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Provision of Personal Information and the Willingness-to-Pay for Receiving Critical Information in Time of an Unprecedented Disaster

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Abstract

Following the Great East Japan Earthquake, information and communications technology (ICT) is expected to play an important role in future pioneering disaster prevention programs and post-disaster reconstruction. The increase in smartphone users allows big data to be accumulated from such diverse sources as personal information posted on social networking services (SNS), location data, and communication histories. Japan is willing to promote the use of this big data for various business opportunities; however, people remain anxious about personal information being divulged. To use big data during disasters, it is important to conduct research and surveys focused on Internet users' perspectives.

The purpose of this paper is to analyze internet users' evaluation about providing personal information and to measure the willingness-to-pay (WTP) for receiving information services at the time of large-scale disasters. In order to quantify internet users' evaluation about providing personal information, we drew up a questionnaire and conducted a survey. To obtain more accurate and practical estimation and evaluation, we adopted the Contingent Valuation Method (CVM). To identify the factors that impacted recipients' WTP for providing personal information and to estimate the marginal contribution of each attribute to the value of WTP.

We assessed the value of providing personal information at the time of large-scale disasters for ordinary internet users quantitatively. In the case of location information, the average WTP was found to be JPY2,943. The estimated average WTP for the five cases ranged between JPY2,202 and JPY3,618, in which the highest amount was found to be for "Medical history" and the lowest for "Measurements." In order to identify the factors that impacted the respondents' WTP, we estimated the marginal contribution of the 21 attributes to the value of WTP.

Keywords: Unprecedented Disaster, Personal Information, CVM, WTP, Quantitative Assessment

1. Introduction

ICT is expected to play an important role in future large-scale disaster prevention programs and post-disaster reconstruction. After the Great East Japan Earthquake, there was an explosive increase in the number of SNS users. Moreover, the increase of smart phone users allows diverse data collected by posting personal information on SNS, location information, communication histories, and other information to be accumulated as big data. The revision of the Personal Information Protection Law in 2015 has made it possible to provide personal information that can be processed anonymously to a third party or be used for business purposes without the individual's permission. Japan is willing to promote the utilization of big data in various business opportunities. Since many people post their personal messages, photos, and videos on SNS, they seem less likely to resist their personal information being public. On the other hand, anxiety about personal information being leaked remains. To make effective use of big data during disasters, it is important to conduct research and surveys focused on Internet users' perspectives.

2. Purpose of the Study

In recent years, many types of free Internet services have appeared. Furthermore, during past disasters, such as the 2016 Kumamoto Earthquake, fee-based services have often been provided to disaster victims for free. However, in light of predictions for future earthquakes directly under the Tokyo Metropolitan Area, it is unlikely that the national government or local municipalities will be able to provide such free services to all victims. Moreover, to enable private companies to offer various information services, personal information must be supplied.

This paper aims to analyze internet users' evaluation about providing personal information and to measure the willingness-to-pay (WTP) for receiving information services at the time of large-scale disasters.

3. Earlier Research

Prior research and surveys on privacy concerns and personal information (Ackerman et al., 1999; Dommeyer and Gross, 2003; Earp and Baumer, 2003) concluded that the level of anxiety is influenced by age: older people worry more about privacy and are more cautious about disclosing information than younger people. Regarding the value of privacy, Robinson et al. (2010) estimated that people attending a large public event, such as an Olympics' opening ceremony, preferred identity checks using picture IDs, and were willing to pay £1–2. So far however, no other study has focused on Internet

users' perspectives of the value of providing personally identifiable information. Together with our former studies¹⁾, estimating users' evaluation of security concerning six types of personal information, this study may obtain a closer estimate of personal information; we aim to contribute to the development of information services provided by private companies.

4. Evaluation Method

In reference to our former studies, we drew up a questionnaire and conducted a survey to quantify internet users' evaluation about providing personal information. To obtain more accurate and practical estimation and evaluation, we adopted CVM. CVM is a well-known analytical method based on stated preference data, often used to estimate an economic value of a unique object or phenomenon whose value is hardly identifiable. Although environmental issues are a typical target, CVM has been applied to other phenomena that can be recognized as common by people. In this survey, recipients were shown various scenarios and asked whether they would agree to pay for the information service under specific circumstances.

5. Survey Design for the CVM

To avoid any bias, it is recommended that the "NOAA Guideline"²⁾ be followed for the CVM survey design. Before conducting the main survey, we carefully examined every item on the questionnaire, and undertook a paper-based and preliminary online survey (in March 2016) for the CVM. Data was collected from 730 participants, among whom there was an equal number of, and distribution of ages between, men and women.

Through these surveys, we selected five cases of information services using: 1) Location information, 2) Family information, 3) Measurements, 4) Medical history, and 5) Financial information. In each case, we provided the respondents a randomly chosen amount of money from a sample of ten alternative amounts (shown in Table 1) for receiving information at the time of large-scale disasters. Respondents could state if they were willing to pay the randomly selected amount. Additionally, we asked questions regarding experiences of past earthquakes, troubled experiences of the Great East Japan Earthquake, preparation for disasters, and so on.

Table 1. Ten Alternative Amounts

	JPY
1	250
2	400
3	650
4	1,100
5	1,800
6	3,000
7	5,000
8	8,000
9	13,000
10	22,000

Figure 1 is a sample of scenarios related to location information.

This is a hypothetical question.

A large earthquake is predicted to hit your hometown in the near future. In the event of an earthquake, you will have no means to access any information yourself through your smartphone or Internet. However, if you register your personal information and pay in advance for services, you will receive reliable information via your cell- or smartphone. Registered personal information includes your name, address, gender, age, phone number, email, and location data. Information available will comprise escape routes between your current location and home, using trains or buses, the nearest evacuation area, or available accommodation. If you are trapped beneath buildings, you will be traced and rescued using your location data.

If this service costs JPY _____ (random selection from 10 prices), would you pay the fee?

1. YES
2. NO (Choose one reason):
 - 1) I don't want to provide my personal information.
 - 2) I don't mind providing my personal information, but I don't want to pay.
 - 3) The sample cost is too high, although I would be willing to pay a fee.
 - 4) I disagree with any system of collecting personal information.
 - 5) I don't understand the question.
 - 6) Others (Please give details):




Figure 1: Sample of Scenarios

6. Summary of the Survey

To identify the factors that impacted recipients' WTP for providing personal information and to estimate the marginal contribution of each attribute to the value of WTP, an online survey was conducted in August 2016, through which 3,090 samples were collected. Table 2 shows the summary of the survey.

Table 2: Summary of the Survey

Date of the Survey	August 5-6, 2016
Participants	Internet users in the Kanto region of Japan
Method	Questionnaire comprising 20 questions: 15 on general attitudes toward past large earthquakes, preparations against disaster, experiencing of network issues, etc.; 5 pertaining to the CVM
Number of respondents	3,090
Gender	Males: 1,545(50.0%), Females: 1,545(50.0%)
Age	Between 20 and 69 years, average age: 44.6
Married or not	Married 1,806 (58.4%), Unmarried 1,284(41.6%)
Occupation	Workers 2,041(66.1%), Students 138(4.5%), Non-workers 911 (29.5%)
Members of household	Live with other(s) 2,542 (82.3%), Live with children 1,116 (36.1%)
Medical conditions	Myself 821 (26.6%), Family member 1,348 (31.5%)
Annual income (family)	JPY4 million–5 million (10.3%), JPY3 million–4 million (9.7%), JPY10 million–20 million (9.7%), JPY5 million–6 million (8.7%), JPY2 million–3 million (7.8%)
Disposable money (monthly)	JPY20,000–30,000 (19.1%), JPY10,000–20,000 (17.2%), JPY5,000–10,000 (13.2%), JPY30,000–40,000 (10.6%), JPY40,000–50,000 (10.5%)

7. Estimation of WTP

From among the 3,090 respondents, we excluded data from those whose answers might not have reflected their unwillingness to pay in the scenarios. It is recommended that such answers, known as “protest bids” and common in CVM surveys, are excluded as invalid³⁾. “Protest bids” were assessed by asking the respondents why they selected “No,” removing such responses as “I don’t understand the meaning of the question,” “There is no verification of the amount,” “I don’t think that the system would work well in such a turbulent time,” “I am anxious about the safe management of personal information.” As seen in Table 3, the protest bids ranged from 5.0% to 7.9%.

Table 3: Number of Valid Responses

	Number of Valid Responses	Missing Value	%
Location information	2867	223	7.2%
Family information	2899	191	6.2%
Measurements	2845	245	7.9%
Medical history	2935	155	5.0%
Financial information	2901	189	6.1%

In addition to the detailed primary data analysis, we tabulated recipients' WTP. We chose a parametric approach to estimate the recipients' WTP, which helped infer the WTP distribution of the population. Among the parametric approaches, we adopted survival analysis using the Weibull distribution⁴. Weibull distribution is extremely flexible and empirically fits many kinds of data in WTP studies.

Table 4: Estimated Results of WTP

	Average WTP (JPY)	
	Valid Respondents	3,090 Respondents
Location information	2943	2737
Family information	3085	2908
Measurements	2202	2024
Medical history	3618	3432
Financial information	2963	2783

Table 4 indicates the estimated results of WTP for both valid and all 3,090 respondents. In the case of valid respondents, the estimated average WTP for the five cases ranged between JPY2,202 and JPY3,618, in which the highest amount was found to be for "Medical history" and the lowest for "Measurements." On the other hand, in the case of all 3,090 respondents, the average WTP for the five cases ranged between JPY2,024 and JPY3,432. The results show that the average WTP of valid respondents are JPY 177 to JPY 206 higher than that of all 3,090 respondents; the differences are not large. Therefore, the results when excluding protest bids did not produce an overestimation.

8. Effects of Attributes on the Value of WTP

In order to identify the factors that impacted the respondents' WTP, we estimated the marginal contribution of the 21 attributes to the value of WTP. The estimation results of greater than 10% significance are tabulated in Table 5, from which we can determine the exact attributes with an impact on WTP, despite the small numbers. Attributes that had impacts on WTP of all five cases were: "Having children living together," "Evacuating immediately on receiving early earthquake warning," "Experiencing network issues," "Being positive about using big data," and "Having more disposable money in one month." Although we expected positive figures for "Experiences of past earthquakes," "Troubled experiences of the Great East Japan Earthquake," and "Preparation for disasters," significant impacts of the three attributes were not extracted.

Table5: Marginal Contribution to WTP (JPY)

	Location information	Family information	Measurements	Medical history	Financial information
Gender	84	34		79	
Age	14	6	1		0
Experiences of past earthquakes					2
Troubled experiences of the Great East Japan Earthquake		32			
Having children living together	45	38	7	44	2
Medical conditions—myself				69	2
Medical conditions—family member	-54				
Participated in disaster drills		51			
Evacuating immediately on receiving early earthquake warning	88	61	14	133	3
Evacuating after collecting information				78	3
Evacuating with other people			8		
Long-term smartphone use in single day		5			
Long-term PC use in single day		-3	-1	-6	0
Extensive use of network services			2	21	
Experiencing network issues	68	46	5	52	2
Being positive about using big data	80	45	10	67	3
Having more disposable money in one month	37	17	4	26	1

9. Conclusion

As seen in Table 4, we quantitatively assessed the value of five types of personal information to ordinary Internet users during large-scale disasters. Considering between 14.9% and 23.9% of respondents chose “Yes” to paying, 27.4% thought that “It would be good if there were such kinds of services” and 19.4% replied that “I understand that using personal information is necessary at the time of large-scale disasters”; we therefore estimate that around 20% of people are willing to use paid services.

Of the respondents, 42.9% agreed to allow use of their location data, search histories, and other information as big data under certain conditions. On the other hand, 16.1% rejected the use of big data, while 28.9% were anxious about sharing their personal information. These figures show how resistance to using personal information as big data remains.

We aimed to quantify the value of personal information to promote the sharing of it. Although we believe our estimation of Internet users’ WTP for guaranteed access to five types of personal information to be significant, and carefully designed this survey in accordance with the NOAA guideline, this survey was conducted online while CVM might have biased the results; therefore, further research should be conducted.

The Great East Japan Earthquake was followed by the 2016 Kumamoto Earthquake, causing

extensive damage, and large earthquakes in Tottori Prefecture and Tohoku District. With the frequency of earthquakes, people’s attitudes towards disaster preparations may change; therefore, this type of research should be ongoing, to measure the change in value of, and possibly contribute to promoting use of, personal information in the future.

Note

- 1) Sakurai, N., Otsuka T., Nagano, H., & Mitomo, H., “Monetary Value of Security Damage - An Estimation Based on the Subjective Evaluation by Internet Users in Japan”, 18th European Regional ITS Conference, 2007
Sakurai, N., "The value and Evaluation of Information Security", Bunshindo Publishing, 2011 (Japanese)
- 2) A guideline that covers all the necessary items in order to obtain a reliable evaluation using the CVM.
NOAA Guideline, Report of the NOAA Panel on Contingent Valuation, Vol. 58, No.10 Proposed Rule, January 15, 1993, p.4601-4610
- 3) Hidano, N, "A Complete Guide for Contingent Valuation Method", Keiso Shobo Publishing, 1999, p26-27 (Japanese)
- 4) We define the probability of answering “Yes” as $S(T) = 1-G(T)$, where $S(T)$ is the survival function and $G(T)$ is the cumulative distribution function when the proposed amount is T ; the survival function expresses the probability of acceptance with each proposed amount. If the distribution model of WTP is hypothesized to be a Weibull distribution, then the survival curve is formulated as function (1).

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

T : Proposed amount
 μ 、 σ : Parameter

To estimate the variables that affect WTP, we use the model with related variables. If the parameter μ in function (1) differs in each individual attribute, function (1) is expressed as function (2). The parameters in function (2) are estimated by the maximum likelihood estimation method.

$$S(T) = \exp\left[-\exp\left(\frac{\ln T - \beta' Xi}{\sigma}\right)\right]$$

(2)
 T : Proposed amount
 σ : Parameter
 Xi : Attributes for individual i
 β' : Parameter vector for attributes

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