An Empirical Study on a Tradeoff between Security and Convenience: The Case of i-PIN System

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Abstract

The resident registration numbers were used for administrative purposes including people's up-to-date residence information and vital statistics or provision of public services in Korea. In 2005, the government of Korea devised the i-PIN, a new online personal identification system replacing resident registration numbers. In the context of the i-PIN, the present study intended to shed light on the relationship between security and convenience. Also, we tried to explore the antecedents of adoption of the i-PIN. As a result, user support and perceived security had positive effects on the perceived ease of use, perceived usefulness respectively. The perceived ease of use also had significant effects on the perceived usefulness and satisfaction, whereas it did not exert direct effects on the use intention. Not surprisingly, the most significant variable influencing the use intention and satisfaction was perceived usefulness.

Keywords: Authentication, i-PIN; Resident Registration Numbers

1. Introduction

Recently, personal information is under dire threats of leakage by insiders, external hackers and unlawful marketers¹. According to a civic group, no fewer than 374 million resident registration numbers in Korea were estimated to have been collected illegally for crimes from 1991 to 2014². Concluding the on- and off-shore leakage of national resident registration numbers has reached to an uncontrollable level, the government is discussing overhauling the resident registration number system. The resident registration numbers were used for administrative purposes including people's up-to-date residence information and vital statistics or provision of public services³. Since the early 2000, web sites indiscreetly began to collect resident registration numbers for identification of their members, leading such numbers to be saved across the DBs of countless websites, which increased the risk of personal information leakage. According to a survey conducted in 2008, more than 62.2% of domestic internet web sites, and over 90% of top 200 online sites, were collecting, saving and using resident registration numbers for identification of subscribers⁴.

The resident registration numbers contain personal information such as date of birth and gender, which is considered the most significant issue. Moreover, even when a number is found to have been leaked, one cannot change his or her number and may be exposed to crimes for life⁵. Thus, resident registration numbers are vulnerable to identify theft and financial loss once leaked⁶. In 2005, the government perceived the graveness of such issues, and devised the i-PIN, a new online personal identification system replacing resident registration numbers on local web sites⁷. The i-PIN is comprised of an ID and password.
for personal identification, designed to protect personal information, saving a user the trouble of using the resident registration number. Unlike the permanently unchangeable resident registration numbers, i-PINs can be reissued or suspended once they are found to have been leaked. Furthermore, the i-PIN informs its user of a list of websites where it is used for identification as well as the date and time, effectively serving to protect the user’s personal information and to strengthen the person’s control over such information.

In the context of the i-PIN, the present study intended to shed light on the relationship between security and convenience. Also, we tried to explore the antecedents of adoption of the i-PIN.

2. Literature Review

2.1 i-PIN
Identification refers to proving who you are. This is the process of determining who the person is when he or she tries to access an information system using a user name and ID. This is part of open information easily exposed externally. Authentication refers to proving the identification. That is, authentication is a process of seeing one’s identity. Authentication often requires a password for an ID. A person trying to access an information system proves who he or she is using a personal secret password. The i-PIN is an authentication system performing the identification and authentication simultaneously upon an ID and password being provided. The authentication system identifies a subject to be authenticated and provides relevant authentication services. i-PINs are usually used for personal identification of new subscribers. i-PINs replace the conventional approach of using real names and resident registration numbers for personal authentication. By providing an i-PIN ID with a password, one can join a website and use other services without having to present his resident registration number. Furthermore, should an i-PIN account be exposed, one can discard the compromised i-PIN and have a new pin issued, significantly lessening the potential risk of intrusion.

Previous local literature on i-PINs focused on technical application or implementation rather than users’ behavior. Also, a few studies introduced policy aspects or simple service frameworks. Yet, to vitalize the i-PIN service, the behavioral analysis of user-side actual service experience should not be overlooked although it is important to pay attention to supplier-side technical and policy aspects. After all, it is the subjective perception of a potential user that decides on whether to use a newly adopted system or service. Still, no previous studies viewed the intention to use i-PINs from the perspective of user behavior. The Korean government’s initiative for developing and proceeding with an online ID management model is a rare case. Recently, the EU including Germany is preparing to introduce the eID in connection with identification cards. Also, some states including Japan and the US are benchmarking Korea’s i-PIN system. Meanwhile, lots of similar empirical studies in this field dealt with the intention to accept multiple authentication measures and relevant factors including OTPs, smart cards, email authentication services.

2.2 Authentication
Previous studies drew on significantly different models and variables leading to a paucity of consistency despite their commonality of investigating authentication approaches and of proposing alternatives to broaden the use of authentication methods. Thus, models and variables need to be generalized so that they can be used to develop a model for predicting the use of a new authentication approach. The present study reviewed previous studies to find out common factors that would facilitate the acceptance of authentication measures by potential users. Zviran and Erlich proposed 4 factors that should be considered in choosing a means of authentication, i.e. effectiveness, ease of implementation, ease of use and user attitude and acceptance. Furnell et al. stated effectiveness, cost and user acceptance are important in considering alternatives for authentication. Likewise, Yeom and Lee suggested security, convenience and required legal level or economic feasibility should be considered extensively before choosing an option. From the previous literature, security and convenience were derived as the two factors affecting the user acceptance, as the ease of implementation and economic feasibility are supplier-side factors; they were excluded from this study focusing on the user-side factors.

2.3 Technology Acceptance Model
Davis et al. developed the TAM (Technology Acceptance Model), which has been one of the most widely used models by many studies for explaining and analyzing users’
acceptance behavior of information systems. The present study adopted the perceived usefulness, perceived ease of use and intention to use from TAM and included these in the model as important factors. The TAM stated attitude is an antecedent of the intention to use. Yet, we excluded the factor from the model. To maximize the simplicity of TAM and to prevent the model from getting too complicated, the present study skipped the measurement of attitude. Meanwhile, many authors extended TAM for their study objectives. Also, we added the satisfaction variable to scale up the dependent variables.

3. Proposed Model and Hypothesis

The present study identified the factors influencing the intention to accept i-PINs, and analyzed the effects of such factors on the intention to accept i-PINs. Figure 1 is the model proposed in this study.

The proposed model is based on TAM with the variables likely to affect the intention to accept i-PINs among other authentication methods being added. To be specific, the present study focused on the convenience dimension including user support and perceived ease of use, and the security dimension including security and perceived usefulness to find out their effects on users’ satisfaction and intention to accept i-PINs.

Figure 1. The proposed model.

Kim and Kankanhalli22 argued that organizational supports in the form of training or resources in firms about to adopt new information systems reduced the time and effort required to learn the new business process and also difficulties in adjusting to the new systems. According to his study, the more the organizational supports are provided, the more the users’ resistance decreased. Kim and Song23 asserted that government’s diverse supports for its portals would make it easier to use the information system, improving performance and promoting the acceptance of the system.

H1: User support will positively influence perceived ease of use.

The perception of security may have a considerable effect on raising the usefulness of systems23. As i-PINs operate in mobile environment, they do encompass the disadvantages of mobile devices and networks. Hacking attacks against smart phones are increasing. Mobile environment makes it easy to produce applications carrying malicious codes and uses limited OS, increasing the likelihood of migrating malicious applications, which is suggestive of a continuous growth of security risks24. Im et al.25 studied on people’s acceptance of technology regarding the internet electronic voting system and reported positive correlations between the perceived usefulness and the integrity of information delivered as well as personal information provided by users for the system, and between the perceived usefulness and the perceived security of authentication25. A study on mobile cloud service users’ continuance use intention demonstrated the users’ perceived security influenced their perceived usefulness26.

H2: Perceived security will positively influence perceived usefulness.

Shin13 surveyed i-PIN users on their satisfaction with the issuance and use of i-PINs. The linear regression analysis of the survey results illuminated the higher the satisfaction, the more intense the continuance intention. Taherdoost et al.9 argued that the satisfaction with security had direct effects on the acceptance of smart cards. Limayem and Cheung27 delved into the relationship between the perceived usefulness, satisfaction and continuance use intention, and argued the satisfaction with the experience of internet-based learning skills would bring a high level of continuance use intention. In short, it was found that the higher the perceived usefulness, the higher the satisfaction, which ultimately exerted effects on the continuance use intention for information systems. In a paper on e-government’s trust models, TAM’s core variables, viz. the perceived ease of use and the perceived usefulness were found to have effects on citizens’ satisfaction with e-government systems28.

H3: Perceived ease of use will positively influence satisfaction.
H4: Perceived usefulness will positively influence satisfaction.
H5: Satisfaction will positively influence intention to use i-PIN.

As aforementioned, the present paper is based on TAM. Studies adopting TAM as the underlying model in the specific contexts of interest took the perceived ease of use and the perceived usefulness as the most important antecedents of the acceptance intention, which has been proved by follow-up studies. Moreover, the perceived ease of use can affect not just the acceptance intention but also the perceived usefulness. Kim and Song reported when it was easier to use government portals, users found the technology more useful than any other element.

Bae found a sequential relationship where the perceived ease of use led to the perceived usefulness, which in turn led to the continuance usage intention. Previous studies reported that the effects on the use intention mediated via the perceived usefulness were more significant than those of the perceived ease of use on the use intention. Yet, under certain conditions in some cases, the perceived ease of use had greater effects on the use intention than the perceived usefulness. The present study verified the following hypotheses with reference to the relationships between general variables suggested in TAM.

H6: Perceived ease of use will positively influence intention to use i-PIN.
H7: Perceived ease of use will positively influence Perceived usefulness.
H8: Perceived usefulness will positively influence intention to use i-PIN.

4. Data Analysis and Results

The present study verified the model using SmartPLS 2.0.

4.1 Data Collection

An online survey was administered by a research firm from December 15-17, 2014. The survey respondents were at least aware of i-PINs and recruited regardless of regions

| Table 1. Measurement Instrument |
|--------------------------------|
| **Construct** | **Item** | **Wording** |
| User Support | USP1 | I can get some clear explanation from issuing and operating organizations when I have to be issued and use i-PIN |
| | USP2 | i-PIN issuing organizations provide me assistance when I wonder about i-PIN and have a trouble |
| | USP3 | i-PIN issuing organizations provide me guide on how to get an i-PIN and log in |
| | USP4 | i-PIN issuing organizations provide me assistance when I have to be issued and use i-PIN |
| Perceived Security | PSC1 | I don’t worry that my personal information will be exposed when I use i-PIN |
| | PSC2 | i-PIN is a safe service protecting user’s personal information |
| | PSC3 | When I use i-PIN, I feel that i-PIN is protecting my personal information |
| Perceived Ease of Use | PEOU1 | Learning to use and get i-PIN would be easy for me |
| | PEOU2 | How to get an i-PIN is not difficult |
| | PEOU3 | Learning to use and get i-PIN would be easy for me |
| Perceived Usefulness | PU1 | Overall, i-PIN is useful |
| | PU2 | i-PIN use is beneficial to user |
| | PU3 | i-PIN is of utility value |
| | PU4 | i-PIN use is advantageous |
| Satisfaction | SFC1 | I’m satisfied with interface of i-PIN |
| | SFC2 | I’m satisfied with processing speed of i-PIN |
| | SFC3 | I’m satisfied with functions i-PIN has |
| | SFC4 | I’m satisfied with procedure of i-PIN |
| | SFC5 | Overall, I’m satisfied with i-PIN |
| Intention to Use | IU1 | I will use i-PIN continuously |
| | IU2 | I think I will use i-PIN if possible |
| | IU3 | I plan to use i-PIN |
| | IU4 | Maybe I will use i-PIN in the future |
with equal distribution of gender and age. Of 396 people accessing the online survey window, 360 respondents completed the survey, which showed a very high response rate of 90.9%. Excluding 43 insincere copies, 317 copies were analyzed.

Regarding the demographics of respondents (Table 2), males and females were 48.9% and 51.1%, respectively. 34.7%, 32.2% and 33.1 of respondents were in their 20s, 30s and 40s and older, respectively. Those living in the capital area accounted for 65% in comparison to 35% living in other regions. The largest numbers of respondents (54.9%) were employees, followed by students (13.6%), other occupations (12.9%), professionals (12.9%), small business owners (3.2%) and public servants (2.5%) in the order named.

### Table 2. Demographic characteristics

| Classification | Frequency (unit:people) | Distribution (%) |
|----------------|-------------------------|------------------|
| Gender         |                         |                  |
| Male           | 155                     | 48.9             |
| Female         | 162                     | 51.1             |
| 20s            | 110                     | 34.7             |
| Age            |                         |                  |
| 30s            | 102                     | 32.2             |
| More than 40s  | 105                     | 33.1             |
| Capital area   | 206                     | 65.0             |
| Other than capital area | 111 | 35.0 |
| Public officials | 8                       | 2.5              |
| Salaried worker | 174                     | 54.9             |
| Job            |                         |                  |
| Professionals  | 48                      | 12.9             |
| Self-employed  | 10                      | 3.2              |
| Student        | 43                      | 13.6             |
| Etc.           | 41                      | 12.9             |

### 4.2 Reliability and Validity

The PLS analysis requires testing internal consistency, convergent validity, and discriminant validity of question items and constructs. To test the internal consistency, the user support, perceived security, perceived ease of use, perceived usefulness, satisfaction and use intention were analyzed in terms of Fornell and Larcker’s composite reliability and internal consistency. Table 3 shows the analysis results. The composite reliability proved to be higher than 0.7, the reference standard suggested by Nunnally and Thompson et al. The Cronbach’s α, widely in use for testing the reliability, proved to be 0.7 and higher, indicating the internal consistency was good.

### Table 3. Internal consistency analysis

| Construct | Composite reliability | Cronbach’s α |
|-----------|------------------------|--------------|
| USP       | 0.916                  | 0.924        |
| PSC       | 0.941                  | 0.906        |
| PEOU      | 0.940                  | 0.904        |
| PU        | 0.938                  | 0.911        |
| SFC       | 0.943                  | 0.924        |
| IU        | 0.953                  | 0.935        |

The convergent validity was tested with AVE and factor loadings of constructs. As in Table 4, the AVE proved to be higher than 0.5, the reference standard suggested by Fornell and Larcker and Chin. All factor loadings of constructs proved to be 0.7, the reference standard suggested by Fornell and Larcker.

### Table 4. Internal consistency analysis

| Construct | AVE | Item | Factor loading | t-value |
|-----------|-----|------|----------------|---------|
| USP       | 0.56| USP1 | 0.829          | 38.899  |
|           |     | USP2 | 0.847          | 45.313  |
|           |     | USP3 | 0.873          | 42.291  |
|           |     | USP4 | 0.874          | 48.123  |
| PEOU      | 0.71| PEOU1| 0.912          | 75.087  |
|           |     | PEOU2| 0.919          | 61.936  |
|           |     | PEOU3| 0.917          | 71.932  |
| PU        | 0.81| PU1  | 0.915          | 85.001  |
|           |     | PU2  | 0.839          | 33.300  |
|           |     | PU3  | 0.926          | 99.021  |
|           |     | PU4  | 0.872          | 52.193  |
| IU        | 0.88| IU1  | 0.919          | 79.500  |
|           |     | IU2  | 0.906          | 64.886  |
|           |     | IU3  | 0.940          | 118.570 |
|           |     | IU4  | 0.893          | 50.328  |
| SFC       | 0.70| SFC1 | 0.839          | 33.650  |
|           |     | SFC2 | 0.833          | 30.860  |
|           |     | SFC3 | 0.897          | 73.162  |
|           |     | SFC4 | 0.900          | 73.357  |
|           |     | SFC5 | 0.909          | 79.423  |
| PSC       | 0.70| PSC1 | 0.905          | 74.188  |
|           |     | PSC2 | 0.937          | 129.578 |
|           |     | PSC3 | 0.910          | 74.342  |

As in Table 5 the discriminant validity was tested based on whether the square root of every AVE marked on the diagonal axis of correlation coefficients was bigger than the coefficients of the other constructs. As a result, the smallest square root of AVE (0.856) was bigger than the largest coefficient (0.773), indicating the discriminant validity was good.
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Table 5. Correlation between latent variables

| Construct | SFC  | IU   | USP  | PSC  | PEOU | PU   |
|-----------|------|------|------|------|------|------|
| SFC       | 0.876|      |      |      |      |      |
| IU        | 0.725| 0.915|      |      |      |      |
| USP       | 0.658| 0.560| 0.856|      |      |      |
| PSC       | 0.569| 0.638| 0.574| 0.917|      |      |
| PEOU      | 0.560| 0.460| 0.469| 0.246| 0.916|      |
| PU        | 0.764| 0.773| 0.630| 0.638| 0.483| 0.889|

The present study performed the confirmatory factor analysis as in Table 6. In the confirmatory factor analysis, the factor loading of a construct should be higher than those of the other constructs. As a result, every question item met the requirement.

Table 6. Confirmatory factor analysis

| Construct | USP  | PEOU | PU   | SFC  | PSC  | SFC  |
|-----------|------|------|------|------|------|------|
| USP1      | 0.829| 0.403| 0.564| 0.492| 0.562| 0.520|
| USP2      | 0.847| 0.376| 0.579| 0.521| 0.582| 0.558|
| USP3      | 0.873| 0.415| 0.482| 0.455| 0.533| 0.448|
| USP4      | 0.874| 0.410| 0.536| 0.454| 0.575| 0.447|
| PEOU1     | 0.441| 0.912| 0.489| 0.464| 0.554| 0.224|
| PEOU2     | 0.444| 0.919| 0.432| 0.391| 0.499| 0.244|
| PEOU3     | 0.401| 0.917| 0.400| 0.404| 0.479| 0.209|
| PU1       | 0.588| 0.509| 0.915| 0.740| 0.740| 0.589|
| PU2       | 0.528| 0.357| 0.839| 0.587| 0.608| 0.501|
| PU3       | 0.595| 0.431| 0.926| 0.708| 0.690| 0.605|
| PU4       | 0.524| 0.408| 0.872| 0.699| 0.669| 0.564|
| IU1       | 0.482| 0.461| 0.694| 0.919| 0.687| 0.554|
| IU2       | 0.526| 0.427| 0.732| 0.906| 0.663| 0.591|
| IU3       | 0.521| 0.444| 0.726| 0.940| 0.676| 0.588|
| IU4       | 0.522| 0.349| 0.673| 0.894| 0.627| 0.602|
| SFC1      | 0.530| 0.439| 0.596| 0.570| 0.839| 0.449|
| SFC2      | 0.552| 0.477| 0.597| 0.526| 0.833| 0.413|
| SFC3      | 0.591| 0.482| 0.718| 0.687| 0.897| 0.552|
| SFC4      | 0.613| 0.576| 0.633| 0.606| 0.900| 0.451|
| SFC5      | 0.593| 0.482| 0.775| 0.755| 0.909| 0.600|
| PSC1      | 0.515| 0.263| 0.603| 0.612| 0.520| 0.905|
| PSC2      | 0.551| 0.186| 0.602| 0.594| 0.543| 0.937|
| PSC3      | 0.514| 0.229| 0.547| 0.546| 0.502| 0.909|

4.3 Structural Model Analysis

In the PLS analysis, the explanatory power of the path model is expressed as the explained variance, $R^2$. The PLS analysis of $R^2$ showed the perceived ease of use, perceived usefulness and satisfaction explained 64.2% of the use intention, whilst the perceived ease of use and perceived usefulness explained 63.1% of satisfaction, which exceeded Falk and Miller’s power (10%). Next, in GoF (goodness-of-fit) testing, the impact of GoF was 0.635, which was higher than Wetzels et al.’s reference standard, indicating a very high goodness of fit of the model.

With the PLS analysis, path coefficients and their significance were tested. For this, the full sample was used to find out the path coefficients of the structural model. The bootstrapping provided in PLS was used to calculate the t-value for the path coefficient. Table 7 summarizes the analysis results. The results of the analysis are as follows in the order of hypotheses. In brief, 7 out of 8 hypotheses set up in the present study except the hypothesis 6 were found significant and adopted.

Table 7. The results of the hypotheses

| Hypothesis | Path coefficient | t-value | Result |
|------------|-----------------|---------|--------|
| H1         | USP → PEOU      | 0.469   | 9.657 Supported |
| H2         | PSC → PU        | 0.552   | 11.983 Supported |
| H3         | PEOU → SFC      | 0.249   | 5.152 Supported |
| H4         | PU → SFC        | 0.664   | 16.354 Supported |
| H5         | SFC → IU        | 0.308   | 5.168 Supported |
| H6         | PEOU → IU       | 0.037   | 0.776 Not supported |
| H7         | PEOU → PU       | 0.347   | 8.448 Supported |
| H8         | PU → IU         | 0.520   | 9.984 Supported |

5. Discussion

As above mentioned, the constructs and question items used here were found to be fit for the structural model analysis as their internal consistency, convergent validity and discriminant validity met the reference requirements.

The user support was found to have positive effects on the perceived ease of use ($\beta=0.469$). Those who used to draw on their resident registration numbers or mobile authentication would not find it easy to use i-PINs including their issuance process. Particularly, the senior citizens are not accustomed to computer and Internet and are likely to find it difficult to understand the technology and thus become unwilling to learn how to use i-PINs. Therefore, the entities operating i-PINs need to develop creative and efficient ways to increase their user supports so that users will perceive using i-PINs is not difficult.
The perceived security was found to have positive effects on the perceived usefulness ($\beta=0.552$). As a service for protecting personal information, the i-PIN system prevents personal information from being leaked on the internet, in which sense security is the overriding component. All systems that are potentially connected to external networks have vulnerabilities to security issues. So does the i-PIN system. The servers managed by the i-PIN operators might be attacked by hackers. The information delivered to the i-PIN servers from personal computers of users might suffer sniffing and spoofing. As such, the i-PIN system in its entirety is exposed to severe potential risks. Despite the possibility of i-PIN data being exposed on networks, technical encryption measures should be taken so that hackers cannot read the plain texts of data unlawfully acquired.

The perceived ease of use had significant effects on the perceived usefulness ($\beta=0.347$) and satisfaction ($\beta=0.249$), whereas it did not exert direct effects on the use intention. Those who are unwilling to use i-PINs pointed to the complexity of the issuance procedures, the installation of Active X or multiple other security programs and the requirement to enter the illegible security characters, all of which should be improved to raise the perceived ease of use of i-PINs. If using i-PINs remains challenging, users will get back to the conventional authentication methods. Such challenging aspects hinder further penetration of i-PINs, which has significant implications for i-PIN-related policy makers.

The perceived usefulness proved to be the variable having the most significant effects on the use intention ($\beta=0.520$) and satisfaction ($\beta=0.664$). To increase the perceived usefulness, its antecedent, that is, the perceived security should be considered. It is important to guide potential users to become aware of the advantages of i-PINs over certificates or mobile authentication. To that end, in addition to the aforementioned technical security measures, i-PIN-related campaigns or advertisements should strategically emphasize the privacy protection and the prevention of personal information from any leakage gained by using i-PINs.

Satisfaction as a variable was found to have positive effects ($\beta=0.552$) on the intention to use i-PINs. When users are forced into using the system, they feel dissatisfied because they have to use it without resistance. The present study empirically demonstrated the satisfaction with i-PINs instead of the attitude variable had mediating effects on TAM’s core elements. Furthermore, the present survey findings suggested that the attitude variable in the conventional TAM should possibly be replaced in the sense that the perceived usefulness affected the use intention not directly but indirectly via the satisfaction. Thus, the present study proposes that the satisfaction variable should be considered in the environment where a certain means of authentication is enforced by the government or other organizations.

6. Conclusion

This study built on previous studies on authentication methods to propose a model with additional variables likely to exert effects on the intention to accept i-PINs. To verify empirically the proposed model, those who were aware of i-PINs were surveyed online with the help of a research firm. The selection of variables from the features of authentication methods will give a fresh insight into developing a model for generalization. Also, the academic value of this study lies in the fact that previous studies hardly investigated the psychological perception and behavioral attributes of i-PIN users excluding a few simple questionnaire surveys. The present findings will be conducive to further studies on psychological aspects of i-PIN users.

i-PINs are not used prevalently given the fact that it has been adopted for a decade. The present findings will help policy-makers understand how people think of i-PINs and what they value. Especially, the government should give priority to understanding the complexity of the issuance procedures of i-PINs, the settings of many security programs and the inconvenience of entering security characters. The present findings will facilitate the government’s understanding of budget priorities in addition to the i-PIN PR campaign.

The present study lacked in considering demographic variables. The intention to use information systems may vary with gender or age, which could be proved by analyzing the moderating effects of demographic variables. In addition to such demographic variables as gender, occupation, education and income levels, the moderating effects of personal experience of authentication methods and of leakage of personal information should be considered. Future studies need to establish the variables comparable to the perceived security such as the perceived...
risk, perceived privacy and perceived trust. Finally, it is worth investigating whether any significant difference arises when the resistance to authentication methods, not the intention to accept those, is included as a dependent variable in a model.

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