Digital Inclusive Finance and Individual Commercial Pension Insurance Participation

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Abstract— *With the increasingly severe problem of social aging, commercial pension insurance, as an important supplement to personal pension security, has become the focus of public attention. The rise of digital financial inclusion provides new opportunities for individuals to participate in commercial pension insurance, and financial literacy and financial development play a crucial role in this process. This paper explores the relationship between digital financial inclusion and the participation rate of individual commercial pension insurance. The results show that digital inclusive finance significantly improves the probability of residents participating in commercial pension insurance by providing convenient and low-cost financial services. At the same time, financial literacy and financial development play an important intermediary role in this process, helping residents better understand financial products, thereby increasing their willingness to participate in commercial pension insurance. In addition, personal characteristics, family status and regional economic factors also have a significant impact on the participation rate of commercial endowment insurance, healthy individuals, individuals participating in basic endowment insurance, women, individuals with more real estate and vehicles are more inclined to buy commercial endowment insurance, families with more children are less demanding for commercial endowment insurance, and the increase in government public budget expenditure also prompts residents to be more inclined to buy commercial endowment insurance. Further analysis shows that digital inclusive finance has a more significant promoting effect among non-party members, residents who often use the Internet, agricultural residents, urban residents, and residents in the eastern region. Overall, the rapid development of digital inclusive finance has provided a strong impetus for the participation of individual commercial pension insurance, and financial literacy and financial development have played a bridge role in this process, promoting residents' awareness and participation in commercial pension insurance.*

Keywords—Commercial Endowment Insurance, Digital Financial Inclusion, Financial Literacy, Financial Development.

I. INTRODUCTION

With the intensification of the global aging problem, the traditional old-age security system is facing huge challenges. In many countries, especially China, the rate of population aging is accelerating, and the pressure on old-age security is increasing day by day. In order to cope with this social challenge, commercial endowment insurance, as an important supplement to personal endowment security, has gradually attracted widespread attention. Compared with the traditional pension model, commercial pension insurance can provide individuals with more flexible and personalized protection options, and has become an indispensable part of the aging society. However, despite the obvious advantages of commercial pension insurance, there are still a large number of residents who have not fully participated in it, especially in low-income groups and in some areas [2]

In recent years, with the rapid development of digital technology, digital inclusive finance, as an innovative financial service model, provides a new opportunity for individuals to participate in commercial pension insurance. Digital inclusive finance has lowered the threshold for financial services through Internet technology, enabling more residents, especially those in remote areas, to obtain financial products at a lower cost and participate in commercial pension insurance [1]. This emerging financial

model not only increases the penetration of financial services, but also improves the financial availability of residents, thus providing them with more pension security options[3]. However, although digital inclusive finance has brought a positive impact on the promotion of commercial pension insurance, the actual effect is constrained by many factors [4]

In this context, financial literacy refers to an individual's ability to understand and apply financial products, which directly affects whether residents can correctly understand and choose commercial pension insurance products suitable for themselves. Individuals with high financial literacy are often better able to make rational financial decisions, so they are more willing to participate in commercial pension insurance. At the same time, the degree of financial development, including the maturity of the financial market and the popularity of financial services, will also affect residents' participation behavior in the context of digital financial inclusion.

The purpose of this paper is to explore how digital inclusive finance can promote residents' willingness to participate in commercial pension insurance by improving financial literacy and promoting financial development. Through empirical analysis, this paper will deeply reveal the mechanism of digital financial inclusion, financial literacy and financial development in promoting residents' participation in commercial pension insurance, and explore the influence of multiple factors such as individual characteristics, family status and regional economy on this process. The study will also examine the differences in the participation of different groups in commercial pension insurance, especially in terms of the impact of digital financial inclusion in different regions, income levels, frequency of Internet use, and other socio-economic factors.

II. LITERATURE REVIEW AND RESEARCH HYPOTHESIS

2.1 Research on digital financial inclusion:

As an emerging financial innovation, digital inclusive finance is profoundly changing the financial behavior of Chinese residents. The research shows that digital inclusive finance significantly improves the possibility of residents participating in various financial products, including commercial pension insurance, by providing convenient and low-cost financial services. In the existing literature, digital financial inclusion is often regarded as the core explanatory variable, and its impact on financial participation and insurance participation rate has been widely explored.

Yu et al. [5] (2022) pointed out that digital inclusive finance has significantly promoted the transformation of rural residents' consumption structure, enabling them to more easily access and purchase various financial products, including commercial pension insurance. Similarly, Li et al. [6] (2022) also found that digital financial inclusion enhances residents' financial access capacity, especially among economically weaker groups, and further promotes their possibility of participating in commercial pension insurance. Li et al. [7] (2020) discussed how digital inclusive finance can improve residents' awareness and acceptance of products such as pension insurance by simplifying financial processes and access to information.

Financial literacy as a mediating variable has also received attention in several studies. Hasan et al. [8] (2021) pointed out that financial literacy indirectly affects residents' acceptance of long-term security products such as commercial pension insurance by enhancing their awareness of investment and savings products. In particular, the popularization of digital inclusive finance has improved residents' financial literacy, which in turn has affected their insurance purchase behavior. Hasan et al. [8] (2021) and Yi et al. [9] (2024) both showed that financial literacy can enhance residents' understanding of financial products and make them more willing to participate in commercial pension insurance.

2.2 Research on the participation rate of commercial pension insurance:

The participation rate of commercial pension insurance is affected by a variety of factors, involving multiple levels such as individuals, families and regions. The study shows that factors at the individual level, such as age, marital status, education level, participation in basic pension insurance and medical insurance, as well as economic status and demographic structure at the family level, have an important impact on whether residents participate in commercial pension insurance. In addition,

external environmental factors such as price levels and policy support at the regional level also affect residents' participation in pension insurance decision-making to a certain extent.

At the individual level, age and gender were the control variables that were widely studied. Age and gender have been selected in several studies as factors influencing participation rates in commercial pension insurance [10][11]. In addition, marital status was also included as one of the influencing factors, and there were differences in the participation rate between married and unmarried residents [11]. Education level is also generally regarded as an individual-level variable in the study, and it is believed that people with higher education level have different attitudes towards commercial pension insurance [12]. The participation of basic pension insurance is also a control variable in many literatures, and researchers believe that residents who participate in basic pension insurance may have a lower demand for commercial pension insurance [13].

At the household level, garage ownership is widely used to analyze households' participation behavior as an indicator of economic status [14]. In addition, the number of family members and the number of children are also commonly studied variables, and it has been found that the number of family members may influence the intention to participate [15]. These factors reflect the family's financial situation and needs.

Among the control variables at the regional level, the price level (CPI) has been mentioned many times, and the price level affects residents' spending ability and willingness to save, so it has become an important factor influencing the decision to participate in insurance [16]. Another common regional-level variable is local government policy support, such as the proportion of fiscal expenditure in each province, and studies have shown that the level of local government fiscal expenditure is closely related to the likelihood of residents participating in commercial pension insurance [17].

To sum up, the decision-making of residents' participation in commercial endowment insurance is the result of the joint influence of multiple factors. Individuals' age, marital status, educational background, participation in basic security, family wealth status and member composition, as well as regional price levels and government policy support, all affect the participation rate of commercial pension insurance to varying degrees. Understanding the impact of these control variables on insurance decision-making will help to better design targeted policies and promote the healthy development of the commercial pension insurance market.

2.3 Research on the participation rate of digital inclusive finance and commercial pension insurance:

The impact of digital inclusive finance on the participation rate of commercial pension insurance has become a research hotspot in recent years. Wang et al. [18] (2020) argue that digital inclusive finance effectively promotes the popularization of social security and increases the participation rate of commercial pension insurance by improving the availability of financial services, especially for low-income groups. Liu Dongjiao and Zhuang Pengtao [19] (2021) found that digital inclusive finance significantly increased households' willingness to purchase commercial insurance by simplifying the insurance application process and reducing transaction costs. Li et al. [20] (2021) further pointed out that the popularity of digital finance has enhanced consumers' trust in insurance products, especially in economically underdeveloped regions. Wang Renzeng and Huang Xiaoying [21] (2021) showed that the convenient online services and information transparency provided by digital inclusive finance have further reduced the complexity of insurance products and promoted the participation of commercial pension insurance. Xie et al. [22] (2024) analyzed that digital inclusive finance promotes the participation of low-income families in pension insurance by reducing information asymmetry.

International research has also confirmed the positive impact of digital financial inclusion. Zhang and Tang [23] (2022) found that digital financial inclusion not only drives the health insurance market, but also has a positive impact on participation in the pension insurance market [8]. Hasan et al. [24] (2022) highlighted that improving financial inclusion through digital financial services can enable more uninsured groups to access financial services and further promote the popularization of pension insurance . Hou et al. [25] (2024) showed that the differences in digital financial inclusion in different regions and groups have contributed to the popularization of commercial insurance, especially in countries with large regional differences.

2.4 Research hypotheses:

With the continuous progress of digital technology, digital inclusive finance has become a key direction for the development of financial services in China. Through technologies such as the Internet, big data, and artificial intelligence, digital inclusive finance has lowered the threshold for financial services and provided more convenient and low-cost financial products and services [8]. Previous studies have shown that digital financial inclusion not only promotes financial inclusion in rural areas, but also improves the availability of financial services for low-income groups in urban areas, especially in areas and populations that are difficult to be covered by traditional financial services [9][26].

In this context, digital inclusive finance is expected to increase the participation rate of China's individual commercial pension insurance. By providing low-barrier financial products, digital inclusive finance enables residents to access financial services such as commercial pension insurance at a lower cost. At the same time, the optimization of information dissemination channels and the popularization of financial literacy have further reduced the barriers to participation [6]. Therefore, the development of digital inclusive finance is expected to significantly increase the participation rate of commercial pension insurance. In summary:

Hypothesis H1: Digital inclusive finance can promote the participation rate of commercial pension insurance in China.

Previous studies have shown that the level of financial literacy directly affects residents' cognition and use of financial products, and then affects their enthusiasm to participate in the financial market [8]. Especially in China, financial literacy is generally low, and there are still great obstacles for residents to understand complex financial products, especially commercial pension insurance [6]. With the development of the financial market, improving financial literacy has become an important way to improve residents' participation in the financial market.

Digital financial inclusion can help improve residents' financial literacy by providing financial education resources, information popularization, and online consultation [26]. Through the digital platform, residents can not only easily access relevant financial knowledge, but also better understand the features and advantages of various financial products. In addition, the digital financial inclusion platform can also guide residents to participate in financial products that meet their needs through precise recommendations[5]. Therefore, digital inclusive finance can not only improve the financial literacy of residents, especially by increasing the number of investment products, enhance their tendency to participate in the financial market, and further promote the purchase of commercial pension insurance. In summary:

Hypothesis H2: Digital inclusive finance can improve residents' financial literacy and enhance their tendency to participate in the financial market, thereby promoting residents' purchase of commercial pension insurance.

Financial development plays a key intermediary role between digital inclusive finance and the participation rate of commercial pension insurance. Specifically, the popularization of digital inclusive finance has promoted financial development, thereby promoting the innovation of financial products and the improvement of market efficiency. Financial development is measured by the added value of the financial industry, which improves the accessibility of financial services and enhances consumer trust in participation, especially in the field of pension insurance, and promotes wider participation. Therefore, financial development has become a bridge for digital inclusive finance to affect the participation rate of commercial pension insurance by improving the quality and popularity of financial services.

The added value of the financial sector is an important indicator to measure the contribution of the financial sector to the economy, reflecting the gross domestic product of financial services and their role in resource allocation and economic growth. With the development of digital financial inclusion, financial services have become more accessible through the Internet and mobile technology, especially in low-income groups and rural areas. The promotion of digital inclusive finance not only enhances the added value of the financial industry, but also promotes the innovation and popularization of financial products, provides convenient financial services for more people, and creates favorable conditions for the participation of long-term financial products such as commercial pension insurance. In summary:

Hypothesis H3: As an indicator of financial development, the added value of the financial industry plays an intermediary role between digital inclusive finance and the participation rate of commercial pension insurance.

III. RESEARCH DESIGN

3.1 Data sources:

The data used in this paper is mainly composed of three parts: First, the data of commercial pension insurance comes from the survey data of the Chinese general social survey (CGSS) project in 2021, which is the earliest micro survey project based on comprehensive and continuous nationwide in China, CGSS has collected data since 2003, covering multiple dimensions including society, community, family and individual. It is of great scientific and practical significance. Second, the data on digital financial inclusion comes from a joint research group composed of the Digital Finance Research Center of Peking University and the Ant Technology Group Research Institute, which is used to measure the development of digital financial inclusion. Third, the data at the provincial level come from the provincial statistical yearbooks, which ensures the authenticity, integrity and representativeness of the data. In this paper, the data of the above three aspects are matched and combined, and a total of 5810 samples are involved after excluding outliers and missing values.

3.2 Variable selection:

3.2.1 Explanatory variables:

Commercial pension insurance participation rate (CEI), this paper uses the answers of "whether you currently participate in the following social security programs - commercial pension insurance" in the 2021 CGSS questionnaire to measure the commercial pension insurance participation rate, and assigns the explanatory variable to 0 or 1 according to the respondents' choice from the options "participated, not participated, not applicable, do not know, refuse to answer", in which no participation, not applicable, do not know, refuse to answer 0, participation is 1.

3.2.2 Core explanatory variables:

Digital Financial Inclusion Index (Ln_DFI). The logarithm of the Peking University Digital Inclusion Index, compiled by a joint research group composed of the Peking University Digital Finance Research Center and the Ant Technology Group Research Institute, is used to measure the development of digital financial inclusion. In addition, this paper also uses Breadth, one of the sub-dimensions of digital inclusive finance, to further explore the impact of different dimensions of digital inclusive finance on the participation rate of individual commercial pension insurance, and the coverage breadth is selected as a substitute variable for the robustness analysis of the model.

3.2.3 Intermediary variables:

Financial literacy (Totle_Investment). Financial literacy is selected as the mediating variable, and financial literacy is measured by the number of investments involved (e.g., stocks, bonds, real estate, etc.). The number of investments can reflect the knowledge and behavioral ability of residents in financial decision-making, and then reflect their ability to understand and use different financial products.

Financial Development (Ln_Finance). With the continuous development of the financial industry, the popularity and quality of financial services have been significantly improved, which makes it easier for residents to access and use digital inclusive financial products. By improving the accessibility and diversity of financial services, financial development has effectively promoted residents' participation in commercial pension insurance.

3.2.4 Control variables:

The control variables in this paper mainly include three levels: individual, family and region, including age (Ln_Age), marital status (Marriage), basic pension insurance (Basic_pesion) and medical insurance (Medical_pention), education level (Edu), household registration status (Accounts), Political, and Internet usage; At the household level, it includes car and house ownership, children and total family size. The regional level, including the price level, is measured as the logarithm (Ln_CPI) of the consumer price index of each province, and policy support (Gov) is measured as the logarithm of the general public budget expenditure of each provincial government as a share of the province's GDP. The definitions, symbols, and descriptive results of each variable are shown in Table 1.

TABLE 1
VARIABLE DEFINITIONS AND DESCRIPTIVE STATISTICS

Variable		Valid sample size	Mean	Variance	Min	Max	Variable definitions
Explanatory variables	Commercial_Pension	5,810	0.078	0.269	0	1	Whether or not to participate in commercial pension insurance (yes=1, no=0)
Core explanatory variables	Ln_DFI	5,810	3.858	0.311	3.3	4.45	The logarithm of the Master Index for Digital Financial Inclusion
	Ln_DFI20	5,810	5.867	0.089	5.7	6.04	
	Ln_DFI19	5,810	5.814	0.092	5.64	5.99	
	Ln_DFI18	5,810	5.736	0.091	5.57	5.91	
Mediation variables	Total_Investment	5,810	0.137	0.433	0	2	Number of investment types purchased (stocks,funds,bonds,futures,warrants,property speculation,foreign exchange investments)
	Ln_Finance	5,810	8.051	0.683	5.62	9.11	The logarithm of value added in the financial sector
Control variables	Children	5,810	0.884	0.768	0	3	Number of children
	Gender	5,810	0.505	0.5	0	1	Gender (0=Female 1=Male)
	Ln_Age	5,810	3.84	0.367	3	4	The logarithm of age
	Edu	5,810	1.785	1.586	0	4	Highest education (0=elementary school and below 1=junior high school, high school, technical secondary school and technical school 2=college degree or above)
	Health	5,810	3.494	1.061	1	5	Health (1=Very Good 2=Very Good 3=Good 4=Fair 5=Poor)
	Marriage	5,810	2.437	1.054	0	3	Marital status (0=cohabiting/unmarried, 1=divorced, 2=widowed, 3=having a legal spouse)
	Basic_Pension	5,810	0.765	0.424	0	1	Participation in basic pension insurance (0=no 1=yes)
	Medical_Pesion	5,810	0.947	0.224	0	1	Whether or not to participate in basic medical insurance (0=no 1=yes)
	Gov	5,810	2.899	0.271	2.35	4	The logarithm of the general public budget expenditure of each provincial government as a percentage of the GDP of the province
	Size	5,810	3.317	1.736	1	9	Total household population
	Property	5,810	1.26	0.748	0	5	Number of properties
	Car	5,810	0.429	0.495	0	1	Car ownership (0=no 1 = yes)
	Ln_CPI	5,810	4.615	0.004	4.61	4.62	The logarithm of the consumer price index
	Accounts	5,810	1.437	0.52	0	2	Hukou registration status (0=Other, 1=Rural 2=Urban)
	Political	5,810	0.146	0.354	0	1	Political outlook (0=non-party member 1=party member)
	Internation	5810	1.731	0.443	1	2	Frequent internet use (1=No 2=Yes)

3.3 Model setting:

3.3.1 Benchmark model:

In order to test the impact of digital inclusive finance on the participation of commercial pension insurance, since the questionnaire of the relevant dependent variable is set to "whether you currently participate in the following social security programs - commercial pension insurance", which is a binary variable, it is necessary to use a probabilistic model for fitting and estimating, and the benchmark model is set as follows:

$$\mathrm{CEI_{i,j}} = \alpha_i + \beta_i \mathrm{ln\_DFI_j} + \gamma_i \mathrm{X_{i,j}} + \varepsilon_{i,j} \quad (1)$$

In Eq. (1), the explanatory variable $CEI_{i,j}$ indicates whether the individual i in province j participates in commercial pension insurance, the explanatory variable $\ln\_DFI_j$ indicates the degree of digital inclusive financial development of province j, and $X_{i,j}$ represents the control variables at the individual, family and regional levels: at the individual level, including age, marital status, participation in basic pension insurance and medical insurance, education level, political outlook, and household registration status; At the household level, it includes garage ownership, individual children and the total family population; At the regional level, it includes the price level and related policy support (the proportion of the general public budget expenditure of each provincial government in the GDP of the province), which ε is a random error term, and α_i,β_i and γ_i are the parameters to be estimated.

3.3.2 Mediation effect model:

In order to test the mediating effect of the benchmark regression model, this paper draws on the method proposed by Hasan et al. [8] to construct the model with financial literacy (whether or not to engage in investment activities) as an intermediate variable. Therefore, the following intermediary effect model is set up to test the impact mechanism of digital inclusive finance on the participation rate of commercial pension insurance:

$$\mathrm{CEI_{i,j}} = \alpha_1 + \beta_1 \mathrm{ln\_DFI_j} + \gamma_1 \mathrm{X_{i,j}} + \varepsilon_{i,j} \quad (2)$$

$$\mathrm{M_{i,j}} = \alpha_2 + \beta_2 \mathrm{ln\_DFI_j} + \gamma_2 \mathrm{X_{i,j}} + \varepsilon_{i,j} \quad (3)$$

$$\mathrm{CEI_{i,j}} = \alpha_3 + \beta_3 \mathrm{ln\_DFI_j} + \vartheta \mathrm{M_{i,j}} + \gamma_3 \mathrm{X_{i,j}} + \varepsilon_{i,j} \quad (4)$$

In equations (2), (3) and (4), $\mathrm{M_{i,j}}$ is the mediating variable, which represents the financial literacy of the ith individual located in province J, $\mathrm{CEI_{i,j}}$ represents the participation of individual i in the commercial pension insurance located in province J, the explanatory variable $\mathrm{DFI_j}$ represents the degree of digital inclusive financial development of province J, $X_{i,j}$ is the control variable, the ε is the random error term, and the β_1 value represents the total utility of the digital inclusive finance index level on the participation rate of commercial pension insurance, $\beta_2 * \vartheta$ represents the mediating effect of financial literacy on the participation rate of commercial pension insurance, and $\frac{\beta_2 * \theta}{\beta_1}$ represents the proportion of the mediating effect of financial literacy on the participation rate of commercial pension insurance.

IV. EMPIRICAL RESULTS AND ANALYSIS

4.1 Benchmark regression results:

First, the benchmark model was analyzed, and the results are shown in Table 2.

From the results of the benchmark regression model in Table 2, it can be seen that the digital inclusive finance index has a significant positive effect on the participation rate of commercial pension insurance, so the hypothesis H1 is verified. The coefficients of health status, participation in basic pension insurance, number of real estate ownership, car ownership and policy support were significantly positive at the 1% significance level, gender was significantly negative at the 5% significance level, and the coefficient of basic medical insurance purchase and the number of children was negative at the 1% significance level.

In summary, individuals with healthier physical conditions are more inclined to purchase commercial endowment insurance, which may be related to their strong sense of self-protection and risk management ability. Healthy individuals often expect to live longer and have a higher quality of life, so they tend to plan financially ahead of time to ensure that their quality of life in retirement is not compromised. In addition, healthy individuals often enjoy lower premiums when purchasing insurance, which also incentivizes them to accumulate wealth through commercial pension insurance. In summary, the behavior of healthy

individuals purchasing commercial endowment insurance reflects their active response to future uncertainty and the importance they attach to financial security.

TABLE 2
BENCHMARK MODEL REGRESSION RESULTS

Variable	(1)	(2)	(3)
	Commercial_Pension	Commercial_Pension	Commercial_Pension
Ln_DFI	0.077***	0.074***	0.087***
	-0.011	-0.011	-0.016
Gender		-0.012*	-0.014**
		-0.007	-0.007
Ln_Age		0.005	0.017
		-0.011	-0.012
Edu		0.002	0
		-0.002	-0.002
Health		0.020***	0.016***
		-0.003	-0.003
Marriage		-0.001	0
		-0.004	-0.004
Basic_Pension			0.036***
			-0.009
Medical_Pension			-0.043***
			-0.016
Size			-0.003
			-0.002
Property			0.014***
			-0.005
Car			0.046***
			-0.008
Children			-0.015***
			-0.005
Ln_CPI			0.687
			-0.95
Gov			0.063***
			-0.017
_cons	-0.219***	-0.290***	-3.721
	-0.044	-0.062	-4.357
N	5810	5810	5810
R^2	0.008	0.014	0.033

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively, and the robustness standard error is in parentheses.

Individuals who participate in basic social pension insurance are more likely to purchase commercial pension insurance, which reflects the need for multi-level protection. The limited nature of basic endowment insurance prompts them to seek commercial insurance to fill the protection gap, and at the same time, their strong risk aversion awareness and financial planning ability make them inclined to achieve long-term economic security and asset appreciation through commercial insurance.

In contrast, individuals participating in basic medical social insurance have a lower demand for commercial pension insurance. Due to the unpredictability of disease and the priority of medical insurance, medical insurance expenditure often replaces the investment of commercial pension insurance, thereby reducing the willingness to participate in insurance.

Women are more likely to buy commercial pension insurance, mainly because they have a longer life expectancy and pay more attention to long-term financial security. At the same time, women take on more family care responsibilities and have relatively low or unstable incomes, making them more reliant on commercial insurance to ensure financial security in retirement. In addition, the socio-cultural and policy environment may also encourage women to choose insurance as a risk management tool.

Individuals with more real estate tend to buy commercial pension insurance because they have more economic capital and risk aversion needs. As a symbol of wealth, real estate not only enhances purchasing power, but also reflects the focus on economic security and asset preservation and appreciation after retirement.

Individuals who own vehicles also show a higher propensity to purchase commercial pension insurance, reflecting their stronger economic strength and financial planning capabilities. As the embodiment of economic capital, the vehicle is consistent with a higher sense of risk aversion, prompting it to protect economic security after retirement through insurance.

On the contrary, families with more children are more dependent on family pension, reducing the demand for commercial pension insurance. At the same time, the increase in the number of children has led to the dispersion of resources and reduced investment in insurance products.

In addition, the increase in the proportion of general public budget expenditure of the provincial government in GDP (Gov) is positively correlated with the tendency of residents to purchase commercial pension insurance. Stronger policy support has boosted residents' confidence in future pension security and encouraged them to actively participate in commercial insurance schemes.

4.2 Mediation effect test:

4.2.1 Analysis of the mediating effect of financial literacy:

In order to further test the promotion effect of the digital inclusive financial index on the participation rate of commercial pension insurance in each province, this paper tests the mediating effect based on the results of the previous paper. The results of the mediating effect of financial literacy are shown in Table 3.

According to the results in Table 3, the β_1 value, ϑ value and β_3 value all reached significant levels, indicating that there was a significant mediating effect. At the same time, the digital inclusive finance index has a significant positive impact on the participation rate of commercial pension insurance, with a total effect value of 0.087, which further supports the positive role of digital inclusive finance in promoting the participation rate of commercial pension insurance.

TABLE 3
RESULTS OF THE MEDIATING EFFECT OF FINANCIAL LITERACY

Variable	(1)	(2)	(3)
	Commercial_Pension	Total_Investment	Commercial_Pension
Ln_DFI	0.087***	0.450***	0.045***
	-0.016	-0.024	-0.016
Gender	-0.014**	0.022**	-0.016**
	-0.007	-0.011	-0.007
Ln_Age	0.017	-0.102***	0.027**
	-0.012	-0.018	-0.012
Edu	0	-0.004	0
	-0.002	-0.003	-0.002
Health	0.016***	0.011**	0.015***
	-0.003	-0.005	-0.003
Marriage	0	-0.009	0.001
	-0.004	-0.006	-0.004
Basic_Pension	0.036***	0.044***	0.031***
	-0.009	-0.013	-0.009
Medical_Pension	-0.043***	-0.011	-0.041***
	-0.016	-0.024	-0.016
Size	-0.003	-0.015***	-0.002
	-0.002	-0.003	-0.002
Property	0.014***	0.053***	0.009*
	-0.005	-0.007	-0.005
Car	0.046***	0.102***	0.037***
	-0.008	-0.012	-0.008
Children	-0.015***	-0.039***	-0.012**
	-0.005	-0.008	-0.005
Ln_CPI	0.687	-3.554**	1.018
	-0.95	-1.445	-0.94
Gov	0.063***	0.197***	0.045***
	-0.017	-0.026	-0.017
Total_Investment			0.093***
			-0.009
_cons	-3.721	14.548**	-5.078
	-4.357	-6.629	-4.315
N	5810	5810	5810
R^2	0.033	0.139	0.053

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively, and the robustness standard error is in parentheses.

TABLE 4
RESULTS OF THE SOBEL TEST OF FINANCIAL LITERACY

	Mediator effect size	Standard error	z
Sobel	0.042***	0.004	9.44
Aroian	0.042***	0.004	9.43
Goodman	0.042***	0.004	9.45

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively, and the robustness standard error is in parentheses.

According to the analysis provided in Table 4, three different methods (Sobel, Aroian, Goodman) were used to test the significance of the mediating effect, and the results showed that the mediating effect estimates of the three methods were 0.042, the standard error was 0.004, and the z-statistic was 9.439, 9.430, and 9.449, respectively, and the corresponding P values were 0.000, which was significantly less than 0.05. This suggests that the mediating effect is significant.

TABLE 5
INDIRECT, DIRECT AND TOTAL EFFECTS (FINANCIAL LITERACY)

	Coefficient	Standard error	z
a_coefficient	0.450***	0.024	18.81
b_coefficient	0.093***	0.009	10.91
Indirect_effect_aXb	0.042***	0.004	9.439
Direct_effect_c'	0.045***	0.016	2.784
Total_effect_c	0.087***	0.016	5.508

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively, and the robustness standard error is in parentheses.

According to the results in Table 5, the indirect effect was 0.042, the direct effect was 0.045, and the total effect was 0.087. The P values for all effects were less than 0.05, indicating that these effects were statistically significant. At the same time, financial literacy has a significant role in promoting the participation rate of commercial pension insurance, and the intermediary effect accounts for 4.2%. Specifically, financial literacy plays a significant mediating role in the impact of the participation rate of commercial pension insurance, and about 48.5% of the effect is transmitted through the mediating variable of financial literacy. Therefore, it can be concluded that the mediating variable plays a key role between the independent variable and the dependent variable, and a considerable part of this effect is transmitted through financial literacy, so the hypothesis H2 is validated.

4.2.2 Analysis of the intermediary effect of financial development:

In order to further test the promotion effect of the digital inclusive financial index on the participation rate of commercial pension insurance in each province, this paper tests the mediating effect based on the results of the previous paper. The results of the intermediary effect of financial development (added value of the financial sector) are shown in Table 6.

TABLE 6
RESULTS OF THE INTERMEDIARY EFFECT OF FINANCIAL DEVELOPMENT

Variable	(1)	(2)	(3)
	Commercial_Pension	ln_Finance1	Commercial_Pension
Ln_DFI	0.087***	1.208***	0.056***
	-0.016	-0.018	-0.021
Gender	-0.014**	-0.019**	-0.013*
	-0.007	-0.008	-0.007
Ln_Age	0.017	0.053***	0.016
	-0.012	-0.014	-0.012
Edu	0	0.006**	0
	-0.002	-0.003	-0.002
Health	0.016***	-0.002	0.016***
	-0.003	-0.004	-0.003
Marriage	0	-0.012***	0
	-0.004	-0.005	-0.004
Basic_Pension	0.036***	0.01	0.035***
	-0.009	-0.01	-0.009
Medical_Pension	-0.043***	0.013	-0.043***
	-0.016	-0.019	-0.016
Size	-0.003	-0.003	-0.003
	-0.002	-0.002	-0.002
Property	0.014***	0.016***	0.014***
	-0.005	-0.006	-0.005
Car	0.046***	0.008	0.046***
	-0.008	-0.009	-0.008
Children	-0.015***	-0.023***	-0.015***
	-0.005	-0.006	-0.005
Ln_CPI	0.687	-3.766***	0.781
	-0.95	-1.11	-0.95
Gov	0.063***	-1.095***	0.091***
	-0.017	-0.02	-0.021
ln_Finance1			0.025**
			-0.011
_cons	-3.721	23.761***	-4.319
	-4.357	-5.093	-4.363
N	5810	5810	5810
R^2	0.033	0.796	0.034

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively, and the robustness standard error is in parentheses.

From the analysis in Table 6, it can be seen that the β_1 value, ϑ value, and β_3 value are all significant, indicating that the mediating effect exists and is significant. At the same time, the digital inclusive finance index also showed a significant positive impact on the participation rate of commercial pension insurance, with a total effect size of 0.087. This shows that digital inclusive finance has a positive role in promoting the participation of commercial pension insurance.

TABLE 7
RESULTS OF THE SOBEL TEST FOR FINANCIAL DEVELOPMENT

	Mediator effect size	Standard error	z
Sobel	0.030**	0.014	2.24
Aroian	0.030**	0.014	2.24
Goodman	0.030**	0.014	2.24

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively, and the robustness standard error is in parentheses.

According to the results of Table 7, the three methods (Sobel, Aroian, Goodman) were used to test the significance of the mediating effect, and the estimated values of the mediating effect of the three methods were 0.030, the standard error was 0.014, and the z-statistic was 2.239, 2.238 and 2.239, respectively, and the corresponding P values were all 0.025, which was significantly lower than 0.05, which further proved the significance of the mediating effect.

TABLE 8
INDIRECT, DIRECT AND TOTAL EFFECTS (FINANCIAL DEVELOPMENT)

	Coefficient	Standard error	z
a_coefficient	1.208***	0.018	65.7
b_coefficient	0.025**	0.011	2.24
Indirect_effect_aXb	0.030**	0.014	2.239
Direct_effect_c'	0.056***	0.021	2.708
Total_effect_c	0.087***	0.016	5.508

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively, and the robustness standard error is in parentheses.

As can be seen from Table 8, the indirect effect is 0.030, the direct effect is 0.056, and the total effect is 0.087. The P values for all effects were less than 0.05, indicating that they were statistically significant. At the same time, financial development (added value of the financial industry) has a certain role in promoting the participation rate of commercial pension insurance, of which the indirect effect accounts for 3%. Specifically, the added value of the financial industry plays a significant mediating role in the impact of the participation rate of commercial pension insurance, and about 35.1% of the effect is transmitted through the intermediary variable of the added value of the financial industry. Therefore, it can be concluded that the value added of the financial industry plays an important mediating role between the independent variable and the dependent variable, and about one-third of the effect is transmitted through this intermediary, so the hypothesis H3 is validated.

4.3 Robustness test:

4.3.1 Replace the explanatory variable:

In order to alleviate the influence of endogeneity on the estimation results, this paper uses the digital inclusive financial index with a lag of one period, the next two periods, and the third lag period as the core explanatory variables for regression, in order to reduce the estimation bias caused by reverse causality and prove that the development of digital inclusive finance has a long-term impact on the purchase of commercial pension insurance.

Since the development of digital inclusive finance can affect the purchase of commercial pension insurance for a long time, but the purchase behavior of commercial pension insurance may only affect the digital inclusive financial index of the current year, this paper replaces the core explanatory variables with the total index of digital inclusive finance development in 2020, 2019 and 2018 respectively to solve the possible reverse causality and prove the long-term impact of the development of digital inclusive finance on the purchase of commercial pension insurance, and the regression results are shown in Table 9.

TABLE 9
REPLACE THE REGRESSION RESULTS OF THE CORE EXPLANATORY VARIABLES

Variable	(1)	(2)	(3)
	Commercial_Pension	Commercial_Pension	Commercial_Pension
Ln_DFI20	0.312***		
	-0.056		
Ln_DFI19		0.287***	
		-0.053	
Ln_DFI18			0.290***
			-0.052
Gender	-0.014**	-0.014**	-0.014**
	-0.007	-0.007	-0.007
Ln_Age	0.017	0.017	0.017
	-0.012	-0.012	-0.012
Edu	0	0	0
	-0.002	-0.002	-0.002
Health	0.016***	0.016***	0.016***
	-0.003	-0.003	-0.003
Marriage	0	0	0
	-0.004	-0.004	-0.004
Basic_Pension	0.036***	0.036***	0.036***
	-0.009	-0.009	-0.009
Medical_Pension	-0.043***	-0.042***	-0.042***
	-0.016	-0.016	-0.016
Size	-0.003	-0.003	-0.003
	-0.002	-0.002	-0.002
Property	0.014***	0.014***	0.014***
	-0.005	-0.005	-0.005
Car	0.046***	0.046***	0.046***
	-0.008	-0.008	-0.008
Children	-0.015***	-0.015***	-0.015***
	-0.005	-0.005	-0.005
Ln_CPI	0.809	0.965	1.073
	-0.94	-0.934	-0.928
Gov	0.067***	0.063***	0.062***
	-0.017	-0.017	-0.017
_cons	-5.792	-6.339	-6.826
	-4.244	-4.229	-4.207
N	5810	5810	5810
R^2	0.034	0.033	0.033

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively, and the robustness standard error is in parentheses.

The results in Table 9 show that the lag period of the total index of digital inclusive finance has a significant impact on the participation rate of commercial pension insurance, indicating that the total index of digital inclusive finance has a significant positive impact on the participation rate of commercial pension insurance. 0.312>0.290>0.287, the 2019 Digital Inclusive Finance Development Index is slightly lower than that in 2018, which may be affected by the early stage of the new crown epidemic, financial activities are restricted, and the financial demand of enterprises and individuals has weakened. At the same time, the epidemic has led to a slowdown in the construction of digital financial infrastructure and the implementation of inclusive financial policies in some regions, affecting the overall development. Among them, the coefficient of the total index of digital inclusive finance development in 2020 is 0.312, indicating that if the total development index increases by 1% in 2020, the probability of individuals purchasing commercial pension insurance in 2021 will increase by 31.2 percentage points, but factors such as the impact of the epidemic, the constraints of economic conditions and the low penetration rate of the pension insurance market limit the actual play of this effect. Therefore, the increase in the probability of purchasing commercial endowment insurance does not fully meet the theoretical expectations.

4.3.2 Replace the model:

In order to verify the robustness of the regression results of the linear regression model, this paper refers to the study of Peng Weizhujia [29] (2020), and uses another model, the Probit model and the Logit model, to perform regression analysis on the same sample. By comparing the regression results of models based on different distribution assumptions (linear regression vs. Probit and Logit regression), the consistency of the models is tested to ensure the reliability and robustness of the research conclusions. The regression results of the Probit and Logit models are shown in Table 10, and it can be found that the regression results of Probit and Logit are consistent with the regression results of the linear regression model, and the results show that the total index of digital inclusive financial development has a significant positive effect on the participation rate of commercial pension insurance, which indicates that the benchmark model is relatively stable.

TABLE 10
LOGIT AND PROBIT REGRESSION RESULTS OF THE BENCHMARK MODEL

Variable	Logit	Probit
	Commercial_Pension	Commercial_Pension
Ln_DFI	0.943***	0.477***
	-0.194	-0.101
Control variables	YES	YES
Sample size	5810	5810
Pseudo R2	0.0607	0.0599

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively, and the robustness standard error is in parentheses.

4.4 Heterogeneity analysis:

The previous empirical results show that the digital financial inclusion index and the digital financial inclusion index have a significant promoting effect on the participation rate of commercial pension insurance. However, due to the differences in the characteristics of different individuals and families, there may be heterogeneity in the facilitation effect. In order to explore the heterogeneity of the impact of the Digital Financial Inclusion Index on the participation of commercial pension insurance, this paper conducts group regression of the samples according to the individual's political outlook, urban and rural conditions, region, and whether they often use the Internet. The results are shown in Table 11,Table 12 and Table 13.

TABLE 11
THE HETEROGENEITY OF THE TOTAL INDEX OF DIGITAL FINANCIAL INCLUSION ON THE PARTICIPATION OF COMMERCIAL PENSION INSURANCE

Variable	Non-party members	Party	Rarely use the internet	Use the internet a lot
	Commercial_Pension	Commercial_Pension	Commercial_Pension	Commercial_Pension
Ln_DFI	0.098***	0.028	0.011	0.091***
	-0.017	-0.041	-0.021	-0.02
Control variables	YES	YES	YES	YES
N	4959	851	1934	3876
R^2	0.037	0.026	0.012	0.035

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively, and the robustness standard error is in parentheses.

TABLE 12
HETEROGENEITY OF THE DIGITAL INCLUSIVE FINANCE GENERAL INDEX ON THE PARTICIPATION OF COMMERCIAL PENSION INSURANCE

Variable	Other	Agricultural	Urban
	Commercial_Pension	Commercial_Pension	Commercial_Pension
Ln_DFI	-0.057	0.043*	0.085***
	-0.16	-0.025	-0.023
Control variables	YES	YES	YES
N	70	3130	2610
R^2	0.126	0.022	0.038

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively, and the robustness standard error is in parentheses.

TABLE 13
HETEROGENEITY OF THE GENERAL INDEX OF DIGITAL INCLUSIVE FINANCE ON THE PARTICIPATION OF COMMERCIAL PENSION INSURANCE III

Variable	Eastern	Central	Western
	Commercial_Pension	Commercial_Pension	Commercial_Pension
Ln_DFI	0.075***	-0.027	0.173
	-0.023	-0.068	-0.121
Control variables	YES	YES	YES
N	2228	1716	1556
R^2	0.035	0.033	0.025

Note: ***, **, and * represent the significance levels of 1%, 5%, and 10%, respectively, and the robustness standard error is in parentheses.

The results show that the promotion effect of digital inclusive finance on the decision-making of commercial pension insurance exists in the samples of non-party members, the samples of agricultural residents, the samples of urban residents and the samples of eastern regions, and the probability of non-party members purchasing commercial pension insurance increases by 9.8%, 9.1% and 4.3% for agricultural residents with each unit of digital inclusive finance index. The probability of urban residents purchasing commercial endowment insurance increased by 8.5%, and that of residents in eastern China increased by 7.5%.

Non-Party members are more sensitive and involved in digital inclusive finance, perhaps because they lack the policy support and information resources of Party organizations, and rely more on the popularization and innovative products of digital inclusive finance. On the contrary, the financial inclusion index of the party member group is not significant, probably because

they have obtained sufficient social security information and resources through other channels, and the promotion of digital financial inclusion is relatively small.

Residents who regularly use the Internet are more inclined to buy commercial pension insurance, mainly because they can more easily obtain relevant information about pension insurance through the Internet platform. The internet provides users with a wealth of resources that make it easy to compare different insurance products, learn about what is covered, and how much it costs. The availability of this information has increased their interest in and willingness to purchase commercial pension insurance. In addition, the convenience of the internet allows residents to quickly purchase insurance online, saving time and effort. As a result, residents who regularly use the Internet are generally more willing to participate in commercial pension insurance because they can easily and quickly access information and make decisions.

Urban dwellers generally have better access to infrastructure and financial services than rural dwellers, and access to financial services is higher. As a result, the impact of digital financial inclusion on them is likely to be more immediate and significant, as they have greater access to digital financial services and a higher level of acceptance of these services.

The economic and financial infrastructure in the eastern region is relatively developed, and residents have a high acceptance of digital inclusive finance, so digital inclusive finance can significantly promote the participation of commercial pension insurance. On the contrary, due to the slow economic development, insufficient financial services, and low financial literacy of residents in the central and western regions, the promotion of digital inclusive finance on commercial pension insurance is relatively limited.

V. CONCLUSIONS AND POLICY RECOMMENDATIONS

Through empirical analysis, the impact of digital inclusive finance on the participation rate of individual commercial pension insurance is deeply discussed, and the mediating role of financial literacy and financial development in it is investigated. The results of the study found that, first, the health status of individuals, their participation in basic pension insurance, the number of houses and cars they owned, and policy support had a significant impact on the decision to purchase commercial pension insurance. Individuals in better health tend to purchase commercial pension insurance for long-term financial planning and risk management, while individuals in lower health tend to rely more on insurance due to their health risk sensitivity. Individuals who participate in basic pension insurance are more likely to purchase commercial pension insurance to fill the protection gap; Women, individuals with more properties and cars show higher willingness to buy due to their greater economic strength and risk aversion needs. Policy support also has a positive impact on purchasing decisions, reflecting residents' trust in the security system. In general, these factors work together to promote the willingness to purchase commercial pension insurance.

Second, financial literacy plays a significant mediating role between digital inclusive finance and the participation rate of commercial pension insurance. Specifically, digital inclusive finance enhances residents' understanding of financial products by improving their financial literacy, which in turn increases their willingness to participate in commercial pension insurance. The mediating effect of financial literacy accounted for 48.5%, reflecting its key role in promoting the participation rate of commercial pension insurance. At the same time, financial development also plays a significant intermediary role between digital inclusive finance and the participation rate of commercial pension insurance, accounting for 35.1%, indicating that the promotion of financial development on the participation rate of commercial pension insurance cannot be ignored.

Third, the role of digital inclusive finance in promoting the decision-making of commercial pension insurance is reflected in many groups, especially among non-party members, residents who often use the Internet, agricultural residents, urban residents and residents in the eastern region. Non-party members and internet-frequent residents are more sensitive to digital financial inclusion because they have easier access to information and purchase decisions through digital platforms. Urban residents are more receptive to digital inclusive finance because they enjoy better infrastructure and financial services, and the promotion effect is more obvious. In the eastern region, due to its developed economic and financial infrastructure, the influence of digital inclusive finance is particularly prominent. In contrast, due to lagging economic development, insufficient financial services and low financial literacy of residents in the central and western regions, the promotion of digital inclusive finance to commercial pension insurance is relatively weak.

Based on the conclusions of the paper, this paper puts forward the following policy suggestions: First, strengthen health management and risk awareness training, and find that the health status of individuals has a significant impact on the purchase decision of commercial pension insurance. Individuals in better health tend to use commercial pension insurance for long-term financial planning, while individuals in lower health may be more reliant on insurance due to their greater sensitivity to health risks. Therefore, it is suggested that policymakers should strengthen health management and risk awareness training, especially

for groups with poor health status, and encourage them to achieve better risk sharing and financial security through commercial pension insurance. At the same time, it can be combined with the comprehensive product design of health insurance and pension insurance to enhance residents' willingness to participate.

Second, to promote the construction of financial infrastructure in the eastern and central and western regions, considering that the eastern region has stronger acceptance and influence on digital inclusive finance, it is recommended to increase the construction of financial infrastructure in the central and western regions to improve residents' awareness and accessibility of digital financial products. This will not only narrow the gap between regions, but also promote the overall access to financial services and enhance the social inclusion of digital financial inclusion.

Third, the design and marketing of diversified financial products, due to the differences in the acceptance of digital inclusive finance by different groups, it is recommended that financial institutions consider more diversified demand characteristics when designing commercial pension insurance products, such as launching financial products with low thresholds and strong flexibility. At the same time, the marketing of financial products should be accurately launched through different channels and platforms, combined with the specific conditions of each group.

Fourth, to enhance policy support and incentives, local governments should strengthen policy support for commercial pension insurance, especially in terms of fiscal expenditure. By increasing incentives such as subsidies or tax incentives for commercial pension insurance products, residents will be able to enhance their confidence in the future pension security, encourage them to actively participate in commercial insurance plans, and improve the level of pension security for the whole society.

Through the implementation of these policy recommendations, we can effectively promote the development of digital inclusive finance and enhance residents' financial participation, thereby promoting the popularization and development of commercial pension insurance and helping more people achieve economic security and retirement security.

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