the 0ABJ-type IP phone (whose QoS are guaranteed) are popular in FTTH (39%). For free or pay music usages and movie downloading, there is no significant difference between ADSL and FTTH, but the figure is lower in CATV Internet.

Next, details about mobile phone usage are given in Table 9.4. Selection ratios follow: 2G (30%) and 3G (70%). Market shares are 47% for NTT DoCoMo, 32% for KDDI's *au*, and 22% for Softbank. Current major functioning usages are indicated in Table 9.5. Note that overall, from basic services (ie email, Web browsing) to advanced services (ie movie viewing, financial transactions), the services available to 3G users are superior to those for 2G users although the differences between them still seem small.

Estimation models

In this section, we explain a method that measures the lock-in effects between fixed-line broadband and mobile phone services.

Two-stage logit model method

Here, we have to consider the two simultaneous-equations model and address the problem of endogeneity across those equations. The full-information maximum likelihood (FIML) method that jointly treats all equations and all parameters is the most efficient among estimators with normally distributed disturbances (Hausman, 1983). However, since the FIML estimator requires immense computations, it is often difficult to perform. Instead, the limited-information maximum likelihood (LIML) method must be considered.

Suppose that logit specification is appropriate in which error terms follow independently and identically distributed extreme value (IID-EV) distribution. A simultaneous logit equations model is also called a multivariate logit model (Schmidt and Strauss, 1975). In this case, the problem is quite simple. Analysis of the multivariate logit model proceeds with separate estimation from each of the two equations, following the LIML method. The LIML method by separate estimation leads to consistent but asymptotically less efficient estimators than the FIML method by joint estimation (Amemiya, 1978). LIML computation, however, can be considerably simpler than the FIML method, especially in models involving multinomial dependent discrete variables, as in this chapter.⁴

Table 9.1 Sociodemographics

(a) Gender			
Ratio	Male 50.3%	Female 49.7%	
(b) Age			
Ratio	20s 19.4%	30s 38.9%	40s 26.9%
			50s and over 14.8%
(c) Occupation			
Ratio	Office worker 40.9%	Self-employed 6.9%	Professional 5.3%
			Public official 5.2%
			Students 4.4%
			Housewife 19.7%
			Part-time 10.9%
			No occupation 4.6%
			Other 2.0%
(d) Annual household income class			
Ratio	¥3 M < 15.0%	¥3–5 M 27.9%	¥5–7 M 23.6%
			¥7–10 M 22.0%
			¥10–15 M 8.9%
			<¥15 M 2.7%

Source: Ida and Sakahira (2007).

Table 9.2 Fixed-line broadband share

(a) Type of Internet access line

	<i>ADSL</i>	<i>FTTH</i>	<i>CATV</i>
Ratio	51.9%	33.1%	15.0%

(b) ADSL market share

	<i>NTT E/W</i>	<i>Softbank</i>	<i>E-access</i>	<i>Acca</i>	<i>Other</i>
Ratio	35.7%	38.0%	8.6%	8.2%	9.5%

(c) FTTH market share

	<i>NTT E/W</i>	<i>USEN</i>	<i>KDDI</i>	<i>K-Op</i>	<i>Other</i>
Ratio	63.4%	8.2%	3.4%	6.3%	18.7%

(d) CATV Internet market share

	<i>Jupiter</i>	<i>Kansai multi</i>	<i>Other</i>
Ratio	23.1%	7.8%	69.0%

Source: Ida and Sakahira (2007).

As such, we adopt the two-stage logit estimation method that consists of the following two-stage analysis. First, we separately estimate the induced-form equations by the logit model. Second, we estimate the structural-form equations by the logit model, inserting expected choice probabilities as instrumental variables into the model.

Mixed logit model analysis

Conditional logit (CL) models, which assume independent and identical distribution (IID) of random terms, have been widely used in past studies. However, IIA's property derived from the IID assumption of CL models is too strict to allow flexible substitution patterns. The most prominent schemes are ML models, which accommodate differences in the variance of random components (Ben-Akiva, Bolduc, and Walker, 2001).⁵ They are flexible enough to overcome the limitations of CL models by allowing random taste variation, unrestricted substitution patterns, and the correlation of random terms over time (McFadden and Train, 2000).

In what follows, we assume that key parameters including lock-in effect parameters follow normal distribution. Accordingly, we can demonstrate variety in preferences at the individual-level. We use the maximum simulated likelihood (MSL) method for estimation by setting both 100 Halton sequence and 100 random draws to confirm the robustness of the estimation results.⁶

Table 9.3 Fixed-line broadband usage

(a) ADSL Internet usage (multiple answers)										
Ratio	<i>Email</i> 97.4%	<i>Web browsing</i> 83.8%	<i>050-IP phone</i> 44.9%	<i>0ABI-IP phone</i> 0.0%	<i>Security</i> 38.5%	<i>Online game</i> 24.1%	<i>Online shopping</i> 68.0%	<i>Net banking</i> 58.6%		
Ratio	<i>Free music</i> 21.2%	<i>Pay music</i> 11.3%	<i>Free movie</i> 59.1%	<i>Pay movie</i> 22.2%	<i>TV phone</i> 1.2%	<i>FMC</i> 0.6%	<i>Other free contents</i> 3.0%	<i>Others</i> 0.6%		
(b) FTTH Internet usage (multiple answers)										
Ratio	<i>Email</i> 98.9%	<i>Web browsing</i> 85.2%	<i>050-IP phone</i> 17.7%	<i>0ABI-IP phone</i> 39.0%	<i>Security</i> 40.9%	<i>Online game</i> 24.2%	<i>Online shopping</i> 70.5%	<i>Net banking</i> 60.5%		
Ratio	<i>Free music</i> 21.7%	<i>Pay music</i> 11.0%	<i>Free movie</i> 58.9%	<i>Pay movie</i> 22.5%	<i>TV phone</i> 1.8%	<i>FMC</i> 1.0%	<i>Other free contents</i> 4.2%	<i>Others</i> 2.1%		
(c) CATV Internet usage (multiple answers)										
Ratio	<i>Email</i> 97.5%	<i>Web browsing</i> 83.6%	<i>050-IP phone</i> 7.1%	<i>0ABI-IP phone</i> 0.0%	<i>Security</i> 44.8%	<i>Online game</i> 20.6%	<i>Online shopping</i> 63.7%	<i>Net banking</i> 48.0%		
Ratio	<i>Free music</i> 15.3%	<i>Pay music</i> 6.4%	<i>Free movie</i> 48.0%	<i>Pay movie</i> 15.7%	<i>TV phone</i> 2.1%	<i>FMC</i> 0.7%	<i>Other free contents</i> 2.5%	<i>Others</i> 1.1%		

Source: Ida and Sakahira (2007).

Table 9.4 Mobile phone market

(a) Type of providers			
Ratio	<i>NTT DoCoMo</i> 47.1%	<i>au</i> 31.6%	<i>Softbank</i> 21.3%
(b) Type of standard			
Ratio	<i>2G</i> 29.5%	<i>3G</i> 70.5%	
(c) 2G market share			
Ratio	<i>NTT DoCoMo</i> 48.3%	<i>au</i> 7.6%	<i>Softbank</i> 44.1%
(d) 3G market share			
Ratio	<i>NTT DoCoMo</i> 46.6%	<i>au</i> 41.6%	<i>Softbank</i> 11.8%

Source: Ida and Sakahira (2007).

Lock-in effects from broadband to mobile phone services

This section measures the lock-in effects from broadband to mobile phone services. The choice ratios of mobile phone service conditioned on the choice of broadband service are shown in Table 9.6. It follows that 51% of NTT East/West broadband users choose NTT DoCoMo mobile phone services, while 44% of the users of other providers choose NTT DoCoMo mobile phone services. In particular, 52% of NTT East/West broadband users choose NTT DoCoMo 3G services, while 42% of the users of other providers choose NTT DoCoMo 3G services. Are there lock-in effects from broadband to mobile phone services within the NTT group?

In what follows, we consider three models for measuring the lock-in effects from broadband to mobile phone services. The first (Model 1) assumes that the explained variables are NTT DoCoMo mobile phone service (2G+3G) and another mobile phone service (2G+3G). The second (Model 2) assumes that explained variables are NTT DoCoMo 3G service and another 3G service. The third (Model 3) assumes that the explained variables are NTT DoCoMo 2G service and another 2G service.

Let us begin with the first (2G+3G) model. While adopting the ML model, explanatory variables are divided into normally distributed random and non-random parameters. We assume here that random variables are: (1) NTT broadband service choice probability (NTT-BB) and (2) monthly fixed basic fee (PRICE). On the other hand, non-random parameters are: (3) Web browsing (WEB), (4) transmitting still picture data (PICTURE), (5) transmitting music data (MUSIC), (6) transmitting moving picture data (MOVIE), (7) using TV phone (TVPHONE), (8) watching TV or listening to radio programs

Table 9.5 Mobile phone usage

(a) 2G usage (multiple answers)									
Ratio	<i>Email</i> 89%	<i>Web browsing</i> 29%	<i>Camera</i> 51%	<i>Watch</i> 50%	<i>Picture data</i> 11%	<i>Music data</i> 6%	<i>Game</i> 7%	<i>TV/Radio</i> 4%	
Ratio	<i>TV phone</i> 1%	<i>Movie data</i> 3%	<i>Felica</i> 1%	<i>Wireless</i> 4%	<i>Bar code</i> 5%	<i>Global roaming</i> 0%	<i>GPS</i> 0%	<i>Other</i> 1%	
(b) 3G usage (multiple answers)									
Ratio	<i>Email</i> 93%	<i>Web browsing</i> 46%	<i>Camera</i> 61%	<i>Watch</i> 58%	<i>Picture data</i> 19%	<i>Music data</i> 18%	<i>Game</i> 19%	<i>TV/Radio</i> 5%	
Ratio	<i>TV phone</i> 3%	<i>Movie data</i> 8%	<i>Felica</i> 9%	<i>Wireless</i> 13%	<i>Bar code</i> 15%	<i>Global roaming</i> 2%	<i>GPS</i> 3%	<i>Other</i> 1%	

Source: Ida and Sakahira (2007).

Table 9.6 Lock-in effects from broadband to mobile phone

	<i>NTT DoCoMo</i>	<i>Other</i>	<i>Total</i>
(a) NTT E/W broadband users who choose NTT DoCoMo (2G+3G)			
NTT E/W	51.3%	48.7%	100%
Other	44.3%	55.7%	100%
BB total	47.1%	52.9%	100%
(b) NTT E/W broadband users who choose NTT DoCoMo (3G)			
NTT E/W	51.7%	48.3%	100%
Other	42.4%	57.6%	100%
BB total	46.7%	53.3%	100%
(c) NTT E/W broadband users who choose NTT DoCoMo (2G)			
NTT E/W	50.2%	49.8%	100%
Other	45.6%	54.4%	100%
BB total	47.7%	52.3%	100%

Source: Ida and Sakahira (2007).

(ONESEG), and (9) financial transactions (MONEY). The basic descriptive statistics of Model 1 are shown in Table 9.7(a). The estimation results of Model 1 are shown in Table 9.8(a). The main results are summarized as follows:

- Choosing NTT broadband service is statistically significantly associated with the probability of choosing NTT DoCoMo mobile phone service.
- PRICE has a statistically significantly negative influence on the probability of choosing mobile phone services.
- TVPHONE and MONEY are statistically significantly positive for choosing the NTT DoCoMo mobile phone service.
- MUSIC and ONESEG are statistically significantly negative for choosing the NTT DoCoMo mobile phone service.

Next, let us turn to the second (3G) model. Following Model 1 with respect to the definitions of variables, the basic descriptive statistics of Model 2 are shown in Table 9.7(b), and its estimation results are shown in Table 9.8(b). The main results are summarized as follows:

- Choosing the NTT broadband service is statistically significantly associated with the probability of choosing the NTT DoCoMo 3G service.
- PRICE has a statistically significantly negative influence on the probability of choosing 3G services.
- WEB, TVPHONE, and MONEY are statistically significantly positive for choosing the NTT DoCoMo 3G service.

Table 9.7 Mobile phone choice basic statistics

	<i>Choice ratio</i>	<i>Price</i>	<i>Web</i>	<i>Picture</i>	<i>Music</i>	<i>Movie</i>	<i>TV Phone</i>	<i>Oneseg</i>	<i>Money</i>
(a) Mobile phone (2G+3G)									
NTT DoCoMo	47.1%	¥3,267	43.0%	17.1%	13.5%	6.7%	3.7%	0.6%	9.8%
Other	52.9%	¥2,975	38.8%	15.6%	15.8%	6.7%	1.1%	8.8%	3.6%
(b) Mobile phone (3G)									
NTT DoCoMo	46.7%	¥3,378	49.6%	20.2%	17.7%	0.9%	6.0%	9.4%	9.4%
Other	53.3%	¥3,034	42.7%	16.9%	19.5%	9.6%	1.0%	7.5%	7.5%
(c) Mobile phone (2G)									
NTT DoCoMo	47.7%	¥3,012	49.6%	20.2%	17.7%	0.9%	6.0%	9.4%	13.2%
Other	52.3%	¥2,847	42.7%	16.9%	19.5%	9.6%	1.0%	7.5%	5.5%

Source: Ida and Sakahira (2007).

Table 9.8 Mobile phone estimation results

	(a) 2G+3G				(b) 3G				(c) 2G			
	No. of sample		1874		No. of sample		1321		No. of sample		553	
	Max LL		-1220.505		Max LL		-847.329		Max LL		-368.107	
	Initial LL		-1298.958		Initial LL		-915.647		Initial LL		-383.310	
	McFadden R2		0.060		McFadden R2		0.075		McFadden R2		0.040	
	Estimates		SE		Estimates		SE		Estimates		SE	
Random parameter												
	NTT-BB	MEAN	0.33420	0.10205	***	0.45642	0.13049	***	0.20213	0.16901		
		SD	0.16613	1.07217		0.12338	2.06169		0.18507	3.01694		
	PRICE	MEAN	-0.000384	0.00011	***	-0.000541	0.00015	***	-0.000011	0.00012		
SD		0.001347	0.00033	***	0.001658	0.00040	***	0.000028	0.00086			
Non-random parameter												
	NTT-Web		0.21336	0.10937		0.33280	0.13701	**	0.08847	0.18588		
			0.03724	0.16859		-0.01109	0.20213		0.15903	0.31742		
	NTT-Picture		-0.40463	0.17919	**	-0.51368	0.20703	*	-0.04611	0.42091		
			-0.11811	0.25958		-0.07556	0.29416		-0.73653	0.68136		
	NTT-Movie		1.37965	0.43564	***	2.23314	0.57682	***	-	-		
			-3.40242	0.54162	***	-3.22384	0.57834	***	-31.16640	1321520		
	NTT-TVPhone		1.45635	0.27435	***	1.42946	0.29401	***	-	-		

Note: ***1% significance level, **5% significance level, *10% significance level.

Source: Ida and Sakahira (2007).

- MUSIC and ONESEG are statistically significantly negative for choosing the NTT DoCoMo 3G service.

Last, let us explain the third (2G) model. Following Model 1 with respect to the definitions of variables, except for TVPHONE and MONEY, which are unavailable to 2G users, the basic descriptive statistics of Model 3 are shown in Table 9.7(c). The estimation results of Model 3 are shown in Table 9.8(c). The main results are summarized as follows:

- Choosing the NTT broadband service is not statistically significantly associated with the probability of choosing the NTT DoCoMo 2G service.
- PRICE does not have a statistically significantly negative influence on the probability of choosing 2G services.
- No variables are statistically significant for choosing the NTT DoCoMo 2G service.

We can summarize the main points as follows:

Lock-in effects from broadband to mobile phone services

Choosing the NTT broadband services, including broadband and FTTH services, are statistically significantly associated with the probability of choosing the NTT DoCoMo 3G services.

Lock-in effects from mobile phone to broadband services

This section measures lock-in effects from mobile phone to broadband services. The choice ratios of broadband service conditioned on the choice of mobile phone service are shown in Table 9.9. Note that 43% of NTT DoCoMo mobile phone users choose NTT East/West broadband services, while 36% of the users of other providers choose NTT East/West broadband services. In particular, 65% of NTT DoCoMo mobile phone users choose NTT East/West FTTH services, while 62% of the users of other providers choose East/West FTTH services. Are there lock-in effects from mobile phone to broadband services within the NTT group?

In what follows, we consider three models to measure the lock-in effects from mobile phone to broadband services. The first (Model 4) assumes that the explained variables are NTT East/West broadband service and another broadband service. The second (Model 5) assumes that the explained variables are NTT East/West FTTH service and another FTTH service. The third (Model 6) assumes that the explained variables are NTT East/West ADSL service and another ADSL service.

Table 9.9 Lock-in effects from mobile phone to broadband

	<i>NTT E/W</i>	<i>Other</i>	<i>Total</i>
(a) NTT DoCoMo users who choose NTT E/W Broadband (broadband)			
NTT DoCoMo	43.1%	56.9%	100%
Other	36.4%	63.6%	100%
Total	39.5%	60.5%	100%
(b) NTT DoCoMo users who choose NTT E/W Broadband (FTTH)			
NTT DoCoMo	65.0%	35.0%	100%
Other	61.9%	38.1%	100%
Total	63.4%	36.6%	100%
(c) NTT DoCoMo users who choose NTT E/W Broadband (ADSL)			
NTT DoCoMo	41.0%	59.0%	100%
Other	31.2%	68.8%	100%
Total	35.7%	64.3%	100%

Source: Ida and Sakahira (2007).

Let us begin with the first (broadband) model. While adopting the ML model, explanatory variables are divided into normally distributed random and non-random parameters. We assume here that random variables are: (1) NTT DoCoMo mobile phone service choice probability (NTT-DoCoMo) and (2) monthly fixed basic fee (PRICE). The non-random parameters are: (3) using 050-IP phone (050-IP), (4) using 0ABJ-IP phone (0ABJ-IP), (5) transmitting moving picture data (MOVIE), (6) apartment dummy variable (APARTMENT), and (7) income class index variable (INCOME). The basic descriptive statistics of Model 4 are shown in Table 9.10(a). The estimation results of Model 4 are shown in Table 9.11(a). The main results are summarized as follows:

- Choosing the NTT DoCoMo mobile phone service is statistically significantly associated with the probability of choosing the NTT East/West broadband service.
- PRICE does not have a statistically significantly negative influence on the probability of choosing broadband services.⁷
- 0ABJ-IP and MOVIE are statistically significantly positive for choosing the NTT East/West broadband service.
- 050-IP and APARTMENT are statistically significantly negative for choosing the NTT East/West broadband service.

Next, let us move to the second (FTTH) model. Following Model 4 with respect to the definitions of variables, except for 050-IP, the basic descriptive

Table 9.10 Broadband choice basic statistics

	<i>Choice ratio</i>	<i>Price</i>	<i>IP phone</i>	<i>Movie</i>	<i>Apartment</i>	<i>Income</i>
(a) Broadband						
NTT E/W	39.5%	¥4,685.9	33.1%	60.2%	40.1%	2.9
Other	60.5%	¥3,817.7	40.0%	56.2%	48.2%	2.9
(b) FTTH						
NTT E/W	63.4%	¥5,370.2	47.5%	40.4%	62.4%	2.9
Other	36.6%	¥4,912.8	63.4%	36.6%	54.6%	3.1
(c) ADSL						
NTT E/W	35.7%	¥3,908.9	31.7%	24.8%	57.6%	2.9
Other	64.3%	¥3,308.4	51.2%	56.0%	60.5%	2.8

Source: Ida and Sakahira (2007).

Table 9.11 Broadband estimation results

		(a) Broadband		(b) FTTH		(c) ADSL	
		No. of sample	1874	No. of sample	621	No. of sample	972
		Max LL	-1124.109	Max LL	-395.040	Max LL	-550.208
		Initial LL	-1298.958	Initial LL	-430.444	Initial LL	-673.739
		McFadden R2	0.135	McFadden R2	0.082	McFadden R2	0.183
		Estimates	SE	Estimates	SE	Estimates	SE
Random parameter							
NTT-DoCoMo	MEAN	11.21450	1.34839	9.97832	2.47831	9.24629	1.94774
	SD	16.72580	2.25868	15.57380	4.28989	14.63830	3.80238
PRICE	MEAN	0.000155	0.00009	0.000127	0.00015	-0.000053	0.00016
	SD	0.000072	0.00033	0.000009	0.00036	0.000694	0.00041
Non-random parameter							
NTT-050-IP Phone		-1.75546	0.221095	-	-	-1.71446	0.27401
NTT-0ABJ-IP Phone		1.45510	0.24259	0.62811	0.26177	-	-
NTT-Movie		0.37727	0.11193	0.71567	0.19580	0.21629	0.17721
NTT-Apartment		-0.43779	0.14146	-0.25580	0.23343	-0.98350	0.22207
NTT-Income		-0.00090	0.03622	0.17591	0.06768	0.17373	0.05839

Note: ***1% significance level, **5% significance level, *10% significance level.

Source: Ida and Sakahira (2007).

statistics of Model 5 are shown in Table 9.10(b). The estimation results of Model 5 are shown in Table 9.11(b). The main results are summarized as follows:

- Choosing the NTT DoCoMo mobile phone service is statistically significantly associated with the probability of choosing the NTT East/West FTTH service.
- PRICE does not have a statistically significantly negative influence on the probability of choosing FTTH services.
- 0ABJ-IP, MOVIE, INCOME are statistically significantly positive for choosing the NTT East/West FTTH service.

Last, let us explain the third (ADSL) model. Following Model 4 with respect to the definitions of variables, except for 0ABJ-IP, the basic descriptive statistics of Model 6 are shown in Table 9.10(c). The estimation results of Model 6 are shown in Table 9.11(c). The main results are summarized as follows:

- Choosing the NTT DoCoMo mobile phone service is statistically significantly associated with the probability of choosing the NTT East/West ADSL service.
- PRICE does not have a statistically significantly negative influence on the probability of choosing ADSL services.
- INCOME is statistically significantly positive for choosing the NTT East/West ADSL service.
- 050-IP and APARTMENT are statistically significantly negative for choosing the NTT East/West ADSL service.

We can summarize the main points as follows:

Lock-in effects from mobile phone to broadband services

Choosing the NTT DoCoMo mobile phone services, including mobile phone, 3G, and 2G services, are statistically significantly associated with the probability of choosing the NTT East/West FTTH services.

Impacts of lock-in effects between broadband and mobile phone services

This section measures the impacts of lock-in effects between broadband and mobile phone services using the elasticities of choice probabilities. Elasticity of choice probability indicates how much a 1% increase in the choice probability of one service increases the choice probability of another service,

therefore representing the size of the lock-in effect between two markets. Note that figures can have an asymmetric relationship.

First, Figure 9.1 diagrammatically indicates the lock-in effects from broadband to mobile phone services. In Model 1, the elasticity of choice probability from NTT East/West broadband to NTT DoCoMo mobile phone services is 0.059 (1% level statistically significant). In Model 2, the elasticity of choice probability from NTT East/West broadband to NTT DoCoMo 3G services is 0.076 (1% level statistically significant). In Model 3, the elasticity of choice probability from NTT East/West broadband to NTT DoCoMo 2G services is 0.040 (statistically insignificant). To sum up, there are statistically significant lock-in effects (but ADSL) from NTT East/West broadband to NTT DoCoMo mobile phone services whose impacts are small.

Next, Figure 9.2 diagrammatically indicates the lock-in effects from mobile phone to broadband services. In Model 4, the elasticity of choice probability from NTT DoCoMo mobile phone to NTT East/West broadband services is 1.046 (1% level statistically significant). In Model 5, the elasticity of choice probability from NTT DoCoMo mobile phone to NTT East/West FTTH services is 1.067 (1% level statistically significant). In Model 6, the elasticity of choice probability from NTT DoCoMo mobile phone to NTT East/West ADSL services is 0.872 (1% level statistically significant). To sum up, there are statistically significant lock-in effects from NTT DoCoMo mobile phone to NTT East/West broadband services whose impacts are large.

In conclusion, we can summarize the main results below. There are lock-in effects between broadband and mobile phone services that reinforce the brand power of the NTT group. However, the effects are asymmetric; impacts from mobile phone to broadband services are larger than the opposite impacts from broadband to mobile phone services. At present, the NTT group is strictly regulated enough to prohibit joint business and cross-subsidization between NTT East/West and DoCoMo. Therefore, we cannot conclude that these lock-in effects result from the anticompetitive conduct of

Figure 9.1 Lock-in effects from broadband to mobile phone.

Note: Figures are elasticities. ***1% significance level, **5% significance level, *10% significance level.

Source: Ida and Sakahira (2007).

Figure 9.2 Lock-in effects from mobile phone to broadband.

Note: Figures are elasticities. ***1% significance level, **5% significance level, *10% significance level.

Source: Ida and Sakahira (2007).

the NTT group; they presumably reflect consumer preference for NTT's brand power.

In addition, Figure 9.3 depicts the variety of preferences for the lock-in effects from broadband services to mobile phone. While adopting ML models that allow for individual-level varieties in preferences, we represent them by a histogram. Note that lock-in effects from broadband services to mobile phone services are very diverse across users, although their average impacts are significant.

Figure 9.3 Variety in individual-level preferences (lock-in effects from broadband to mobile).

Source: Ida and Sakahira (2007).

We can summarize the main points as follows:

Impacts of lock-in effects between broadband and mobile phone services

A 1% increase in the broadband market share of NTT East/West only increases the mobile phone market share of NTT DoCoMo by 0.06%. On the other hand, a 1% increase in the mobile phone market share of NTT DoCoMo increases the broadband market share of NTT East/West by 1.05%.

Conclusion

This chapter investigated the lock-in effects between broadband and mobile phone services and obtained two conclusions. First, lock-in effects statistically significantly exist from fixed-line broadband to mobile phone services, although the impacts are quite small. Second, lock-in effects statistically significantly exist from mobile phone to fixed-line broadband services, and the impacts are large. These conclusions are important when discussing future Japanese information-communication policies. Broadband and mobile phone services, especially FTTH and 3G services, are two bases for the FMC service. We are concerned that oligopolistic providers, especially the NTT group, which are providing both services, may abuse their market dominance. Since lock-in effects are much larger from mobile phone to fixed-line broadband services, we need to carefully monitor the market to insure that mobile phone providers do not abuse their dominant positions.

10 The digital divide: Closing the gap

In this chapter we will investigate the usage-based digital divide from both *qualitative* and *quantitative* points of view. We will compare two regions in which fiber to the home (FTTH) services have already been started by carrying out the same survey by questionnaires: Yawata in Yamagata Prefecture (a typical depopulated area) and the Tokyo Metropolitan Area. The data will be analyzed by using a mixed logit model, and we will measure willingness to pay (WTP) values for various public services over FTTH.

The first finding here is that from a quantitative aspect, there is no usage-based digital divide between the two FTTH available areas—provincial and urban. This paper considers three categories and nine services provided over FTTH, as shown in Table 10.1: telecommunication and broadcasting services (IP phone, 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 figure for the provincial area (Yawata) is slightly higher than for the urban area (Tokyo), meaning that there are sufficient needs for public services over FTTH even in the provincial area.

The second conclusion is that from a qualitative aspect, 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.

What is digital divide?

As has been discussed, broadband Internet access services in Japan have developed rapidly. However, we must turn our attention to the negative aspects of the information society, including the digital divide problem. Digital divide is defined as the *inequality between the information haves and information have-nots*; more precisely, the gap between individuals, households,

Table 10.1 Public services over FTTH

<i>Service</i>	<i>Explanations</i>
(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 videoconferencing 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.

businesses, and geographic areas at different socioeconomic levels regarding both opportunities to access information technologies and their Internet use for a wide variety of activities (OECD, 2001, *Understanding the Digital Divide*). 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.

A difficult question when considering digital divide is that the social and economic impacts of broadband services are controversial.¹ As Firth and Mellor (2005) pointed out, 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. Therefore, we look at various viewpoints concerning digital divide policies. 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, Borgida, Sullivan, and Jackson (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. Also, Gillett, Lehr, and Osorio (2004) discussed that since a growing number of communities is adopting policies to promote advanced telecommunications services, including broadband access, governments should be considered broadband users, rulemakers, financiers, and infrastructure developers.

Furthermore, Strover (2003) approached the digital divide problem from various angles in a special issue of *Information Society vol. 19* 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, subsequent policy steps should leverage the utility of existing infrastructures to expand human capital development. Van Dijk and Hacker (2003) separated digital divide into two large categories:

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

They correctly 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. Turning to Japan's digital divide, FTTH is now becoming available in cities and larger towns; there is hardly any provision for starting FTTH in smaller towns or villages. 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 a solution for 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 *quantitative* aspects from the *qualitative* aspects of the remote provision of public services over FTTH.² We summarize the main points of this section as follows:

Digital divide problem

Digital divide can be broken down into two problems: *access-based* and *usage-based* digital divide. The core problem has shifted from the former to the latter. Furthermore, it is important to distinguish the *quantitative* aspects from the *qualitative* aspects of the digital divide problem.

Japan's digital divide

In this section we will give a summary overview of Japan's digital divide, hewing closely to a recent report published by the Ministry of Internal Affairs and Communications (MIC) entitled the *Next Generation Broadband Concept 2010*, released in July 2005. Drafted by the MIC's Committee for Development of Well-Balanced Broadband Infrastructure, the report is well considered, contains a wealth of recent data, and provides a remarkably clear roadmap for moving forward in the years ahead.

The *Next Generation Broadband Concept 2010* report first enumerates four basic qualities characterizing the frontrunner broadband infrastructure. First, to eliminate the digital divide, the broadband infrastructure shall provide an environment giving each and every citizen access to either high-speed or ultra-high-speed broadband services. Second, to provide a robust platform for delivering information and supporting advanced broadband services, the broadband infrastructure must be extensively available and support use of advanced applications, distribution of massive amounts of content at upload speeds in excess of 30 Mbps. Third, to support more advanced utilization, the infrastructure shall accommodate triple-play (high-speed Internet, broadcasting, and telephone service) and other advanced services. And fourth, to ensure the highest standard of safety and security, the broadband

infrastructure shall provide excellent quality and security, robustness against disasters and failures, and safety and security for users.

Let us quantify Japan's digital divide in numerical terms. Table 10.2 shows the state of broadband infrastructure deployment in Japan broken down by number of households and number of municipalities. Virtually all households and communities have access to some form of broadband service—ADSL, cable Internet, or FTTH—but FTTH is only available to 80% of households and 54% of municipalities. In short, we see that progress continues to be made for reducing the latent broadband digital divide, but a real disparity still remains in peoples' access to FTTH services.

Table 10.3 shows the state of broadband infrastructure deployment broken out by size of municipal population. One can observe a trend toward greater availability of the full range of broadband services with increasing population of urban centers, but the differences are not all that striking. But looking just at the relation between FTTH availability and municipal population size, one can see that the population break point of 50,000 is quite significant, and the population break point of 10,000 is even more striking in terms of availability of FTTH service. In other words, the digital divide measured in terms of availability of FTTH is very apparent at these two population break points of 10,000 and at 50,000.

The *Next Generation Broadband Concept 2010* highlights two target objectives for implementing the next-generation broadband environment. The first objective addresses the digital divide, and calls for the elimination of *broadband zero municipalities* (areas where broadband is completely unavailable) by the year 2008, and the elimination of other *broadband zero areas* (remaining gaps where broadband is totally unavailable) by the year 2010. The second objective is to put in place the most advanced broadband infrastructure in the world with the deployment of an ultra-high-speed interactive broadband network (UIBN) with upload speeds in excess of 30 Mbps available to more than 90% of Japan's households by the year 2010.

Table 10.2 Broadband infrastructure deployment in Japan (by number of households and municipalities)

	<i>Available</i>	<i>Unavailable</i>
(i) Any form of broadband service		
Households (50,390,000 in total)	93.9% (47,330,000)	6.1% (3,060,000)
Municipalities (1,843 in total)	97.9% (1,804)	2.1% (39)
(ii) FTTH service		
Households (50,390,000 in total)	79.7% (40,150,000)	20.3% (10,240,000)
Municipalities (1,843 in total)	53.5% (986)	46.5% (857)

Note: Figures are as of March 2006.

Source: MIC (2005b).

Table 10.3 Broadband infrastructure deployment in Japan (by size of municipal population)

	<i>Completely available</i>	<i>Partially available</i>	<i>Unavailable</i>
(i) Any form of broadband service			
Less than 10,000 (491 in total)	55.0% (270)	37.3% (183)	7.7% (38)
10,000–50,000 (788 in total)	61.4% (484)	38.5% (303)	0.1% (1)
50,000–100,000 (282 in total)	64.5% (182)	35.5% (100)	0.0% (0)
100,000–300,000 (200 in total)	69.0% (138)	31.0% (62)	0.0% (0)
300,000 and over (82 in total)	65.9% (54)	34.1% (28)	0.0% (0)
All municipalities (1843 in total)	31.2% (1,128)	36.7% (676)	2.1% (39)
(ii) FTTH service			
Less than 10,000 (491 in total)	6.9% (34)	8.6% (42)	84.5% (415)
10,000–50,000 (788 in total)	10.4% (82)	36.9% (291)	52.7% (415)
50,000–100,000 (282 in total)	22.7% (64)	68.1% (192)	9.2% (26)
100,000–300,000 (200 in total)	30.0% (60)	69.5% (139)	0.5% (1)
300,000 and over (82 in total)	29.3% (24)	70.7% (58)	0.0% (0)
All municipalities (1843 in total)	14.3% (264)	39.2% (722)	46.5% (857)

Note: Figures are as of March 2006.

Source: MIC (2005b).

The report sets out five key policy areas within the framework for a new public-private partnership: first, to fundamentally strengthen finance and taxation measures to significantly strengthen investment incentives for operators; second, enhanced support measures to local public entities including financial assistance, providing information, and support for training human resources that will further imaginative solutions, self-motivated efforts, and other kinds of local initiatives; third, policies promoting research and development on wireless access combined with optical fiber to promote construction of more flexible networks integrating wireline and wireless systems; fourth, policies promoting deployment of local public networks that are open and assessable to the public in order to promote more effective utilization of fiber-optic networks deployed by local public entities; fifth, policies promoting deployment awareness through cooperating among stakeholders and interested parties, development of applications and content, and imaginative business models to create demand for broadband services in information disadvantaged areas.

The first four policy objectives seek to eliminate the digital divide from the standpoint of physical access. Regarding this point, the policies will likely succeed in gradually reducing the scale of the digital divide. However, one

area where it is likely the situation will gradually become more problematic is in dealing with the digital divide from the standpoint of service usage. The fact that this issue is only addressed by the fifth policy area leaves us feeling somewhat apprehensive, so in this chapter we will focus on the digital divide in terms of service usage, and conduct an analysis comparing rural areas with metropolitan areas. We summarize the main points of this section as follows:

Japan's digital divide

MIC directly addresses the problem of Japan's digital divide in its recent report, the *Next Generation Broadband Concept 2010*. The report makes detailed recommendations for dealing with the access aspects of the digital divide issue, but does not fully address the service usage dimensions of the issue.

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-thirties in prefectural income and around fortieth 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%, most of whom 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. As for 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,” 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 MIC 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 the FTTH service, 610 families subscribed,³ 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 10.4, current Internet usage in Table 10.5, and the actual or expected utilization of public services over FTTH in Table 10.6, respectively.

FTTH usage in Tokyo

In the Tokyo Metropolitan Area, such Internet access line companies as NTT East, 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 10.4, current Internet usage in Table 10.5, and the expected utilization of public services over FTTH in Table 10.6.

Comparison of FTTH usage between Yawata and Tokyo

We investigate the differences in FTTH utilization between Yawata and Tokyo.⁴ First, we examine Table 10.4 in which the demographics of respondents are indicated. As for age, many respondents in Yawata are in their fifties, while those in Tokyo are in their thirties. 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 above findings precisely reflect the general differences between provincial and urban areas.

Next we turn to Table 10.5, which demonstrates the current Internet usage

Table 10.4 Demographics of respondents

		<i>Yawata (Yamagata)</i> <i>Respondents = 163</i>		<i>Tokyo</i> <i>Respondents = 182</i>	
		<i>No.</i>	<i>Ratio</i>	<i>No.</i>	<i>Ratio</i>
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%

Source: Ida and Horiguchi (2007).

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.⁵ Remarkably for frequently used services, current utilizations are more progressive in Tokyo than in Yawata for all terms.⁶ 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

Table 10.5 Current Internet usages

		<i>Yawata (Yamagata)</i> <i>Respondents = 163</i>		<i>Tokyo</i> <i>Respondents = 182</i>	
		<i>No.</i>	<i>Ratio</i>	<i>No.</i>	<i>Ratio</i>
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 ¥2,000	1	0.6%	11	6.0%
	2. ¥2,000 through ¥3,000	6	3.7%	21	11.5%
	3. ¥3,000 through ¥4,000	6	3.7%	32	17.6%
	4. ¥4,000 through ¥5,000	82	50.3%	35	19.2%
	5. ¥5,000 through ¥6,000	48	29.4%	27	14.8%
	6. ¥6,000 through ¥7,000	15	9.2%	22	12.1%
	7. ¥7,000 through ¥8,000	3	1.8%	15	8.2%
	8. ¥8,000 through ¥9,000	0	0.0%	2	1.1%
	9. More than ¥9,000	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. Online games	24	14.7%	45	24.7%
	6. Online shopping	99	60.7%	127	69.8%
	7. Online 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%

Source: Ida and Horiguchi (2007).

Table 10.6 Utilization of public services over FTTH

		<i>Yawata (Yamagata)</i> <i>Respondents = 163</i>		<i>Tokyo</i> <i>Respondents = 182</i>	
		<i>No.</i>	<i>Ratio</i>	<i>No.</i>	<i>Ratio</i>
(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
(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

Table 10.6 Continued

		<i>Yawata (Yamagata)</i> <i>Respondents = 163</i>		<i>Tokyo</i> <i>Respondents = 182</i>	
		<i>No.</i>	<i>Ratio</i>	<i>No.</i>	<i>Ratio</i>
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	
(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	

Source: Ida and Horiguchi (2007).

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 10.6, 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 they want to use the service.

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.⁷ We summarize the main points of this section as follows:

FTTH usage between Yawata and Tokyo

The current Internet usage of FTTH subscribers is more progressive in Tokyo than in Yawata for all terms. By contrast, there is higher demand for the provision of public services, including terrestrial digital broadcasting, over FTTH in Yawata than in Tokyo.

Econometric analysis of usage-based digital divide

In this section we explain conjoint analysis and a mixed logit model, which is a generalization of a conditional logit model. Then we show estimation results and analyze various outputs including willingness to pay and individual level parameters.

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).⁸ 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.⁹

Conjoint analysis, or discrete choice experiment (DCM), assumes that a service is a profile composed of attributes.¹⁰ In a 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 the attributes indicated in Table 10.1 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, Hensher, and Swait, 2000, ch. 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 10.1 depicts the representative questionnaire covering profiles and attributes. We asked eight questions per respondent and used a stratified random sampling method on a dataset, totaling 1,304 (163×8) samples for Yawata and 1,456 (182×8) samples for Tokyo.

Mixed logit model

This section describes our econometric model. Conditional logit (CL) models that assume independent and identical distribution (IID) of random terms

		Option 1		Option 2		Option 3	
Monthly charge		Y7000		Y5000			
Functions available	Telecommunication and broadcasting	IP phone	IP phone		No choice		
		TV phone	TV phone				
		Digital broadcasting					
	Health and security	Tele-medicine	Tele-care				
		Disaster alarm	Disaster alarm				
	Society and life	Tele-working	Tele-working				
		Electronic-government					
Tele-education		Tele-education					
Choose one you like							

Figure 10.1 Questionnaire sample.

Source: Ida and Horiguchi (2007).

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 partitions the choice set, allowing alternatives to have common unobserved components compared with non-nested 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, and Walker, 2001).

Consequently, the most prominent model is a mixed logit (ML) that accommodates differences in variance of random components (or unobserved heterogeneity).¹¹ 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 and Train, 2000).

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

We used an ML model for estimating the data, as explained above. Table 10.7 indicates the estimation results for Yawata on the left and Tokyo on the right. McFadden's pseudo R^2 exceeds 0.3, corresponding to over 0.6 of OLS R^2 , which indicates quite good fitness for a discrete choice model (Domencich and McFadden, 1975). The parameters signs are all correct, except 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.¹²

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 (χ^2) distributed (see Louviere et al., 2000, p. 244). As a result, the test statistic is 148.3, and the critical value of $\chi^2(d.f. = 20, p = 0.05)$ is 31.4. Thus, we conclude that the preferences are not equal between Yawata and Tokyo.

Table 10.7 Estimation results

	Yavata (Yamagata)				Tokyo			
Respondent No.	163							
Sample No.	1,304							
LL Max	-990.6							
LL (0)	-1432.6							
Pseudo R2	0.30851							

Tele-working	Mean	-0.17044	0.19411	-0.878	0.380	¥-191	0.56963	0.21270	2.678	0.007	¥511
	SD	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
	SD	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
	SD	0.98654	0.25242	3.908	0.000		1.35399	0.20293	6.672	0.000	
<hr/>											
χ^2 (d.f=20, p=5%)		31.4	Total WTP				¥8,773	Total WTP			¥8,620
Test statistic		148.3									

Source: Ida and Horiguchi (2007).

Willingness to pay

We calculate the average willingness to pay (WTP) for public services over FTTH,¹³ as indicated in Table 10.7.¹⁴ Also, a graphical presentation of WTP is given in Figure 10.2. 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 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

Figure 10.2 Comparison of WTP values.

Source: Ida and Horiguchi (2007).

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 *quantative* 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 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.¹⁵ 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. We summarize the main points of this section as follows:

Estimation results

The total WTP value of FTTH users is higher in Yawata, even though their information literacy seems lower than in Tokyo. Thus, there is not a *service-based* digital divide from a *quantative* point of view. However, a large difference can be observed regarding individual WTP values between Yawata and Tokyo. In Yawata, FTTH is mainly considered a measure to counter poor reception, and in Tokyo, FTTH is expected to improve social lives including work and school. Thus, there is a *service-based* digital divide based on a *qualitative* point of view.

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 is more various 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 10.3 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. 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 10.6, which demonstrates that in Tokyo, FTTH users who want to use IP phone 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 10.6, suggesting that FTTH users living in Tokyo have much higher evaluation for tele-working than in Yawata.

(a) IP phone.

(b) TV phone.

Figure 10.3 Conditional parameters.

(c) Terrestrial digital broadcasting.

(d) Tele-care.

(e) Tele-medicine.

Figure 10.3 continued.

(Continued overleaf)

(f) Disaster alarm.

(g) Tele-working.

(h) Electronic government.

Figure 10.3 continued.

(i) Tele-education.

Figure 10.3 continued.

Source: Ida and Horiguchi (2007).

Conditional distributions of random parameters

In an ML model, we can indicate varieties in individual preferences by standard deviations of random parameters. For example, evaluation for tele-medicine is more various than for tele-care partially because FTTH subscribers still believe that directly receiving outpatient treatment is important, while sharing the close preferences for tele-care as home-based care, which is now becoming quite common.

Conclusions

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, this chapter focuses on the latter problem by using conjoint analysis and a mixed logit model. We reached two main conclusions. First, we did not quantitatively observe 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. In this way, 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, our results will have broad implications concerning the industrial policies of telecommunication services that need careful consideration in the future.

Notes

1 Competition policy in the broadband era

- 1 In Chapter 2, I attribute the success of Japan's telecommunications industry to four factors: the unintended result of policy, the intended result of policy, the challenge of new entrants, and the efforts by incumbent operating companies.
- 2 Here I mention three basic services as a criterion considering that, in oligopolistic markets, competitive prices fall and consumer surpluses increase the more firms there are, so operators must offer at least the same number of service options as currently available to ensure consumer *status quo* fairness.
- 3 A weak point of this book is that there is little mention regarding South Korea, which is in many ways just as advanced as Japan in broadband. However, it will be beyond the scope of this book to investigate South Korea totally. I recommend Chung (2006) as an excellent review of the Korean broadband industries.
- 4 Several types of government failure have been pointed out in various studies. The first type is X inefficiency (Leibenstein, 1950), which is the difference between the efficient behavior of a firm assumed by economic theory and the observed behavior in practice when the cost is promised to be reimbursed by the government. The second is Averch-Johnson effect (Averch and Johnson, 1962), which insists that since the allowed profit is predicated on the rate base, the firm has an incentive to augment its capital stock. The third is rent seeking (Posner, 1975), which represents the expenditure of resources in order to bring about an uncompensated transfer of services from another person to one's self as the result of a favorable decision on some public policy.
- 5 This may be a one-sided view of the issue of which market structure most promotes R&D. The efficiency effect shows that under some conditions monopolies have more incentive to invest than do more competitive firms (Gilbert and Newbery, 1982).
- 6 Note that representation of the retail service profit effect as the second term of the denominator in my analysis of market dominance by vertically integrated firms differs from that of Hausman, Leonard, and Velturo (1996).
- 7 If Firm A's retail market profits increase by raising prices, then $\theta \geq \theta^*$, and the critical market share of a vertically integrated firm is less than that of a non-vertically integrated firm. In other words, assuming Firm A is a vertically integrated firm and considering the effect on both wholesale market and retail market profits from raising prices, the firm's critical market share will decrease and the probability of Firm A leveraging its market dominance will increase.
- 8 This issue of the cost burden to upgrade facilities is now of far greater interest to electric utility economists than to telecommunications economists in Japan. This is because network congestion did not occur to the extent predicted, while

apprehensions have grown concerning insufficient power transmission capacity in the midst of a major competitive struggle between power companies.

- 9 Note, however, that the same kind of problem on rural Internet access in the early years of the ISP solved itself without much interference (Greenstein, 1998).
- 10 Note, however, that Hausman (2002), Shelanski (2002), and others have argued that granting free access causes the incumbents to invest less in broadband infrastructure. Thus, I should reserve concluding remarks.
- 11 I agree that there is a distribution of potential profits across geographic markets and there are some marginally profitable areas that are profitable if higher future returns are expected, due to the ability to reap higher profits.
- 12 A merit good is a commodity that is judged, which an individual or society should have on the basis of a norm other than respecting consumer preferences (Musgrave, 1957).

Appendix to Chapter 1 Critical market share of vertically integrated firms

- 1 Even when the elasticity value is negative, the sign is not changed to a plus.
- 2 Since SSNIP is not a temporary price change, it is assumed that wholesale price changes are passed on to retail prices. But the fact that the wholesale market price increase rate α coincides with the retail market price increase rate α is a simplification. To be exact, the retail market margin must also be factored in.
- 3 The first term on the left is profit derived from current prices, the second term is the profit change from the price change first-order effect, the third term is the profit change from the demand change first-order effect, and the fourth term is the profit change from the price and demand changes second-order effect.
- 4 The difference between θ and θ^* is the second term of the denominator. If $\Pi_1^D \geq \Pi_0^D$ then $(\frac{D}{M} - 1)[1 + (1 + a)\eta_A] > 0$.

2 Broadband in Japan: Current situation and issues

- 1 For telcos, migration to FTTH is not necessarily a desirable thing. ADSL uses existing phone lines, so revenue cost-effectiveness is optimized. Provisioning of FTTH, on the other hand, requires deployment of new fiber access networks and cancellation of fixed telephony services when signing up for FTTH, so revenue cost-effectiveness is still unknown.
- 2 FTTH is also a best-effort service, but there is little attenuation of speed with distance as in the case of ADSL, so unless there is a network bottleneck, there is practically no difference between the nominal throughput and the actual throughput.
- 3 The regulatory theoretical framework is discussed in Chapter 3.
- 4 Competition maintenance and monitoring structural measures (Domain III) might involve entrusting decision-making to a competent antitrust policy authority or might be invoked when deciding industry reorganization is needed to sustain effective competition. However, it is rare to actually implement these kinds of measures.
- 5 Prominent Western economists have made observations that are to the point. For example, Katz (2004) contends that, in the field of telecommunications, competition cannot be achieved without regulation, and antitrust policy is no substitute for regulation. Tirole (2004) has argued that achieving the right balance between regulation and antitrust policy is important, and rules should not be bent in applying antitrust policies to the telecom sector.
- 6 Some of the specific qualitative factors in the analysis include economies of scale, economies of scope, network externalities, capital ties, essential facilities, switching costs, technological innovations, and brand penetration.

- 7 Based on the changing nature of the market, some of the issues addressed include how to pursue competitive dynamism and infrastructure stability, how to promote network infrastructure upgrading while ensuring stability, how to promote technological innovation that fuels diverse technology and service development, how to sustain competition pressure in ways that prevent competition-limiting collaboration, how to implement environmental arrangements supporting convergence of fixed network and mobile network services, how to implement a layered market structure and market discipline (MIC 2005a, p. 617).
- 8 The Council's report stated the following specific objectives of reorganizing NTT: (1) Reorganization of NTT into a long-distance operator and two regional operators, one covering the eastern part of Japan and the other the western part of the country; (2) The long-distance company shall be completely privatized and be allowed to enter international communications, cable TV, content, and local communications markets; (3) The regional companies shall continue to be subject to business regulations under a holding company for the time being, but shall be allowed to enter each other's territories.
- 9 The Ministry of Posts and Telecommunications (MPT) was reorganized (along with the Management and Coordination Agency and the Ministry of Home Affairs) as the new Ministry of Internal Affairs and Communications (MIC) in January 2001. In this chapter I will use the ministry names that prevailed during the events under discussion.
- 10 Japan's largest power company, Tokyo Electric Power Company (TEPCO), has also entered the FTTH market, but lags behind Kansai Electric Power Company's efforts. This is because TEPCO was caught trying to conceal troubling information about one of its nuclear power plants in 2002, and this incident led to the forced resignation of the company's president and substantial voluntary scaling back of the company's business activities. However, in 2005, TEPCO entered into an agreement with KDDI, and the market for FTTH in eastern Japan is expected to become markedly more competitive over the next few years.
- 11 Note, however, that 72,600 of these employees were transferred to subsidiaries, so the net reduction in workforce was actually closer to 100,000.
- 12 The number of subscribers peaked at 61.46 million in 1997, then turned downward.

3 Network economics: Theory and policy

- 1 See Braeutigam (1989) for further details on public utilities regulation.
- 2 The conditions for a perfect contestable market are: (1) all firms have homogeneous cost and demand functions; (2) the entry-and-exit of all firms are completely free, that is to say that "sunk costs" do not exist; (3) there is a time lag for an incumbent firm to change its price; and (4) there is no time lag for consumers to react to a price difference (Dixit, 1982).
- 3 Profit sharing regulation was actually adopted in the U.S. electricity industry after the war. Also, the sliding scale method used in the Japanese city gas industry is another example.
- 4 Leob and Magat (1979) provides a theoretical foundation for profit sharing regulation, arguing that if the government gives the excess profit to a firm, the first-best resource allocation can be attained.
- 5 Price cap regulations have been actually introduced in a lot of countries since the Littlechild Report was published in 1983.
- 6 Vogelsang and Finsinger (1979) provide a theoretical foundation for price cap regulation, arguing that a capped price will finally converge towards the second-best price. On price caps and broadband, Prieger and Lee (2007) examines U.S. data and the link between price caps and broadband deployment.

- 7 Shleifer (1985) provides a theoretical ground for yardstick regulation, arguing that yardstick competition brings about desirable resource allocation.
- 8 Demsetz (1968) provides a theoretical foundation for franchise bidding, arguing that even an incumbent firm cannot set a monopolistic price because it is afraid that an entrant will offer a cheaper price when a business license is bid for. It is interesting to note that this idea anticipates the contestable market theory.
- 9 Bayesian regulation can be classified into two types: (1) the adverse selection model in which firm's type is private information (Baron and Myerson, 1982); and (2) the moral hazard model in which firm's behavior is private information (Laffont and Tirole, 1986).
- 10 The price level is lower in the states where incentive regulations have been adopted than in those where traditional rate-of-return regulations are still in effect (Donald and Sappington, 1995). Also, the price levels are lower in the states whose experiences of deregulation are longer than in those where traditional regulations are still in effect (Kastner and Kahn, 1990).
- 11 This is sometimes called the "TELRIC (total element long-run incremental cost)" method, and some economists insist that this rule satisfies allocative efficiencies, technical efficiencies, and dynamic efficiencies (Economides and White, 1994, 1995).
- 12 Service-based competition model is also called one-way connection model. See Baumol and Sidak (1994), Laffont and Tirole (1994) for details of the one-way connection model.
- 13 Facility-based competition model is also called two-way connection model. See Laffont and Tirole (2000) for details of the two-way connection model. In the model analysis below, we will extend the definition of the two-way interconnection so that one customer can choose a component of services from multiple companies.
- 14 It was Matutes and Regibeau (1988) and Economides (1989) who introduced the components model.
- 15 Since prices are higher than marginal costs, outputs are considered socially too low. Accordingly, we can regard the total output of systems as an index indicating social welfare. It is thought that the greater the total output, the higher the social welfare.
- 16 We assume here that each firm can purchase a necessary component to provide an end-to-end service. This means that this industry satisfies the *open access* condition.
- 17 Note that the QWERTY case is often referred but is criticized by Liebowitz and Margolis (2001).
- 18 The Betamax format did not satisfy the condition of two-hours' recording time at the beginning, but Sony sold a new version that satisfied this condition the following year.
- 19 Other related concepts are interconnection, compatibility, and technical standards. Interconnection means the ability of users of one network to communicate with users of another network; compatibility means the ability of the base products of all suppliers to work in conjunction with the same complementary products; technical standards means the protocol that defines how the base product works in conjunction with the complementary products.
- 20 However, note that the literature on network economics cited here is mostly the older papers from the 1980s. On the more recent and advanced dynamic models of network industries, see Harrington, Chen, and Doraszelski (2007).

4 Discrete choice analysis: Methodology and case studies

- 1 RUT was developed by Thurstone (1927) in psychology and by Marschak (1960) in economics.
- 2 The CL model is otherwise called the multinomial logit (MNL) model.
- 3 Luce (1959) derived the logit model from the IIA property; Marschak (1960) clarified that the IIA property was consistent with RUT; Luce and Suppes (1965) showed that the extreme value (EV) distribution resulted in the CL model; finally, McFadden (1974) demonstrated that the CL model implied that the random term is distributed to an extreme value.
- 4 The correspondence between McFadden's ρ of the CL model and R^2 of the OLS model is approximated as follows (Domencich and McFadden, 1975): $\rho \in [0.1, 0.2, 0.3, 0.4, 0.5] = R^2 \in [0.3, 0.5, 0.6, 0.8, 0.9]$.
- 5 The generalized extreme value (GEV) model allows for correlations across alternatives, in which random terms are jointly distributed. The most popular GEV mode is NL model, which originated in Ben-Akiva (1973) and others.
- 6 Cameron (1982) discussed that there are 2^J possible combinations of elemental alternatives; therefore, a priori criterion that should be employed is the anticipated correlation between the random components among elements of each subsets (Louviere et al. 2000 p. 148).
- 7 The NL model was developed by Daly and Zachary (1978), McFadden (1978), Williams (1977), and so on.
- 8 The term $\lambda_k IV_{nk}$ is the expected utility of decision-maker n choosing alternatives in nest B_k , where IV_{nk} is called the inclusive value of nest B_k , and λ_k is called the IV parameter that represents the degree of independence among random terms for alternatives in nest B_k .
- 9 The degree of freedom is 2 because the parameters are price and speed, excluding constant terms.
- 10 The cross-elasticities of the ADSL and CATV Internet access demands are still constant with respect to the FTTH price, which is called the IIN property.
- 11 Applications of the HEV model include Allenby and Ginter (1995), Bhat (1995), and Hensher (1997a, 1998a, b).
- 12 Early examples of the ML model on customer-level data include Train et al. (1987) and Ben-Akiva, Bolduc, and Bradley (1993). Due to improvements in simulation methods, numerous research has attempted the ML model, including Bhat (1998a), Brownstone and Train (1999), Erden (1996), Revelt and Train (1998), and Bhat (2000).
- 13 The log normal distribution is useful when the coefficient has the same sign like price coefficients that are expected to be negative.
- 14 However, two cautions are needed for using Halton draws. First, an anomaly may arise in the analysis, and therefore the properties of Halton draws in simulation-based estimation must be investigated further. Second, Halton draws, defined by large primes, may be highly correlated with each other for simulation of high-dimensional integrals (Train 2003 p. 224).
- 15 The binomial probit model was advocated by Thurstone (1927). The recent development of the MNP model owes much to Hausman and Wise (1978), Daganzo (1979), and so on. Important applications include Ben-Akiva and Bolduc (1996), Revelt and Train (1998), Bhat (1997a), McFadden and Train (1996), and Brownstone, Bunch, and Train (1998).
- 16 Important studies in this line include Morikawa (1989), Ben-Akiva and Morikawa (1990), and Ben-Akiva, Morikawa and Shiroishi (1991).

5 Fixed-line broadband: From ADSL to FTTH

- 1 In October 2006, Tokyo Electric Power Company integrated the business activities of TEPCO's Fiber Optic Network Company with KDDI.
- 2 McFadden (1984) claims that it is difficult to obtain reliable estimations for an alternative that has less than 50 samples. Therefore, we integrate the 18 dialup observations and the 40 ISDN observations into one narrowband alternative.
- 3 In the subsequent models, therefore, a dummy variable is specified for NTT users. NTT services are significantly more expensive, probably because the NTT group holds strong brand power. To grasp this effect, we insert an NTT dummy variable into the model that has a large positive but statistically insignificant effect, as seen later.
- 4 Note that an endogeneity problem is caused by using the price and speed averages chosen by others as the price and speed proxies of a non-chosen alternative while using the actual price and speed for the chosen alternative. Suppose that dependent variable is $D_{nj} = 1$ if person n chose alternative j , and 0 otherwise; the price of alternative j for person n is calculated as $\text{price}_{nj} = (\text{actual price of alternative } j \text{ for person } n) D_{nj} + (\text{average price for alternative } j \text{ over other people})(1 - D_{nj})$. Therefore, dependent variable D_{nj} enters into the calculation of price variables.
- 5 Model selection is indeed difficult. We tried to select models based on their log likelihood function values (corresponding to McFadden R^2), following a suggestion by Louviere et al. (2000). A promising approach is Akaike's Information Criterion (AIC). We confirmed that the same conclusion holds even if we adopt AIC.
- 6 Furthermore, analyzing three-level NL (3NL) models, the sign conditions of price/nominal-speed parameters are satisfied, while the statistical significances of both price and nominal speed parameters are not satisfied, even at a 5% level. Even though the figures of McFadden R^2 of the 3-NL models are higher than the 2-NL models, we do not think it is appropriate to adopt 3-NL models because the statistical significance of price, the most important parameter, is not satisfactory. Unfortunately, we cannot use price elasticities of access demand in our analysis.
- 7 We also have calculated cross-elasticities. Note, however, that a nested logit model relaxes the IIA assumption between categories while still preserving it within a category. As a result, cross elasticities are constant among alternatives in the same category (see Green, 2003, p. 734, Table 21.16 for details). For reference, the cross-elasticity of ADSL for FTTH/CATV is 1.661, FTTH for ADSL/CATV is 0.272, and CATV for ADSL/FTTH is 0.501. Additionally, according to Werden (1993, 1998), own-elasticity rather than cross-elasticity is more important for identifying markets. For these reasons, we will not look further into cross-elasticities in the following analysis.
- 8 Concerning the own nominal *speed* elasticities of access demand, ADSL and CATV are less elastic than FTTH.
- 9 In this sense, Internet services are considered "experience goods" (see Nelson, 1970).
- 10 On this point, Miller (1956) pointed out that it is too complex for human beings to process more than six attributes at the same time.
- 11 On the other hand, it is true that the demand density of broadband services is much smaller in rural areas than in urban areas. Therefore, the problem of the high cost of providing broadband services in rural areas still matters. We suggest that the digital divide problem may not be due to excessive low needs, but high costs.
- 12 As mentioned in Note 4, Ida and Kuroda (2006) redefine some of the data in making their deductions, so their conclusions are somewhat different from arguments made by the MIC (2004, p. 87). We are in agreement however that the intermediate-speed ADSL market should not be defined as a separate market.

- 13 Three adjustments are needed when defining markets based on demand substitutability (Gual, 2004). First, careful consideration must be given to competition with all potential operators. Second, demand complementarities between bundled services must be taken into account. And third, in the telecom service industry characterized by enormous fixed costs, price-cost markup cannot simply be regarded as a proxy variable for market power.

6 IP telephony: Inception to widespread deployment

- 1 KDDI launched its *Metal Plus* service in February 2005 using a dedicated IP network for the transit trunk and NTT East/West's fixed-line dark-fiber for the access line network. The service features full IP capability, but does not impose modem use on the terminal side and uses conventional fixed-line access, so here *Metal Plus* will not be considered full IP telephony.
- 2 The analysis in this section is based on Ida, Kinoshita, and Sato (2008).
- 3 In addition, since interconnections among voice over Internet protocol (VoIP) circuits are not complete, 050-type IP telephony may not be used if different Internet service providers (ISPs) are involved.
- 4 For previous research using conjoint analysis, for example, see Bryan and Parry (2002), Kim et al. (2005), Madden and Simpson (1997), Roe et al. (2005), San Miguel, Ryan, and McIntosh (2000).
- 5 Field pioneers McKnight and Leide (1998) have analyzed the costs, pricing, and policy problems of Internet telephony, arguing for a comprehensive regulatory framework concerning the convergence of fixed telephone and Internet telephony. Ono and Aoki (1998) have also compared how policy makers and regulators in the US, the EU, Japan, and Singapore responded to the emergence of IP telephony; they insist that existing regulatory frameworks will not be aligned within dynamically changing environments. Jaiswal and Raghav (2004) have suggested that IP telephony is a potential key enabler for service delivery in developing countries.
- 6 Note that Fields and Kumar (2002) indicated a potential defect of SPM (including conjoint analysis): it only models current consumer attitudes for market forecasting; their current intentions will become accurate reflections of future choices if the current environment represents a future in which the choices are to be realized. We believe that this condition is satisfied in the example of the Japanese IP telephony service.
- 7 Miller (1956) points out that it is too complex for human beings to simultaneously process more than six attributes.
- 8 If a user opts to preselect a specific carrier called MYLINE, calling charges are decreased according to a discounted fee schedule.
- 9 Since we conducted the survey online, the data may have a bias because the monitors who participated may be more interested in the Internet than average people. We believe, however, that such sampling bias is allowable because the purpose here is to study the future usage of such new technology as the Internet.
- 10 Due to space constraints, we avoid detailed analysis of each Internet connection preference (ADSL, CATV Internet, FTTH, and narrowband). However, note that choice ratios for alternatives 1, 2, and 3 differ depending on the type of Internet connection. For example, the IP telephony ratio is higher among broadband than narrowband users. This suggests that the type of Internet connection influences consumer preferences for the adoption of IP telephony. We will investigate whether parameter estimates (namely, consumer preferences) are equal among user groups based on their Internet connection type by using a likelihood ratio (LR) test.
- 11 Since conjoint analysis is essentially based on substitutability between attributes, it cannot deal with non-compensatory decision-making, which results in biased

WTP estimation. Therefore, it might be wise to exclude such non-compensatory responses from the data for estimation.

- 12 We should carry out the Hausman test and investigate whether the independence from irrelevant alternatives (IIAs) assumption holds, since we adopt a CL model. Accordingly, we carried out the Hausman test, excluding Alternative 2, for the six groups (see Hausman and McFadden, 1984). Consequently, the IIA assumption is rejected in some cases, but not rejected in others. Concretely, the results for (d), the ADSL user group, are 6.76, and, therefore, the IIA assumption is not rejected, given that the critical value is χ^2 ($p=0.05$, $d.f=6$)=12.59. On the other hand, the results for (f), the NB user group, are 166.91, and, therefore, the IIA assumption is rejected. Since we tried complicated simulation analysis for predicting IP telephony penetration based on the estimation results, we adopt a simple CL model. However, we understand that the IIA assumption is rather strict, and we should try more general models including a nested logit (NL) model, a mixed logit (ML) model, or a probit model to allow for the variety of individual preferences or flexible demand substitution patterns. We consider this problem a subject for future research.
- 13 Sociodemographic differences may lie behind the differences in the preferences of BB and NB users. Therefore, we investigate such demographic characteristics of both groups as age, gender, living in the three largest metropolitan areas (namely, Tokyo, Osaka, and Nagoya), education levels, employment history, and household income. Consequently, we see that only the ratio of living in the three largest metropolitan areas (Tokyo, Osaka, and Nagoya) differs between BB and NB users, whereas the other characteristics are almost identical. It is more likely that BB users live in metropolitan areas and that NB users live in rural areas.
- 14 See Shin, Weiss, and Correa (2004) who theoretically demonstrate that guaranteeing QoS could become a progressive equilibrium strategy in the future Internet market, which includes IP telephony or videoconferences.
- 15 In a simulation analysis it may be natural to assume that a service of low quality is inexpensive while one of high quality is expensive. However, we set the same price for the 050-IP and 0ABJ-IP phones because we wanted to separate the effects of functional improvements on choice probabilities from the effects of price differences. Note here that the estimated penetration rate of 0ABJ-IP phone may be rather overestimated.
- 16 Examples in line with this include Islam and Meads (1996) and Ahn and Lee (1999).
- 17 In November 2004, NTT announced a "Middle-term Management Strategy" that aims to gain 30 FTTH million lines by 2010. If satisfied, IP telephony will increase market penetration rates much faster than in our projections.

7 Mobile telephony: From voice to data services

- 1 Vodafone Japan later changed its name to SoftBank Mobile. Here we use the name Vodafone for consistency, since that was the company's name when we began our analysis.
- 2 In the following, mobile telephony includes PHS services in addition to second- and third-generation (2G and 3G) mobile telephony services, but where there is no risk of misunderstanding, we will simply refer to mobile telephony.
- 3 The analysis here is based on Ida and Kuroda (2008).
- 4 In addition, Grzybowski (2005) will be informative, which analyzes the impact of regulatory policy on prices and demand for mobile telecommunications services across the European Union. McKenzie and Small (1997) and Foreman and Beauvaisare (1999) are also important in that they estimate cost structures for mobile telephony in the United States.

- 5 According to the MIC, actual market shares for the technical standards were 3G (27.1%), 2G (67.6%), and PHS (5.3%); while provider market shares are NTT (56.1%), KDDI (26.0%), and Vodafone (17.9%) as of September 2004.
- 6 Figures represent amounts subtracted by various discount services and do not include information service charges.
- 7 Louviere, Hensher, and Swait (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 (see also Revelt and Train, 1998), although the number of random draws is still an issue of controversy.
- 8 The adoption of other draw methods including Halton sequence draw is an important problem to be examined in the future (see 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 needs to be investigated further (see Bhat, 2001; Train, 2003).
- 9 McFadden (1984) claimed that it is difficult to obtain reliable estimations for an alternative that has less than 30 samples. Therefore, we deleted Vodafone's 3G service from the choice set, integrated au's 2G service and TuKa's service into KDDI's 2G service, and considered various PHS services as one brand.
- 10 Estimating any form of demand structure for mobile telecom services that does not include the price of fixed-line services, even in Japan, may be a misspecification of the model. Fixed-mobile convergence (FMC) service is especially an important problem to be studied in the future research.
- 11 Note that all flat rate and usage charge estimates are statistically significant at the 1% level according to t-values.
- 12 The choice of the binary values assigned to certain 2G and 3G services are based on the determination of "often used" according to the survey of users who replied that they frequently use Web browsing services. This definition may be too subjective, and we need to refine this in the future research.
- 13 Note that for this reason parameters such as call time (PHS), mail no. (PHS), and so on do not appear explicitly in Table 7.14.
- 14 Before estimating the ML model, we carried out ordinary CL model estimation and confirmed that the IIA property is rejected at the 1% statistically significant level because the value of Hausman test statistic is 48.24 when we excluded KDDI's 2G alternative.
- 15 Note that MIC has decided to introduce a number portability system into the Japanese mobile telephone market in 2006 to encourage competition.
- 16 McFadden (1979) suggests an aggregation rule of elasticities over multiple alternatives and variables.

8 Fiber to the home: Migration and lock-in

- 1 The ML models are also called random parameter models if focusing on the distribution of parameters, or as error component models if focusing on flexible substitution patterns (Revelt and Train, 1998; Brownstone and Train, 1999).
- 2 Louviere et al. (2000) suggested that 100 replications are normally sufficient for a typical problem involving five alternatives, 1,000 observations, and up to 10 attributes (also see Revelt and Train, 1998). The adoption of Halton sequence draw is an important challenge 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 sometimes arises in this approach, and therefore the properties of Halton sequence draws in simulation-based estimation need to be investigated further (Train, 2003). The results here are 250 random draws.
- 3 We set other variables at sample mean values for the following simulation analysis.

- 4 Figure 56% is calculated from 26.5%/47.6%.
- 5 Figure 59% is calculated from 17.9%/30.2%.
- 6 Foros (2004) interestingly found that if the integrated firm's ability to offer value-added services is much higher than that of the rival, the integrated firm uses overinvestment as an alternative foreclosure tool in the broadband access market. See also Faulhaber and Hogendorn (2000) and Rubinfeld and Singer (2001).
- 7 Instead of past decisions, we can include other variables such as the number of times of an alternative being previously chosen (Adamowicz, 1994) and the attributes of the previously chosen alternative (Erden, 1996).
- 8 See also Schmidt and Strauss (1975) and Maddala and Lee (1976).
- 9 Parameters (iii)–(vii) are intersected by the NTT's FTTH dummy variable.
- 10 Note that only PAST CHOICE (SD) is significant in Model 2 at the 10% level.
- 11 We do not mean that strong *ex ante* regulation is promptly required in the broadband market because NTT does not necessarily abuse its dominance. We mean that careful monitoring is important.

9 The future of fixed-mobile convergence

- 1 British Telecom (BT) started an FMC service called BT Fusion from June 2005. This service makes it possible to use one handset as IP phone at home (via Bluetooth or Wi-Fi) and mobile phone outdoors.
- 2 Other studies include Madden, Savage, and Coble-Neal (1999), Eisner and Waldon (2001), Kridel, Rappoport, and Taylor (2001), Duffy-Deno (2003) on the basis of the revealed preference method (RPM) and Madden and Simpson (1997), Savage and Waldman (2005), Ida, Kinoshita, and Sato (2008) based on the stated preference method (SPM).
- 3 Few papers have studied demand for mobile telephone services, especially for 3G, as previously pointed out by Taylor (2002, p.130). An exception is Kim (2005), which investigated consumer stated preferences for 3G services (called International Mobile Telecommunication 2000, or IMT2000) in Korea by using conjoint analysis. In addition, Tishler, Ventura, and Watters (2001), Kim and Kwon (2003), Iimi (2005), Doganoglu and Grzybowski (2007) are important in that they analyzed demand for Israeli, Korean, Japanese, and German mobile phone markets by using logit models.
- 4 We have seen that we can address the problem in the case of logit models even with endogenous regressors. The logit specification, however, may be inappropriate. Then we turn to probit specification. As far as the estimation of the probit model is concerned, one could use the FIML method, but it is practically difficult to simultaneously estimate the multinomial probit model (Train, 2003). As an alternative to the FIML method, one can use the LIML method including two-stage estimation (Nelson and Olson, 1978).
- 5 The ML models are also called random parameter models if focusing on the distribution of parameters, or as error component models if focusing on flexible substitution patterns (Revelt and Train, 1998; Brownstone and Train, 1999).
- 6 Louviere, Hensher, and Swait (2000) suggested that 100 replications are normally sufficient for a typical problem involving five alternatives, 1,000 observations, and up to 10 attributes (also see Revelt and Train, 1998). The adoption of Halton sequence draw is an important challenge 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 sometimes arises in this approach, and therefore the properties of Halton sequence draws in simulation-based estimation need to be investigated further (Train, 2003). The results adopted here are 100 Halton draws.
- 7 This result does not mean that price does not influence the choice probabilities

of broadband services including ADSL, CATV Internet, and FTTH. Ida and Kuroda (2006) indicated that price had statistically significantly negative impact on the choice probabilities of broadband services. The reason why price does not matter here is that the market share of NTT broadband service is large although its price is expensive. Therefore, price effects depend on choice structures that the models assume.

10 The digital divide: Closing the gap

- 1 Most recently, the indices used to measure the digital divide were critically evaluated (see Barzilai-Nahon, 2006; Vehovar, Sicherl, Hüsing, and Dolnicar, 2006, for details).
- 2 The term *public service* is repeatedly used below. However, we do not decisively define because the academic definition of public goods does not always correspond to the popular image of public services. We tentatively use the term in the 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; third, services whose social effects are so large that the government should assist or even subsidize the startup for their diffusions, including tele-working and tele-education.
- 3 Note that since 700 households living in the mountain zone of Yawata suffered from poor reception, they expect FTTH to be an effective transmission way of terrestrial digital broadcasting. This is one reason why many households in Yawata joined the FTTH service.
- 4 In our survey, a representative responds from each family, but his/her opinion may not correctly reflect the preference of the family.
- 5 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.
- 6 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.
- 7 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 fifties, while those in Tokyo are in their thirties.
- 8 Examples that have analyzed broadband services by using RPM include: Madden, Savage, and Coble-Neal (1999), Eisner and Waldon (2001), Kridel, Rappoport, and Taylor (2001), Duffy-Deno (2003), Ida and Kuroda (2006).
- 9 Examples that have analyzed broadband services by using SPM include: Madden and Simpson (1997), Savage and Waldman (2005), Ida and Sato (2007), Ida, Kinoshita, and Sato (2008).
- 10 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 and Kumar, 2002).
- 11 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 and Train, 1998; Brownstone and Train, 1999).

- 12 These results were expected because those utilizations were very low in the questionnaire survey.
- 13 The WTP 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 (eg 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 (eg public services) over FTTH, they are often in conflict with content/application providers.
- 14 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.
- 15 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 terrible commutes, while many in Yawata are engaged in agriculture and are unconcerned with commuting, which results in different evaluations of tele-working.

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