The impact of the aging population on financial stability

——Analysis of the mediating effect based on digital financial inclusion

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Abstract: Based on the panel data in China, this paper analyses the relationship between the aging population, digital financial inclusion and financial stability. We firstly construct an index to measure the degree of financial stability by the entropy method. Then we run the regression and verify the mediating effect of digital financial inclusion using bootstrap mediating effect test. The results show that China's aging population promotes financial stability; digital financial inclusion is one of the mediating paths through which the aging population affects the financial stability; the mediating effect of digital financial inclusion reflects the incomplete development of digital financial inclusion in China.

1. Introduction

The Working Conference of China Banking and Insurance Regulatory Commission held on January 26, 2021, pointed out that while trying to improve financial services in two aspects, quality and effectiveness, it is necessary to spare no effort to prevent and defuse financial risks. Ensuring the financial system's stability and security is becoming an important goal of Chinese government regulatory agencies. As China focuses on restraining financial stability, the aging population also comes into their minds and becomes a significant problem. According to *China Development Report 2020: China's aging population Development Trends and Policies* released by China Development Research Foundation, China's aging population continues to become deepen, and the aging trend is irreversible. It is expected that China's total population will reach a peak between 1.42 billion and 1.44 billion by 2030, after which it will enter a long-term negative growth phase.

In China, the heavy influx of older people has impacted financial stability, which also provides new chances for digital financial inclusion development. Ma Shaogang, deputy director of the Consumer Insurance Bureau of the People's Bank of China, at the CPCP Shanghai high-level seminar in 2019, emphasized the dual background of the aging population and the rapid development of digital technology, digital financial inclusion encounters both challenges and the opportunity of the "silver economy". It takes advantage of digital financial inclusion to mitigate the aging population's negative impacts has become a big talking point in China. This article analyses the relationship between financial stability, aging population, and digital financial inclusion in the hope of promoting practical exploration through theoretical analysis and providing policy recommendations.

2. Literature Review

There are both positive and negative effects of the aging population on financial stability. Wang (2020) argued that the aging population has a "wealth effect" and a "burden effect" on savings. When the "wealth effect" is greater than the "burden effect", the aging population is beneficial to realize the second demographic dividend and financial stability. Chen(2018) stated that older people are less risky and prefer bank deposits and other flexible and asset allocation methods with low-risk. Nie Gaohui and Yin Luyao (2020) reckoned that the aging population promotes the insurance market's development because older people have a greater demand for insurance and require more types of them, facilitating the circulation of funds in the financial market. Jin Guoxuan (2016) used the overlapping generation model to illustrate that the aging population causes a change in individual preferences for using or storing funds. The total domestic savings level gradually decreases as the

population is aging, resulting in a weaker ability to resist risks.

There are three main academic views on the relationship between digital finance inclusion and financial stability. The first view is that digital financial inclusion is one of the causes of financial instability. Using research methods such as impulse response analysis and variance decomposition analysis, In Ci Mengke (2019)'s study on inclusive finance, it is found that the index did not promote the level of financial stability but rather increased the likelihood of financial instability. Siddik and Kabiraj (2018) argued that the development of digital finance inclusion might shock the financial market, thus leading to poor financial stability. The second view is that the development of digital finance inclusion contributes to the development of financial stability. Waas (2015) implied that the development of digital financial inclusion improves financial markets' efficiency and reduces the systemic risk posed by shadow banking, therefore conducive to financial stability. The third view considers that the impact of digital financial inclusion on financial stability is inhibited at first and then promoted. Applying generalized moment estimation and Bootstrap mediating effect test procedures, Han Guyuan and Zhu Chen (2019) found an endogenous relationship between financial stability and digital financial inclusion. Its impact on financial stability is inhibited firstly and then promoted as digital financial inclusion improves.

The aging population constrains the development of digital financial inclusion. Guo Yanling (2020) found a threshold effect between the aging population's degree and the development of financial inclusion by constructing a panel data threshold regression model. The aging population's inhibitory effect on inclusive finance development becomes more potent when two indexes cross the threshold value. Shi, Y., and Huang, M.C. (2019) found that the aging population inhibits inclusive finance development by building a panel regression model. The aging population's inhibitory effect on digital financial inclusion varies in different parts of China, indicating that the inhibitory effect is most significant in the western districts and lowest in the eastern districts. Bian Zhongping and Wu Xiaoyi (2019) argued that the elder group's features, such as low receptiveness, lack of financial knowledge, and low-income level, hinder digital financial inclusion development.

Recently, scholars mainly conduct an empirical analysis of the relationship between the aging population and financial stability from asset returns and financial structure perspectives. In contrast to existing studies, this paper empirically analyzes the relationship between aging population and financial stability from digital financial inclusion, which has great practical significance in China, where digital financial inclusion is booming.

3. Methodology

3.1 Econometric Model

Based on the cointegration test and Hausman test results, this paper investigates the relationship between aging population, digital inclusion, and financial stability. We establish the following fixed effects model:

$$STAB_{it} = c + b_1 AGE_{it} + \sum_{k=1}^{k} \beta_k x_{kit} + u_{it}$$

In this model, STAB stands for financial stability index. AGE represents the old-age dependency ratio. k stands for the number of control variables. x_k represents the control variables, which mainly includes the following indexes: the degree of digital financial inclusion development (DFIIC), represented by PKU-DFIIC; the degree of financial support (FIN), represented by the ratio of fiscal spending to GDP of each province; the interaction term (DFIIC*AGE). We centralized the interaction term in this research to further improve the meanings of coefficients in this model.

3.2 Financial Stability Index

Based on the research of Guo, Chen et al. (2015), Neaime and Gaysset (2018), this paper uses the entropy value method to construct the financial stability index. We select five indicators: securities industry, banking, insurance, the proportion of the tertiary industry, and unemployment rate. These indicators are considered from three dimensions: financial market, industrial structure, and economic stability.

The entropy value method aims to weight assignment objectively. There are two main steps to operate the entropy value method: work out the information entropy of indexes and measure the weight according to the relative variation of indices. The index with higher strength has a greater weight. The principle of the entropy method dates back to information theory. In theory, information entropy is the magnanimity of the disorder level of a system. The enormous amount of information means a higher order level of system structure and less entropy value. Therefore, in the construction of an index system, entropy can gauge dispersion on different indicators. More excellent dispersion will have more effect on the overall comprehensive evaluation. Assume a regional financial stability index matrix $X = (x_{ij})_{m \times n}$, where $i = 1,2,3 \cdots, m$ represents the year and $j = 1,2,3, \cdots, n$ represents the evaluation index.

(1)Standardize the matrix X to eliminate dimensions:

$$x_{ij}' = \frac{x_{ij} - \min(x_{1j}, x_{2j}, \cdots, x_{mj})}{\max(x_{1j}, x_{2j}, \cdots, x_{mj}) - \min(x_{1j}, x_{2j}, \cdots, x_{mj})}$$

(2)Compute the proportion of the index j in the year i :

$$p_{ij} = \frac{x_{ij}'}{\sum_{i=1}^{m} x_{ij}'}$$

(3)Calculate the information entropy of index j :

$$e_j = -\frac{1}{\ln m} \sum_{i=1}^{m} p_{ij} \ln p_{ij}$$

(4)Calculate the weight of index j :

$$w_j = \frac{1 - e_j}{\sum_{j=1}^{n} (1 - e_j)}$$

(5)Sum the weighted items to get the index value of year i :

$$U_i = \sum_{j=1}^{n} w_j p_{ij}$$

Each year, we calculate the financial stability indexes following the steps above to measure each province's financial stability degree. This financial stability index is positive, which means the more extensive the index's value, the higher the degree of financial stability.

4. Empirical Results

4.1 Regression Analysis Results

In this paper, we used the statistical data of 31 provinces in China from 2011 to 2018. We conduct two regressions by using OLS estimation. The second regression adds interaction terms to study the

moderating effect of digital financial inclusion. This equation allows some degree of multicollinearity due to the interaction terms. Relevant data are obtained from the *Digital Financial Inclusion Index of Peking University* (PKU-DFIIC), *China Statistical Yearbook,* and Database of China Economic Information Network. Table 1 shows the results of OLS estimation.

Table 1. OLS estimation results

Variable	OLS1	OLS2
AGE	1.283926*** (2.793950)	1.329819*** (2.846228)
DFIIC	-0.239761** (-2.572587)	-0.242096** (-2.590945)
FIN	0.900828*** (3.051440)	0.905939*** (3.062367)
DFIIC*AGE		-0.003562 (-0.572213)
c	127.4668***	127.5320***
R^2	0.922841	0.922963

Note: ***, ** and * indicate significance at the level of 1%, 5% and 10%. The results in parentheses are t values.

From the results of the first regression, R^2 is large. Besides that, The coefficients of AGE and FIN are significantly positive at the level of 1%, and the DFIIC coefficient is significantly negative at the level of 5%. So we can conclude that the model is well fitted. It suggests that China's aging population and the financial support are now promoting financial stability, while digital financial inclusion inhibits it. Referring to the explanation of Sahay et al. (2015) and Ci Mengke (2019), we conclude that the lack of appropriate supervision is the main reason for the financial instability caused by digital financial inclusion in China. In contrast to some developed nations, China's current financial regulatory system in digital financial inclusion lacks independence. Moreover, there is no standardized theory and system related to supervision, which increases financial risks.

After introducing the interactive item, the significance of each variable coefficient remains constant. However, the interactive item's coefficient is not conspicuous, and R^2 alters slightly, so the moderating effect is negligible. The changes from the development of digital financial inclusion do not affect the degree of the impact which is caused by the aging population on financial stability. It is signified that, in China, the acceptance of digital financial inclusion is low in the elderly group.

4.2 Bootstrap Mediating Effect Test

We believe that the aging population may promote financial stability by inhibiting digital financial inclusion, so we use the digital financial inclusion index as the main mediating variable. At present, there are three main methods to test the mediating effect: Stepwise regression, the Sobel test, and the Bootstrap test. According to the research of Zhao et al. (2010) and Chen Rui et al. (2013), we use the Bootstrap method to test the mediating effect. The estimated results of this approach include total effect, direct effect, an indirect effect. The direct effect refers to the direct influence of the independent variable on the dependent variable, while the indirect effect refers to the influence of the independent variable on the dependent variable. The total effect is the sum of them.

Furthermore, the mediating effect is considered to exist when the indirect effect is significant. According to the direct effect's significance, the mediating effect can be divided into full intermediate effect and incomplete intermediate effect. If the indirect effect is significant, but the direct effect is not, we call it a full mediating effect. If both indirect and direct effects are significant, we call it incomplete intermediate effect. The relationship between the three effects is expressed in Figure 1.
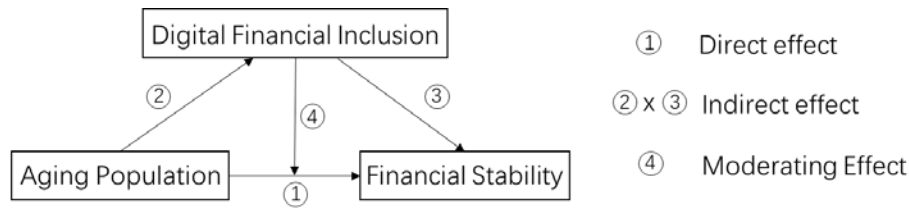
Figure 1. Diagram of mediating and moderating effects

Preacher and Hayes (2004) first introduced the Bootstrap method and was later summarized as a mediating effect testing procedure by Zhao et al. (2010). The procedure has been recognized internationally. Compared with the Stepwise regression method and Sobel test, the Bootstrap method loosens the typical distribution assumption and estimates the standard error by resampling, which is especially suitable for a small sample size. This study divides the whole country into two parts: middle eastern districts and middle western districts. It estimates the effects by extracting samples 1000 times with a repeat pattern, computed under a 95% confidence interval. Table 2, 3, 4 respectively shows the results of direct, indirect, and total effects.

Table 2. Direct and indirect effects of aging population on financial stability

	Effect size	Boot (SE)	Boot (LLCI)	Boot (ULCI)
Direct effect	0.7908541	0.3195443	0.1645588	1.417149
Indirect effect	3.050296	0.3422595	2.379479	3.721112
Total effect	3.8411501			

Table 3. Direct and indirect effects of aging population on financial stability in the middle eastern region

	Effect size	Boot (SE)	Boot (LLCI)	Boot (ULCI)
Direct effect	1.239141	0.437308	0.3820326	2.096249
Indirect effect	3.173708	0.4321834	2.326644	4.020772
Total effect	4.412849			

Table 4. Direct and indirect effects of aging population on financial stability in the middle western region

	Effect size	Boot (SE)	Boot (LLCI)	Boot (ULCI)
Direct effect	-0.02172375	0.43145135	-0.8673528	0.8239053
Indirect effect	3.2063616	0.43860406	2.346713	4.06601
Total effect	3.18463785			

Table 2 shows that the direct effect value of the aging population on financial stability is 0.7908541, and the significant interval is (0.1645588,1.417149), excluding 0, which implies the direct effect is of significance. The indirect effect value of digital financial inclusion is 3.050296, and the significant interval is (2,379479,3,721112), excluding 0, indicating that the indirect effect is of conspicuousness. The above results indicate an incomplete intermediate effect of digital financial inclusion, and the aging population can promote financial stability by inhibiting the development of digital financial inclusion. As the mediating effect is incomplete, and practical research is challenging to find all the mediating variables, digital financial inclusion is not the only mediating variable between the aging population and financial stability.

Table 3 and Table 4 show that the indirect effect values of digital financial inclusion in middle eastern districts and middle western districts are 3.173708 and 3.2063616. The significant interval is (2.326644,4.020772) and (2.346713,4.06601), both of which do not contain 0, so it can be concluded that the indirect effect is of significance. Therefore, the mediating effect of digital financial inclusion will not be affected by the region. The aging population's direct effects on financial stability in middle eastern districts and middle western districts are 1.239141 and -0.02172375. The significant ranges are (0.3820326,2.096249) and (-0.8673528,0.8239053). The direct effect is still conspicuous in

middle eastern districts but is not conspicuous in middle western districts. Excluded that, the direct effect value becomes negative in the middle western regions. The aging population in China presents a geographical distribution, and its effect on financial stability is affected by the degree of financial development.

5. Conclusion and Recommendations

This paper empirically studies the relationship between the aging population, digital financial inclusion, and financial stability. The conclusions are listed as follows:

1) The aging population has a promoting effect on financial stability, but it is affected by local financial growth. The effect expresses negatively in districts where the level of financial development is low.

2) Digital financial inclusion is not conducive to financial stability. The lack of appropriate regulation is the main reason.

3) Digital financial inclusion has an incomplete mediating effect between the aging population and financial stability. The aging population promotes financial stability by inhibiting the development of digital financial inclusion.

4) Digital financial inclusion does not play a moderating role in the aging population's influence on financial stability, which is related to the low penetration rate of digital financial inclusion among the elderly group.

It is a feature of China's current development that the aging population promotes financial stability by restraining the development of digital financial inclusion, which reflects the problems of digital financial inclusion development in China, such as the low development level of digital financial inclusion; the lack of appropriate supervision and low acceptance among the elderly. With the development of digital financial inclusion in China, its inhibiting effect on financial stability will promote a promoting effect. At that time, digital financial inclusion will have a high penetration rate among the elderly so that the mediating effect will become lower and the moderating effect will become higher. The development of digital financial inclusion will enhance the positive effect of an aging population on financial stability.

Based on the above consequences, we bring forward the following recommendations for Chinese agencies and institutions:

1) Financial supervision departments should pay more attention to financial stability. For the level of financial stability, it will restrict the level of financial development. A low level of financial development may increase the negative effect of the aging population on financial stability. The decline of financial stability will further amplify the aging population's negative effect, which forms a vicious circle. So relevant departments should improve financial-tax revenue, regulatory and other policies to prevent and defuse financial risks timely.

2) Improve relevant laws to regulate the development of digital financial inclusion. The development of digital financial inclusion should not only go fast but also go steady. In developing digital financial inclusion, relevant government departments should establish a sound regulatory and legal system to reduce the technical and financial risks. In this way, digital financial inclusion can be better accepted by the elder group.

3) Use digital financial inclusion to boost the development of aging finance. Senior finance is an important measure to deal with the aging population. China should make full use of digital financial inclusion's technological advantages to further develop aging finance and increase the popularity of digital financial inclusion among the elderly. The intermediary effect of digital financial inclusion will become a moderating effect to cope with the aging of the population.

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