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Estimating switching costs involved in changing mobile phone carriers in Japan: Evaluation of lock-in factors related to Japan's SIM card locks

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ABSTRACT

This paper employs a web-based conjoint-type questionnaire to examine empirically user preference for a hypothetical Subscriber Identity Module (SIM) unlock situation in Japan's mobile phone market. This paper also analyzes carriers' other marketing strategies to lock in consumers. The empirical analysis in this study reveals the following: over 80% of survey respondents evaluate a highly compatible platform with the SIM unlocked. Approximately 70% of consumers find that the value of discounts on initial payments exceeds the discounts on one-year monthly payments. In addition, conditions set by continuing agreements for mobile carriers and mobile handsets reduce consumer benefit by 35% at the median in the case of SIM unlocking with compatible platforms.

1. Introduction

Switching costs are the various economic and psychological costs incurred in changing suppliers. Jones, Mothersbaugh, and Beatty (2002) categorize sources of switching costs from their marketing aspects. Shapiro and Varian (1998) organize various lock-in and related switching costs in information systems. Farrell and Klemperer (2007) review previous studies concerning switching costs and covers both theoretical and empirical approaches.[1] Although some authors such as Dubé, Hitsch, and Rossi (2009) provide counter examples in which switching costs can reduce prices, most studies indicate that sufficiently high switching costs create market power. Viard (2007) studies how switching costs affect price competition under a single-price regime (firms cannot price discriminate between new and old locked-in consumers), then show that switching costs make markets less competitive. Gabrielsen and Vagstad (2003) study switching costs under consumer heterogeneity, keeping recent telecommunications markets in mind. They point out that a larger switching cost is needed for a sustainable monopoly price under consumer heterogeneity. Switching costs bind inter-temporal supplier choices. As Klemperer (1995) indicates, switching costs lead to higher prices for old locked-in consumers but to a decrease in prices for new consumers not yet locked-in to any supplier because of competition for market share in early stages of the market. In this sense, the policy of reducing switching costs is appropriate only if the consumer benefit from intense competition in the locked-in consumers market is greater than benefit in the new-users market.

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[1] There exist some other comprehensive reviews of the switching costs literature from both economics (Klemperer, 1995; Chen & Hitt, 2006) and marketing aspects (Seetharam, Ainslie, & Chintagunta, 1999).

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Many studies also have examined switching costs in the telecommunications sector.[2] Knittel (1997) analyzes the U.S. interstate long-distance market and shows that switching costs have endowed long-distance carriers with market power. Shy (2002) proposes a quick method for estimating switching costs and applies it to the Israeli mobile phone market. Buehler and Haucap (2004) argue that the introduction of mobile number portability (MNP) generates various competitive effects. Lee, Kim, Lee, and Park (2006) empirically estimate switching costs in the Korean mobile phone market with conjoint-type data and show that the recently introduced MNP reduced switching costs. They include handset portability as an attribute in their conjoint analysis. Shi, Chiang, and Rhee (2006) study the effect of MNP in Hong Kong and show it causes a sharp price decrease. These previous empirical studies suggest that switching costs exist in telecommunications markets.

The number of subscribers in Japan's mobile phone market surpassed 100 million in 2007, accounting for approximately 76% of Japan's population. When infants and the elderly are excluded, it is no exaggeration to say Japan's mobile phone market is saturated. In fact, the focus of competition in the mobile phone market has shifted from acquiring new users to vying for rival carriers' subscribers. In this context, the Ministry of Internal Affairs & Communications (MIC) in Japan introduced the MNP policy in October 2006 to reduce consumers' switching costs and to encourage competition in the mobile phone market. However, there remain other lock-in factors in the mobile phone market after MNP was introduced. It is beneficial for the government to monitor and evaluate these factors in order to boost competition in the saturated mobile phone market. Moreover, new services have been aggressively introduced, and some consumers may wish to change their service provider were it not for switching costs. A reduction in switching costs will benefit these consumers.

This paper's primary purpose is to examine empirically which factor causes switching costs in Japan's mobile phone market by employing a web-based stated preference (SP) survey. In particular, this paper focuses on evaluating the Subscriber Identity Module (SIM) card lock policy that each carrier has adopted. However, even if a SIM unlocking policy were introduced, carriers might introduce other lock-in factors such as long-term agreements,[3] including implicit agreements. These issues are incorporated in this paper. To the author's knowledge, there is no prior empirical evaluation of the SIM lock policy. Original empirical evaluation is the main feature of this paper.

This study's empirical analysis reveals that consumers expect to benefit by receiving a highly compatible platform and handsets when government implements a SIM unlock policy. Meanwhile, at least 20% of consumers will benefit from unlocking of the SIM, even when incompatibility exists. Unlocking is possible with current platforms and handsets, so this policy can be introduced immediately for consumers' benefit. Approximately 70% of consumers find that the value of discounts on initial payments at the time of their subscribing decision exceeds the discounts on one-year monthly payments. In addition, conditions set by continuing agreements for mobile carriers and mobile handsets reduce consumer benefit by 35% at the median in the case of SIM unlocking with compatible platforms.

This paper is organized as follows: Section 2 briefly reviews Japan's mobile phone market, focusing on the SIM lock situation. Section 3 describes the design of the SP experiment and the data used in this paper. The econometric model framework and estimation procedure are presented in Section 4. Section 5 presents the estimation results and the discussion based on them. Section 6 concludes by providing a brief summary of findings and a mention of issues needing further research.

2. Japan's mobile phone market and SIM locks

In Japan there are three major mobile phone carriers: NTT docomo, au, and SoftBank mobile, all of which provide cellular phone services. The combined Japanese mobile phone market share of these three carriers was approximately 95% at the end of 2008. Besides the major three companies, EMobile started providing a cellular phone service in March 2007. In addition to the cellular phone system, the Personal Handy phone System (PHS) is also present as a mobile phone system. As of December 2008, only WILCOM offered the PHS service. If the PHS service is excluded, the three major carriers own over 99% of Japan's mobile (cellular) phone service market.

Table 1 shows the recent share trend in Japan's mobile phone market, which was opened to competition in 1988 and spread widely after the government approved sale of mobile handsets in 1994. The number of mobile phone subscribers in Japan exceeded 110 million in 2009, approximately equal to the number of people in Japan over 12 years old. According to Table 1, NTT docomo, the former state-owned monopoly, still has half the market share, and each carrier's share has not changed dramatically, especially in recent years. Part of the reason why few consumers have changed mobile phone carriers is thought to be the existence of switching costs in this market.

MIC introduced the MNP policy to reduce consumers' switching costs and to encourage competition in the mobile phone market. After the MNP policy was introduced, NTT docomo's churn rate in the third quarter of 2006 increased by about 30% (from 0.72 to 0.93) over that of the third quarter 2005.[4] However, customers' switching costs in the mobile phone market

[2] There are many empirical analyzes of switching costs in other sectors: Stango (2002) analyzes credit card markets, and Kim, Kliger, and Vale (2003) study bank loan services. Giulietti, Price, and Waterson (2005) study the switching choice in the UK residential natural gas market and find that welfare gains from the competitive process could be increased by reducing switching costs.

[3] Sharpe (1990) studies implicit long-term agreements in bank lending. Eber (1999) is a theoretical study of the emergence of long-term agreements in a model with overlapping generations of consumers facing switching costs. Fundenberg and Tirole (2000) show that an incumbent firm has an incentive to create contractual switching costs through the use of long-term agreements to lock-in their consumers.

[4] The churn rate of SoftBank mobile also increased by approximately 9% (from 1.47 to 1.60) during the same term. Only au's rate declined by approximately 10% (from 1.11 to 1.00).

Table 1
Share trend of Japan's mobile phone market*.

	Cellular phone					PHS total (reference)
	NTT docomo	au	SoftBank	Emobile	Cellular phone total	
1996	4935 (48.4%)	4095 (40.1%)	1173 (11.5%)	–	10 203	–
1997	10 960 (52.5%)	7045 (33.7%)	2873 (13.8%)	–	20 878	6030
1998	17 984 (57.0%)	9420 (29.9%)	4123 (13.1%)	–	31 527	6728
1999	23 898 (57.5%)	11 453 (27.6%)	6179 (14.9%)	–	41 530	5780
2000	29 356 (57.4%)	13 619 (26.6%)	8166 (16.0%)	–	51 141	5708
2001	36 219 (59.2%)	14 940 (24.4%)	9978 (16.3%)	–	61 137	5842
2002	41 011 (59.1%)	16 106 (23.2%)	12 232 (17.6%)	–	69 349	5698
2003	44 149 (58.1%)	17 832 (23.5%)	13 963 (18.4%)	–	75 944	5462
2004	46 328 (56.6%)	20 591 (25.1%)	15 002 (18.3%)	–	81 921	5136
2005	48 825 (56.1%)	23 132 (26.6%)	15 041 (17.3%)	–	86 998	4476
2006	51 144 (55.7%)	25 439 (27.7%)	15 210 (16.6%)	–	91 792	4692
2007	52 621 (54.4%)	28 188 (29.1%)	15 909 (16.4%)	–	96 718	4980
2008	53 388 (52.0%)	30 339 (29.5%)	18 586 (18.1%)	412	102 725	4615
2009	54 601 (50.8%)	30 843 (28.7%)	20 633 (19.2%)	1410 (1.3%)	107 487	4563

* Figures in thousands at March of each year. Figures in parentheses are shares within the cellular phone market.

entail more than a change in their mobile number. Japanese consumers also must change their handsets because of the SIM card lock policy adopted by each carrier. A SIM card is originally designated for the availability of changing handsets on third generation mobile phones. It contains basic subscriber information, so even another carrier's handset would become available by inserting the other carrier's SIM card if it were unlocked. Since Japan's mobile phone service has been developed under the SIM locked situation, Japanese mobile phone carriers supply handsets and provide content services along with telecommunications services. Content services are certified by the carriers. Although third-party companies also offer content services, the share of official content provided by the carrier is still large. Part of the reason for the large official content share is that only official content can be accessed through each carrier's portal page. Handsets are made by vendors in accordance with each carrier's standard and are supplied by the carriers. In this way, each carrier's SIM lock policy paves the way for a vertically integrated mobile phone business model in Japan. At present, the propriety of Japan's vertically integrated mobile phone business model[5] is discussed in terms of future mobile phone market competition (MIC, 2007). One of the biggest issues in current discussions is the SIM lock/unlock policy.

There is no government policy related to SIM locks in Japan. Introduction of a SIM unlock policy will improve handset portability, might reduce consumers' switching costs when changing mobile phone carriers, and might boost competition in Japan's saturated mobile phone market. However, a critical factor works against the SIM unlock business model: platform software is incompatible across carriers. Hence, phone users would not have access to all available Internet content even if SIM cards were unlocked. Only calling services and short message services (SMS) would be available under present circumstances. In this sense, standardization costs are incurred in order for SIM unlocking to contribute fully to the portability of handsets and contents.

3. Ranking experiments

This section briefly explains the data used in this study. Data are obtained from an SP survey conducted in collaboration with the Information Communications Research Institute of Japan in December 2007. This paper employed the SP survey to capture consumer preferences because each carrier currently locks SIM cards to restrict the use of its handsets to its subscribers. An SP experiment allows the researcher to assure the variability of attribute levels. The SP survey uses a conjoint questionnaire. Conjoint analysis is among the SP experimental techniques applied to a wide array of study areas. Hensher (2004) applied this method to evaluate automobile travel. Layton (2000) conducted environmental research using this technique. Kim (2005) analyzed 3G mobile phone demand by applying this method to the Korean mobile phone market. Marketing is among the most popular research areas using conjoint analysis (Huber & Train, 2001). In conjoint analysis, researchers construct hypothetical bundles of attributes that describe a product/service and ask respondents to state preferences among these hypothetical alternatives. This paper's conjoint questionnaire covers attributes related to a consumer switching mobile phone carriers. The range of attributes and levels that comprised each alternative in this experiment are shown in Table 2.

In this analysis, each alternative is bundled according to brand names of mobile phone carriers and to six attributes: the necessity of buying a new handset, availability of network content with the exception of e-mail service, the discount price

[5] Valletti (2000) examines switching costs in vertically related markets considering UK mobile telecommunications industry, then finds that integrated structures are predicted when switching costs are high.

Table 2
Design of conjoint analysis and descriptions of variables.

Variable name	Description	Definitions		Distribution of coefficient
		Alternative cards	Status quo	
Rank	Ranking variable given by the respondents	1, 2, 3, 4		None (if extreme value)
Au	Dummy variable for choosing au cards	1 if the card is au, 0 otherwise		Normal distribution
SB	Dummy variable for choosing SoftBank cards	1 if the card is SoftBank, 0 otherwise		Normal distribution
SW	Dummy variable for changing the current carrier	1 if the card is not the current carrier, 0 otherwise	0	Normal distribution censored from below zero
SIMUL	Dummy variable for the retention of mobile phone handset (SIM unlock) with all the contents available	1 if a SIM card is unlocked, 0 otherwise	0	Normal distribution censored from below zero
LSIMUL	Dummy variable for the retention of mobile phone handset (SIM unlock) with only voice transmitting and e-mailing available	1 if a SIM cards is unlocked 0 if all the services are available	0	Normal distribution censored from below zero
DISC	Discount in the price of a mobile phone handset when a new handset is needed (divided by JPY10 000 for normalization)	0, 3	0	Log-normal distribution
CCONT	Dummy variable for necessity of continuing the agreement for the carrier	2 if 2-year continuing contract is needed; 0 otherwise	0	Normal distribution censored from below zero
HCONT	Dummy variable for necessity of continuing the agreement for the handset	2 if 2-year continuing contract is needed; 0 otherwise	0	Normal distribution censored from below zero
MPRICE	Discount in monthly service price (divided by JPY 1000 for normalization)	1, 2, 5, 4	0	Log-normal distribution

when a consumer needs to buy a new handset, the necessity of adhering to the agreement with the mobile carrier, the necessity of adhering to agreements for the mobile handset, and the monthly service fee discount.

The necessity of buying a new handset and the availability of network content (excluding the e-mail feature) are reflected in the SIM lock/unlock situation. If each carrier unlocked its SIM cards, consumers need not buy a new handset when changing mobile phone carriers. However, as the previous section mentioned, platform software is incompatible across carriers, and only calling services and SMS would be available even if SIM cards were unlocked. During the pretest some respondents asked about the difference between SMS and Internet e-mail features on mobile phones, which are not available when the SIM card is unlocked. Use of e-mail via mobile phone is very popular in Japan, but the SMS feature is not. Therefore, some consumers are unable to recognize the difference between Internet e-mail and SMS because they have never used the latter feature. Since an SP survey is a hypothetical experiment, comprehending the meaning of each attribute is critically important for respondents' understanding of the hypothetical situation. Therefore, the survey did not distinguish between the e-mail and SMS features, although the services differ. The survey inquires into two SIM unlock attributes. The first captures the reduction in consumers' switching costs if SIM is unlocked with full functionality on a standardized platform. The second captures the reduction in switching costs from unlocking SIM with limited functionality on a non-standard platform. Since carriers' costs incurred by these two types of SIM unlocking differ by the standardized costs, evaluating each consumer's benefit is practically important for policymakers in deciding what types of SIM unlocking would be introduced.

In addition, this survey introduced a discount in handset price as an attribute. In Japan, sales promotion rebates have been used to capture new subscribers and to market new handsets that come with new services. In these rebate schemes, the monthly phone fee is high. In this situation, MIC noted the problem that consumers are unable to select the alternative of a high handset price and a low monthly fee (MIC, 2007). In response, each carrier recently has voluntarily introduced high handset price and low monthly fee plans[6] in addition to low handset price and high monthly fee plans, thus providing consumers a choice. Handset prices are closely related to the SIM lock strategy; therefore, the survey adopted the handset price discount as an attribute in the experiment and also introduced the monthly service fee discount as an attribute. By comparing the effects of these two monetary attributes, it becomes possible to investigate consumers' preference between an initial payment discount (handset discount) and a monthly payment discount. The ratio of these two payments can function as an implicit long-term agreement.

As for purchase of handsets, variations of Japan's mobile handsets are worth mentioning. In Japan, almost all handsets are full-function. Even simple handsets for the elderly are available with Internet and digital camera features. In fact, the share of smart phones in Japan is low because customary mobile phone handsets function almost like smart phones. In addition, each

[6] The sales promotion rebate has become smaller, but it is still present even in the high handset price plans.

Table 3
Basic statistics.

Gender		Age		Income (million JPY/Year)		The number of household members		Household total telecom expenditures (JPY/Month)		Household Mobile Phone Expenditures (JPY/Month)	
Male	481	Under 20	26	Under 1million	36	1	117	Under 5000	2	Under 5000	134
Female	735	20–29	225	1–2 millions	48	2	290	5000–9999	108	5000–9999	351
		30–39	468	2–3 millions	94	3	318	10 000–14 999	319	10 000–14 999	333
		40–49	305	3–4 millions	141	4	320	15 000–19 999	291	15 000–19 999	154
		50–59	123	4–5 millions	174	5	109	20 000–24 999	206	20 000–24 999	114
		60–69	58	5–6 millions	131	6	36	25 000–29 999	117	25 000–29 999	40
		Over 70	11	6–7 millions	100	7	11	30 000–34 999	53	30 000–34 999	55
				7–8 millions	76	Over 8	4	35 000–39 999	51	35 000–39 999	8
				8–9 millions	52			40 000–44 999	22	40 000–44 999	14
				9–10 millions	54			45 000–50 000	21	45 000–50 000	8
				Over 10 millions	84			Over 50 000	26	Over 50 000	5
				Data not available	226	Data not available	11				
Total	1216	Total	1216	Total	1216	Total	1216	Total	1216	Total	1216

vender offers functionally identical handsets to each carrier. Notwithstanding a few exceptions or minor options, the major functions of Japan's handsets are homogeneous. Considering respondents' cognitive capacity,[7] this experiment does not account for handset attributes such as with/without camera.

As MNP was being introduced in Japan, each carrier aggressively offered long-term contracts to offset the effect of reduced switching costs. A long-term agreement is an artificial contract-based switching cost and is considered an important marketing strategy under the SIM unlocked situation. Therefore, this survey adopted the necessity of adhering to the agreement with the mobile carrier and the agreement for the mobile handset as attributes in the experiment. These might undercut the benefits of SIM unlocking. However, in the conjoint questionnaire setting, it is difficult to introduce the case with the necessity of long-term agreements for handsets but not for carriers; therefore, the attribute of long-term agreements for handsets is introduced only in the case that the long-term agreement for carriers is necessitated.

The conjoint experimental exercise was pretested several times. Respondents were queried about their understanding of terminology – that is, whether they felt they could meaningfully evaluate the hypothetical SIM unlock situations – and about their attitudes regarding the number and presentation of the experiments. A few revisions were made in wording of the survey after the first pretest. To capture consumers' preferences more precisely, specific attribute levels were tested, such as varying degrees of price discounts and lengths of required contracts.

Survey participants were members of a panel assembled by an Internet survey company, goo research, Inc. Respondents were asked a series of eight multiple-choice questions.[8] Each experiment listed four alternatives: a status quo card that expresses the option of staying with the current carrier without a contract change and no discount, a contract change alternative card that expresses the option of remaining with the current carrier but adding long-term agreements with a discount, and two-carrier alternative cards (See Table 2 and Appendix for details). Each respondent was asked to rank the four alternatives according to his/her preference. The sample size in this survey was 1235; participants were limited to subscribers of the three major Japanese mobile phone carriers, namely NTT docomo, au, and SoftBank Mobile. Survey forms were distributed such that the sample reflects the market share of mobile phone carriers. Table 3 indicates the basic statistics of the dataset.

4. Econometric approach

4.1. Model specification

The consumer behavior model in this paper is based on McFadden's (1974) random utility framework. The model's specification follows the random parameter logit (RPL) model, which allows for individual differences in consumers' tastes. The RPL model also is known as the mixed logit model. McFadden and Train (2000) showed that the mixed logit model can approximate any random utility choice model by appropriately choosing variables and mixing distributions.

Assuming that individual i faces a choice among J alternatives in each of T choice sets, the utility functional form in case individual i chooses alternative j in a choice set t is as follows:

$$U_{ijt} = \beta'_i x_{ijt} + \varepsilon_{ijt}.$$

[7] Miller (1956) points out that using too many attributes in a conjoint analysis questionnaire causes the respondent to undergo psychological burden.

[8] The number of profiles becomes unwieldy if all possible combinations of attributes are considered. Therefore, the conjoint profiles in the survey are narrowed down to 24 patterns (8 sets*3 blocks), using orthogonal design methods and considering each main effect and possible interaction effects (for details, see Louviere, Hensher, & Swait, 2000; Hensher, Rose, & Greene, 2005).

The distribution of random disturbance ε_{ijt} is assumed to be an independent and identical extreme value. The unknown coefficients vector β_i, each element of which is given by $\beta_{i,x}$, is assumed to be distributed normally across the population with mean vector b and non-diagonal variance covariance matrix W. More concretely, this study's assumed utility function is as follows:

$$U_{ijt} = \beta_{i,au} au_{ijt} + \beta_{i,SB} SB_{ijt} + \beta_{i,SW} SW_{ijt} + \beta_{i,SIMUL} SIMUL_{ijt} + \beta_{i,LSIMUL} LSIMUL_{ijt} + \beta_{i,DISC} DICS_{ijt} + \beta_{i,CCONT} CCONT_{ijt} + \beta_{i,HCONT} HCONT_{ijt} + \beta_{i,MPRICE} MPRICE_{ijt} + \varepsilon_{ijt}$$

Except for brand dummy variables (*au*, *SB* based on NTT docomo=0) and switching cost dummy variables (*SW*), the independent variables correspond to the attributes in the experiment. SW_{ij} is 1 if the alternative j involves a change in carrier. This definition is the same as that in Lee et al. (2006). Definitions of the other variables are detailed in Table 2. $SIMUL_{ij}$ and $LSIMUL_{ij}$ describe the two types of SIM unlock situations. The former is 1 if the alternative j is SIM unlocked with full functions and 0 otherwise; the latter is 1 if the alternative j is SIM unlocked with limited functions, which means SIM unlock with only voice service and mail service available on different carriers' handsets, and 0 otherwise. The estimated coefficients of these two variables indicate two types of SIM unlock benefits. $CCONT_{ij}$ and $HCONT_{ij}$ are the necessity of long-term agreements for carrier and handset, respectively. The coefficients of these two variables express the disutility of long-term agreements. $DISC_{ij}$ expresses the amount of handset discount when buying a new handset. $MPRICE_{ij}$ indicates a monthly mobile phone fee discount.

As mentioned previously, this paper's survey data are contingent ranking conjoint data. The model makes full use of all ranking information by repeatedly applying the multinomial logit model. Each choice set consists of a ranked choice and lower-ranked alternatives. The probability of the individual i's observed sequence of rankings is expressed as follows:

$$L(r_i = \{r_{i1}, \ldots, r_{iT}\} | \beta) = \prod_{t=1}^{T} \prod_{m=1}^{J-1} \frac{e^{\beta' x(r_{imt})}}{\sum_{k=m}^{J} e^{\beta' x(r_{ikt})}},$$

where r_{it} is the vector of the individual i's ranking responses of the choice set t, and $x(r_{imt})$ is the vector of independent variables of the alternative ranked m in a descending order of preference.

It must be noted that some of the coefficient parameters would be inappropriate if they take negative/positive values. SIM-lock related attributes (*SIMUL*, *LSIMUL*) are optional benefits, and therefore these coefficients cannot be negative. On the contrary, on a like-for-like basis the necessity of long-term agreements (*CCONT*, *HCONT*) cannot increase consumer utility, since these contracts cause consumers to be locked in with a particular carrier. Switching costs (*SW*) would take negative values. All consumers would value monetary discount attributes such as *DISC* and *MPRICE*.

Therefore, in this analysis these coefficient parameters are transformed into log-normal distributions or truncated normal distributions. As Train and Sonnier (2005) pointed out, the willingness to pay (WTP) is unboundedly large for some consumers if the distribution of monetary coefficients overlaps zero. Therefore, it is assumed that the price discount coefficients follow a log-normal distribution. It is assumed that coefficients of undesirable attributes, such as long-term contracts and switching cost variables, have a truncated normal distribution with truncation at zero after changing their sign. It is assumed that coefficients for SIM-lock related variables have a truncated normal distribution with truncation at zero. This type of transformation is useful for coefficients with an attribute to which some consumers are indifferent and other customers find undesirable (Train & Sonnier, 2005; Kim, 2005).

Coefficients of brand dummy variables are assumed to follow a normal distribution. When the transformation operators are defined as $T(\beta_i)$, the utility function is expressed as

$$U_{ijt} = T(\beta'_i) x_{ijt} + \varepsilon_{ijt}. \quad (1)$$

4.2. Estimation procedure

The RPL model captures preference variation by introducing stochastic terms into the coefficients created through deviations from the mean preferences and by allowing these terms to be correlated with each other. Even under logit specifications, these stochastically correlated terms relaxed the independence from irrelevant alternatives property. Both the classical and Bayesian procedures can be used for estimating RPL models.

In recent studies, the classical approach to estimating RPL models is generally based on simulation methods. Integration of multivariate densities is usually required for estimating RPL models. The use of simulation methods has allowed researchers to calculate multivariate integrations. The estimation of the maximum simulated likelihood is the most popular method employed for estimating RPL models. However, in order to obtain a consistent parameter using the maximum simulated likelihood method, the number of drawings used in a simulation increases with sample size. Efficiency is attained only if the number of drawings increases faster than the square root of the sample size (Hajivassiliou & Ruud, 1994). These techniques have been used in various studies, such as Calfee, Winston, and Stempski (2001).

The parameters of the RPL models can be estimated using the Bayesian procedure instead of classical estimation. As Train (2003) has pointed out, Bayesian procedures have certain advantages over the classical approach. First, they do not require maximization of any function; therefore, the related difficulty of numerical maximization of likelihood functions can be

avoided. In practice, improper choice of starting values often results in the algorithm failing to converge in maximizing the simulated likelihood functions. Moreover, convergence does not guarantee that the attained maximum is a global one. Second, in comparison to the classical approach, the Bayesian approach attained consistency and efficiency under more relaxed conditions. Further, results of the Bayesian procedures can be interpreted simultaneously from both the Bayesian and classical perspectives. The Bernstein-von Mises theorem established that the mean and asymptotic covariance of the posterior distributions is asymptotically equivalent to those of the classical estimators.

Considering these advantages, this study employed the Bayesian procedure to estimate the RPL model.

5. Estimated parameters and discussion

5.1. Estimated parameters

Before estimating the RPL model, this study conducted a standard rank-ordered logit (ROL) model estimation that maintained the original signs of undesirable attributes. Table 4 shows the estimation result of the ROL model. The ROL model estimation results indicate the significant estimates with appropriate signs, except the insignificancy of the *LSIMUL* and *CCONT* coefficients. *LSIMUL* indicates SIM unlock with only calling services and e-mail available. This result indicates that consumers evaluate SIM unlock with every function available on the different carrier's handset, not with limited functional SIM unlock. The variable *CCONT* represents the necessity of entering a long-term agreement with a carrier; therefore, its insignificant coefficient implies that consumers are little concerned about being tied to one carrier for a stated period. However, the coefficient of *HCONT* takes a significantly negative value. This shows that consumers dislike the additional restraint on changing handsets.

In the RPL model estimation, it is assumed that parameters for all variables have densities indicated in Table 2. Further, the data can be considered as a type of panel data since respondents repeatedly completed eight multiple-choice questions (for details, see Allenby & Rossi, 1999). Thus, a standard random effect method, in which random draws were repeatedly reused for the same respondent, is applicable to this data. All the coefficient parameters – $\beta_{i,x}$ in the model – are transformed from normally distributed variables. Therefore, one can draw $\beta_{i,x}$s from a normal distribution such as $N(b,W)$. This paper assumes that the prior distributions of the K-dimensional (K: the number of $\beta_{i,x}$s) imply that vector b is normal with an unboundedly large variance and that the prior distribution of W is an inverted Wishart distribution with K degrees of freedom and a scale matrix I, the K-dimensional identity matrix. The same approach for the Bayesian procedure described in Train (2003) is applicable to this conjoint analysis. The only difference is that data used here are ranking data. Therefore, in calculating the conditional posterior distributions of individual parameters, this paper calculated the probability of an individual's sequence of rankings, and not the probability based on the response indicating the most-preferred choice, as described by Train (2003). This approach is the same as that of Kim (2005) and Lee et al. (2006).

To obtain draws from the posterior distribution, this paper used Gibbs sampling, generating 20 000 draws. The first 10 000 were discarded, and every tenth draw in the next 10 000 was retained for inference. Table 5 indicates the means of the 1000 draws of b and of the diagonal elements of W. Parameters b and W are the population-level parameters. Therefore, one can simulate each β_i before transformation by taking draws from a normal distribution with mean equal to the estimated b and a variance–covariance matrix equal to the estimated W. For simulating each β_i before transformation, 2000 draws are used. After normally distributed β_i are drawn, they are transformed to $T(\beta_i)$ when they enter the utility function expressed as Eq. (1) in Section 3. The transformed parameters $T(\beta_i)$ and the estimated shares of population for each coefficient are listed in Table 6.

The "Shares of population for coefficients column" in Table 6 shows that nearly 40% (37.1%) of survey respondents diminish their utility by changing carriers. This indicates that nearly 40% of consumers stay with their current carriers unless there is compensation for switching, even after the MNP was introduced in 2006. As for the SIM unlock, about 84% (83.7%) of consumers react positively to the introduction of a policy of unlocking SIM with full functions. About 23% (22.7%) of survey

Table 4
Estimation results of rank-ordered logit models.

	Coefficients[a]	Standard deviations
au	0.0916	(0.0190)*
SB	−0.0826	(0.0194)*
SW	−1.3975	(0.0257)*
SIMUL	0.5808	(0.0331)*
LSIMUL	−0.0481	(0.0350)*
CCONT	−0.0092	(0.0101)*
HCONT	−0.1190	(0.0107)*
DISC	0.0718	(0.0113)*
MPRICE	0.2381	(0.0066)*
McFadden quasi R^2 index	0.189	

*Represents significance at the 5% level.
[a] Unlike RPL model estimation, the original signs of the undesirable attributes are maintained.

Table 5
Estimation results of RPL models (before transformation).

Variable	Mean (b) of β[a]		Variance (W) of β[a]	
au	0.8425	(0.1688)**	26.0204	(1.9104)**
SB	0.1688	(0.1200)*	10.6413	(0.8487)**
SW[b]	−1.2553	(0.2163)**	16.5867	(2.9886)**
SIMUL	2.1072	(0.1043)**	4.7111	(0.6016)**
LSIMUL	−2.7995	(0.5436)**	13.7235	(2.6042)**
CCONT[b]	−0.05	(0.0533)	1.1686	(0.1136)**
HCONT[b]	−0.5019	(0.1221)**	1.2821	(0.2329)**
DISC	−1.9137	(0.1146)**	1.3488	(0.1799)**
MPRICE	−0.9671	(0.0451)**	1.343	(0.0907)**
McFadden quasi R^2 index	0.189			

*Represents significance at the 5% level.
**Represents significance at the 10% level.
[a] (Posterior) standard deviations in parentheses.
[b] The index variables are not desirable. These variables are assigned negative values such that the distributions of the coefficients (transformed distributions) for these variables in the estimation procedure are always nonnegative.

Table 6
Transformed random coefficient estimates of RPL models.

Variable	Transformed mean (mean of $T(\beta)$)	Transformed variance (variance of $T(\beta)$)	Shares of population for coefficients	
au	0.9901	26.7071	57.9%	(NTT docomo < au)
SB	0.0017	11.0761	49.4%	(NTT docomo < SB)
SW	1.0266	3.5556	37.1%	(0 < SW)
SIMUL	2.33	3.451	83.7%	(0 < SIMUL)
LSIMUL	0.4696	1.4325	22.7%	(0 < LSIMUL)
CCONT	0.406	0.3643	48.5%	(0 < CCONT)
HCONT	0.2392	0.2378	31.8%	(0 < HCONT)
DISC	0.2921	0.4594	–	Assumed as log-normal (0 < Whole coefficients)
MPRICE	0.7531	1.3185	–	

respondents say that even a limited functional SIM unlock, where only mail service and voice service are available, increases their utility. On the other hand, nearly 50% (48.5%) of survey respondents experience a decrease in utility if a long-term agreement with the carrier is introduced. An additional long-term agreement for a handset causes disutility for about 30% (31.8%) of survey respondents. These estimation results indicate that the SIM unlocking has limited effectiveness if long-term agreements were simultaneously introduced.

Taking into account the differences in signs between the RPL model and the ROL model, the transformed means of RPL model estimation parameters differ little from those of the ROL model estimation. However, Table 5 shows that all parameters' variances are significantly not equal to 0. This indicates a large variation in consumer tastes. McFadden quasi R-square indexes also indicate that the RPL model has more power to explain consumer preferences. Therefore, this paper hereafter focuses on results from the RPL model when discussing policy implications.

5.2. Discussion

To draw implications from the estimation results above, this paper investigated the relative importance of each attribute change. The relative importance between two attribute changes is calculated as the ratio of the coefficients of those attributes. Each respondent's individual preference is captured in the distributed coefficients within the construct of the RPL model. Therefore, this study calculated the ratios of the coefficients by using each draw of the individual parameter, β_i, using the same simulation described earlier, to obtain the distributions of these ratios via the simulation described earlier.

5.2.1. Payback time

The above estimation model employed two types of monetary attributes. The first is the handset discount attribute (*DISC*)—that is, an initial payment discount. The second is the monthly fee discount attribute (*MPRICE*). As mentioned earlier, in Japan a consumer can select between two types of tariff plans: the low handset price and high monthly payment type, or the high handset price and low monthly payment type. The payback time of the difference between the low handset price and the high handset price is one of the most important strategic variables for all carriers. After recovering the high handset payment, a low monthly fee plan benefits a consumer while they continue to use that handset. Each consumer's preference with regard to initial payment and monthly payment must be diverse; this is another important consideration to investigate.

Table 7
Estimating a consumer's payback time for initial payment discount.

Percentiles	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	Mean of all data	Mean (10–90%)
Payback time (Months)	0.0	4.0	7.5	12.3	18.1	26.8	38.3	59.0	92.5	179.2	7929.6	76.4	41.9

The ratio of the coefficients of the two types of monetary attributes indicates each consumer's subjective payback time, whose percentiles and means are shown in Table 7. However, it was assumed that the coefficient for the initial payment discount follows a log-normal distribution, which takes values very close to zero and very large values. As a result of this assumption, the estimated payback time of tail parts becomes extremely large. Therefore, this paper estimates the mean by omitting 10% of both tails.

The estimation result reveals that at the median, the discount received when purchasing a new handset approximately equals the two-year monthly discount when the time discount factor is neglected. In addition, approximately 70% of consumers find that the value of discounts on initial payments is higher than the discounts on one-year monthly payments (cf. 12.3 months in the 30% column). This implies that 70% of consumers would choose a high handset price and low monthly payment plan if the payback time for the high handset price was one year. In fact, in the incumbent NTT docomo's high handset price plan, the payback value of the handset price is equal to the difference between the monthly service fees of the two plans (high and low handset price plans) over an one-year period. Considering that almost all consumers continue to use handsets for more than one year, the introduction of this type of payment plan is considered a substantial price reduction.

5.2.2. Welfare impacts of introducing SIM unlocks

The ratio of the coefficient for each attribute to the coefficient for monetary attribute is interpreted as WTP in terms of compensating variation. The model employed two types of monetary attributes – the initial payment discount and the monthly fee discount – which allows the model to estimate WTP based on two different payment options. However, the latter (the monthly fee discount) is reflected in each consumer's payback time difference. Therefore, the WTP in terms of the initial payment discount would be the more consistent measure for evaluating the overall trend of consumer preference. This section of the paper employs the initial payment discount for estimating WTP.

For evaluating SIM unlocks by WTP, the following four alternative scenarios are assumed: (1) SIM unlock with a highly compatible platform where all Internet content services are available. (2) Scenario (1) with a two-year continuing agreement for mobile carriers and handsets. (3) SIM unlock with an incompatible platform where no Internet content services except e-mail are available. (4) Scenario (3) with a two-year continuing agreement for mobile carriers and handsets.

Scenario (1) cannot be possible until new standard handsets and platforms are developed, since current handsets with current platforms are specialized for each carrier. Therefore, to realize scenario (1), standardization is necessary, which will require time and effort. For estimating WTP for scenario (1), the value of "*SIMUL*" is taken as 1, with the value of other remaining variables as 0, in the utility function after the changes. As for scenario (3), SIM cards are simply unlocked without standardizing current handsets and platforms. This can be beneficial for consumers who only use voice transmitting and e-mail on a mobile phone. For this estimation, the value of "*LSIMUL*" is taken as 1, with the value of other remaining variables as 0, in the utility function after the changes. Scenarios (2) and (4) are assumed for each carrier's endogenously increasing switching cost strategy by continuing agreements (values of both *CCONT* and *HCONT* are taken as 1). In fact, NTT docomo started to offer a tariff plan combined with a continuing agreement regarding handsets and an initial handset price discount after the MNP policy was introduced in Japan. For all scenarios, the WTP is obtained by dividing the utility by the coefficient of handset discount coefficient.

Table 8 indicates the means and percentiles of estimated WTP for each scenario, based on the handset price discount. For the reason explained above, this paper also estimated the mean by omitting 10% of both tails. The numbers in Table 8 are calculated by reusing 2000 draws for estimating Table 5 in the last section. According to the numbers in Table 8, WTP for scenario (1) is very high, about JPY 90 000 at the median. This indicates that consumers expect a highly compatible platform upon implementation of the SIM unlock policy. In this sense, the government needs to standardize mobile phone platforms while considering the SIM unlock policy. Meanwhile, at least 20% of consumers will benefit even if only the SIM cards are unlocked as in scenario (3). Scenario (3) is possible with the current platform and handsets, so it can be introduced immediately for the benefit of consumers. As for conditions set by the continuing agreements for carriers and handsets, they reduce benefit to consumers by about 35% (=[JPY 93 854 – JPY 59 949]/JPY 93 854) at the median in scenario (1).

6. Concluding remarks

This study employs a web-based conjoint-type questionnaire to examine empirically users' preferences in a hypothetical SIM unlock situation. Japan's SIM lock policy has resulted in a vertically integrated mobile phone business model. This paper's estimation results suggest that SIM unlocking is highly beneficial with standardized mobile phone platforms and handsets where all Internet content services are available. In practice, standardization needs time and costs. Therefore, this paper also evaluated the benefits of SIM unlocking with current incompatible platforms, which can be introduced immediately. The

Table 8
WTP of each attribute change based on handset price discount (JPY)*.

	Scenario (1)	Scenario (2)	Scenario (3)	Scenario (4)
0%	0	−6753 571	0	−6753 571
10%	0	−68787	0	−184395
20%	20568	0	0	−80236
30%	46880	17403	0	−43405
40%	67974	39827	0	−19034
50%	93854	59949	0	−3739
60%	123042	83171	0	0
70%	162570	116071	0	0
80%	217451	162385	8281	0
90%	305758	249115	67332	51243
100%	2679 474	1362 560	2416 533	2416 533
Mean of all samples	140427	59897	26975	−53555
Mean (10–90%)	108994	71093	4396	−26044

* As of December 2007, JPY100 equals USD0.89.

Table 9
Example of a ranking experiment question for a docomo user.

Brand names	Change to au	Change to SoftBank	Stay with docomo	Stay with docomo
Retaining the mobile phone handset	Current handset is available	A new handset is needed (No discount)	–	Current contract
Availability of additional content services	E-mail only	All services are available		
Necessity of continuing the agreement for the carrier	2-year continuing contract is needed	No continuing agreement	2-year continuing contract is needed	
Necessity of continuing the agreement for the handset	No continuing agreement	No continuing agreement	2-year continuing contract is needed	
Discount in monthly service price	4000JPY/month	1000JPY/month	2500JPY/month	
RANKING	( )	( )	( )	( )

estimation result reveals that at least 20% of consumers would benefit from the SIM unlock policy even if standardization of platforms is postponed.

The empirical analysis demonstrates that both SIM unlock policies potentially reduce consumers' switching costs in the Japanese mobile phone market. Such a reduction in the mature market causes the incumbent to follow new entrants' competitive strategies, such as adopting a low-price strategy. Of course, consumers' switching behaviors depend not only on switching costs but also on the benefits of switching carriers. Therefore, consumers' usage behavior should be analyzed as part of further discussion of the mobile market competition policy.

In addition, SIM locking/unlocking is closely related to issues of vertically integrated markets. Tying and foreclosure issues in vertically integrated markets have been discussed elsewhere and comprehensively reviewed by Ray and Tirole (2007). This paper investigates this issue only from consumers' perspectives. However, if the platform were standardized with the SIM unlock policy in place, third-party content providers, handset vendors, and carriers also would change their behavior. Government should take these supply-side behaviors into account when considering the SIM unlock policy. These issues remain for future research with the hope that this empirical analysis will help policymakers determine potential competitive policies.

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Appendix. Example of a ranking experiment question

"Currently you need to buy a new handset when you change mobile phone carriers. How would you rank the carriers under the following hypothetical situations (Table 9)? Note that you to need pay approximately 5000 JPY (2000 JPY as MNP commission and 3000 JPY as new contract commission) when you change carriers with MNP."

The first row, Brand Names, is appropriately modified for each carrier's users.

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