

Tale of Two Browsers: Understanding Users’ Web Browser Choices in South Korea

Jihye Woo¹, Ji Won Choi¹, Soyeon Jeon¹, Joon Kuy Han¹, Hyoungshick Kim²,
and Simon S. Woo² *

¹ Stony Brook University, Stony brook, NY, USA

{jihye.woo,jiwon.choi.2,soyeon.jeon,joonkyu.han}@stonybrook.edu

² Sungkyunkwan University, Suwon, South Korea

{hyoung,swoo}@skku.edu

Abstract. Internet users in South Korea seem to have clearly different web browser choices and usage patterns compared to the rest of the world, heavily using Internet Explorer (IE) or multiple browsers. Our work is primarily motivated to investigate the reasons for such differences in web browser usage, relating with the use of government mandated security technology, digital certificate. We conducted an IRB-approved semi-structured online user study to examine internet users’ browser choices in South Korea and analyze their usage patterns. Our user study results reveal that there are clearly different users’ browser preferences across different web services, and they are in turn closely related with the security policy enforced by the government 20 years ago. In our study, while younger age group tends to prefer two browsers (Chrome and IE), older age group prefers to use IE browser. Also, all age groups commonly prefer the IE browser for the services requiring digital certificates issued from Korean government agencies such as finance and e-commerce sites. Our user study is quantitative to show how the standardization of technologies in a country could affect users’ web browsing activities. Also, despite of the abolishment of the mandatory security technology, we still observe that people are not aware of such abolishment and habitually use technology locked-in IE browser.

Keywords: Web Browser, Digital Certificate, Public Key Infrastructure

1 Introduction

South Korea is one of the countries with the highest number of internet users in the world (with over 47 million). Interestingly, however, internet users in South Korea seem to make different choices when using web browsers compared to the rest of countries. According to the report by Korea Internet and Security Agency (KISA) [6] in 2017, 93% of internet users in South Korea strongly prefer to use Internet Explorer (IE). On the other hand, people in other countries strongly prefer other browsers such as Chrome (53.9%) and Safari (8.1%) in 2019 [10].

* Corresponding Author

Our study is motivated by the observations on this unique trend in South Korea. Specifically, we aim to understand why South Korean internet users' choices and preferences significantly differ. We surmise that the use of digital certificates for user authentication mandated by Korean government has influenced users' web browser choices – the Korean government introduced the ‘Digital Signature Act (DSA)’ [8] was mandated in 1999. The goal of DSA was to support a regulated Public Key Infrastructure (PKI) to guarantee the interoperability of digital signature and encryption algorithms for all electronic transactions processed in Korean government and banking web services. As the IE was the dominant browser in South Korea at that time, the banks and security companies implemented these plugins as ActiveX controls only. This may cause the technology lock-in on IE, even after abolishment of DSA policy in 2015. More specifically, we aim to understand how mandatory security technologies enforced by the government 20 years ago still influence users' browser choices today. To better understand this phenomenon, we conducted an IRB-approved quantitative user study to investigate the browser choices preferred by users and analyze the specific browsers preferred for specific web services. Next, we correlated web services with respect to services used to require digital certificates. Our contributions are summarized below:

- We conducted a user study to understand different browser choices by users in South Korea over different services across varying age groups. The user study results show that South Koreans strongly prefer to use IE over other browsers (54% of 105 participants).
- In spite of the significant inconvenience, 20-29 age group uses two browsers for different services: IE for banking and government sites, and Chrome for entertainments, online shopping, and web searching, while older age group are not.

2 Background and Related Work

In 1999, the Korean government passed Digital Signature Act (DSA), enforcing the use of digital signature with a proprietary encryption algorithm called (SEED) [11] to use online Korean government, online banking and shopping websites. Because SEED was not supported by all commercial web browsers such as IE and Netscape, SEED had to be implemented as external plugins; ActiveX was chosen to implement them [9]. However, ActiveX only runs under Microsoft IE, resulting in the heavy use of IE (and/or Windows operating systems). To address this interoperability issue, South Korean government abolished the mandatory use of digital certificates in 2015 so that users are no longer forced to use ActiveX running on IE. Kim et al. [6] investigated which services require the use of digital certificates. According to their user survey results, the services in which digital certificates were most frequently used are ‘internet banking (98.1%)’ and ‘government services (91.6%)’. Also, they reported that 93% of the survey participants use IE, and the second most used browser was Chrome (53.9%). Kim et

al. [5] studied the correlation between compatibility of the Korean banks' proprietary mechanisms and usability for bank service in Korea. They found out that usability of banking service was significantly influenced by the use of IE. Park [9] studied the low web accessibility in Korean government websites and concluded that the use of digital certificates is a main reason of the low accessibility because users should be forced to use IE when they visit Korean government websites. In this research, we conduct user studies to investigate how mandated proprietary security technologies (abolished in 2015) affect users' browser choices.

For browser usage, Weinberger and Felt [12] studied the effect of security warning with Chrome browser. They specifically evaluated the usability of different storage policies for browser warnings. Mathur et al. [7] investigated the usability of browser-based blocking extensions. They found that ill-designed blockers can significantly lower user adoption. On the other hand, Garg and Camp [3] showed that current policy and enforcement may lead to worse security outcomes, as they underestimate the market forces of supply and demand, reduce competition, and user needs. Therefore, their work shows similar conclusion as ours on risk from a government intervention on security policy. Also, Asgharpour et al. [1] researched the mental models between self-identified security experts and non-experts and showed the importance of designing the effective risk communication methods. We believe understanding mental models are also important when a national-level policy for the adoption of security technologies has been chosen.

3 Survey Methodology

We construct 17 survey questions as shown in Appendix A.1. Each question is categorized into one of the following five high level survey question (SQ) categories in Table 2 in Appendix. SQ1 and SQ2 are constructed to assess users' browser usage and preference over different web service access. SQ3 and SQ4 are designed to ask users about their experience and reasons about digital certificate usage related to habits. SQ5 is to determine whether users still use the digital certificates, after knowing the abolishment of the mandatory use of certificates to investigate the technology lock-in phenomenon. All of the user studies were reviewed and approved by our Institutional Review Board (IRB). We recruited 112 volunteers via social medias such as Facebook and KakaoTalk [4], which are popular social networking services widely used in South Korea. We posted the survey link on Facebook and also sent it to acquaintances through KakaoTalk to recruit volunteers who were older than 18 years old. We asked participants about their gender, age, occupation, current degree, nationality, and major, and We conducted the survey for 3 months.

Our survey was composed of 6 demographic questions, 3 open-ended questions, 1 Likert scale question, 5 multiple choice questions, and 2 Yes/No questions as shown in Appendix. All open-ended questions were independently coded by two different researchers in our research group and the agreement between two coders were around 90%. Cohen's kappa was used to calculate inter-rater reliability. Also, we used the Likert scale from 0 to 10 (0: Strongly disagree, 5:

Neutral, 10: Strongly agree) to measure responses from participants. Specifically, we use a 10 point Likert-scale to understand more variance than a smaller Likert scale provides. With a 10 point Likert-scale, we can obtain a higher degree of measurement precision and more power to explain an agreement.

For the statistical analysis, we constructed contingency tables to test the correlation between various user responses across different age groups. We used Fisher’s exact test (FET) for categorical variables with small sample size (expected values less than 5) and Chi-square (χ^2) test for categorical variables with large sample size. In addition, we used the Wilcoxon rank-sum test to compare two independent samples of the Likert scale data. For all statistical tests, we use a significance level of $p = 0.05$. We further conducted pairwise tests and compared a subset of possible pairs of conditions. If pairwise tests showed a significance, then we performed a Bonferroni correction.

Our study had the following limitations, where many of which are common for semi structured online user studies. Although we have more than 100 participants, the number of participants who were recruited for our online survey may not accurately represent the real internet user population in South Korea. We did try to mitigate this issue by recruiting from diverse age groups as shown in demographic section. Also, because of the nature of self-report surveys, users’ actual behavior might be different from their responses.

4 User study results

Among participants, 52.2% of them are identified as female and 47.3% as male. We broke down the age group into 5 groups based on the participants’ age (18–19, 20–29, 30–39, 40–49, and 50–59), where, 50% were between 20 and 29 years old (20–29), 17.9% between 40 and 49 (40–49), and 25.9% between 50 and 59 (50–59). Because of small number of participants in other groups, we proceeded our analysis with 3 groups (20–29, 40–49, and 50–59), where 20–29 age group can capture the behavior of younger internet users, and both 40–49 and 50–59 age groups can characterize older internet user population.

4.1 Analysis of Browser Usage

First, we asked each age group about a browser that they most frequently use (SQ1). As shown in Fig. 1, Chrome was the most frequently used browser in 20–29 age group with 70%. On the other hand, IE was the highest in both 40–49 and 50–59 with 100% and 79%, respectively. However, percentage of “Other” browser (Safari, Firefox, Microsoft Edge, Opera, Whale, Swing) was only 11%, 0%, and 7% for 20–29, 40–49, and 50–59 age groups, respectively. Therefore, we can observe the differences in browser preferences vs. age groups.

To find the statistical differences between different age groups, we analyzed them with the Fisher’s exact test and additionally performed Bonferroni correction for pairwise-tests. The statistical test result between 20–29 vs. 40–49 age group (p -value $\approx 2.33 \times 10^{-10} \ll 0.05$), and 20–29 vs. 50–59 age group (p -value

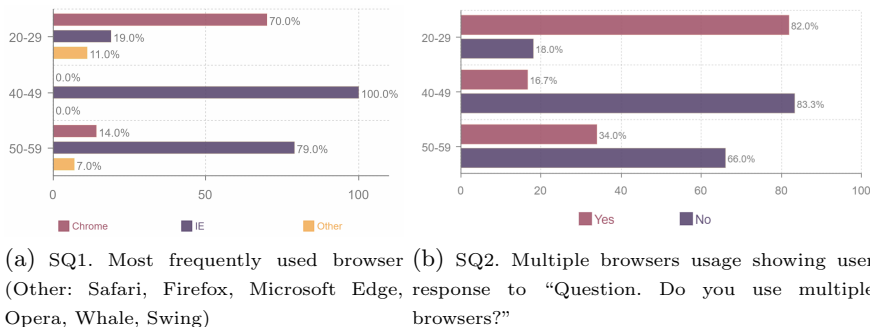


Fig. 1: Survey Question Responses for SQ1 and SQ2.

$\approx 3.50 \times 10^{-7} \ll 0.05$) show significant statistical differences. On the other hand, the result of 40–49 and 50–59 age groups (p -value $\approx 0.299 > 0.05$) does not. These results are also summarized in Table 4 in Appendix.

4.2 Analysis of Multiple Browsers Usage

Next, we determine whether users prefer to use a single browser vs. multiple browsers for specific web applications (SQ2). We analyze if there are any different browser usages with respect to the number of browsers (single or multiple browsers) for specific application types (e.g., internet banking). We further quantify, if there are any differing behaviors across different age groups. We first asked the following question: “Do you use multiple browsers?” and participants are responded with “Yes/No.” 82% of participants in age group of 20–29 responded they use multiple browsers group, while 75% of 40–49 and 66% of 50–59 said they do not use multiple browsers, which clearly demonstrate the differences.

In order to further examine, we performed the statistical testing on the use of the multiple browsers using the Fisher’s exact test (FET) with additionally conducting Bonferroni correction for pairwise tests. The result between 20–29 vs. 40–49 age groups (p -value $\approx 2.33 \times 10^{-10} \ll 0.05$), and 20–29 vs. 50–59 (p -value $\approx 3.50 \times 10^{-7} \ll 0.05$) were statistically significant. However, the result between 40–49 vs. 50–59 (p -value $\approx 0.2999 > 0.05$) did not show significant difference. Therefore, we confirm the differences between younger group (20–29) vs. older age groups (40–49 and 50–59), where younger age group prefers to use multiple browsers and older age groups prefer single browser. To find out why there were differences in multiple browsers usage for different age groups, we asked participants about the specific browsers they use for different types of web services in the next section.

4.3 Browser usage for different services

We examine the browser usage for the following 5 different web service categories: 1) online shopping, 2) government sites, 3) internet banking, 4) web searching,

and 5) entertainment, where both government and internet banking sites used to require digital certificates and IE by DSA. Figure 2. shows the aggregated percentage of browser usage per each specific service across different age groups. For all services, IE has the highest percentage, compared to other browsers. In particular, government sites, internet banking, and online shopping have the highest percentage of using IE with 74.7%, 69%, and 58.9%, respectively. The second highest browser is Chrome with 44%, 40%, and 31.1%, respectively. Other browsers such as Safari, Firefox, Microsoft Edge, Opera, Whale, Swing, etc. are rarely used as shown in Fig. 2. Next, we specifically investigate how different age groups have distinctive or similar browser choices for each service.

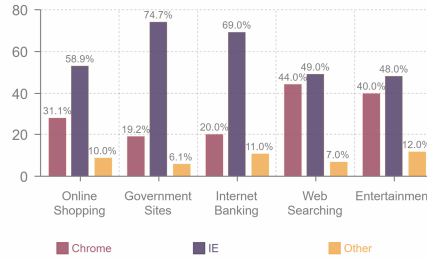


Fig. 2: Overall browser usage for each service (Other: Safari, Firefox, Microsoft Edge, Opera, Whale, Swing)

Table 1. shows the actual number of participants who use specific browsers along with the percentage of those in parentheses. For example, in online shopping case, the number of participants who prefer IE is 18 (3rd row and 3rd col) with 90% in Table 1. and the number of participants who specify to use Chrome for internet banking is 2 (4th row and 8th col) with 7%. Overall, we find that most participants in 40–49 and 50–59 age groups prefer IE, regardless of service types. However, 20–29 age group shows an interesting result. When 20–29 age group uses online shopping, web searching, and entertainment service, Chrome was the highest with 38 (60%), 42 (71%), and 39 (64%), respectively.

Table 1: Number of participants use specific browser for each service across different age groups (Other: Safari, Firefox, Microsoft Edge, Opera, Whale, Swing).

Age Group	Online Shopping			Government Sites			Internet Banking			Web Searching			Entertainment		
	Chrome	IE	Other	Chrome	IE	Other	Chrome	IE	Other	Chrome	IE	Other	Chrome	IE	Other
20–29	38 (60%)	16 (26%)	9 (14%)	18 (30%)	36 (60%)	6 (10%)	20 (32%)	32 (51%)	11 (17%)	42 (71%)	11 (19%)	6 (10%)	39 (64%)	10 (16%)	12 (20%)
40–49	2 (10%)	18 (90%)	0 (0%)	1 (5%)	19 (95%)	0 (0%)	1 (5%)	19 (95%)	0 (0%)	2 (10%)	19 (90%)	0 (0%)	1 (5%)	19 (95%)	0 (0%)
50–59	3 (10%)	26 (87%)	1 (3%)	2 (7%)	26 (90%)	1 (3%)	2 (7%)	26 (90%)	1 (3%)	5 (16%)	25 (78%)	2 (6%)	5 (17%)	24 (80%)	1 (3%)

On the other hand, in government sites and internet banking which require Korean National Digital Certificates, the IE usage in 20–29 age group is 36 (60%), and 32 (51%), which are higher than usage of Chrome (30% and 32%). Therefore, this result also confirms that 20–29 age group tends to use 2 or more browsers. These results are also summarized as histograms in Fig. 3, where the percentage of browser usage for each service vs. each age group are presented. For example, 50–59 age group uses IE for government sites with 90%, whereas

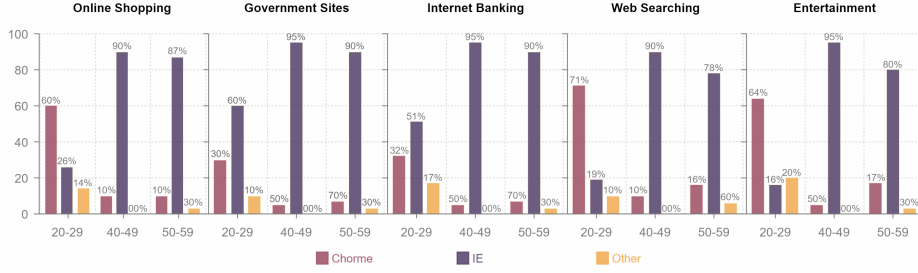


Fig. 3: Browser choice for different services (Other: Safari, Firefox, Microsoft Edge, Opera, Whale, Swing).

20–29 age group uses IE with 60%. While 20–29 age group uses Chrome for web searching with 71%. Hence, we can clearly observe the differing browser preference for each group vs. specific service, which also results in the use for single vs. two browsers for specific service.

Despite of inconvenience of using multiple browsers and abolishment of mandatory use of digital certificate, encryption and browser standard, it is interesting to observe that IE is the still most dominant browser across all age groups for Internet banking and government websites. To statistically analyze different characteristics per each age group, we further analyzed user’s browser usage patterns by using the Fisher’s exact test. As shown in Table 5, in all services, results of comparing browser choice of different age groups (20–29, 40–49, and 50–59) were statistically significant. However, it is notable that for two services such as government sites and internet banking, which require digital certificates, show relatively high p -values (2.54×10^{-2} and 7.50×10^{-4}) than other services. This shows that the differences between the user’s browser usage patterns are relatively smaller compared to the usage patterns of the other services. To analyze further, we conducted an additional survey to find correlations between the use of digital certificates and the specific browser participants use by asking users’ perception and usage behaviors on the use of digital certificates.

4.4 Usability of Korean National Digital Certificates

We conducted a survey to find out the usability of digital certificates by asking the following statement: “It is easy to use the Korean National Digital Certificates.” And participants’ responses were measured in the Likert-scale in Fig. 5 in Appendix. We calculate “Agree” as the total number of responses greater than neutral (5) and “Disagree” as the total number of responses less than neutral. As shown in Fig. 5, across different age groups, “Disagree” was much higher than “Agree”, meaning *more participants felt that it is not easy to use digital certificates*. More participants in 20–29 age group (64%) felt inconvenient (“Disagree”) than 40–49 (45%) and 50–59 (54%) age groups.

In Fig. 5, the proportion of “Agree” was also slightly different across different age groups. 22% of 50–59 age group perceived that it is convenient to use Korean

National Digital Certificates, which was higher than the percentages from 20–29 (16%) and 40–49 (15%). We believe that this is due to the fact that 50–59 age group has used digital certificates longer than the other age groups. Therefore, participants in age group of 50–59 are much aware of and familiar with digital certificates, and they appear to have been habitually used the technology longer than younger group.

Furthermore, we conducted open-ended question survey in SQ3. Q in Appendix to find out why participants think using Korean National Digital Certificates was inconvenient. Interestingly, participants’ open-ended responses varied by age groups. A user, P2, in 20–29 age group mentioned “it is very complicated to install software”, showing their distaste of the Korean National Digital Certificates. In addition, both P5 (40–49 age group) and P6 (50–59 age group) commonly mentioned the complicated procedure which requires obtaining certificates issued from Korean government. Also, P7 (40–49 age group) mentioned that they are “frustrated because they have to renew and obtain new certificates within 1 or 2 years after certificates expiration”.

4.5 Common Reasons for Using Digital Certificates

We asked the participants their reasons for using Korean National Digital Certificates. In particular, we tried to determine whether participants used Korean National Digital Certificates on their own will or it was required. This question is composed of multiple choices, where we provided the following choices for participants to choose: Required by services (banking (RQ1), government sites (RQ2)), personal reasons (P), and security reason (S). In particular, we divided the required reasons (RQ) to internet banking (RQ1) and government sites (RQ2) to identify specific services which users are more commonly required to use. Also, we also provide personal (P) and security (S) reasons.

Our result shows that, interestingly, security was the least common reason (0%–3.5%) to use Korean National Digital Certificates as shown in Fig. 4 in Appendix. On the other hand, most participants (20–29: 86%, 40–49: 85%, and 50–59: 93%) said they use Korean National Digital Certificates because it is required by banks as well as government sites. In particular, we find that the percentage on required by banks (RQ1) was much higher than government sites (RQ2) as shown in Fig. 4. We believe participants more frequently use internet banking over government sites. Therefore, RQ1 is much higher than RQ2. On the other hand, personal reason (P) was the third highest but it is much less than RQ1 or RQ2. Therefore, it is surprising to observe that most of participants passively use digital certificates, since it is required by service providers and not because of higher usability or added security. Therefore, this result shows that it is important to educate users about security benefits of technology than merely enforcing those.

4.6 Knowledge on the Abolishment of the Mandatory Use of National Digital Certificates

We also asked participants whether they knew about the recent abolishment of the mandatory use of Korean National Digital Certificates [9]. This question was

asked to find out what percentage of the people were aware of the change and determine whether participants would still use digital certificates in spite of new recent changes. Surprisingly, our results show that 61% of 20–29 age group and 54% of 50–59 age group did not know about the changed policy. Although 60% of 40–49 age group knew about the revised changes as shown in Fig. 6, there was no statistical difference. Overall, most of participants were not aware of recent changes and they still continue to use digital certificates.

5 Discussion and limitations

In this study, we found significant differences in browser choices across different age groups for accessing certain types of web services. Even though mandatory DSA was abolished, IE is still strongly preferred by “Government Sites” and “Internet Banking” websites that are used to require mandatory digital certificates and legacy encryption technology. Although our study appears to be specific and focused on South Korea, our work provides a valuable lesson on how the mandatory use of a proprietary security technology can affect the users’ technology choice through a practical case study at large scale. We observed that “Government Sites” and “Internet Banking” no longer require the use of Korean National Digital Certificate anymore after 2015. However, older generation who are more accustomed to old digital certificate technology appears to habitually use IE for all services. Also, the majority of the users in the 20-29 age group use IE to access these services instead of using Chrome as shown in Fig. 3. This shows that today internet users still perceive that they are required to use a web browser that is compatible for the use of older security technology and users are subsequently locked onto IE, even though this security technology is no longer required. While younger generations appear to move away from IE by using Chrome for entertainment and search services, they could not get completely away from IE, still using IE for banking and government sites. This results in young generation users to use two different browsers simultaneously, tolerating inconvenience. In addition, in contrast to widely known *technology acceptance model (TAM) theory* [2], where users choose technology based on perceived usefulness and ease of use, we observe that users tend to use mandated technology despite inconvenience. Therefore, government needs to more proactively put an effort to educate and increase the awareness of the new change so that users can explore other alternative technology options that they can choose for usability, convenience, and security. Our work clearly shows that users are habitually use older technology than exploring and adopting different options.

Along the same lines, we think it is important to provide more diverse and usable authentication alternatives to users in the future, which are compatible with all browsers. Most participants responded that they had to use digital certificates because it is required, in the presence of low usability and vulnerability. Therefore, we believe it is crucial to provide more usable, secure, and diverse authentication choices that consider needs of users’ needs. In particular, when government designs a cybersecurity policy, it should be designed with caution,

and government policy must consider the usability and compatibility costs they impose on users, which are not likely to be trivial, in addition to the technology values. Also, sometimes, we believe it would be better for industries to lead the cybersecurity policies development, which they are good at and taking into account users' needs. Our study recommends, instead for government directly intervenes and regulates specific, government can have a supporting and overseeing role, and also provide several options for users/industry to choose, instead of enforcing a single proprietary technology (e.g., IE/ActiveX).

Current limitation of this research is that our participants may not represent the real internet population in South Korea and our sample size is small (112 participants). We did not collect participants' expertise in using digital certificates. Future research is to recruit more participants and their detailed demographics information to validate our findings. A simple Likert scale was only used to measure the usability of Korean National Digital Certificate. However, our current questionnaire is not sufficient to derive conclusive results on the usability of Korean system. Although we included open-ended questions in our survey to discuss users' perceptions, it would be desirable to include more qualitative questions to more deeply understand users' reasoning. Our work provides the partial evidence on security technology adoption vs. users' habit; however more qualitative study is needed to find users' perceptions and reasoning. Lastly, we only compare the browser usage across different age groups within South Korea. However, it would be interesting to extend our user study to include and compare populations in other countries that do not enforce national digital certificate-based authentication. This will allow us to compare users' browser choices, patterns, and perceptions in the same age groups in different countries.

6 Conclusion

We shows that the external factors of the establishment of Digital Signature Act and its real-world software implementations led to a behavioral change in the population. Our results indicate one of the underlying causes of different web browser preference patterns are closely related to the use of a proprietary system (called Korean National Digital Certificate system) by cross-examining different web services that require digital certificate-based authentication. Therefore, significant differences were observed between age groups in their browser choices. Moreover, an unique coping strategy by employing two different browsers was notable. Our work sheds light on this issue by analyzing the interplay between the use of browsers and digital certificate through the lens of a user study. We also bring up the opportunity and needs, where more diverse authentication choices should be available to users and the government should enhance the awareness of new policy changes.

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A Appendix

A.1 Survey Questions

Table 2: Five categorized survey questions.

Survey Question Category
SQ.1. (Preference) Users’ browser preference
SQ.2. (Usage) Users’ browser usage for different services
SQ.3. (Usability and habit) Usability of Korean National Digital Certificates
SQ.4. (Reasons) Common reasons of using Korean National Digital Certificates among other authentication methods
SQ.5. (Lock-in) Knowledge of the abolishment of the mandatory use of Korean National Digital Certificates

Demographic information A. Gender

Male Female Do not wish to disclose

B. Age

18-19 20-29 30-39 40-49 50-59 60 or above

C. Occupation

Student Office worker Inoccupation
 Do not wish to disclose Other

D. Current degree

High school Undergraduate College Graduate
 Doctor Do not wish to disclose Other

E. Major

F. Nationality

Korea USA China
 Do not wish to disclose Other

SQ1. Users' browser preference

G. Browser use in Laptop/Desktop

- Most effective browser to use?

Chrome Safari Internet Explorer Firefox
 Microsoft Edge Opera Whale Swing Other

H. Browser use in Laptop/Desktop

- Most frequently used browser?

Chrome Safari Internet Explorer Firefox
 Microsoft Edge Opera Whale Swing Other

I. Have you used Internet Explorer within the past two years?

If so, why?

J. Do you use more than 2 browsers?

Yes No

K. Why do you use more than 2 browsers / or why not?

SQ2. Users' Browser usage for different services

L. Which browser do you use for each service?

- Online Shopping, Internet Banking, Government Sites,
Web Searching, and Entertainment

Chrome Safari Internet Explorer Firefox
 Microsoft Edge Opera Whale Swing Other

M. Which operating system do you use?

Window OS Mac OS Linux OS
 Ubuntu OS Do not know Other

SQ3. Usability of Korean National Digital Certificates

P. (Likert-Scale) I think it is easy to use Korean National Digital Certificates.

0 (Strongly Disagree) 1 2 3 4 5 (Neutral) 6 7 8 9 10 (Strongly Agree)

Q. (Open-ended question) If you think Korean National Digital Certificates are inconvenient, why/what are the inconveniences?

SQ4. Common reasons of using Korean National Digital Certificates among other authentication methods

O. There are many different authentication methods. Is there any reason for choosing Korean National Digital Certificates?

- It is required to use in banks It is required to use in government sites
 Ease to use As a habit Do not know Other

SQ5. Knowledge of the abolishment of the mandatory use of Korean National Digital Certificates

N. The government policy in Korea has changed from mandatory to personal preference on using digital certificates. Did you know this fact?

- Yes No

A.2 Demographics information

Table 3: Demographics of Participants

Category	Number	Percentage
Female	59	52.2%
Male	53	47.3%
18–19	4	3.5%
20–29	56	50%
30–39	3	2.7%
40–49	20	17.9%
50–59	29	25.9%
Student	59	52.7%
Employed	40	35.7%
Unemployed	11	9.8%
NA	2	1.8%

Table 4: Statistically significant results for most frequently used browser

Testing Method	Age Group	<i>p</i> -value
FET	20–29 vs. 40–49	2.33×10^{-10}
FET	20–29 vs. 50–59	3.50×10^{-7}
FET	40–49 vs. 50–59	$0.299 > 0.05$

Note: Bonferroni correction is performed for the pairwise tests, where FET was used for pairwise tests.

A.3 User Responses

Table 5: Statistically significant results for browser use for each service across different age groups using Fisher’s exact test (FET) (Note: Bonferroni correction is performed for the pairwise tests)

Service Type	Age Group	<i>p</i> -value
Online Shopping	20–29, 40–49, and 50–59	3.10×10^{-9}
Government Sites	20–29, 40–49, and 50–59	2.54×10^{-2}
Internet Banking	20–29, 40–49, and 50–59	7.50×10^{-4}
Web searching	20–29, 40–49, and 50–59	2.10×10^{-10}
Entertainment	20–29, 40–49, and 50–59	6.36×10^{-12}

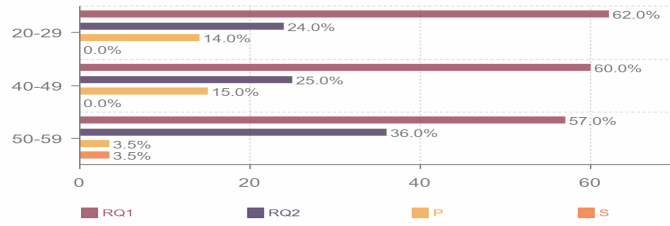


Fig. 4: Common reasons of using Korean National Digital Certificates: RQ1. Required by Banks, RQ2. Required by Government Sites, P: Personal reason, and S: Security reason.

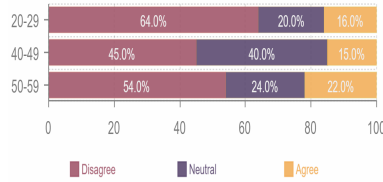


Fig. 5: User responses on usability question “Q. It is easy to use the Korean National Digital Certificates”

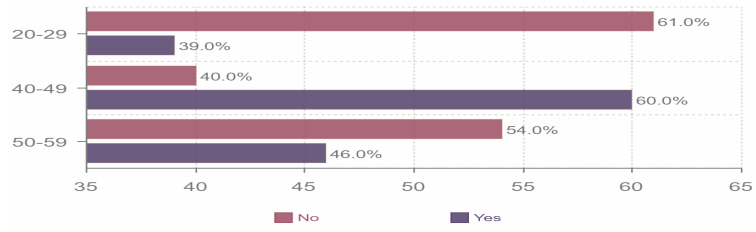


Fig. 6: Percentage of participants who are aware of policy changes