Digital Aging, Mental Vulnerability and Financial Fraud Losses
——Based on the perspective of aging

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Abstract. In the context of the intersection of digitization and aging, the frequent occurrence of fraud incidents among the elderly poses a great threat to family financial security and has attracted the attention of all walks of life. Based on the China Health and Retirement Longitudinal Study data, this paper uses Probit and Tobit regression methods to empirically test the impact of digital aging on the financial fraud losses of the elderly. The research shows that digital aging can significantly reduce the possibility of actual financial fraud and the amount of financial fraud losses of the elderly, among which it has a greater impact on the elderly with higher cognitive ability, frequent contact with children and in the eastern region. Mental vulnerability will weaken the inhibitory effect of digital aging on financial fraud losses. Therefore, it provides corresponding counter-measures and suggestions for the financial risk prevention of elderly families from the aspects of government guidance, enterprise innovation, family feedback and personal fraud prevention, and provides new ideas for the development and implementation of financial anti-fraud.

Keywords: Digital Aging；Financial Fraud；Mental Vulnerability

1   Introduction

According to the 2022 China Pension Finance Survey, more than half of the respondents who have been deceived in financial investment are over 60 years old. The problem of financial fraud of the elderly has attracted more and more attention from academia and government departments. In the context of the intersection of digitization and aging, the development of digital technology has brought " digital dividends " to people[1]. However, due to the decline in learning ability and low level of information skills, the use of digital products and services in China 's elderly population is often limited. Faced with the digital divide, it is often difficult to obtain the empowerment of digital technology and lag behind the development of society, frequently encountering the risk of digital fraud[2].

In the context of the increasingly prominent ' digital divide ' encountered by the elderly population, the concept of ' digital aging ' came into being[3]. By promoting the

aging of digital technology and reducing the obstacles for the elderly to use digital technology, not only can more elderly people be connected to the Internet and bridge the digital divide, but also can broaden the information channels of the elderly, enhance the information literacy of the elderly, and help the elderly enjoy more digital dividends. In this context, it is of great practical significance to study whether digital aging can reduce the financial fraud losses of the elderly for improving the social security of the elderly and promoting social well-being.

2   Theoretical Analysis and Research Hypothesis

The research on digital aging originated in the 1980 s. It is developed and extended on the basis of the concepts of " old age problem, " " aging, " " digital divide, " " digital inclusion, " " smart old-age care " and " Internet + old-age care. " First of all, digital aging reduces the threshold for the use of the Internet from the access end, so that digital technology sinks into the elderly customer group, through access to broadband, improve network speed, so that more elderly people ' touch the Internet '. Secondly, previous studies have shown that the information channel effect brought by the elderly through the Internet can access more financial-related information, improve their financial literacy, and enhance their financial anti-fraud ability[4]. Finally, with the increase in the frequency of use of digital technology for the elderly, the elderly can learn more knowledge from digital technology, understand different means of financial fraud, identify various false investment and financing models[5], and help the elderly prevent financial fraud losses. However, while digital aging brings positive effects to the elderly, it may also cause the elderly to fall into security risks and face many ethical issues[6] , with negative effects. On the one hand, the time for the elderly to ' touch the Internet ' is relatively limited, and the information processing ability is insufficient. It is difficult to screen and identify effective information in the Internet, and it is difficult to judge the true source and channel of information. It is easy to be induced by false information and fall into the trap of fraudsters, causing property losses. On the other hand, some elderly people lack the awareness of personal information protection. When using digital products, they may face the risk of information leakage and increase the possibility of being cheated. Through the above analysis, this paper believes that digital aging has both positive and negative effects on the financial fraud losses of the elderly. Based on this, this paper proposes two competitive hypotheses.

   Hypothesis 1a : Digital aging has an inhibitory effect on the financial fraud losses of the elderly.

   Hypothesis 1b : Digital aging has a promoting effect on the financial fraud losses of the elderly.

   Mental vulnerability is a negative response pattern with psychosomatic and psychiatric symptoms, which is closely related to personality characteristics and affects social interaction[7]. When the elderly are plagued by negative psychological emotions such as mental vulnerability, their rational decision-making framework is more vulnerable to the erosion of irrational factors, which leads to systematic decision-making bias[8] .Based on this, this paper proposes hypothesis 2.

Hypothesis 2 : Mental vulnerability has an aggravating effect on the financial fraud losses of the elderly.

Mental vulnerability is a negative emotional factor. Under the regulation of mental vulnerability, the elderly are more likely to have cognitive bias and irrational decision-making, and tend to take risky behaviors, so they are more likely to participate in risky activities. The negative fear generated by the elderly in the process of aging will affect their susceptibility to fraud[9]. Based on this, this paper proposes hypothesis

Hypothesis 3 : Mental vulnerability plays a moderating role in digital aging and financial fraud losses of the elderly.

The elderly with higher cognitive ability generally have higher information processing ability, can make accurate judgments on fraud information, and have higher financial prevention awareness[10]. Frequent contact between children and parents helps to transmit financial information and improve the awareness of fraud prevention of the elderly[11]. In addition, due to the differences in regional digital technology development and economic development level, households in the central and western regions have a lower level of economic development than those in the eastern region. The elderly are exposed to less digital technologies such as information technology and the Internet, and the level of digital aging may be lower. Based on the above analysis, this paper proposes hypothesis 4.

Hypothesis 4 : Digital aging has a more significant impact on the financial fraud losses of the elderly with higher cognitive ability, frequent child contact, and in the eastern region.

3   Research design and statistical analysis

3.1   Model setting

First of all, when analyzing the impact of digital aging on whether the elderly are actually financially deceived, considering that the explained variable is a dummy variable, this paper constructs a Probit model estimation. The model is set as follows :

$$prob\left(fraud=1\right)=\beta_0+\beta_1 Digital+\beta_2 X+\mu \tag{1}$$

In Equation (1), represents whether the actual financial fraud, the variable representing the digital aging condition is the control variable.

Secondly, since the amount of financial deception loss is truncated, this paper uses the Tobit regression model proposed by James Tobin (1956)[12] to estimate the impact of digital aging on the amount of financial deception loss of the elderly, and the model is set as follows:

$$\ln\_loss^*=\beta_0+\beta_1 Digital+\beta_2 X+\mu \tag{2}$$

$$\ln\_loss=(0,\ln\_loss^*) \tag{3}$$

Among them, it represents the logarithm of the amount of financial fraud losses of the elderly, represents the observed value when it is greater than 0, and the meaning of

other variables is exactly the same as that of formula (1). The model significance test still uses the city-level clustering standard error.

Finally, in order to test the moderating effect of mental vulnerability on the impact of digital aging on financial fraud losses, this paper adds the moderating variable mental vulnerability on the basis of formulas (1), (2) and (3), and constructs formulas (4), (5) and (6).

$$prob\left(fraud = 1\right) = \beta_0 + \beta_1 Digital + \beta_2 MV + \beta_3 Digital * MV + \beta_4 X + \mu \quad (4)$$

$$\ln\_loss^* = \beta_0 + \beta_1 Digital + \beta_2 MV + \beta_3 Digital * MV + \beta_4 X + \mu \quad (5)$$

$$\ln\_loss = (0, \ln\_loss^*) \quad (6)$$

Among them, the core explanatory variables are the interaction terms of digital aging and mental vulnerability, and the other variables are set in accordance with formulas (1), (2) and (3).

3.2   data sources

The data in this paper are from the China Health and Retirement Longitudinal Study database .

Explained variables.

The explained variable of this paper is the loss of financial fraud. The main research is whether the actual financial fraud and the amount of financial fraud losses after the financial fraud.

Explanatory variables.

The core explanatory variable of this paper is digital aging. At present, there is no unified and clear measurement system for digital aging in the academic circle. Digital aging mainly includes two meanings : the first is to eliminate the digital divide, and the second is digital technology empowerment.

Regulating variables.

The moderating variable of this paper is mental vulnerability. The measurement of mental vulnerability in foreign countries is mainly based on the Mental Vulnerability Questionnaire compiled by Eplov et al. (2010), including three dimensions : psychosomatic symptoms, mental symptoms and interpersonal problems[13]. Therefore, according to the connotation of the three dimensions of MVQ, based on the availability of data, this paper selects the corresponding problems in the two modules of health status and function, cognition and depression of CHARLS questionnaire, constructs the mental vulnerability variable by principal component analysis, and normalizes the index.

Control variables.

According to the influencing factors of financial fraud losses of the elderly in the existing literature, drawing on the relevant research of Lei Xiaoyan et al[4] and other

scholars, and combining the characteristics of CHARLS survey data, the control varia-bles selected in this paper are mainly determined from the personal information and family information of the respondents, including age, gender, education level, health status, cognitive ability, and children 's contact degree. In addition, in the regression equation, factors such as the province where the individual is located are also controlled to reduce the differences in the financial investment environment between provinces and the economic characteristics of other provinces.

4   Empirical Results and Analysis

4.1   Analysis of regression results

The first column in Table 1 reports the Probit regression results of digital aging and actual financial fraud, in which the reported coefficients are marginal effects. The co-efficient of digital aging in regression (1) is -0.245, which is significant at the level of 1 %, indicating that for every unit increase in the degree of digital aging, the probability of actual financial fraud will decrease by 24.5 %. The results in Regression (2) show that the average marginal effect of digital aging on the logarithm of financial fraud losses is -1.581, indicating that digital aging can reduce the amount of financial fraud losses. Digital aging makes it easier for the elderly to master digital skills and integrate into the digital age, making it easier for the elderly to obtain information and contact new things, learn more about the fraudulent ways of financial fraud, so as to identify and respond to fraud attempts, and better prevent financial fraud losses. Therefore, hy-pothesis 1a is proven.

From the perspective of control variables, there is no statistical correlation between age, education level and financial fraud losses in the sample, which is similar to the existing research conclusions.

Table 1. Regression results of digital aging and financial fraud losses

. Variable	(1) The actual financial fraud (Probit)	(2) Logarithm of finan-cial fraud losses (Tobit)	(3) The actual financial fraud (Logit)
Digital aging	-0.245*** (0.094)	-1.581** (0.645)	-0.266*** (0.098)
Cognitive ability	-0.008* (0.005)	-0.046 (0.029)	-0.008 (0.005)
Age	0.004 (0.003)	0.022 (0.019)	0.004 (0.003)
Gender	-0.071* (0.041)	-0.442* (0.256)	-0.078* (0.040)
Health status	0.067* (0.040)	0.392 (0.248)	0.066* (0.040)
Children contact	-0.132** (0.054)	-0.877*** (0.335)	-0.128** (0.057)
Education level	-0.039 (0.045)	-0.226 (0.280)	-0.034 (0.047)
Provincial fixed effect	Yes	Yes	Yes
Observed value	528	534	528
Pseudo R^2	0.122	0.054	0.122

4.2   moderating effect analysis

Table 2 reports the results of the moderating effect of mental vulnerability in the impact of digital aging on financial fraud losses. The results of columns (1) and (2) in Table 2 show that mental vulnerability can significantly increase the possibility of actual financial fraud and the amount of financial fraud losses, which verifies Hypothesis 2. The estimated coefficient of the interaction between digital aging and mental vulnerability in the first column is 0.962, which is significantly positive at the level of 10 %. This shows that mental vulnerability has a significant negative moderating effect on the relationship between digital aging and actual financial fraud. thus verifying Hypothesis 3.

Table 2. The regression results of the moderating effect of psychological vulnerability

Variable	(1) The actual financial fraud (Probit)	(2) Logarithm of financial fraud losses (Tobit)
Digital aging	-0.198** (0.095)	-1.220* (0.640)
Mental vulnerability	0.285** (0.120)	2.151*** (0.758)
Digital aging * Mental vulnerability	0.962* (0.562)	8.034** (3.656)
Control variable	Yes	Yes
Provincial fixed effect	Yes	Yes
Observed value	527	533
Pseudo R^2	0.131	0.060

4.3   robustness test

Processing reverse causal errors.

This paper takes the average Internet use frequency of the elderly in the same community as the instrumental variable of digital aging. Table 3 reports the results of instrumental variable regression. Digital Aging is still significantly negatively correlated with the financial fraud losses of the elderly, which is in line with the expectation of Hypothesis 1a.

Table 3. Results of instrumental variable regression

Variable	(1) The actual financial fraud (IV-probit)	(2) Logarithm of financial fraud losses (IV-tobit)
Digital aging	-1.791*** (0.554)	-12.230*** (3.815)
Control variable	Yes	Yes
Provincial fixed effect	Yes	Yes
Observed value	528	534
F	18.75	19.24
t	16.31	16.37
R^2	0.5396	0.5594
Wald Test	5.13	4.88
P	0.0235	0.0272

Replace the measurement model.

This paper further replaces the model of the impact of digital aging on the actual financial fraud of the elderly with the Logit model for empirical analysis. The regression results are shown in Column 3 of Table 1, Which supports the benchmark regression results.

Other construction methods of explanatory variable indicators.

In order to further test the reliability of the above empirical results, this paper will use the entropy method to construct the digital aging index, and the index is normalized. Table 4 examines the impact of the digital aging index synthesized by the entropy method on financial fraud losses, Which is consistent with the conclusions obtained above.

Table 4. The results of the explanatory variable substitution test

Variable	(1) The actual financial fraud (Probit)	(2) Logarithm of financial fraud losses (Tobit)
Digital aging	-0.953*** (0.351)	-6.710*** (2.360)
Control variable	Yes	Yes
Provincial fixed effect	Yes	Yes
Observed value	531	537
Pseudo R²	0.119	0.054

4.4   heterogeneity analysis

Heterogeneity analysis of cognitive ability.

This is shown in Table 5,by grouping regression, it is found that digital aging has a greater mitigation effect on the financial fraud losses of the elderly with higher cognitive ability, but this effect is not obvious in the elderly with lower cognitive ability.

Table 5. Regression results of cognitive ability samples

Variable	(1) High cognitive ability fraud	(2) Low cognitive ability fraud	(3) High cognitive ability ln loss	(4) Low cognitive ability ln loss
Digital aging	-0.439*** (0.116)	0.147 (0.212)	-2.724*** (0.719)	0.946 (1.223)
Control variable	Yes	Yes	Yes	Yes
Provincial fixed effect	Yes	Yes	Yes	Yes
Observed value	254	224	293	241
Pseudo R2	0.195	0.085	0.123	0.057

Heterogeneity analysis of children 's contact degree.

The regression results in Table 6 show that the elderly who have frequent contact with their children are more affected by digital aging, and it is easier to reduce the actual probability of being cheated and the amount of financial fraud losses.

Table 6. The regression results of molecular female connection degree sample

Variable	(1) Frequent con-tact fraud	(2) Infrequent con-tact fraud	(3) Frequent con-tact ln_loss	(4) Infrequent con-tact ln_loss
Digital aging	-0.234** (0.103)	-0.378 (0.260)	-1.591** (0.745)	-1.895 (1.536)
Control variable	Yes	Yes	Yes	Yes
Provincial fixed effect	Yes	Yes	Yes	Yes
Observed value	334	168	345	189
Pseudo R2	0.130	0.149	0.064	0.092

Regional heterogeneity analysis.

It can be seen from Table 7 that the degree of digital aging in the eastern region can significantly reduce the possibility of actual financial fraud and the amount of financial fraud losses of the elderly.

Table 7. Sub-regional sample regression results

Variable	(1) East fraud	(2) Central fraud	(3) West fraud	(4) East ln_loss	(5) Central ln_loss	(6) West ln_loss
	-0.214* (0.119)	-0.243 (0.183)	-0.210 (0.141)	-1.568* (0.874)	-1.470 (1.107)	-1.413 (1.101)
Digital aging	Yes	Yes	Yes	Yes	Yes	Yes
Control variable	Yes	Yes	Yes	Yes	Yes	Yes
Provincial fixed effect	193	157	184	193	157	184
Observed value	0.051	0.092	0.103	0.024	0.035	0.039

In summary, the heterogeneity test results of cognitive ability, children 's contact degree and region show that hypothesis 4 is established.

5   Research Conclusions and Suggestions

Based on CHARLS2018 data, this paper studies the impact of digital aging on the financial fraud loss of the elderly and the moderating effect of mental vulnerability from the perspective of digital aging. The results show that : Digital aging can significantly reduce the actual financial fraud probability and the amount of financial fraud losses of the elderly. After endogenous test and robustness test, the conclusion is still valid.

First, from the perspective of government guidance. We should implement the action of " smart help for the elderly, " further bridge the " digital divide " and help the elderly fully enjoy the " digital dividend " .

Second, from the perspective of enterprise innovation. Leading enterprises should play a leading role in innovation, develop targeted public welfare products and courses, and help the elderly with lower digital skills to better ' touch the Internet '.

Third, from the perspective of family feedback. Children need to correctly understand and properly handle intergenerational relationships, give mental comfort to the elderly, and actively establish good continuous communication with the elderly.

Fourth, from the perspective of personal fraud prevention. The elderly should take active preventive measures to improve their financial security awareness and scientific

quality from the perspective of anti-vulnerability, and improve their ability to access, acquire and use information, so as to effectively prevent and respond to financial fraud.

Reference

1. Zhou Li, Feng Dawei, Yi Xingjian. Digital Inclusive Finance and Urban-Rural Income Gap : ' Digital Dividend ' or ' Digital Divide ' [J].Economist, 2020, (5) : 99-108. DOI:10.16158/j.cnki.51-1312/f.2020.05.011.

2. Wang Junxiu. Vigilance against elderly people falling into ' isolated islands ' [J]. People 's Forum, 2017, (16) : 62-63. DOI:10.16619/j.cnki.rmlt.2017.16.027.

3. Chen Dequan, Du Tianxiang. The practical logic, concept interpretation and implementation path of digital aging [J].E-government, 2022, (12) : 101-110. DOI:10.16582/j.cnki.dzzw.2022.12.010.

4. Lei Xiaoyan, Shen Yan, Yang Ling. Research on the fraud of the elderly in China in the digital age-the role of the Internet and digital inclusive finance [J].Financial Research, 2022, (8) : 113-131. https://kns.cnki.net/kcms/detail/detail.aspx?FileName=JRYJ202208007&DbName=CJFQ2022.

5. Lu Xiaomeng, Wu Yu, Yin Siyuan. The current situation, social harm and negative externality of fraud crime in China-Empirical evidence from micro data [J].Fujian Forum : Humanities and Social Sciences, 2020, (2) : 100-109.https://kns.cnki.net/kcms/detail/detail.aspx?FileName=FJLW202002011&DbName=DKFX2020.

6. Wu Wenying, Zhu Jinde. The ethical reflection and regulation of network aging [J]. Academic Exchange, 2021, No.331 (10) : 115-129 + 192. https://kns.cnki.net/kcms/detail/detail.aspx?FileName=XSJL202110010&DbName=CJFQ2021.

7. Nakaya N，Bidstrup P E，Eplov L F et al.Brief Report：Mental Vulnerability and Survival After Cancer[J].Epidemiology，2009：916-920. DOI: 10.1097/EDE.0b013e3181b5f3b0.

8. Spreng R N，Karlawish J，Marson DC.Cognitive，Social，and Neural Determinants of Dimin-ished Decision-making and Financial Exploitation Risk in Aging and Dementia：A Review and New Model [J].Journal of Elder Abuse & Neglect，2016，28(4)：320-344.DOI: 10.1080/08946566.2016.1237918.

9. Yang Hang, Shao Jingjin, Zhang Qianhan, etc. Fear of aging and susceptibility to deception in the elderly : the mediating role of security and control [J]. Chinese Journal of Clinical Psychology, 2019, (5) : 1036-1040. DOI:10.16128/j.cnki.1005-3611.2019.05.037.

10. Judges R A，Gallant S N，Yang L，et al.The Role of Cognition，Personality，and Trust in Fraud Victimization in Older Adults[J].Frontiers in Psychology，2017，8(3)：275-282. DOI: 10.3389/fpsyg.2017.00588.

11. Li Yuanyuan, Shan Chengyun. Research on the influencing factors of financial fraud of middle-aged and elderly people in China-Empirical analysis based on CHARLS2015 [J].Southern population, 2020, (1) : 13-26. https://kns.cnki.net/kcms/detail/detail.aspx?FileName=LFRK202001002&DbName=CJFQ2020.

12. Tobin,James.Estimation of Relationships for Limited Dependent Variables[J].Econometrica, 1958, 26(1):24-36.DOI:10.2307/1907382.

13. Eplov LF，Petersen J，Jørgensen T，et al.The Mental Vulnerability Questionnaire：a psychometric evaluation[J].Scandinavian Journal of Psychology，2010，51(6)：548–554. https://doi.org/10.1111/j.1467-9450.2010.00834.x.